*COUNTRY REPORTS*

**Bolzano-Bozen,**
**Italy,**
**27-29 September 2023**

# EUROPEAN FORESTRY COMMISSION

## Working Party on the Management of Mountain Watersheds

## Thirty-fourth session

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2023

# Country reports

# Austria

# 34th Session of the Working Party on the Management of Mountain Watersheds (WPMMW)

Bolzano/Bozen (Italy), 27th – 28th September 2023

As the host of this year's event, the Italian government would like to request and invite you to provide a country report on this year's topic: Management of mountain watersheds in a climate change perspective: from the Alps to the Mediterranean areas.

Guiding questions for country report are:

(1) What kind of approaches and measures is your country developing and implementing in mountain watersheds to address climate change issues?
(2) What is the organizational model of the institutions and services involved in mountain watersheds management?
(3) How is the interaction between forest management and technical/bioengineering works considered?
(4) How are protective forests identified?
(5) What are the sources and amount of funding for mountain watersheds management in your country?

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## County Report Austria

(1) 70 % of the Austrian territory are part of the Alps, the European region mostly affected by global heating. Hence, multiple effects on alpine watersheds and the natural hazard processes as well as on protective forests can be detected, that increase the risk for settlement areas, critical infrastructure, economic values and ecosystems in the Alps. Scientific experts pronounce the major paradigm chance towards multiple hazard and multiple risk approaches. This principle also holds true for the major disturbances in the protective forests by climate induced risks, such as storm, forest fire, snow pressure, drought or the massive production of bark beetle leading to the extensive destruction of protective forests.
Austria has made great efforts in research and monitoring to identify the reasons and interrelations for the increase of extreme events by natural hazard triggered by global heating. A comprehensive survey for all kinds of natural hazards was carried out in the project **ExtremA**, incorporating the knowledge of all leading experts in Austria. The results of this study were published as open access and will be updaten periodically.
See the project ExtremA (Univeristy of Vienna): https://extrema.univie.ac.at/en/

See the open access publication on University Press: https://www.vandenhoeck-ruprecht-verlage.com/themen-entdecken/sozial-rechts-und-wirtschaftswissenschaften/natur-landschaft/55101/extrema-2019?c=1824.

Concerning the impact of Global Heating on Protective Forests (besides all other scientific issues) a comprehensive survey was carried out by the Austria Research Agency for Forests in the frame of the Austria Strategy for Protective Forests (Forest Protects us!), compiling the state of knowledge. The results were published in the report "Schutzwald in Österreich – Wissensstand und Forschungsbedarf", issued by the federal ministry.
See the publication on Protective Forest Research in Austria: https://www.bfw.gv.at/wp-content/uploads/sachstandsbericht_schutzwald_k.pdf

The scientific conclusions for the impact of climate change and global heating on natural hazards and protective forests in mountain watersheds in Austria are the basis for two important strategic documents that pave the path for concrete actions and measures to adapt to climate change impact:

- Strategy by the Austrian Service for Torrent and Avalanche Control
- Strategic Action Plan "Forest Protects us!" (https://www.protective-forest.at/dam/jcr:7f2b0d5c-0c87-4db0-9941-64330a37a2c2/UnserWald_BMNT2019_englisch.pdf), issued by the Federal Ministry for Agriculture Forestry and Water Management

The Austrian Service for Torrent and Avalanche Control has developed a specific type of project in order to sustainable manage the risks and protective forests in catchments of torrents and avalanche – the so-called **Watershed Management Project** (Flächenwirtschaftliche Projekt). These projects can be financed by budgets from the Austrian Disaster Relief Fund and contain measures to mitigate degradation and hazard processes in the catchment area, eg. By

- Biological stabilization works versus soil erosion
- Drainage of instable slopes
- Afforestation under the protection of technical measures against avalanches and snow gliding
- Maintenance of protective forests including measures to create a sustainable game density
- Realizing nature-based solutions to use synergies between ecology and natural hazard mitigation.

The investments in Watershed Management Projects in Austria reach € 10 Mio. Federal funds per year. The projects are carried out, as well by the Austria Service for Torrent and Avalanche Control, as by the Provincial Forest Services.

Read more about Flächenwirtschaftliche Projekte (in German): https://www.schutzwald.at/aktionsprogramm/best_practice/flaechenwirtschaftliche-projekte.html

(2) According to the Austria constitution, the legal basis for the Watershed Mangement in Austria is a task of the federal state and layed down in two acts, the Water Act 1959 (for the big rivers and creeks) and the Forst Act 1974 (for torrents and avalanches). From another perspective, the Water Act regulates the competences and measures along the watercourses (including flood plains), while the Forest Act regulates the maintenance of forests within the watersheds. Furthermore, no specific legal regulation is available for watershed management issues in other areas, covered by development planning (settlements, commercial areas) or agricultural planning.

The execution of the two acts is competence of the provincial authorities (on the district and provincial level). These authorities execute federal law under the supervision of the ministry.

In the field of private sector administration, public institutions carry out measures and manage subsidies for the watershed management. These activities are partially also regulated by law, eg. in the Water Act, the Forest Act and the Water Engineering Act, furthermore by European (funding) regulations such as the Rural Development Funding Directive or the Water or the European Water Framework Directive.

Major financial source for measures in the field of watershed management in Austria are:

- The Federal Disaster Relief Fund (Act)
- The Federal Environment Funding Act
- The Austria Forest Fund
- The Rural Development Funding

Measures, financed from these funds can be implemented by public, municipal, water cooperatives and private agencies. Law to the following institutions gives a special function:

- Austrian Service for Torrent and Avalanche Control
- Austrian Service for Flood Control
- Provincial Forest Services

(3) In Austria, the system of integrated and sustainable watershed and natural hazard management are applied. That means in principle, that natural hazards and risks are reduce to an acceptable level by the most efficient combination of non-structural and structural measures. Recently, this approach was enriched by the idea of nature-based-solution, incorporating the protective function of flood plains, wetlands and protective forests. A very new topic is the sealing of soils and the loss of infiltration, where new mitigation concepts are urgently needed.

Concerning the conservation and recovery of protective forests and flood plains, these measures have absolute priority in Austrian natural hazard management. Major legal acts (Water Act, Forest Act) have been adapted due to this principle. Furthermore, protection and mitigation in watersheds is carried out with the by mildest means. On the other hand, ecological and bioengineering measures are limited in protective effects, especially for extreme events, while protective forests might be destroyed by major disturbances like storm or forest fires, leaving a “protecton gap” for serveral decades. In these cases, technical measures are applied as subsidiary means to provide appropriate and permanent safety for human living space. In most cases, a smart combination by ecological and technical measures is the most efficient solution in watershed management.

(4) The identification of protective forests in Austria is stongly related to the legal definition of protective forests in the Austrian Forest Act 1975.

B. Forests Receiving Special Treatment

Protection Forest, Definition

Article 21. (1) Site-protecting forests (forests located on specific sites, referred to as "Standortschutzwälder"), within the meaning of this Federal Act are forests which are located on sites endangered by the eroding forces of wind, water or gravity, and which require special treatment to protect the soil and the plant cover and to ensure reforestation. Site-protecting forests include:

1. forests on wind-blown sand soil or drifting soil;
2. forests on sites with a tendency towards karstification or on sites that are particularly prone to erosion;
3. forests on rocky, shallow-grounded or steep locations if their reforestation is possible only under difficult conditions;
4. forests on slopes where dangerous slope slides might occur;
5. the forest cover in the upper timberline zone;
6. the forest belt immediately bordering the upper timberline zone.

(2) Object-protecting forests ("Objektschutzwälder") within the meaning of this Federal Act are forests which protect humans, human settlements or facilities, or cultivated soil, in particular against natural hazards or injuring environmental impacts and which require special treatment to gain and ensure their protective effect.

(3) The provisions on object-protecting forests are also applicable to the forest cover in the upper timberline zone provided that the cover has a high protective effect for the purposes of Article 6 paragraph (2) point (b).

Protective Forests Declared by Official Notice ("Bannwald")

Article 27. (1) Forests of the following kind shall be declared protective forests by official notice:

1. object-protecting forests which serve to ward off directly certain dangers from humans, human settlements or facilities, or from cultivated soil,
2. forests whose beneficial effect take precedence over the productive effect, and
3. forests which serve to directly ward off dangers resulting from the condition of the forest or its management,

where the economic or other public interest to be safeguarded (purpose of declaring a forest a protective forest by official notice) proves more important than the disadvantages associated with the restriction on forest management resulting from such declaration ("Bannwald").

(2) Purposes of declaring a forest a protective forest, as referred to in paragraph (1), shall be in particular

a. protection against avalanches, rockslide, rockfall, snow displacement, landslip, high water, wind or similar dangers,
b. warding off dangers caused by emissions,
c. the protection of medicinal springs and of tourist locations and conurbations from impairment of the needs of hygiene and recreation, as well as ensuring the necessary afforestation of the environment of such places for these purposes,
d. securing a water supply,
e. ensuring the usability of traffic facilities and energy supply systems,
f. ensuring the defensive effect of national defence systems,
g. protection against dangers resulting from the condition of the forest or its management.

In principal, legal definitions should be sufficient to identify protective and their specific functions in nature by expert opinion applying technical and scientific criteria. In Austria, a rough estimation of the protective function of forests is outlined within the **Forest Development Plan** (WEP, according to art. 6 – 9 Forest Act). This general planning tool is available for all Austrian political districts. The map is applicable on regional level.

See the Geodatabas of WEP in Austria: https://www.waldentwicklungsplan.at/

See the technical WEP-guideline:
https://info.bml.gv.at/service/publikationen/wald/forest-development-plan.html

A more detailed information on the situation of protective forests in Austria is the Protective Forest Indication Map of Federal Ministry for Agriculture, Forestry, Regions and Water Management BML. This map, jointly developed by the Austrian Service for Torrent and Avalanche Control, der Federal Research Agency for Forests and die Provincial Forest Services, was developed from high-resolution data and models on forests stands and natural hazard processes. The map is applicable on local level.

See the Protective Forest Indication Map: https://www.protective-forest.at/maps.html

An even more detailed geoformation on the situation of protective forests is the **Hazard Map** of the Austrian Service for Torrent and Avalanche Control WLV. In this map, available for all Austrian municipalities with catchments of torrents and avalanches, protective forests are outlined that have a direct function for the safety of settlement areas (blue zones) and consequently require a specific treatment. The map can be applied on the detailed level of the real estate catastre, but does not outline protective forests with no direct effects for the spatially relevant area.

See more details to the hazard map of WLV:
https://info.bml.gv.at/en/topics/forests/forest-and-natural-hazards/hazard-zone-plan-what-is-that.html

All relevant geodata concerning the protective function of forests (mentioned above) recently have been condensed on the new **WALDATLAS**, a progressive and state-of-the-arte public geodata platform, providing sophisticated tools for the data analysis appropriate for the interested layperson.

See more details concerning WALDATLAS: https://waldatlas.at/ (at the moment provided only in German language)

In spite of the broad scope of available geodata for the protective, function of forests in Austria, the formal determination of protective forests in Austria is reserved to the authorities by law. According to art. 22 Forst Act protective forest require a specific treatment by the owner, which is determined by law and can be enforced by official measures of the authority. In case, these treatment requirements determining the quality of protective forests are not clearly recognizable for the land owner, a specific official procedure is regulated, in art. 23 Forest Act to specify the protective forest based on a forest-technical expert report.

In case forests guarantee the safety of settlements and critical infrastructure, the authority can declared protective forests by official notice ("Bannwald", art. 27, see above) and oblige the landowner to carry out specific treatment and reforestation measures. The costs of these measures can rolled over to the beneficiaries of the protective function.

(5) As already, mentioned in (2) serveral financial funds are available on European and national level that are accessible for the funding of watershed management measures. The competences for these funds are spread among a large number of federal and provincial institutions. Also the fields of application of these funds and the potential measures are manifold and are related to serveral fields of competence, such as water management, forestry, agriculture, nature protection, development planning or catastrophe management. Also the definition of measures, the count among "watershed management" is blurred.
There is no report available in Austria that comprehensively presents the investments in watershed management in Austria; hence no serious estimate of the total investments can be given.

# Bulgaria

COUNTRY REPORT, BULGARIA

1. What policy instruments and forest management is your country implementing and developing to address climate change issues in mountain watersheds?

**National Climate Change Adaptation Strategy and Action Plan, 2030**

The main policy document in Republic of Bulgaria related to climate change effects and adaptation is the National Climate Change Adaptation Strategy and its Action Plan, 2030.

The National Strategy for Adaptation to Climate Change until 2030 and its Action Plan was adopted by Decision No. 621 of the Council of Ministers dated 25.10.2019. The document was prepared with the assistance of the World Bank and thoroughly examines the risks and vulnerabilities of climate change, with special attention paid to the "Forests" sector. It is emphasized that forest ecosystems in Bulgaria are of great importance for the country and society, as they are extremely diverse and productive. It is indicated that despite the significant efforts made to prepare the process of forest adaptation to climate change, there are several groups of vulnerabilities: 1) significant uncertainties regarding species-specific responses to changing climate conditions; 2) significant areas of artificially created plantations outside the natural area of distribution of the respective forest tree species, low altitude for the respective species and correspondingly high risk of growth decline and various health problems; 3) increased likelihood of large forest fires and other natural disturbances such as windstorms, damage from wet snow and icing, attacks by insects and fungal pathogens; 4) potentially improving conditions for the spread of invasive tree species with a high probability of causing significant damage to forest resources; 5) predominant use of wood for products with low added value and short life cycle.
The strategic goals for the "Forests" sector are: 1. improving the knowledge base and increasing awareness of adaptation to climate change 2. improvement and protection of forest resources; 3. improving the potential for sustainable use of forest resources. In the action plan to the strategic document, the following are adopted as operational objectives for the "Forests" sector, related to the relevant strategic objectives: .1. capacity building for research, education and dissemination of results; 1.2. carrying out research in support of adaptation; 2.1. sustainable management of the processes related to reforestation and increasing the area and growing stock in the forest territories; 2.2. maintaining biodiversity, genetic diversity and resilience of forests; 2.2. improving the management of forest resources; 3.1. improving the potential for long-term use of higher value wood products; 3.2. improving the potential for sustainable and more environmentally friendly use of wood biomass in energy production. [1]

[1] National Climate Change Adaptation Strategy and Action Plan, 2030, https://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=1294

**National strategy for the development of the forest sector in the Republic of Bulgaria to 2030**

**Vision:** By 2030, Bulgarian forests, increasing their area and growing stock and improving their condition, will contribute to the achievement of a prosperous, modern, competitive and climate-neutral economy, preserving their rich biological diversity, contributing to mitigation the negative impact of climate change, provision of clean air, water and soil, and ensuring opportunities for socio-economic development of all people and regions in the country.

**Strategic goals:**

1. Implementation of a purposeful policy for the establishment of sustainable forest management as the main way to guarantee the ecological function of forest habitats, the preservation and increase of biological diversity and contribution to mitigating climate change. The main priorities are related to increasing the area of forests and the growing stock of the forests, improving forest management, preventing and combating forest fires and forest damage, preserving and restoring forest genetic resources, introducing of forest ecosystem services payments, etc.
2. Strengthening the role of forests in ensuring the country's economic growth through the application of bioeconomy principles.
3. Guaranteeing the territorial socio-economic development and the participation of all main stakeholders in the processes of forest policy implementation.

The Ministry of Agriculture and food is responsible for the implementation of the strategic priorities as a whole and in cooperation with the Ministry of Environment and Water, the Ministry of the Interior, the Ministry of Finance and the Executive Forest Agency under Strategic objective 1 "Implementation of a targeted policy for the establishment of sustainable forest management as the main way to guarantee of the ecological function of forest habitats, protection and sustainable use of biological diversity and contribution to mitigating climate change”.[2]

Within “**Programme of measures for adaptation of the forests in Bulgaria and mitigation the negative effect of climate change on them”,** adopted by the Minister of agriculture and food, a determination of the main vulnerability zones of the forest ecosystems in terms of climate changes was elaborated. The measures for adaptation are specified according to every vulnerability zone.[3] The challenge is to secure funding for the implementation of adaptation measures.

2. What is the structure and function of the institutions and services that manage mountain watersheds?

The Executive Forest Agency and its regional structures, the Regional Forest Directorates, are responsible for the regulation and control of forests. State forest enterprises (according to art. 163 of the Forest Act|) are responsible for the management of the forests. Municipal forests are managed by municipality according to the forest management plans. The Executive Forest Agency cooperates with the Ministry of environment and water and with the Executive Environment Agency in order to protect and manage the forests in mountain watersheds in a sustainable way. Ministry of

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[2] National strategy for the development of the forest sector in the Republic of Bulgaria to 2030, https://www.mzh.government.bg/bg/politiki-i-programi/politiki-i-strategii/nacionalna-strategiya-za-razvitie-na-gorskiya-sektor-v-republika/

[3] Programme of measures for adaptation of the forests in Bulgaria and mitigation the negative effect of climate change on them”, 2011, INTERREG IVC, FUTUREforest project publication

Environment and Water (MoEW) is responsible for the management of forests in protected areas (National parks, Reserves and Maintained reserves). The 3 National parks in the country comprise mountain areas in Rila, Pirin and Balkan mountains. There is cooperation on regional level between regional and local forest services and River basin directorates (MoEW) related to water protective forests. (Fig. 1)

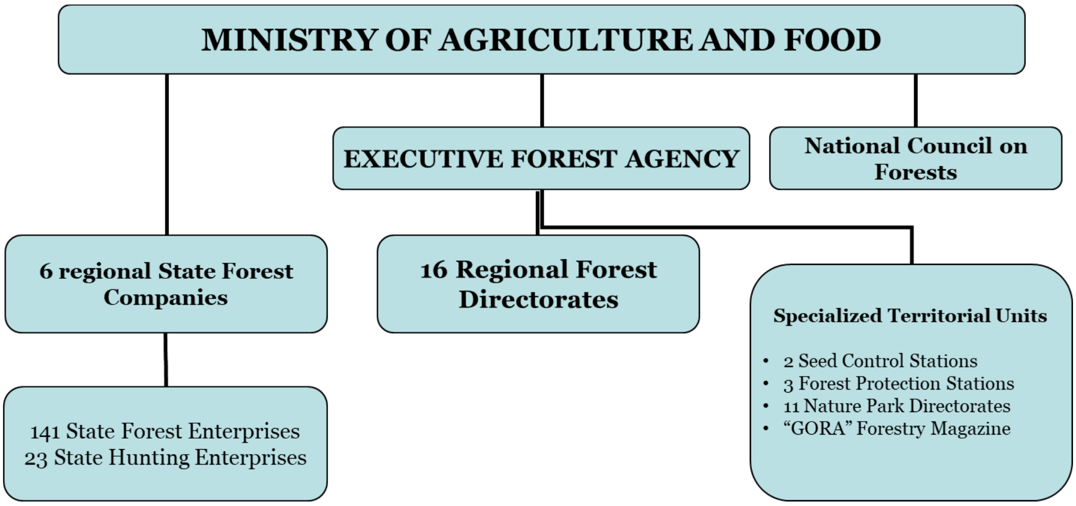


Fig. 1 Organizational structure

3. How do forest management and technical/bioengineering works coordinate and collaborate for the mountain watersheds management?

Bulgarian forests provide /secure/ about 85% of the water flow and are of great importance for the drinking water supply in the country. The water sanitary protected zones and reserves guarantee the conservation of water resources. Integrated efforts of the different institutions (Executive Forest Agency, State Forest Enterprises, Ministry of Environment and Water, River Basin Directorates) with relevance to the protection of water and natural resources and their management, including control and conservation of the water-preservation and protected areas guarantee the protection of drinking water areas and the special regimes inside them. (Fig. 2)
The sanitary protection zones consist of three belts: Inner I, Middle II and Outer III. Within Belt I, the only allowed activities are those, connected to the exploitation of the water source and/or the facility, as well as activities related to the implementation of erosion-control, afforestation and forestry actions. The designated SPZs are given in the River basin management plans.
In Belt I are prohibited durable investments, change of land purpose or excluding of forest territories from the forest fund
In Belt II are prohibited/or limited the activities such as: forest loggings, but only thinings, extraction of underground resources, creation of new or expansion of settlements, building of roads, etc.
In Belt II and III are forbidden or limited the activities such as: building of new roads, fertilization, extraction of underground resources, use of crop dusting detergents, etc.

Fig. 2 Water protected area /Belt I/- capture and tank © EFA

The successful erosion control dates more than 100 years. Main approach is complex utilization of hydro technical and forest melioration activities. The Forest Watershed Management include 617 000 m3 barrages and thresholds, 395 000 m3 small stone thresholds, 597 000 m2 wattles, 428 000 m bank low wattles, 194 000 ha anti erosion afforestation constructed during last century. (Fig. 3)

Fig. 3 Anti erosion facilities[4]

In the country a special automatic systems for observation and alerting of forest fires helps for prevention and protection of forest ecosystems, especially in mountain regions. The lookout towers are 22 and cover about 15% of the territory of the country.

[4] Zuckov D., 2005, 100 years of erosion control in Bulgaria, Aprikom Ltd, Sofia, ISBN: 954-90748-3-8

The towers are built by forest services, but there is one belonging to municipality of Stara Zagora. (Fig. 4 and Fig. 5)

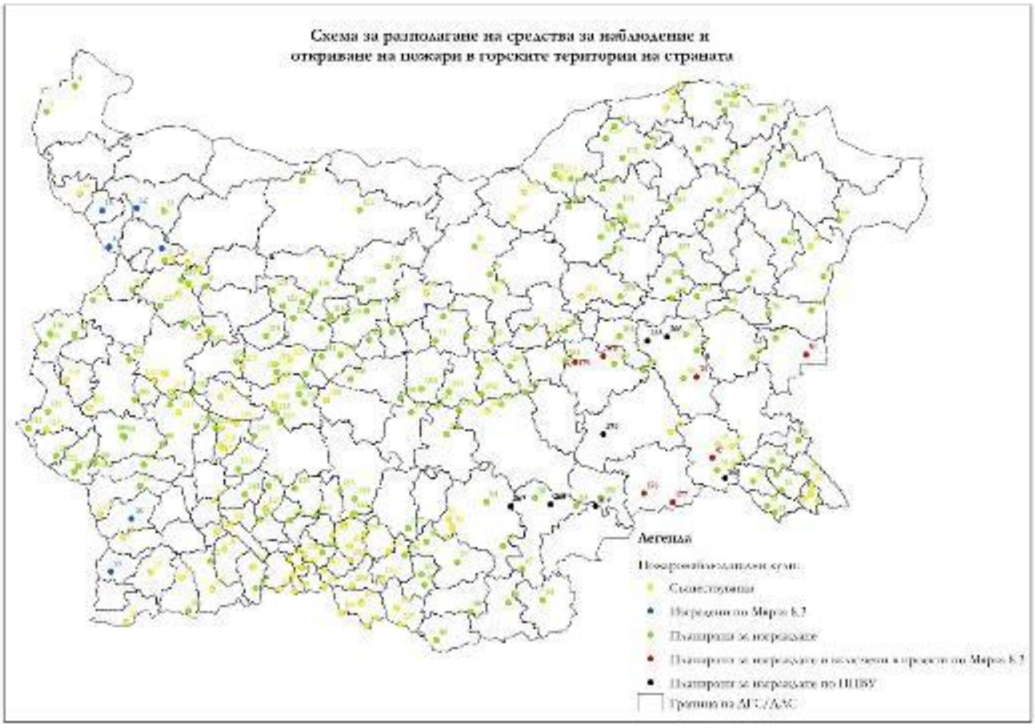


Fig. 4 Scheme of alerting forest fire system on the territory of Bulgaria – yellow – existing, other colors – planned for construction

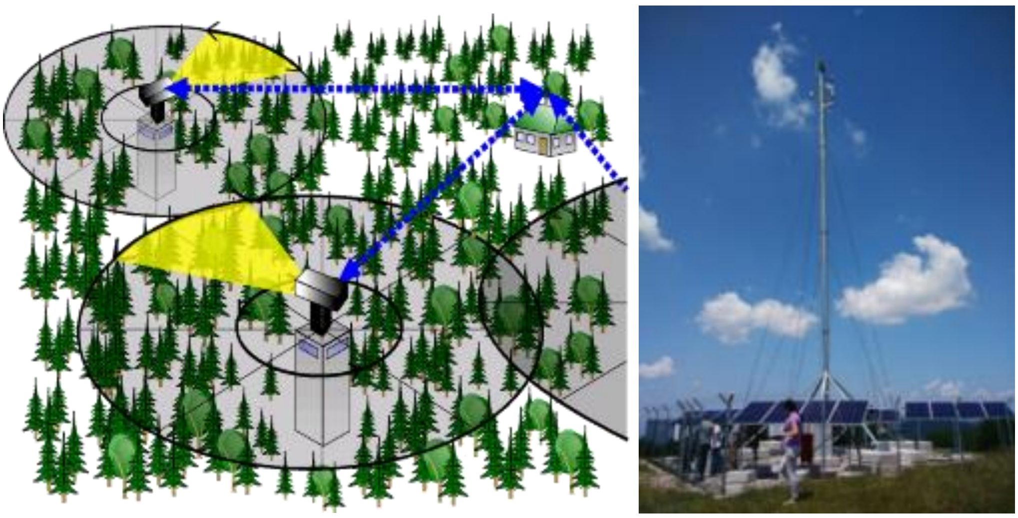

Fig. 5: Scheme of alerting forest fire system in Nature park “Vrachanski Balkan” © EFA.

4. How do you identify and designate protective forest?

The main legal act for the protection functions of forests is the Forest Act. According to it:
Art. 5 “Forest territories, depending on their major functions shall be divided in 3 categories:
1. Protective
2. Special
3. Economic
Protective shall be the forest territories for protection of soils, waters, urban territories, buildings and sites of the technical infrastructure; the upper forest limit; the protective belts, as well as forests for erosion control.
“Forest territories shall fulfill the following basic functions:
1. protection of soils, water resources and cleanness of the air;
2. maintaining the biological diversity of the forest ecosystems;
3.providing social, educational scientific, landscape and recreation uses for society;
4. protection of the natural and cultural inheritance;
5. production of timber and non-timber forest products;
6. regulation of climate and absorption of carbon
Art. 90. (1) The protection of the forest territories against erosion and floods shall cover the activities, related to protection from taking away fine fractions from the threatened soil for maintaining the soil fruitfulness by limiting or decreasing the surface water flow, protection of the upper layer from wind erosion and providing opportunities for development of vegetation, including by technical equipment
(2) The protection of the forest territories against erosion and floods, as well as the structure of the supporting equipment shall be done under the terms and conditions of the ordinance under Art. 95, Para. 2, p. 4.
The law describes that forest territories are considered protective for the protection of soils, water, urban territories, buildings, sites of technical infrastructure and, lastly, biodiversity. Moreover, the upper forest limit, the protective belts, as well as forests created under technical projects to fight erosion, are defined as protective forests. The forests designated for soil protection are those on slopes exceeding 30 degrees and those situated on shallow soils with slopes exceeding 20 degrees. Soil protective forest stands also play an important role between constructed dams for protection against the adverse impact of water, 200 m wide along the Danube River and 100 m wide around other large rivers. In torrential watersheds (Figure 2), soil protective forests are up to 15 m wide and in the lower plains, hills and hilly-mountainous terrain, about 50 m wide around the watercourses. Forests for water protection are located in the sanitary protection zones around the water sources and facilities for drinking water supply, and around the mineral water sources used for therapeutic, prophylactic, drinking and hygiene purposes. The green forest belts around the settlements are belts with a width of about 50 to 100 m from the village boundary. Forest territories for the protection of buildings and technical infrastructure include 25- to 200-m-wide strips along highways, roads and railway networks, and 25- to 50-m strips around the buildings and sites servicing technical infrastructure. In areas with active avalanches, the protective forest belt is 200 m wide. (Fig. 6) [5]

[5] https://www.lex.bg/laws/ldoc/2135721295

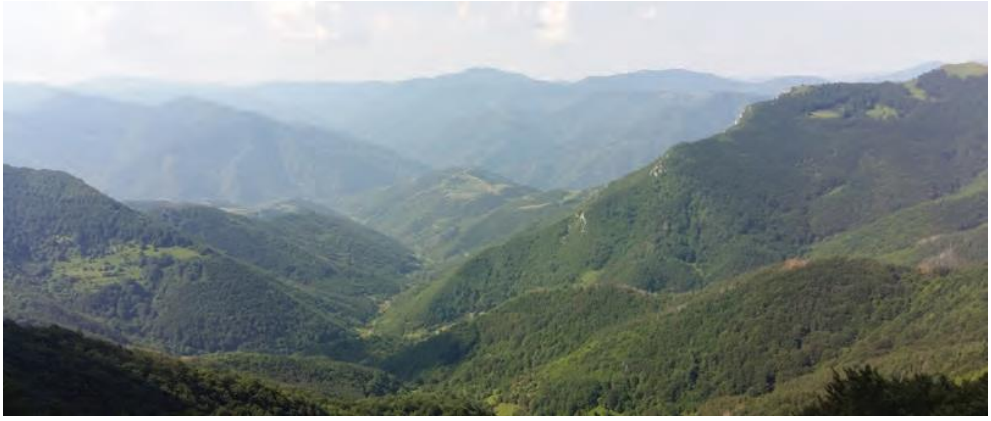

Fig. 6 Protective forests in the watershed “Ochindolska reka," Northwest Bulgaria, EFA©

5. What are the financial sources and amount of funding for mountain watersheds management in your country?

The measures are funded by the state budget, resp. by the budget of every state or municipal forest enterprises or by European funds in case thematic project is available. The activities are planned in the forest management plans. According to the National strategy for the development of forest sector in Republic of Bulgaria to 2030 the financial resource used for activities related to systematic study of the impact of climate change and identification of appropriate sylvicultural practices for adaptation is insufficient. The funding is not especially targeted for mountain watersheds, but is designated for management of the forests according to forest units in the country.

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34th Session of the EFC Working Party on the Management of Mountain Watersheds (WPMMW) and Conference on "Management of mountain watersheds in a climate change perspective: from the Alps to the Mediterranean areas", Bulgaria

**27- 29 September 2023, Bolzano, Italy**

# Policy instruments and forest management to address climate change issues in mountain watersheds

- **National Climate Change Adaptation Strategy and Action Plan, 2030 - adopted by Decision No. 621 of the Council of Ministers on 25.10.2019**

- Examines the risks and vulnerabilities of climate change, with special attention to "Forests" sector.
- It is emphasized that forest ecosystems in Bulgaria are of great importance for the country and society, as they are extremely diverse and productive

## National Climate Change Adaptation Strategy and Action Plan, 2030

### Vulnerabilities

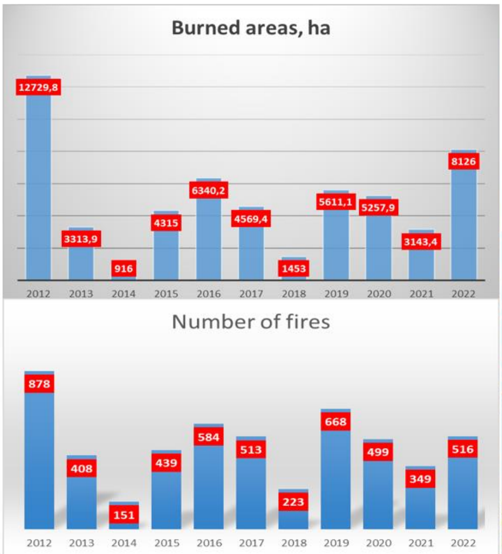
- significant uncertainties regarding species-specific responses to changing climate conditions
- significant areas of artificially created plantations outside the natural area of distribution of the respective forest tree species, low altitude for the respective species and correspondingly high risk of growth decline and various health problems
- increased likelihood of large forest fires and other natural disturbances such as windstorms, damages from wet snow and icing, attacks by insects and fungal pathogens
- potentially improving conditions for the spread of invasive tree species with a high probability of causing significant damage to forest resources
- predominant use of wood for products with low added value and short life cycle

- Coniferous plantations, afforested 40-50 years ago out of their natural areal with the main aim to control the erosion in the country reached their utmost growth.
- They are very susceptible to bark beetle or other forest pests.
- Recently on the territory of the country about 30 000 ha coniferous plantations are affected.
- There are legislative measures for ecological reconstruction of damaged forests, e.g. cutting of the affected forests and encouragement of natural regeneration of the broadleaf species in their natural areal.
- In mountain watershed plantations, *Pinus nigra* and *Pinus sylvestris* are attacked by bark beetle, which leads to deforestation of certain areas and risk of erosion and torrents.

Transformation of coniferous plantations in watershed "Ochindolska reka", Bulgaria

Bark beetle infestation /July 2017/ and sanitary fellings /October, 2017; © EFA
Watershed "Ochindolska reka" /west part of Stara Planina, Camaro-D project /

# Forest fires




## National Climate Change Adaptation Strategy and Action Plan, 2030

### Strategic goals for the "Forests" sector

- improving the knowledge base and increasing awareness of adaptation to climate change;
- improvement and protection of forest resources;
- improving the potential for sustainable use of forest resources.

Action plan operational objectives: 1. capacity building for research, education and dissemination of results; 1.2. carrying out research in support of adaptation; 2.1. sustainable management of the processes related to reforestation and increasing the area and growing stock in the forest territories; 2.2. maintaining biodiversity, genetic diversity and resilience of forests; 2.2. improving the management of forest resources; 3.1. improving the potential for long-term use of higher value wood products; 3.2. improving the potential for sustainable and more environmentally friendly use of wood biomass in energy production.

**National strategy for the development of the forest sector in the Republic of Bulgaria to 2030**

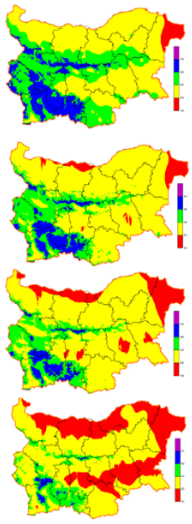
- **Vision:** By 2030, Bulgarian forests, increasing their area and growing stock and improving their condition, will contribute to the achievement of a prosperous, modern, competitive and climate-neutral economy, preserving their rich biological diversity, contributing to mitigation the negative impact of climate change, provision of clean air, water and soil, and ensuring opportunities for socio-economic development of all people and regions in the country.

**National strategy for the development of the forest sector in the Republic of Bulgaria to 2030**

- **Strategic goals:**
- Implementation of a purposeful policy for the establishment of sustainable forest management as the main way to guarantee the ecological function of forest habitats, the preservation and increase of biological diversity and contribution to mitigating climate change. The main priorities are related to increasing the area of forests and the growing stock of the forests, improving forest management, preventing and combating forest fires and forest damage, preserving and restoring forest genetic resources, introducing of forest ecosystem services payments, etc.
- Strengthening the role of forests in ensuring the country's economic growth through the application of bioeconomy principles.
- Guaranteeing the territorial socio-economic development and the participation of all main stakeholders in the processes of forest policy implementation.

## Programme of measures for adaptation of the forests in Bulgaria and mitigation the negative effect of climate change on them

- adopted by the Minister of agriculture and food, a determination of the main vulnerability zones of the forest ecosystems in terms of climate changes was elaborated. The measures for adaptation are specified according to every vulnerability zone. The challenge is to secure funding for the implementation of adaptation measures.

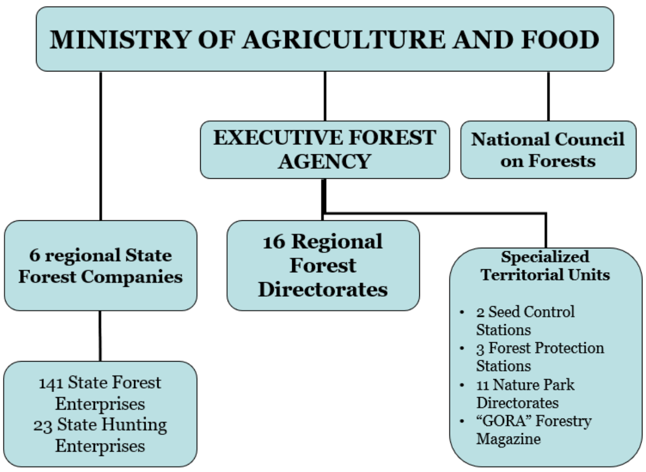


**2020 г.**
**Index of De Marton at realistic scenario**

**2050 г.**
**Index of De Marton at realistic scenario**

**2080 г.**
**Index of De Marton at realistic scenario**

**2080 г.**
**Index of De Marton at pesimistic scenario**




The Executive Forest Agency and its regional structures, the Regional Forest Directorates, are responsible for the regulation and control of forests. State forest enterprises (according to art. 163 of the Forest Act|) are responsible for the management of the forests. Municipal forests are managed by municipality according to the forest management plans.

The Executive Forest Agency cooperates with the Ministry of environment and water and with the Executive Environment Agency in order to protect and manage the forests in mountain watersheds in a sustainable way. Ministry of Environment and Water (MoEW) is responsible for the management of forests in protected areas (National parks, Reserves and Maintained reserves). The 3 National parks in the country comprise mountain areas in Rila, Pirin and Balkan mountains. There is cooperation on regional level between regional and local forest services and River basin directorates (MoEW) related to water protective forests.

Economic Management Functions

Control and Administration Functions

**6 regional State Forestry Companies/ local units**
**Sub-units** – state forestry and hunting enterprises

- •Forest Operations - silviculture, maintenance of forest roads etc.
- •Harvesting - Supervision of harvesting and other operations by private companies
- •Sale of Timber
- •Sale of non Timber Products
- •Hunting and Fishing management operations
- •Forest protection (fires & pests)
- •New Business Development

**Executive Forest Agency**

Forest policy (Policy & Strategy)

- Legislation
- Regulation/Control and inspection
- Forest inventory
- Support to private forest owners - extension services
- Forest protection – coordination, planning and control (erosion control, forest fire management)
- National data base
- Seed control
- Nature park management
- Research

**Cooperation – forest management and technical/bioengineering**

Bulgarian forests provide /secure/ about 85% of the water flow and are of great importance for the drinking water supply in the country. The water sanitary protected zones and reserves guarantee the conservation of water resources. Integrated efforts of the different institutions (Executive Forest Agency, State Forest Enterprises, Ministry of Environment and Water, River Basin Directorates) with relevance to the protection of water and natural resources and their management, including control and conservation of the water-preservation and protected areas guarantee the protection of drinking water areas and the special regimes inside them.

Water protected area /Belt I/- capture and tank © EFA

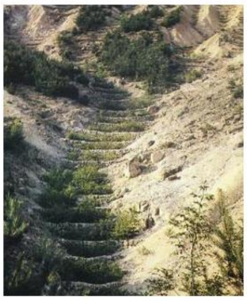
MINISTERO DELL'AGRICOLTURA DELLA SOVRANITÀ ALIMENTARE E DELLE FORESTE

Food and Agriculture Organization of the United Nations

**Cooperation – forest management and technical/bioengineering**

# Erosion control

- The successful erosion control dates more than 100 years
- Main approach – complex utilization of hydro technical and forest melioration activities
- Forest Watershed Management:
  - 617 000 m3 barrages and thresholds;
  - 395 000 m3 small stone thresholds;
  - 597 000 m2 wattles;
  - 428 000 m bank low wattles;
  - 194 000 ha anti erosion afforestation.

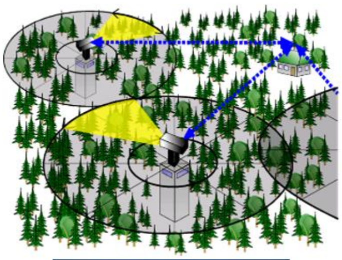


MINISTERO DELL'AGRICOLTURA DELLA SOVRANITÀ ALIMENTARE E DELLE FORESTE

Food and Agriculture Organization of the United Nations

**Cooperation – forest management and technical/bioengineering**

In the country a special automatic systems for observation and alerting of forest fires helps for prevention and protection of forest ecosystems, especially in mountain regions. The lookout towers are 22 and cover about 15% of the territory of the country.



Scheme of alerting forest fire system in Nature park “Vrachanski Balkan” © EFA

# Legal basis
Forest Act

**Forest territories, depending on their major functions shall be divided in 3 categories:**

- 1. protective
- 2. special
- 3. economic
- Protective shall be the forest territories for protection of soils, waters, urban territories, buildings and sites of the technical infrastructure; the upper forest limit; the protective belts, as well as forests for erosion control.

**Forest territories shall fulfill the following basic functions:**

- 1. protection of soils, water resources and cleanness of the air;
- 2. maintaining the biological diversity of the forest ecosystems;
- 3. providing social, educational scientific, landscape and recreation uses for society;
- 4. protection of the natural and cultural inheritance;
- 5. production of timber and non-timber forest products;
- 6. regulation of climate and absorption of carbon

**Art. 52. (5) The territories providing ecosystem services are defined based on the forest categories and according to a Table of compliance in Application 13 of this Ordinance**

Application № 13 to art. 52, para. 5

Relation between the functional zonation and the ecosystem services

| **Forest category (art.5)** | **Ecosystem services (art.249 of the Forest Law)** |
|---|---|
| Protective forests | Water protection; erosion control; soil protection; prevention of landslides and avalanches<br>Protection of urban territories<br>Protection of infrastructure |
| Special forests | Protection of biodiversity and of forests with high conservation value<br>Protection of cultural heritage<br>Maintenance of basic material and seed orchards<br>Recreation services<br>Stands for scientific and research activities |
| Economic forests | |


THANK YOU FOR
YOUR ATTENTION!
Albena Bobeva, PhD – Chief expert
Executive Forest Agency, Sofia, Bulgaria

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# Czech Republic

## Management of Mountain Watersheds in the Czech Republic

[1]Josef Křeček, [2]Marie Jíchová & [3]Eva Pažourková

1) Czech Technical University in Prague
2) Waterways Directorate, Prague
3) AON Impact Forecasting, Prague

### Mountain watersheds

According to the mountain delineation provided by Gløersen *et al*. (2004), in the Czech Republic, mountain watersheds extend over 18,600 km$^2$ (24 % of the country area, Figure 1). The altitudinal range is from 115 m to 1,602 m with the timberline considered at 1,300 m.

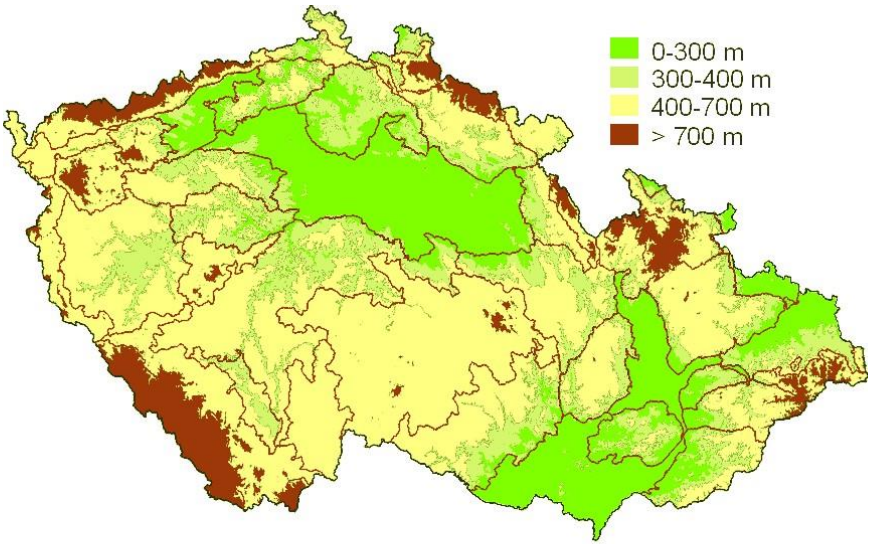


**Figure 1**. Distribution of elevation zones on the Czech Republic territory (www.casopis.ochranaprirody.cz/res/archive).

By only one percent of the country located above 1,000 m, mountain catchments in the Czech Republic are dominantly covered by forests, and, thus mountain forests represent almost 69 % of the national woodland area covering 26,815 km$^2$.

## Forest cover

The temperate climate is represented here by the Kőppen categories *Cfb* (marine west coast), *Dfb* (humid continental), and *Dfc* (sub-arctic, in minor areas with highest elevations). The average annual water balance of Czechia for the period 1961-1990 is characterised by 693 mm of precipitation, 499 mm of evaporation, and 194 mm run-off (CHMI, 2007). Forests represent the climax vegetation over the total territory of the Czech Republic. Still in the early Middle Ages forests percentage there was almost 80 % (Table 1).

**Table 1**. Forest percentage at the Czech territory in 1300-2020.

| **Year** | 1300 | 1789 | 1845 | 1897 | 1930 | 1950 | 1970 | 1980 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Forests (%)** | 80 | 14 | 29 | 29 | 30 | 29 | 33 | 33 | 33 | 34 |

The recent 34 % registered in 2020 (Ministry of Agriculture, 2021) has been relatively stable since the end of the 19th century. The recent afforestation activities (particularly, in 2021-2022) can increase the forest percentage based on the CORINE land cover inventory (Manakos & Brown, 2014) to 37 % (Figure 2).

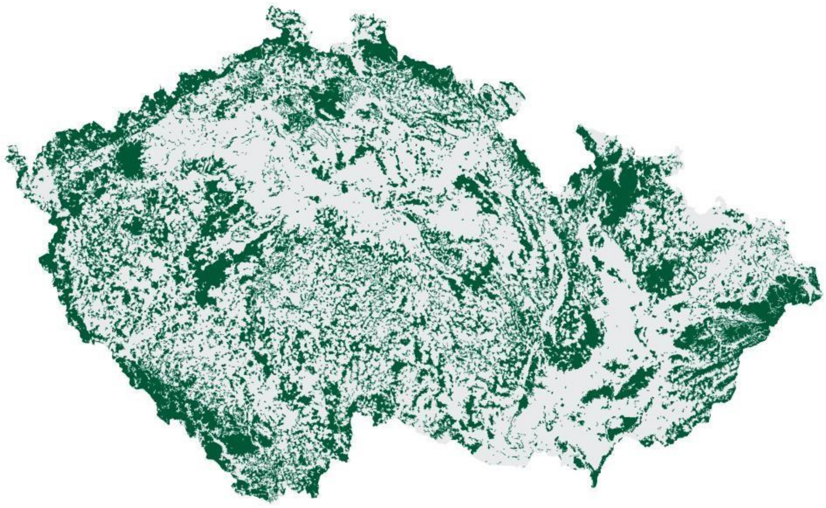

**Figure 2**. Forests in the Czech Republic, 2023 (https://faktaoklimatu.cz/infografiky/lesy-cr-mapa).

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In mountain catchments, the original native tree species composition (mixture of common beech - *Fagus sylvatica*, common silver fir - *Abies alba*, and Norway spruce - *Picea abies*) has been transformed to the dominant spruce plantations, particularly in the second half of the nineteenth century (Ministry of Agriculture, 2021). In the whole country, in 2020, 56 % of forests were owned by the state, 26 % by private and 18 % by municipalities.

Thus, particularly, mountain forests are dominantly managed by the state enterprise Forests of the Czech Republic, responsible for forestry practices controlling almost 80% of national water resources including 38,600 km of small headwater torrents and 887 small water reservoirs.

## Problems and Policies

The history of land use policy in mountain regions of the Czech Republic corresponds namely with interventions in forests noted since the 14th century (Rabštejnek, 1969). The legislature followed the changing priorities in forest functions. Royal decrees followed the aim to protect the forested state boarder and big game hunting (Majestas Carolina 49-56, Krečmer and Křeček, 1986). The poor state of mountain forests in the second half of the 19th century, and occurrence of several catastrophic floods, initiated the declaration of the soil improvement (Act 116/1884 Coll.) and the safe diversion of mountain waters (Act 117/1884 Coll.) in the former Austro-Hungary (Křeček *et al.*, 2019). Consequently, a system of retention reservoirs, torrent control, and forest conservation measures were realized in the beginning of the 20th century. In 1956, the Protected Landscape Regions were set aside by the Czech government to preserve the unique natural elements of the region (Nature Protection Act 40/1956, and, Nature and Landscape Protection Act 114/1992 Coll.). The system of drinking water supply was supported by the Protected Headwater Areas claimed by the Czech Government in 1978 (the Decree 40/1978 according to the Water Act 138/1973 (revised in 2001: Act 254 Coll.), Tureček (2002), Figure 3. Forest stands in the Protected Landscape Areas ('special purpose forests', 6,168 km$^2$) together with the 'protective forests' (forests on extreme sites: high slopes or peatlands, 533 km$^2$) create 36% of mountain forests (Forestry Act 289/1995, 90/2019 Coll.). This value exceeds the mean of 25% of global forests managed with priority of soil and water protection reported by FAO (2018).

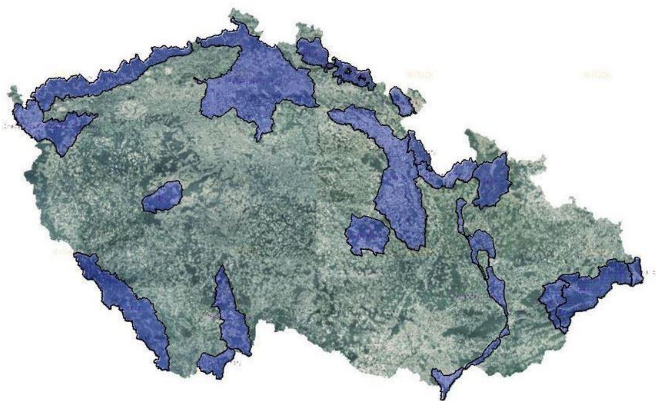

**Figure 3**. Protected headwater areas (blue) in the Czech Republic (www.geoportal.gov.cz).

However, the system of Protected Headwater Areas still faces a serious gap in ensuring forest environmental services; only the reduction of forest areas and the development of drainage are controlled there. Considering the environmental services (MEA, 2005), mountain forests can maintain particularly the provisioning (drinking water supply), regulating (soil and water quality, flood mitigation), and supporting (biodiversity conservation) services. In the context of globalisation, mountain forests face three contradicting challenges: to turn into ‘open museums’ or areas for recreation and protected nature for industrialised societies; to be regarded as regions to be economically exploited, or even over-exploited; and abandonment (Gløersen *et al*., 2004). In the mountain catchments of drinking water reservoirs, structured forestry was adopted to differentiate forestry practices upon the precipitation-runoff genesis: 1) buffer strips around watercourses and reservoirs, 2) stands controlling soil erosion on steep slopes, and 3) forest stands regulating water yield by controlling evaporation (Křeček et al., 2019), Figure 4.

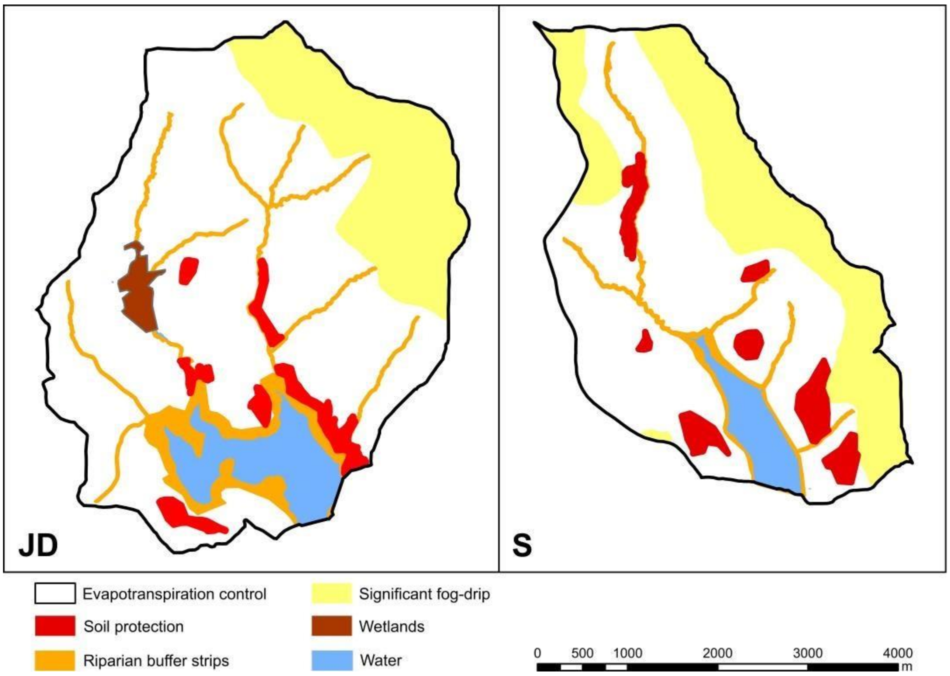


**Figure 4**. Structured forestry in catchment of drinking water reservoirs Josefův Důl (JD) and Souš (S) in the Jizera Mts.

The state supports the stabilization of mountain watersheds by 96 million CZK per year; it is almost 25% of the annual subsidies (390 million CZK) in forestry. That support includes: environmental friendly forestry technologies (36 million CZK), torrent control (5 million CZK), reforestation of damaged forests by the air pollution (11 million CZK), and aerial liming (44 million CZK). The European Union fund on Rural Development 2007 – 2013 (915 million CZK per year) has been used in mountain catchments by some 20 % (183 million CZK), Ministry of Agriculture (2021).

### Climate Change Impacts

During the last century, air temperatures increased averagely in 1.2 ºC (0.45 ºC in the last 30 years). The most intensive warming has been registered in the spring and summer (due to the rising number of episodes with extremely high temperatures); the number of summer days increase twice and tropical days three times. By the year 2030, the prognoses of rising temperatures range from 1.2 to 1.5 ºC; while prognoses of precipitation are more complicated: rising in the winter and decreasing in the summer with ca 4 % increase in the mean annual precipitation, compared with the period 1961–1990 (CHMI, 2019). These changes might affect the climate zonation of mountain forests, Table 2; therefore, some 40 % of the dominant spruce stands are endangered.

**Table 2**: The climate zonation of mountain forests in the Czech Republic (Zlatník, 1976) ($T_a$ – mean annual temperature, $P_a$ – mean annual precipitation).

| **Dominant tree species** | **Area** (km²) | **Elevation** (m) | $T_a$ (ºC) | $P_a$ (mm) | **Veg. period** (days) |
|---|---|---|---|---|---|
| Beech and oak | 2,862 | 400-550 | 6.5-7.5 | 650-700 | 150-160 |
| Beech | 4,505 | 550-600 | 6.0-6.5 | 700-800 | 140-150 |
| Beech and fir | 6,360 | 600-700 | 5.5-6.0 | 800-900 | 130-140 |
| Beech and spruce | 3,445 | 700-900 | 4.5-5.5 | 900-1,050 | 115-130 |
| Spruce and beech | 1,060 | 900-1,050 | 4.0-4.5 | 1,050-1,200 | 100-115 |
| Spruce | 265 | 1,050-1,350 | 2.5-4.0 | 1,200-1,500 | 60-100 |
| Dwarf pine | 53 | > 1,350 | < 2.5 | > 1,500 | < 60 |

The climate change (namely more frequent and longer draughts) can rapidly increase the intensity of insect epidemics and decline the health status of forests. Despite of tendencies to increase percentage of deciduous trees, there is still the dominant proportion of spruce forests with a relatively low ecological stability and high risk of deterioration (forest disruption, humus mineralisation, soil erosion and storm runoff acceleration). This situation might be still impaired by the long-term effects of acidification.

Since the 1850s, ecosystems in central Europe have deteriorated by industrial air pollution and the acid rain impact, initiated namely by the airborne emissions of sulphur and nitrogen from several highly industrialised regions. After World War II, the acid atmospheric deposition caused widespread damage to mountain catchments in the Czech Republic, particularly to spruce forests and surface waters (Křeček *et al*., 2019). That situation culminated in the late 1980s and early 1990s. The first signs of recovery were observed in the 1990s following the 1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes (with loads of sulphur decreased to approx. 40 % of those in 1987). However, nowadays, the stability of mountain forests in the Czech Republic is threatened mainly by the synergy of acidification and global warming. Particularly, extended dry periods contributed to serious bark beetle calamities; in 2017-2018, the related salvage felling reached the volume of 4 $m^3$ $ha^{-1}$ exceeding significantly the abiotic factors (wind, snow, or frosting).

Generally, in comparison with the even-aged spruce plantation, mixed forests near the native composition show higher stability (resilience against insect calamities), higher potential in the carbon segregation and mitigation of climate change, and, additionally, those stands can significantly decrease the annual load of sulphur and nitrogen by approx. 30%. Particularly, at elevations above 900 meters, where the fog drip in mature spruce stands was found critical (ca. 200 – 250 mm, i.e. 14 – 18% of the mean annual gross precipitation) the mixed or deciduous forests can significantly mitigate acidification and declining water quality.

## Conclusions

The legal status of multipurpose mountain forests was established in the belief that they can significantly mitigate the hazard of water quality decline, drop in water resources recharge, acceleration of soil erosion and sedimentation, and decreasing stability of slopes in headwater catchments. The adequate legislative regulation of watershed management shows a delay to the recent rapidly changing environment. However, the principle of forest stands near the native composition, and structured forestry practices in mountain watersheds can significantly increase the mitigation against climate change impacts and acidification.

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# MANAGEMENT OF MONTAIN WATERSHEDS IN THE CZECH REPUBLIC

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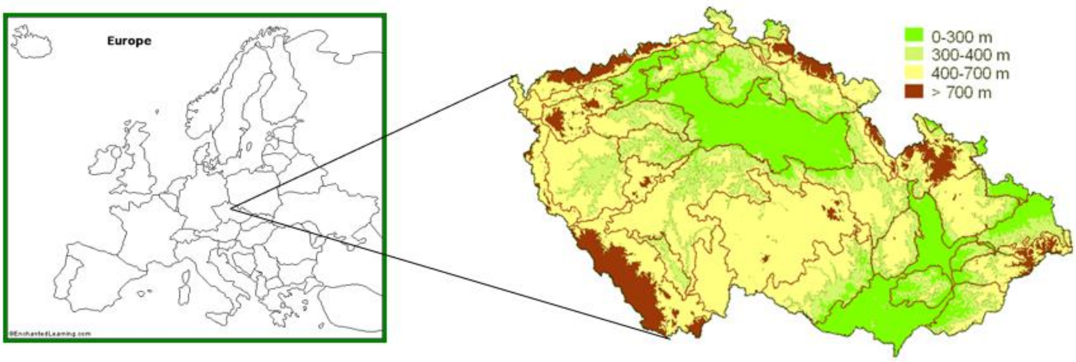
[2] Waterways Directorate, Prague
[3] AON Impact Forecasting, Prague

## MOUNTAIN WATERSHEDS

- **Central Europe** (48-51 N, 12-19 E), elevation range 115-1,602 m



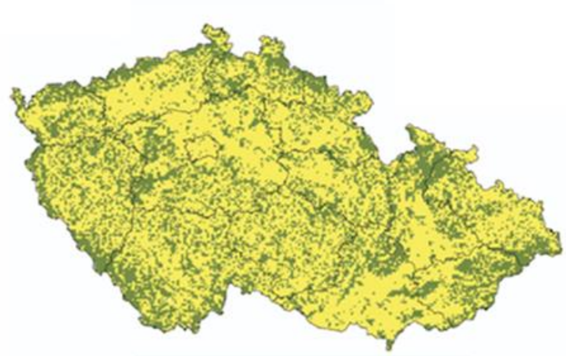

- **Area of 18,600 km$^2$** (24% of the country)

- **Temperate climate,** Köppen districts: Cfb (marine west coast),
  Dfb (humid continental),
  Dfc (sub-arctic).

- **Mostly forested** (timberline: 1,300 m)

# Mountain Forests

- 24 % of the country's area
- 69 % of the national woodland area (26,815 km$^2$)



2020 Forest area (green)

**Forest percentage in the Czech Republic**:

| Year | 1300 | **1789** | 1845 | 1897 | 1930 | 1950 | 1970 | 1980 | 2000 | **2020** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Forests (%)** | 80 | **14** | 29 | 29 | 30 | 29 | 33 | 33 | 33 | **34** |

# Mountain Forests Structure

- 24 % of the country's area
- 69 % of the national woodland area (26,815 km$^2$)

- **Ownership**: 60% state
  23% private (including church)
  17% municipalities

- **Native (climax) tree species**: Norway spruce (*Picea abies*), European beech (*Fagus sylvatica*) and Common silver fir (*Abies alba*)

- **Recent status** 84% of even-aged spruce plantations
  Mean rotation period 115 years
  Annual harvest of timber 6 m$^3$/ha
  Natural regeneration 30% of artificial planting

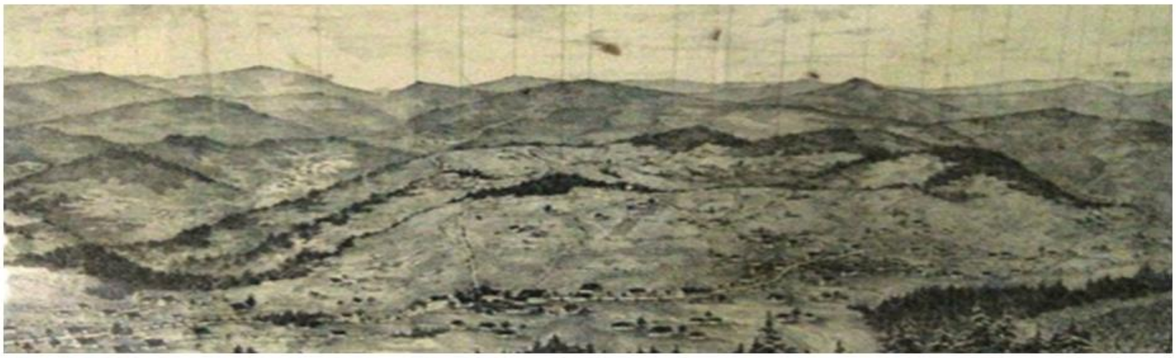
- **Multifunction forestry**: commercial (75 %, timber production),
  protective (2%, steep slopes, peatlands), and
  special purpose forest (23 %, water protection)
  controlling 80% of national water resources,
  38,000 km of streams, and 820 water reservoirs.

# Problems and Policies

- Coincidence of catastrophic floods and pure state of forests in the second half of the 19th century

  initiated the declaration of soil improvement (Act 116/ 1884 Coll.) and the safe diversion of mountain waters (Act 117/1884 Coll.) in the former Austro-Hungary.

- Rehabilitation of runoff genesis:
  - construction of retention dams,
  - reforestation,
  - torrent control.



Forest harvest in the Jizera Mountains (Czech Republic) by the end of the 19th century

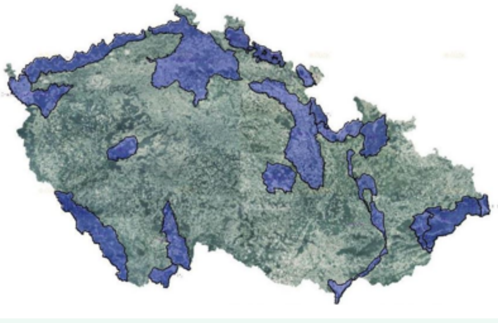
# Protected Headwater Areas

- Provisioning ecosytem services: water resources recharge, water quality, runoff timing, and flood control (mainly restrictions to reduce and drain forest land).

- Water Act 138/1973, 254/2001 Coll., Governmental decrees 40/1978, 10/1979 and 85/1981 Coll.

- Administrated by five state watershed enterprises

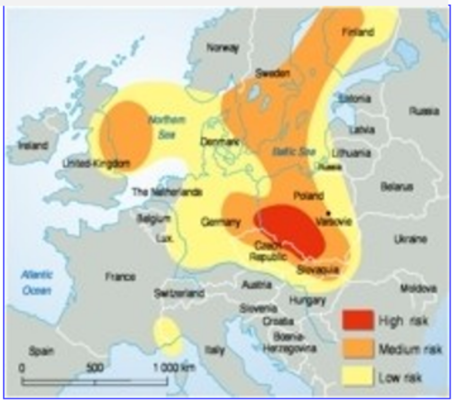
  (Czech Ministry of Agriculture)



Protected headwater areas (blue), 2020

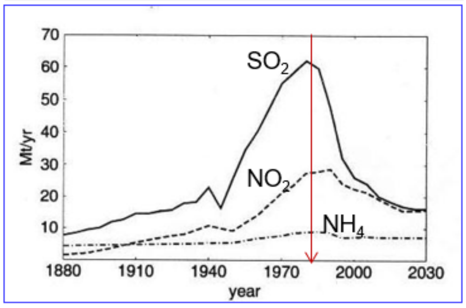
# ACID RAIN IMPACTS

Risk of acidification in Europe




UNEP (2005)

European emissions prognosed




Schöpp *et al*. (2003)

- Culminating in the 1980s by extreme emissions of sulphur and nitrogen
- Increasing the acid load namely in spruce stands
- Deterioration of water quality (including biota)
- Dieback of spruce plantations
- Commercial forestry practices and extended clearcut area

# RECOVERY FROM ACIDIFICATION

- Since the 1990s, drop in Sulphur emissions and lower acid load
- Reforestation by stands near the native composition
- Recovery of mountain watersheds and water ecosystems

Example: Watershed of the drinking water reservoir Souš (the Jizera Mts.), 1991-2017

1991 2004 2012 2017

## Climate Change Impacts

- Global warming: rising mean annual temperature by 1.2 °C in the 20th century (0.45 °C in the last 30 years)
- By the year 2030, the prognoses of rising temperatures range from 1.2 to 1.5 °C; and 4 % increase in the mean annual precipitation (rising in the winter and decreasing in the summer) compared with 1961–1990
- More intensive extremes (floods and draughts), warming projections for the period 2081-2100 report increasing specific peak-flows $Q_{10}$ – $Q_{100}$ by 20 – 30% according to the scenarios RCP2.6 and RCP8.5:
- Increasing risk of draughts upon minimum flows and insect epidemics in forests. Since 2017, extended dry periods contributed to serious bark beetle calamities; the related salvage felling reached a volume of 4 $m^3$ $ha^{-1}$ exceeding the effects of abiotic factors (wind, snow, or frosting).
- By 2030, in mountain catchments 40% of spruce stands endangered
- **Climate change mitigation in mountain watersheds**: mixed forests of higher ecological stability and structured forestry practices

## Shift in Climax Zones

| Climax zone | Area ($km^2$) | Elevation (m) | $T_a$ (°C) | $P_a$ (mm) | Veg. period (days) |
|---|---|---|---|---|---|
| Beech with oak | 2,862 | 400-550 | 6.5-7.5 | 650-700 | 150-160 |
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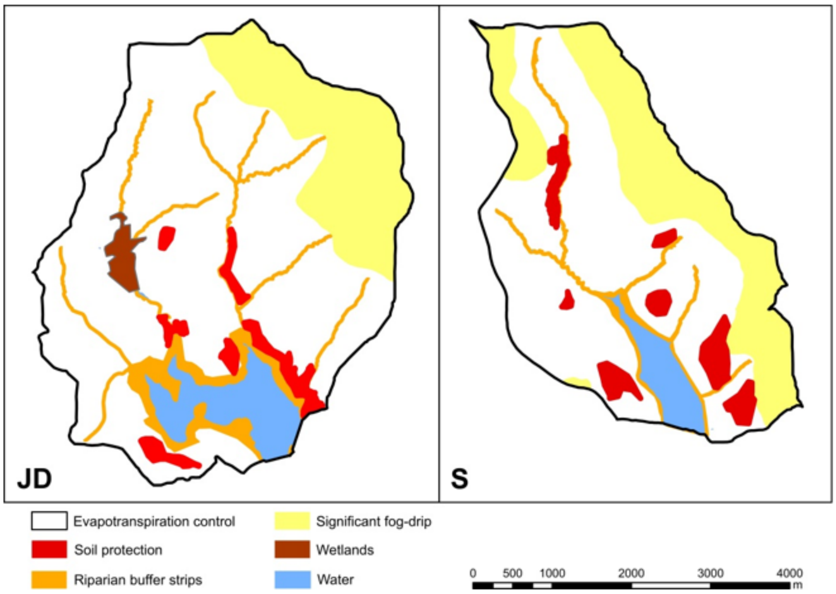
| Spruce | 265 | 1,050-1,350 | 2.5-4.0 | 1,200-1,500 | 60-100 |
| Dwarf pine | 53 | > 1,350 | < 2.5 | > 1,500 | < 60 |

## SRUCTURED FORESTRY PRACTICES




Example of forestry differentiation in catchments of drinking water reservoirs Josefův Důl (JD) and Souš (S), the Jizera Mts.

## CONCLUSIONS

- The legal status of multipurpose mountain forests was established in the belief that they can significantly mitigate the hazard of water quality decline, drop in water resources recharge, acceleration of soil erosion and sedimentation, and decreasing stability of slopes in headwater catchments.

- The adequate legislative regulation of watershed management shows a delay to the recent rapidly changing environment. However, the principle of forest stands near the native composition, and structured forestry practices in mountain watersheds can significantly support the mitigation against climate change impacts and acidification.


… thank you

# France

**34th session of the European Forestry Commission's Working Party on the management of mountain watersheds**

**FAO**

September 27th -29th 2023

Bolzano (ITALY)

French Country Report

# Management of mountain watersheds in a changing climate: from the Alps to the Mediterranean areas

Report established by ONF/DFRN/Department of Natural Hazards (RTM)

# SUMMARY

# Introduction – The climate in France

In mainland France, the main mountain ranges are the Alps (>4,000 m) and the Pyrenees (>3,000 m), but there are also the Massif Central, the Jura (<2,000 m) and the Vosges (<1,500 m). These mountainous areas are home to 4 million of the 65 million inhabitants of the country (Figure 1). They are subject to a mountain climate whose characteristics depend on the altitude, but where annual rainfall is generally higher than elsewhere, temperatures are cool in summer and very cold in winter.

Depending on their location, these mountain ranges are subject to different general climatic trends (Figure 2):

- oceanic climate for the western and central Pyrenees: mild temperatures and abundant rainfall throughout the year, with a slight peak in autumn-winter.
- semi-continental climate for the deep plains of the Northern Alps (except Haute-Maurienne):
  hot summers and cold winters; relatively high annual rainfall, with heavy rains in summer and frequent thunderstorms.
- Mediterranean climate for the oriental Pyrenees and the Southern Alps: mild temperatures in winter and high temperatures in summer; rainfall is irregularly distributed over the year, with dry winters and summers but very wet springs and autumns, often due to very violent thunderstorms that can bring 4 times more precipitations than the monthly average to a given location in just a few hours. This is amplified the closest one gets to the higher areas.

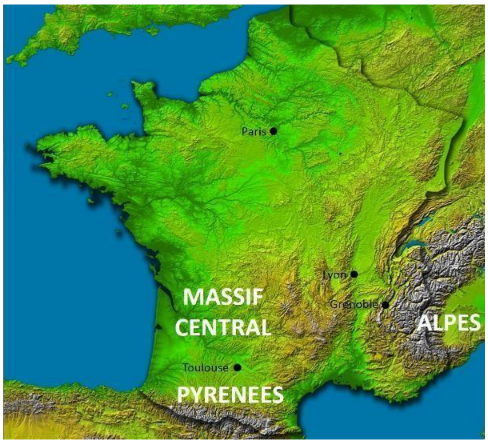



*Figure 1 : Mountain ranges in mainland France*


*Figure 2 : The five climates in mainland France; 1: oceanic climate; 2:altered oceanic climate; 3: semi-continental climate; 4: mountain climate; 5: Mediterranean climate (Source: Météo France)*

# 1. Climate change issues in French mountain watersheds

## 1.1. Climate observations and trends

The most robust effects or trends linked to climate change concern climatic precursors (temperatures, extreme precipitation, extreme snowfall), rather than natural hazards, which are more difficult to observe. While the effects of climate change can be seen throughout France, they are particularly marked in mountainous regions.

### 1.1.1. Temperatures

Over the 2011 to 2019 period, **average warming** in mainland France is +1.8°C compared with the 1901 to 1930 average, and +1.0°C compared with the 1976 to 2005 average[1]. This increase goes along with a rise in the number of days of heat waves: currently 10 to 15 days over the greater north-eastern third of the country and the Pyrenees, and 25 to 30 days around the Mediterranean; in these areas this number would increase by 5 days in the event of a +2°C rise in temperature, and by 10 days with +4°C.

Moreover, this average warming is more pronounced in the eastern part of the country and the Alps (continental effect) than in the western part and the Pyrenees (oceanic effect) (Figure 3).

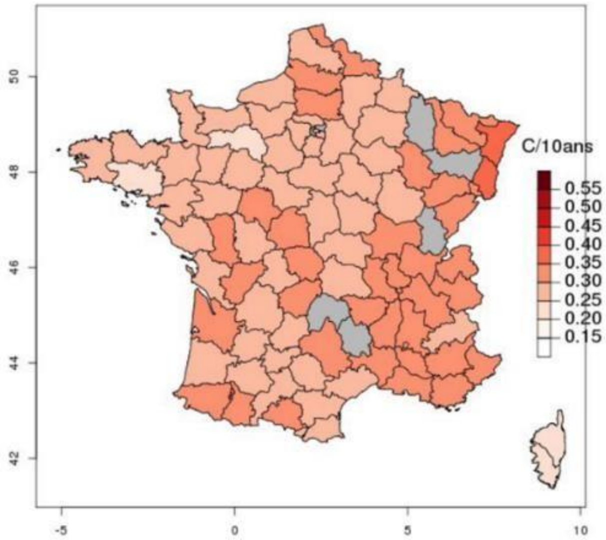



*Figure 3 : Observed distribution of average warming (°C/decade), 1959-2014 (Source: Météo France)*

According to climate models, this trend towards higher average temperatures will be more pronounced in mountain areas, than on the continents (Figure 4).

[1] https://meteofrance.com/climathd

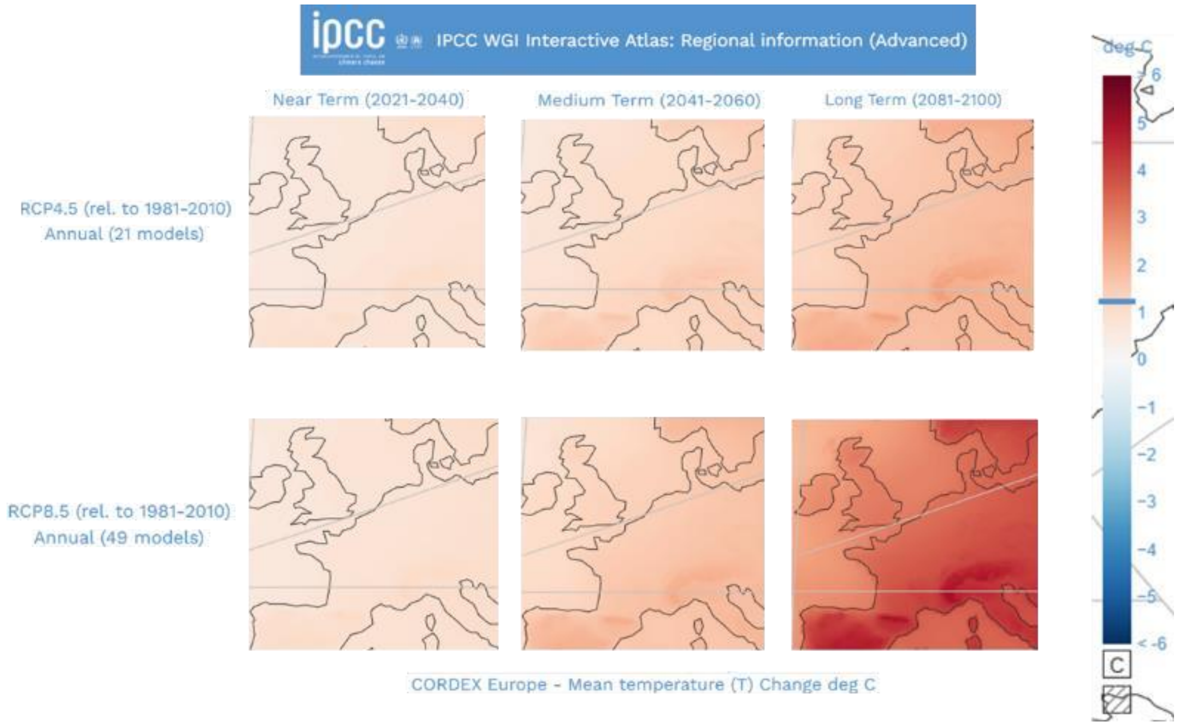



*Figure 4 : Short, medium and long-term trend in mean temperatures, relative to the 1981-2010 period, according to the two forecast trends, medium (RCP4.5) and pessimistic (RCP8.5) (Source: GIEC[2])*

While the temperatures in the Alps have increased by +2°C since pre-industrial times, warming in the French Alps is greatest in spring and summer (Figure 5)[3].

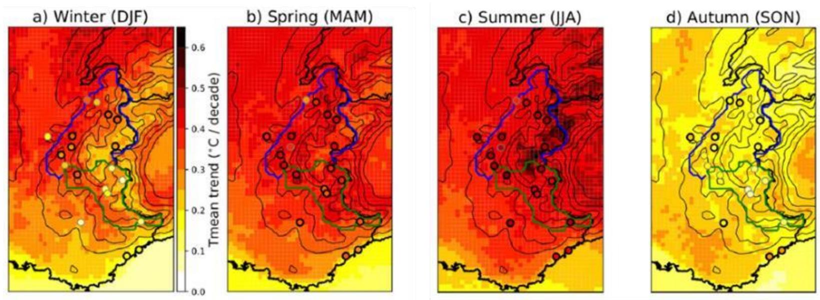



*Figure 5 : Mean temperature trends (°C/decade) in the French Alps (MAR-ERA-20C; 1959-2010)[3]*

### 1.1.2. Precipitation

On an annual **average basis**, according to **future climate models**, precipitation trends for France are on the rise (+2.9% for a typical average warming scenario of +2°C; +1.8% for a typical scenario of +4°C), but the uncertainties associated with these projections, remain very high. Despite this fact, the trend in the Pyrenees and some areas of the Alps is downward (+2°C scenario), in contrast to the national average.

For the Alps and Pyrenees, annual precipitation totals have been relatively stable since 1961, but since then, we have seen (Figure 6) :

- a slight downward trend in winter in the southern half of France, more marked in the Pyrenees than in the Alps.

[2] IPCC WGI Interactive Atlas

[3] Beaumet et al. (2012). Twentieth century temperature and snow cover changes in the French Alps.

- a marked decline in summer around the Mediterranean (Pyrénées Orientales and Alpes du Sud).

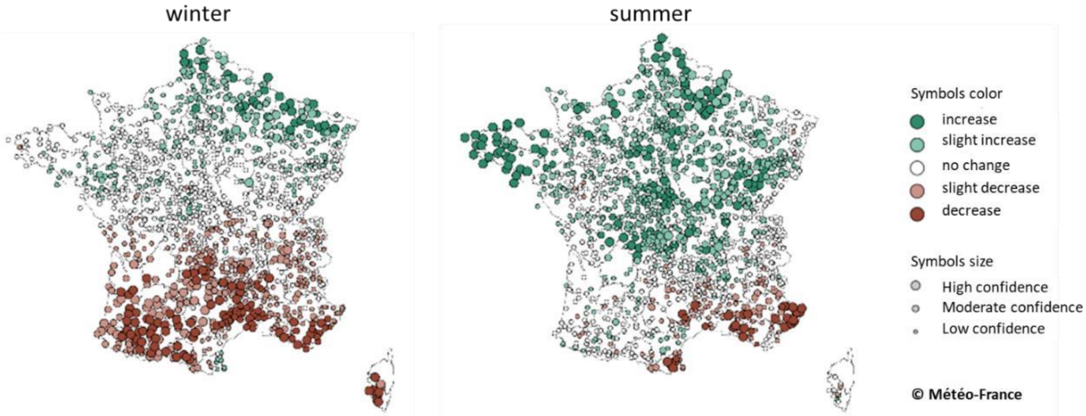



*Figure 6 : Seasonal cumulative precipitation trends (winter on the left; summer on the right) in mainland France, 1961-2012 (Source: Météo France)*

In the mountains, the phase of precipitation (solid/liquid) is changing, with an observed rise in the rainsnow limit. Rain-on-snow events seem to have become increasingly frequent since the 1980's at altitudes of 2000 m in a basin to the east of Switzerland[4], and in the future, rain-on-snow events are likely to occur earlier in spring and later in autumn[5]. They are likely to become less frequent at medium altitudes (in line with decreasing snow cover) and more frequent at higher altitudes.

For **extreme daily precipitation** in the **mountains**, **current observations** show that:

- in the regions concerned by the Mediterranean climate, but also certain valleys of the Northern Alps (Haute-Maurienne notably), there is an increase of about 20% in autumn[6];
- in the Northern Alps, a slight decrease in winter (20-year return period) and the rise in the rain/snow line lead to an increase in extreme rainfalls in spring [7];
- on the short time scales, during which mountain thunderstorms occur, we expect, according to the theory linked to changes in the quantity of water vapor contained in the atmosphere, an increase in precipitation (of the order of 7%/°C**Erreur ! Signet non défini.**), and therefore more intense but not necessarily more frequent thunderstorms; but the lack of observations does not allow clear validation of these trends.

[4] Beniston et al. (2016). Rain-on-snow events, floods and climate change in the Alps: Events may increase with warming up to 4 °C and decrease thereafter.

[5] GIEC, 2019, Rapport Océan et Crysphère, chapitre 2 : Zones de Haute-montagne.

[6] Blanchet et al., 2021, Explaining recent trends in extreme precipitation in the Southwestern Alps by changes in atmospheric influences.

[7] Blanc et al. (2022). Characterizing large-scale circulations driving extreme precipitation in the Northern French Alps

### 1.1.3. Snowfall

In the French Alps, below 2000 m altitude, extreme snowfall (100-year return period) is decreasing in most mountain ranges[8]. At an altitude of 1,500 m, maximum snowfall will tend to decrease, with an estimated -50% by the end of the century according to the pessimistic scenario (RCP 8.5)[9].

In contrast, above 2000 m, precipitation continues to fall in the Northern Alps, but increases in the Southern Alps[8]. This spatial variability in trends between the Northern and Southern Alps is consistent with the trends in extreme precipitation in altitude ranges that are still little affected by the increase in the rainsnow line.

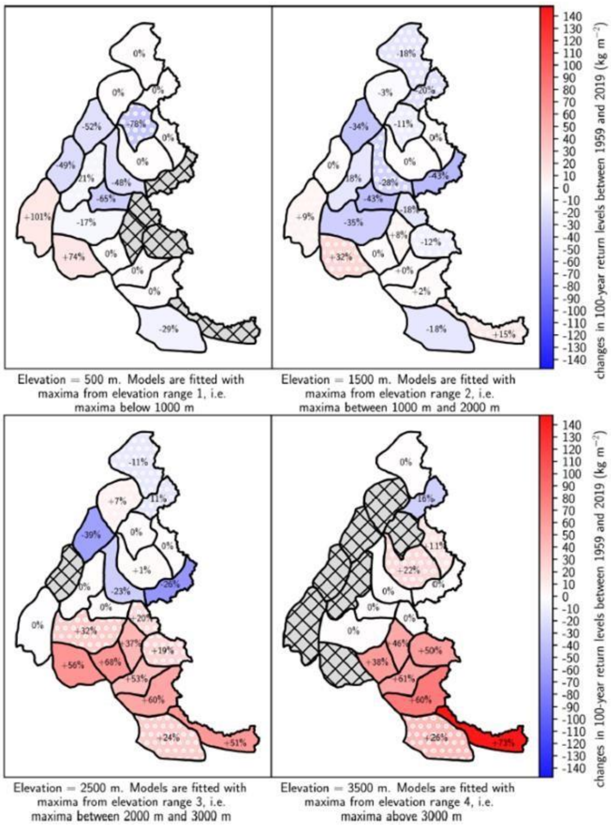



*Figure 7 : Trends (%) in extreme snowfall (100-year return period) in the French Alps, 1959-2019[8].*

## 1.2. Observed and expected effects in mountain areas

Although the effects are more difficult to assess than for previous climate precursors, consequences and trends can be observed in the evolution of natural hazards affecting mountain areas, as well as in forestry, which is an important component in the development and management of mountain watersheds.

### 1.2.1. Natural hazards

#### *Torrential floods (inc. debris flows)*

At the scale of small torrential watersheds, the lack of data makes it impossible to establish with any certainty clear trends in the increase in extreme precipitation.

For mountain torrents, there are no long-term flow data (liquid and solid) that would enable us to identify climatic trends. Thus, the **analysis of observed events**, one of the main sources of which is the **RTM database (BDRTM)**[10], is generally used to provide elements of analysis.

In the Northern Alps, two more exhaustive databases have been created at different scales for dedicated studies: one for the Savoie department; another for the Grenoble conurbation (en Savoie

[8] Leroux et al. (2021). Elevation-dependent trends in extreme snowfall in the French Alps from 1959 to 2019.

[9] Leroux et al. (2022). A non-stationary extreme-value approach for climate projection ensembles: application to snow loads in the French Alps.

[10] carmen.carmencarto.fr/105/ONF_BDRTM.map

et à Grenoble). In both cases, **the occurrence of floods and debris flows seems to be increasing**[11,12]. However, this trend is based on databases that have their own biases: different modes of observation according to census organizations and geographical sectors; census focusing on events that have caused damage, i.e. in areas where the stakes are high... The trend associated with the events observed is thus multifactorial, and the recording of events will depend not only on the evolution of the hazard in a context of climate change, but also on the evolution of the exposure of the stakes, or on the period and method of acquisition of this data.

Paleohydrology, which analyzes sediments in mountain lakes to reconstruct the frequency and intensity of floods in the past, provides additional information. In the Alps, for example, **torrential floods were more frequent in colder periods than in warmer ones**[12] (Figure 8). One hypothesis is that changes in atmospheric circulation may have led to less frequent extreme precipitation events in warmer periods. For a **very limited number of sites** (2 catchments < 3 km² out of the 23 observed), however, **more intense floods were observed in warmer periods**, probably linked to more violent local thunderstorms in a warmer climate.

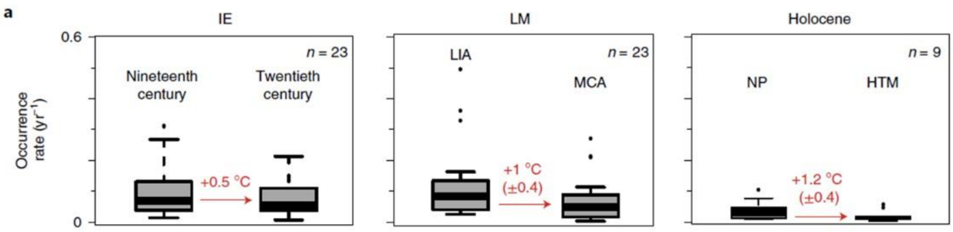



*Figure 8 : Difference in flood frequencies in the European Alps for different periods (recent, last millennium, Holocene). The warm period is systematically shown on the left. The number of observations per period is shown at top right[13].*

Finally, the **destabilization of rock glaciers** leads to an increase in landslides, which in turn **increases the supply of materials for torrential phenomena** (SROCC, GIEC 2019).

Understanding and analyzing the evolution of torrential flooding is therefore subject to **numerous and considerable uncertainties**, making **future modeling particularly difficult** in the context of climate change.

## *Snow avalanches*

The two main avalanche responses to climate change are as follows:

- **decrease in the occurrence of avalanches reaching the valley floor** (observed in the French Alps)[13] ;
- **increase in the occurrence of wet snow avalanches**[14], defined as having an average liquid water content > 10 kg.m$^{-3}$, and decrease in the occurrence of aerosol avalanches.

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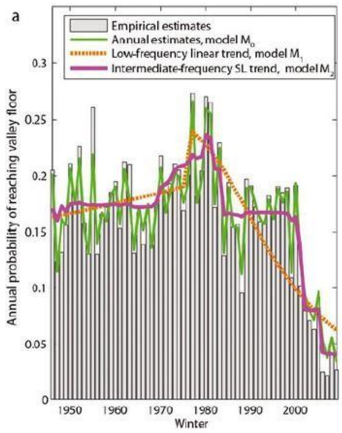
[11] Creutin et al. (2022). Reported Occurrence of Multiscale Flooding in an Alpine Conurbation over the Long Run (1850–2019). [12] Einhorn et al. (2015). Changements climatiques et risques naturels dans les Alpes : Impacts observés et potentiels sur les systèmes physiques et socio-économiques.

[12] Wilhelm et al. (2022). Impact of warmer climate periods on flood hazards in the European Alps.

[13] Eckert et al. (2013). Temporal trends in avalanche activity in the French Alps and subregions: from occurrences and runout altitudes to unsteady return periods.

[14] Naaim et al. (2016). Impact du réchauffement climatique sur l'activité avalancheuse et multiplication des avalanches humides dans les Alpes françaises.



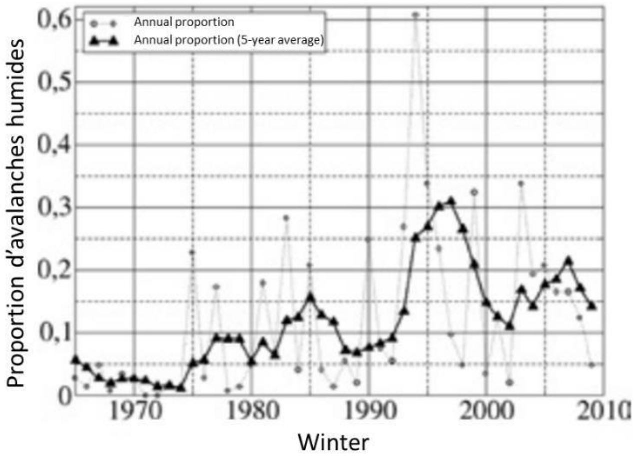




*Figure 9 : Trend in the number of avalanches de reaching the valley floor in the French Alps over the* [14]

*Figure 10 : Evolution of the proportion of wet avalanches in 26 paths*[15] *period 1945-2010*

**In the Southern Alps**, because of the increase in extreme snowfalls at altitudes **> 2000 m**, the trend is likely to be towards an **increase in the frequency of large-volume avalanches** at these altitudes.

In mountain watersheds, structures are generally already in place to protect people from avalanches. The increase in the proportion of wet avalanches will modify their operating conditions. Today, structure degradation phenomena are observed **at medium altitudes (1800-2200 m)**, whereas in the past they were only observed at lower altitudes. ONF-RTM therefore recommends **reducing the spacing between snow stabilization structures in starting zones** at these mid-altitudes. In avalanche propagation zones, it **advises against the installation of deflection structures** that become inoperative once filled by a wet snow avalanche[15].

## *Rockfalls*

**Below 2000 m altitude** (outside permafrost zones), several studies have demonstrated the role of various meteorological factors in triggering boulder falls[16]. Intense precipitation, snowmelt, thermal amplitudes and freeze-thaw cycles all appear to be favourable conditions for the occurrence of such phenomena. It is therefore difficult to establish a relationship between rockfalls and climate fluctuations. Although monitoring and documentation efforts have intensified over the last few decades, the few studies carried out in the Alps have **not revealed any significant increase in the frequency of boulder falls**[18].

**Above 2500 m altitude**, the **melting of permafrost** due to global warming is unequivocally **responsible for an increase in the frequency of rockfalls**, mainly for volumes of less than a million $m^3$. This has been demonstrated across Europe over the past 50 years (SROCC, GIEC 2019). This can also be demonstrated by analyzing event databases, despite the biases identified, at the scale of various highaltitude sites for which rockfalls have been recorded for several decades[12].

[15] ONF-RTM (2022). Génie paravalanche dans un contexte de changement climatique.
[16] D'Amato et al. (2016). Influence of meteorological factors on rockfall occurrence in a middle mountain limestone cliff. [18] Mainieri et al. (2022). Limited impacts of global warming on rockfall activity at low elevations: Insights from two calcareous cliffs from the French Prealps.

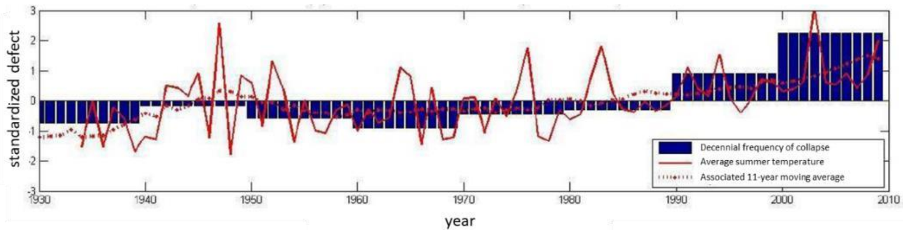



*Figure 11 : Rockslides (Aiguille de Chamonix and west face of Les Drus) and associated summer temperature anomaly [12].*

### *Landslides*

There are very few studies showing a link between climatic fluctuations and the occurrence of landslides. However, in the Ubaye region of the Southern Alps, heavy winter snowfalls combined with positive temperature anomalies in spring (sudden snowmelt) appear to be the cause of landslides[17]. This **result, localized** to a study valley, **suggests** an **increase in the frequency of landslides**, linked to **increasingly rapid spring snowmelt**.

### *Glacial and periglacial hazards*

We have already pointed out that: 1) the destabilization of rock glaciers increases the supply of material for debris flows; 2) above 2,500 m altitude, rock avalanches are becoming increasingly frequent as a result of melting permafrost.

In addition, the breakup of cold glaciers on steep slopes has been and will be facilitated by an increase in glacier base temperatures in the European Alps (SROCC, IPCC 2019). This will lead to an increase in the occurrence of ice avalanches.

In the French Alps, as elsewhere, we are seeing glacial retreat. In the Vanoise/Ecrins region, for example, the relative surface area of white glaciers is shrinking more than in the Mont-Blanc massif. Between 1967/1971 and 2022, the ice-covered surface of the French Alps decreased by 42%, but the distribution was heterogeneous: 22% Mont-Blanc, 53% Vanoise, 47% Ecrins, 65% for the other massifs.

Glacial lakes are increasing in number and size, in line with glacial retreat. Indeed, of the 78 lakes larger than 2500 m² that appeared between 1950 and 2022, 71 are associated with the retreat of a white glacier. These lakes may be held back by ice dams or unstable moraines, favouring rapid emptying and torrential phenomena downstream. In addition, an increase in the frequency of torrential floods resulting from cascading phenomena in the lakes (ice avalanche or rock collapse) has been observed (SROCC, GIEC 2019).

## 1.2.2. On the forest

All the information below is available on the website: Observatoire des forêts françaises (ign.fr).

### *Drought and water stress dieback*

While, in some cases, the consequences of an intense water deficit are not too serious for tree health and growth, repeated droughts can lead to more profound disturbances over the long term. For example, when soil drying is combined with high evaporative demand, drought can eventually lead to the death of the tree and may even cause a stand to die out.

[17] Lopez et al. (2013). Climate change increases frequency of shallow spring landslides in the French Alps.

In mainland France, since 1990, there has been an upward trend in forest area affected by drought. Since 2015, there has been a succession of years in which more than half of forests have been particularly exposed to drought (Figure 12). Along with 1976, 2003 was the most critical year, with three-quarters of the territory exposed. Thanks to a model developed by INRAE's Silva research unit (Biljou©), it is possible to analyze the spatial distribution of this drought, defined as the water deficit of forests, over the territory, particularly in mountain areas. In 2003, all the southern Alps and a small part of the northern Alps and Pyrenees were affected by this deficit (Figure 13).

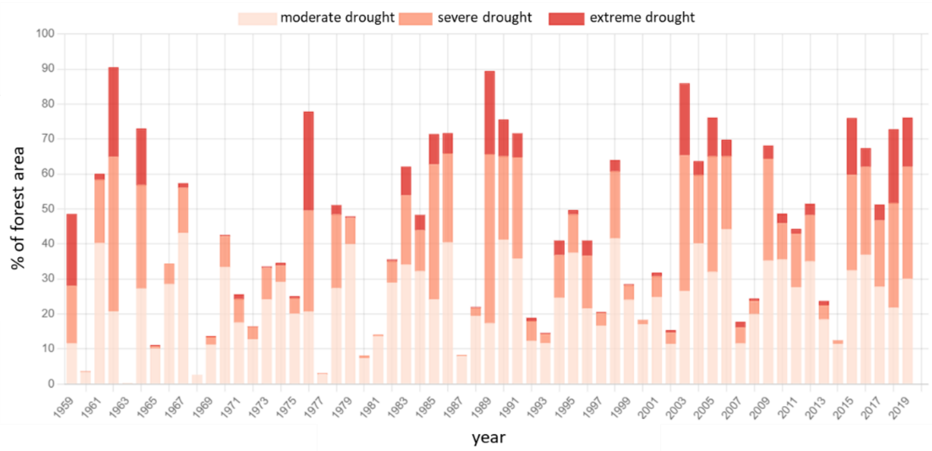



*Figure 12 : Proportion of forest area affected by drought annually according to 3 levels of water deficit (Source : Indicateurs de Gestion Durable (ign.fr)).*

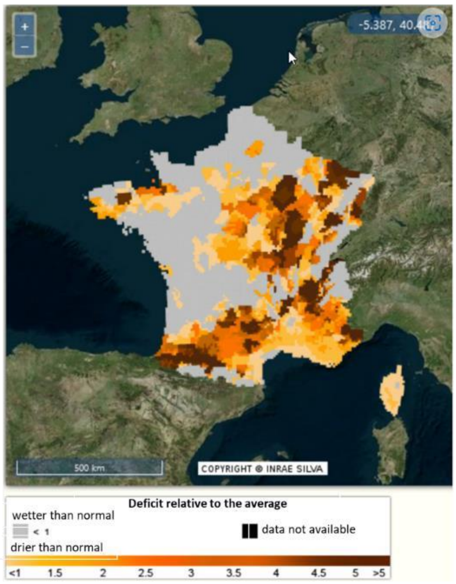
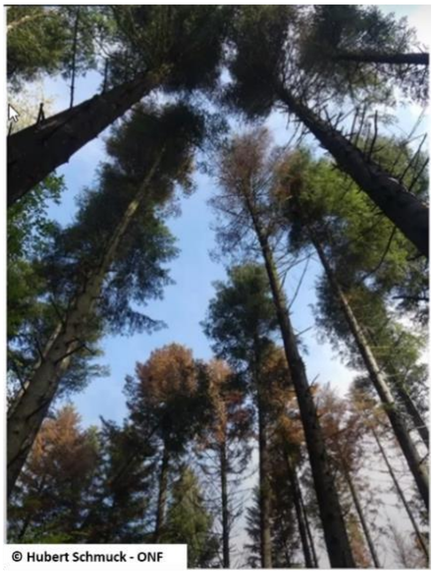



*Figure 13 : Water deficit in 2003, relative to the 1961-1990 average (Source: Biljou© model and Observatoire des forêts françaises (ign.fr))*

Since the 1950s, two indicators, specific to each tree species, have been mainly used as indicators of climate change: budburst (leaf emergence in spring) is earlier, which increases exposure to late spring frosts; yellowing and leaf loss in autumn is delayed, which increases exposure to early autumn frosts. The length of the growing season has thus increased by 10 to 15 days, corresponding to a longer period of photosynthetic activity.

The increase in photosynthetic activity is favorable to growth as long as other factors are not limiting (water reserves in particular). In medium- and high-mountain areas, where stands are slow-growing, growth conditions are theoretically improved (inventaire forestier national). However, there are other limiting factors: older stands, unfavorable soil conditions….

## *Accelerated decline caused by parasites*




Insect and fungus attacks are favored by the state of fatigue and weakening of trees due to water stress. This accelerates their decline.

Warmer weather favors pest reproduction. For example, 2018 and 2020 saw warmer temperatures from spring to autumn, allowing bark beetles to reproduce once more during the year (Figure 15).

*Figure 14 : Example of bark beetle-attacked pectin fir dieback in a mountainous area (Vosges) following a period of drought (RMT AFORCE - Les impacts des changements climatiques sur la forêt - YouTube)*

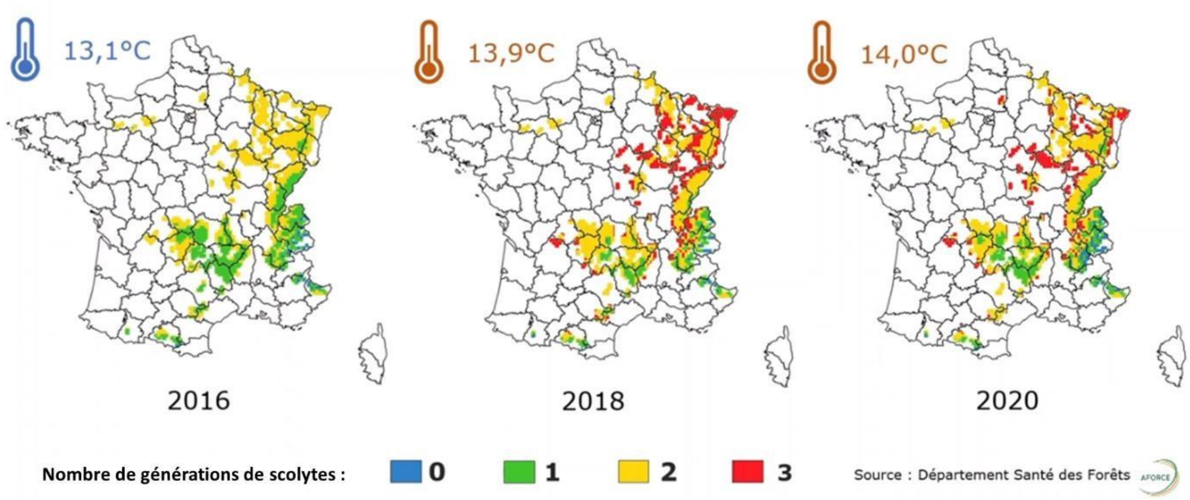



*Figure 15 : Number of potential generations of letterpress beetles on October 1 and mean annual temperature for France (RMT AFORCE - Les impacts des changements climatiques sur la forêt - YouTube).*

## *Variable vulnerability of trees and stands*

The vulnerability of stands to drought or pests differs according to several factors:

- The age of the trees: older trees are more resistant but less resilient to drought; in the mountains, stands tend to be older, making them more vulnerable;
- Species and origin, which must be adapted (ClimEssences) ;

- stand composition: mixed forests will be less vulnerable than mono-species forests, but the characteristics of mixtures are still subject to uncertainty;

- stand structure: dense stands are more vulnerable than open stands;
- regeneration method: naturally regenerated forests are less vulnerable to drought than forests planted in the open;
- soil: the least vulnerable stands are located on soils with high mineral and water fertility (high usable water reserves), with low rooting constraints (few coarse elements, sparse layers, little temporary waterlogging, chemistry), which is generally not the case for stands in mountainous areas.

## *Forest fires*

Over the period 1979-1988, the annual average of burnt woodland areas was around 40,000 ha/year, to be divided by 3 with an average of 15,000 ha/year over the period 2013-2022, despite the exceptional year of 2022. These good results are attributable to the combined effects of prevention and control measures, in particular the effectiveness of the strategy of attacking incipient fires.

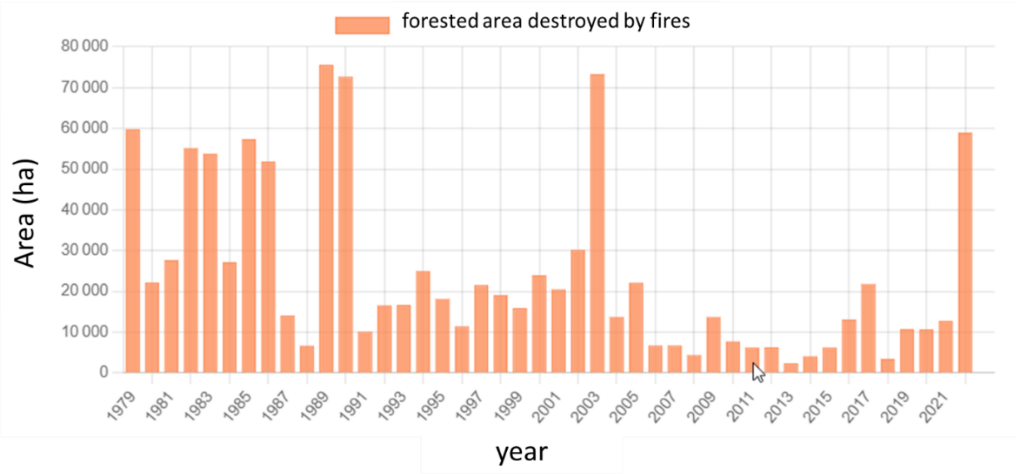



*Figure 16 : Areas of forest and other wooded land destroyed by fire (Data source : [BDIFF : Accueil (agriculture.gouv.fr)](agriculture.gouv.fr))*

In this assessment, the years 2003 and 2022 stand out for their exceptional climatic conditions. These were the hottest years on record, with temperature anomalies compared with the 1991-2020 average of +2.7°C and +2.3°C respectively, a record number of heatwave days and a historic drought.

But 2022 marks a turning point in the impact of forest fires in France, as they spread across the entire country. Historically, due to the favorable climatic conditions of high summer temperatures, long heat waves and drought, only the south of France, and more particularly the Mediterranean and southwestern regions, were exposed to forest fires.

The Indice Forêt-Météo (IFM) provides a daily quantification of the propensity for fires to break out and spread initially, based solely on weather parameters. The expected evolution of its distribution is presented in Figure 17, showing a trend towards coverage of the whole of France, even if the mountain ranges outside the Mediterranean are still partly protected. However, an analysis of the susceptibility of forest massifs, according to vegetation type and state of health (Figure 18), also shows a geographical extension of this susceptibility to forest fires. Thus, the Pyrénées-Orientales, the Pyrenean foothills and the Southern Alps will be increasingly exposed to wildfire, while the Northern Alps are also expected to be affected, albeit moderately: 2022 has already been a case in point.

What's more, in the departments around the Mediterranean, in particular, we can expect the forest fire season to extend from April to October, where it used to be concentrated from June to August.

The Cerbère forest fire in the Pyrénées-Orientales (870 ha) on 16/04/2023 is a case in point. This means that we need to rethink the organization of surveillance and rescue resources, not only on a national scale, but also over time.

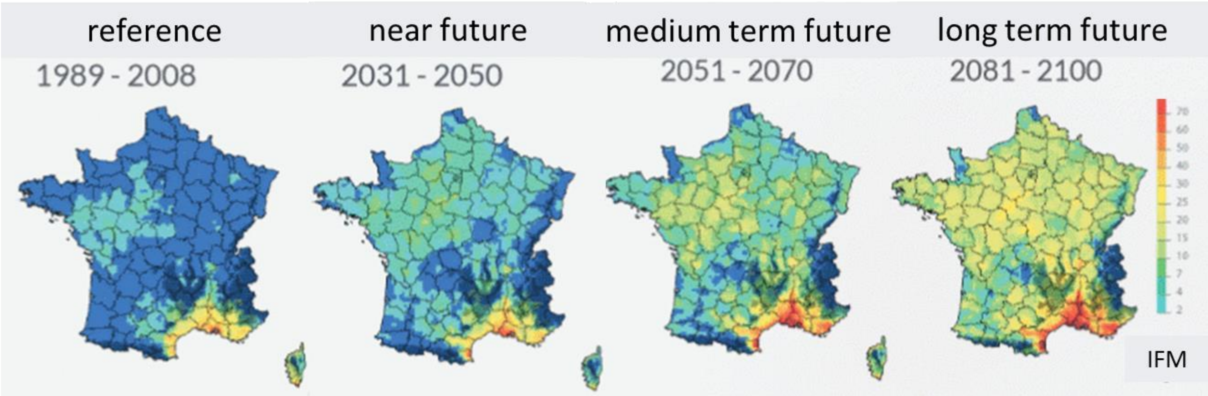



*Figure 17 : Expected trend in the distribution of the Forest-Weather Index (IFM) across France*

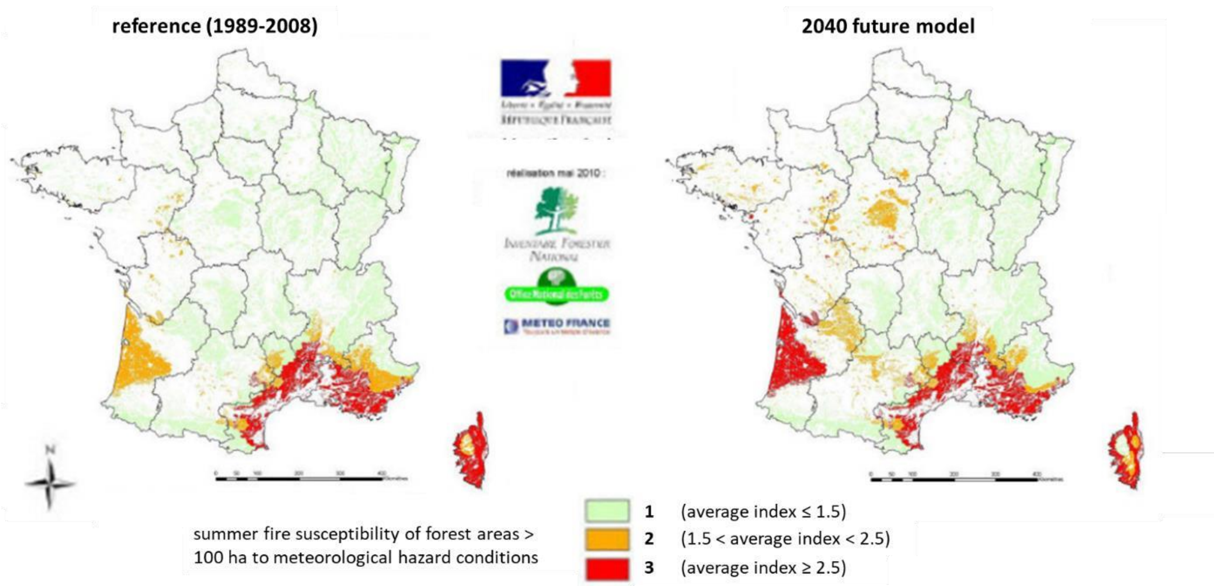



*Figure 18 : Current (left) and 2040 (right) degree of sensitivity to forest fires for forest areas larger than 100 ha, from lowest (green) to highest (red)[18].*

[18] Rapport de la mission interministérielle (2010). Changement climatique et extension des zones sensibles aux feux de forêts.

### ***Storms***

The succession of two storms (Lothar and Martin) in December 1999, are still fresh in the minds of French foresters. Like drought, but more brutal and visible, storms are the source of tree dieback. Weakened, they can then be attacked by parasites which, potentially, accelerate the decline of nearby stands. The question of the impact of climate change on the resurgence of storms (increase in frequency and/or intensity) is therefore raised to identify whether this threat will increase in the future.

On a global scale, storm tracks in the Southern Hemisphere are likely to shift slightly towards the South Pole. On the other hand, the projection of the evolution of storm tracks in the Northern Hemisphere is subject to very high uncertainties, which make it impossible to highlight certain trends (SROCC, GIEC 2019).

This high level of uncertainty is confirmed for mainland France. Projections show no significant longterm trend in storm frequency or intensity, either for 2050 or 2100[1]. This is a factor that should always be considered when planning post-storm measures to ensure long-term forest recovery. For example, following the storms of 1999, it took more than 10 years to restore the forest landscape in the affected areas.

# 2. Policy instruments and forest management implemented and developed to address climate change issues in mountain watersheds.

## 2.1. Multifunctional forest management

In France, the political choice for forest management is a **multifunctional management of each forest**. This means taking into account the different potential functions that a forest can perform such as **production**, **protection against natural hazards**, **biodiversity** and **welcoming the public.**

This is a historic choice:

- as early as the 13th century, Philippe Le Bel introduced sustainable forest management to ensure long-term timber production, which was necessary for the country's economic stability.
- in the 19th century, the function of protective forests against natural hazards had to be considered in forest management. Certain areas of land were acquired by the State for forestry development, with a dedicated protection objective (forests for the Restoration of Mountain Land, dedicated to fight against erosion and landslides, associated with torrential flooding and avalanches; coastal forests dedicated to fight the transport of sand by wind).
- in 1992, the Rio Convention marked a turning point in the objectives attributed to forest management, with the need to protect and support the development of biodiversity.
- at the beginning of the 20th century, the function of welcoming the public, took on an increasingly important role in planning guidelines.

Even if, for each forest, the prerequisite is to establish a development compromise between these different functions to draw up a forest management strategy, certain configurations may lead us to retain only one dedicated management objective: forests dedicated to welcoming the public near urban areas; forests dedicated to maintaining biodiversity (integral reserves) which, incidentally, are mostly in mountain areas.

This choice is the opposite of the dedicated management implemented in other countries (such as Canada) where, for each forest, the basic question is what function it should fulfil. The compromise is then determined at national level, by balancing the forest areas allocated to the different functions.

In France, multifunctional forest management is based on tools that can be applied at different territorial levels:

- **at national level**: **the National Forest and Wood Plan** (PNFB), which targets the production objectives that can be achieved while respecting multifunctionality.
- **at regional level**:
  - **the Regional Forest and Wood Plan** (PRFB): applies to both public and private forests and is an offshoot of the PNFB. ○ **Regional Planning Directive and Scheme** (DRASRA), applicable to **public forests**: framework documents for forest management on a regional scale. They provide guidelines for the species to be used in forest management. However, they were drawn up before 2006 without taking into account the changing climate, and their revision is now being considered. ○ **Private Forest Management Plan** (PSGFP): mainly aimed at balancing the functions of production and biodiversity protection.
  - **Adapting public forests to climate change in PACA[19], 2021:** although focused on production stands, this type of guide can provide valuable support for stands protecting against natural hazards in the mountains.
- **forest management document,** for each public forest drawn up for a 20-year horizon, sets out the silvicultural itineraries to be followed.
- **mountain silviculture guides** (GSM): in mountain areas, these help to define silvicultural itineraries, adapted to the specific climatic and geographical conditions of each massif (Northern Alps, Southern Alps, Pyrenees). In these areas, the function of protection against natural hazards is an important consideration. However, this requires a clear definition of the level of protection afforded by the forest in relation to the natural hazard to which it is exposed, and against which it is intended to protect stakeholders. Discussions are currently underway, on this point (cf. chapter 0).

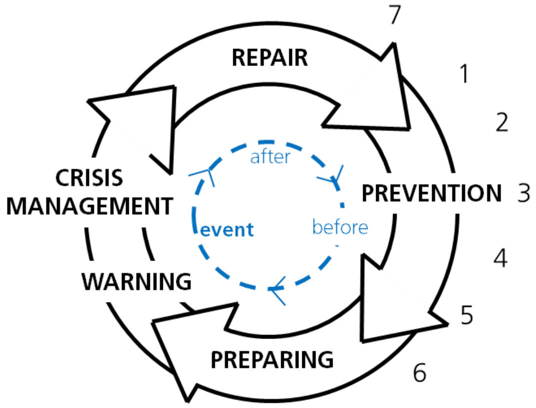
## 2.2. The forest in natural risk management

On a watershed scale, natural hazard management is based on 5 temporal phases, in relation to the occurrence of an event: prevention, preparation, warning, crisis management and repair.

The **prevention phase** is based on 7 pillars: knowledge of phenomena and hazards, monitoring and surveillance, public information, management and control of urbanization, reduction of hazards (mainly protection measures) and of the vulnerability of exposed stakes, preparation for crisis management and feedback.

[19] Provence-Alpes-Cote d'Azur, region in the south-east of France.

- **5 time phases**
  (the circle of risk management)




- **7 pillars of natural risk prevention**

1. knowledge of phenomena and hazards
2. monitoring
3. citizen information
4. controlled urbanization
5. reduced vulnerability
6. preparing for emergencies
7. feedback

*Figure 19 : The foundations of integrated risk management policy in France*

**The forest and its multifunctional management** is therefore **a territorial tool that helps prevent natural hazards in mountain watersheds**.

According to its situation and its state, it can ensure a protection function against the natural hazards: against avalanches, rock falls and in a lesser measure, against landslides and torrential floods (cf. § 0). To maintain this function, the forest management document supports on the adapted GSM, even if these guides are more than 10 years old and do not integrate the now known effects of climate change.

When this protective function is proven, it can be **considered in natural risk prevention plans (PPR)**, the main urban planning management tool. They are then designated as green zones for which specific management conditions must be implemented over time, to enable protected areas to be opened up for construction.

Mountain forests are vulnerable because they are:

- subject to accelerated ageing due to under-exploitation of high-altitude forests, which led to the proposal of Priority Stand Renewal (RPP) actions (2007).
- under pressure from wild game (mainly deer), making forest regeneration difficult.
- exposed to natural hazards such as storms and forest fires (cf. 1.2.2).

It is therefore essential to reduce the vulnerability of these mountain forests. To encourage the renewal of old-growth forests in mountain areas, a study was carried out in 2007 to identify priority stands for renewal. Studies are currently underway to determine whether, in the context of climate change and improved knowledge of the role of forests in protecting against natural hazards, this priority should be reviewed.

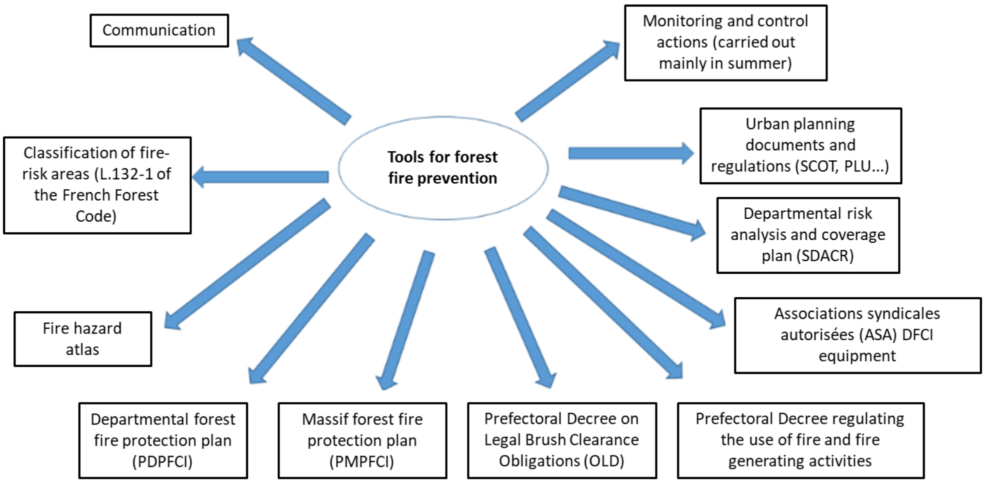
Wild game management is based on hunting plans drawn up by the ONF in conjunction with the hunting federations, which are responsible for their implementation.

Management of the effects of storms is based on a national guide drawn up by the ONF on "Reconstituting forests after storms", the main recommendation of which is to give priority to natural regeneration wherever possible.

## 2.3. Forest fire prevention

The French government pursues an active prevention policy that combines appropriate management of the forest, but also of the space between the forest and housing, information for the public and forest users, as well as surveillance and control of forest fires. This policy particularly involves the Ministries of the Interior and Overseas Territories (**MIOT**), Agriculture and Food Sovereignty (**MASA**), and Ecological Transition and Territorial Cohesion (**MTECT**).

Forest fire protection (DFCI), overseen by the MASA, which is responsible for forests, is based on a global policy of development and maintenance of rural and forested areas, implemented by the Office National des Forêts (ONF). It implements the forestry code's tools for planning, development, and maintenance.




*Source: DDT37, adapted by CNPF, ONF*

*Figure 20 : The main tools for forest fire prevention (Source: Observatoire des forêts françaises (ign.fr))*

For many years now, the public authorities have been running communication campaigns on the prevention of forest and vegetation fires. These campaigns are generally published at the beginning of June, with the start of the summer weather on June 1$^{st}$, marking the official start of the forest fire season.

From a legislative point of view, there are legal obligations to clear undergrowth (OLD), particularly in the vicinity of dwellings, which helps to reduce their individual vulnerability, but their existence remains little known to the citizens concerned. For this reason, an OLD communication and reminder campaign took place in the spring of 2023: over 2.5 million letters were sent to the citizens concerned.

## 2.4. Developments taking account of climate change

In chapter 0, we identified the expected effects of climate change. As far as natural hazards are concerned, the most obvious effects concern changes in avalanche types and an increase in the number of rockfalls at high altitudes. But for other phenomena, or in the case of changes in forest areas and stand health, many uncertainties remain (physical and economic models, etc.). It is therefore necessary to establish forest and natural hazard management strategies **that take account of this uncertainty**, which means, on the one hand, **continuing to acquire knowledge** of the effects of climate change on natural hazards and forests and, on the other hand, developing the **capacity to adapt** tools and organizational methods over time.

### 2.3.1. Forest management

In view of the many uncertainties, we don't know what the scale of forest dieback will be, particularly in mountain areas, although we do know that it will increase.

We know that in a changing context, forests have natural adaptive capacities. For example, tree species have already gradually "migrated" in the past, during climatic evolutions. Trees are also highly genetically diverse within the same stand. With each generation of trees, genetic mixing and mutations generate the dynamics of this diversity, which evolves over time.

But the intensity and speed of current climate change make the effects of these natural mechanisms uncertain. While it is necessary to better understand how they work, it is also important to "get ahead of the game", for example by encouraging or even planting tree species that we think will be better adapted to climate projections.

But here, too, there is a great deal of uncertainty. For example, when a forest management plan is drawn up and a silvicultural itinerary is chosen with a 20-year horizon, it is very difficult to say what the effects and consequences will be.

The principle adopted is therefore to undertake several strategies in parallel, as tests, in order to identify in a few years' time those that work and those that don't: it's a question of "*not putting all your eggs in the same basket*". Among these stand renewal strategies, the following are the main ones to consider: full planting, accompanied natural regeneration, planting in natural regeneration, letting go with natural adaptation.

The ONF's Strategy for Adapting Forests to Climate Change at national level is based on the development and application of the "**Mozaic Forest**" principle, developed around 3 years ago. For forest management, in addition to the preliminary questions relating to the multifunctionality to be ensured by a forest, the aim is to ensure greater diversification than was previously the case, but this general principle need not be systematic. The search for diversification in silvicultural strategies and itineraries must be considered at the outset, to avoid embarking on a potentially more complicated process when, for a given forest, the uncertainties are limited and the strategic choices to be made, are obvious. This new management principle has only recently been considered in forest management (2022).

Furthermore, in view of the effects of climate change on French forests and the uncertainties surrounding their future, MASA and MTECT decided to set up an **Observatory of French Forests** involving the various French players in the field (Observatoire des forêts françaises). The IGN[20] is in charge of the Observatory, in partnership with the ONF, the CNPF (National Center of Private Forestry Property), France Forêt Bois (national interprofession) and the Office Français de la Biodiversité (OFB).

### 2.3.2. Natural hazard prevention

In the field of natural hazard prevention, for which the MTECT is responsible for implementing policy, it makes its knowledge available via the Géorisques website. At present, the question of how to implement prevention policies at local level, requiring local governance by local authorities, is a major challenge. To this end, the French government is supporting the development of local strategies based on a better understanding of local risks, including their evolution in the context of climate change, to enable local authorities to better define and implement these strategies.

[20] Institut national de l'information Géographique et forestière : *https://ign.fr*

These various actions include a program of actions for the prevention of risks of glacial and periglacial origins[21] **(PAPROG)** initiated by the MTECT at the end of 2019. Its main objectives are to coordinate actions to improve knowledge and prevent risks of glacial or periglacial origin (**ROGP**) in France by mobilizing the skills of operational services (ONF-RTM) and scientific and technical partners (INRAE, Météo-France, CNRS, Grenoble Alpes and Savoie-Mont-Blanc Universities). Based on this knowledge, the concerned local authorities are then supported by ONF-RTM services to identify the action plans to be implemented (for example, improving the warning system, draining glacial lakes, etc.).

We can also highlight the development of Territorial Strategies for Mountain Risk Prevention[22] **(STePRiM)**, the idea for which was born in 2013 and led to initial specifications for a call for applications from local authorities in 2017, and the drafting of a methodological guide to help with implementation, scheduled for publication in 2024. The principle is to identify a territorial strategy that considers not only the multiplicity of natural hazards to which a mountain territory is subject, but also the different types of stakes exposed (from housing to roads, for example, for which the risk managers are not the same). Ultimately, the aim is to help build a territorial dynamic that is more adaptable to the uncertainties to which the implementation of the chosen strategy is subject.

In the field of forest fire prevention, for the first time, the 2023 prevention campaign is producing TV spots in the form of weather report sponsorships on France Télévisions from June 19th to August 25th. This year also sees the publication of new information to raise public awareness of the risk of forest fires: **météo des forêts** (Forest weather forecast). This information, which covers all French departments, including those with mountain areas, estimates the fire danger forecast based on weather conditions for the current day and the following day.

The foreseeable extension of the risk of forest and vegetation fires to the whole of France as a result of climate change has been identified by the legislator, as demonstrated by the **law of July 10, 2023,** aimed at **reinforcing prevention and the fight against the intensification and extension of the risk of fire**. In addition to territorial reinforcement on the one hand, and extended fire seasons on the other, technical, and organizational studies are underway into the use and storage of the water needed to fight fires in areas even more exposed to drought in summer.

[21] **P**rogramme d'**A**ctions pour la **P**révention des **R**isques d'**O**rigine **G**laciaire et périglaciaire

[22] Stratégies Territoriales pour la Prévention des Risques en Montagne -STePRim

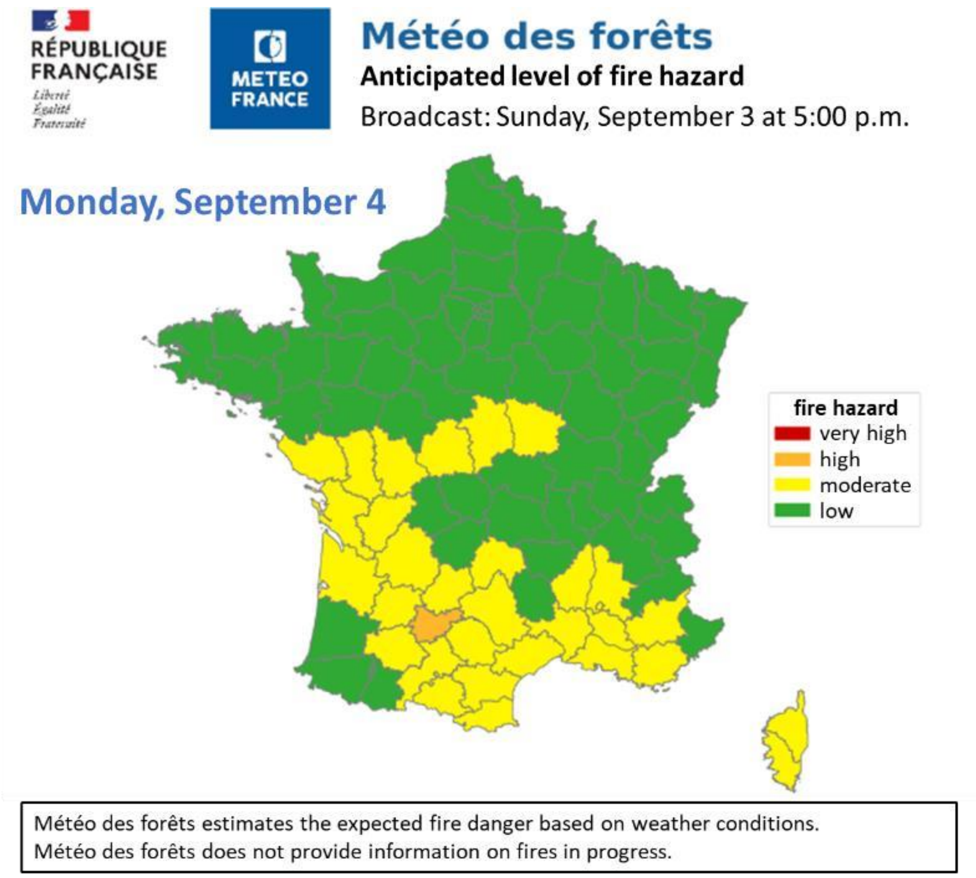



*Figure 21 : Map from Météo des Forêts (extract from 04/09/2023)*

# 3. Structure and function of the institutions and services that manage mountain watersheds in France

## 3.1. Forest management

Mountain forests correspond to approximatively 27% of the total French forest area (i.e., 4.4 million hectares) in which 11% are State's forests (0.49 million hectares), 23% are public local municipality forests (1 million hectares) and 66% are private forests (Figure 22).

**Public forests** (owned by the State - MASA or local authorities) are managed by the **ONF**. Private forests are managed by their owners, who can call on the support of the CNPF, a public technical establishment.

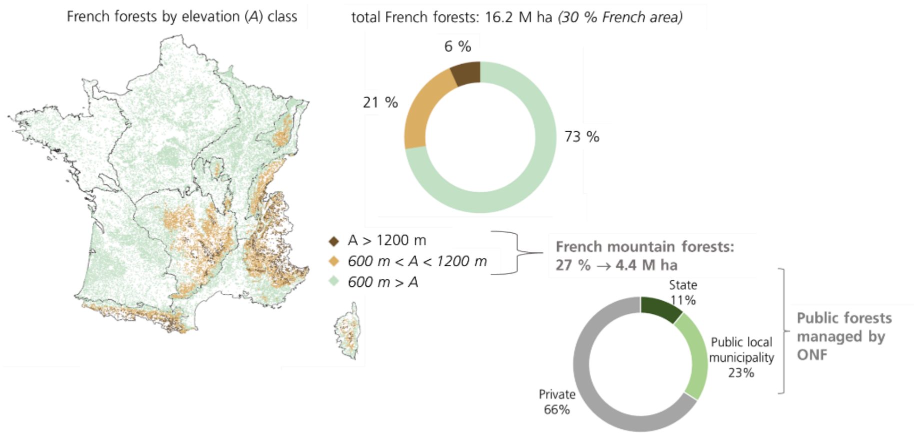



*Figure 22 : Distribution of mountain forests in France and those involved in their management*

## 3.2. Natural hazards management, inc. forest fire

On a given territory, the number of natural risk management players is significant, in order to cover the entire natural risk management cycle (Figure 19 and Figure 23).

### *State*

The **MASA**, in charge of forestry:

- finances the maintenance of protection structures against natural hazards in state-owned forests.
- pilots forest fire protection (DFCI), a global policy for the development and maintenance of rural and forest areas, by guiding and financing the implementation of tools for the programming, development, and maintenance of massifs, based on the Forestry Code.

The **MTECT**, in charge of regional planning and natural risk prevention, is responsible for the town planning policy implemented through various planning documents (Territorial Coherence Schemes, Local Urban Plans or multi-community Urban Plans, Municipality Maps) and the natural risk prevention policy through the Natural Hazard Prevention Plans (PPRn), which include the Forest Fire Risk Prevention Plans (PPRIF).

At local departmental level, MASA and MTECT are represented by one or more departments of the Department Directorate of the Territories[23] **(DDT)**, the local government department.

The **MIOT**, which is responsible for civil protection, is also represented locally by the Prefect of the the department. The Perfect oversees crisis operations when several municipalities are involved, or when the mayor is unable to do so.
On request, the Prefect can receive support from the zonal or national level.

In terms of forest fire prevention, which has historically been more prevalent in Mediterranean departments, a specific zonal government policy has been in place, with a Delegation to the Protection of the Mediterranean Forest[24] **(DPFM)** created in 1987. This specific organization covers the mountainous areas of the oriental Pyrenees and the Southern Alps.

[23] Direction Départementale des Territoires
[24] Délégation à la Protection de la Forêt Méditerranéenne

## *Public Establishments*

**The ONF** is involved in Missions of General Interest[25] (**MIG**) financed by:

- the MTECT to support government services in implementing natural hazard prevention policy in mountain areas; the RTM department is responsible for this MIG RTM in support of the DDT and Prefects (Figure 23).
- the MASA, for:
    - management of the stock of protective structures in state-owned RTM forests (Figure 23), carried out by the RTM department.
    - operational forest fire prevention, carried out by the DFCI department: surveillance patrols and first response to incipient fires, OLD control, support for public DFCI policies. These missions, traditionally carried out in regions around the Mediterranean, will be rolled out across the whole of France from 2023 onwards, to take account of the growing risk of forest fires.

In addition to these MIGs, the ONF-RTM department, with its recognized technical skills in the management of natural risks in mountain areas, also carries out, like other private engineering firms, missions to support local authorities in implementing preventive measures, including the construction and maintenance of protective structures for which they are responsible.

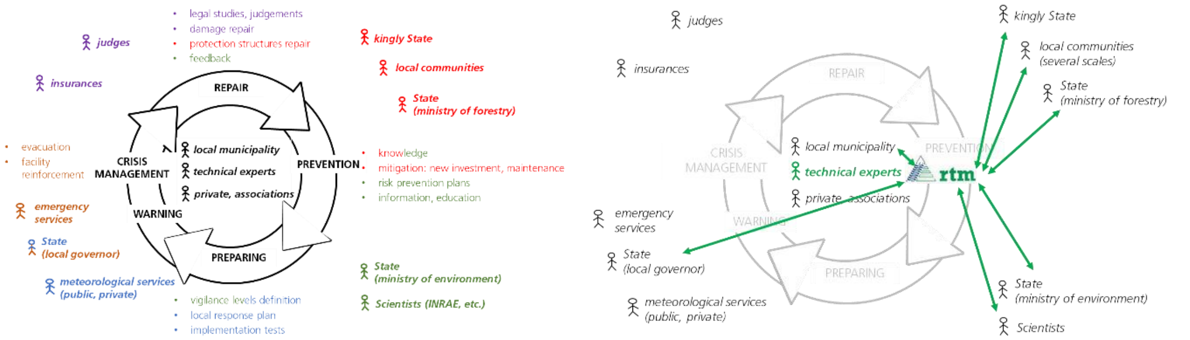



*Figure 23 : French stakeholders in natural risk management according to the actions undertaken (left) and positioning of the ONF-RTM technical service, the technical reference in mountain territories, in this landscape (right).*

**The CNPF** organizes, with the support of the Departmental Fire and Rescue Services (**SDIS**)[26], awareness-raising, training and acculturation meetings on fire risk for private forest owners. Under the law of 10/07/2023, a network of DFCI advisors will be set up in each CNPF regional delegation.

As part of its mission to ensure the safety of people and property, **Météo France** produces daily avalanche and fire weather hazard assessments for the whole of France. For floods, meteorological data is used by the French government's Central Hydrometeorology and Flood Prevention Support Service[27] (SCHAPI), which provides an assessment of flood risk on the scale of the various monitored rivers (not very applicable to mountain torrents).

**INRAE** is the public research establishment working on the theme of mountain natural hazards and forest fires. It develops knowledge in this field and supports expert assessments where necessary.

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[25] Missions d'Intérêt Général

[26] Services Départementaux d'Incendie et de Secours

[27] Service Central d'Hydrométéorologie et d'Appui à la Prévention des Inondations

## *Local authorities*

**The departmental councils** fund the Departmental Fire and Rescue Services (SDIS),which are the emergency response services for crisis situations.

**In communes**, mayors are responsible for safety on their territory, and as such, oversee crisis management within their boundaries. To this end, they are responsible for drawing up Communal Safety Plans[28] (**PCS**). However, the lack of a common risk culture means that these plans are not always put into practice.

Mayors are also responsible for implementing actions to prevent natural hazards on their territory: preventive information, drawing up forestry plans for DFCI, controlling OLDs, opening and closing forestry areas to the public, and overseeing work to protect against natural hazards. In this field, for floods, the management of aquatic environments and flood prevention[29] (**GEMAPI**) has led to the transfer of this project management to larger entities, grouping together several communes, and able to draw on a sufficient budget. On the scale of a torrential watershed, this has led to a division of tasks between different players, who need to be coordinated (Figure 24).

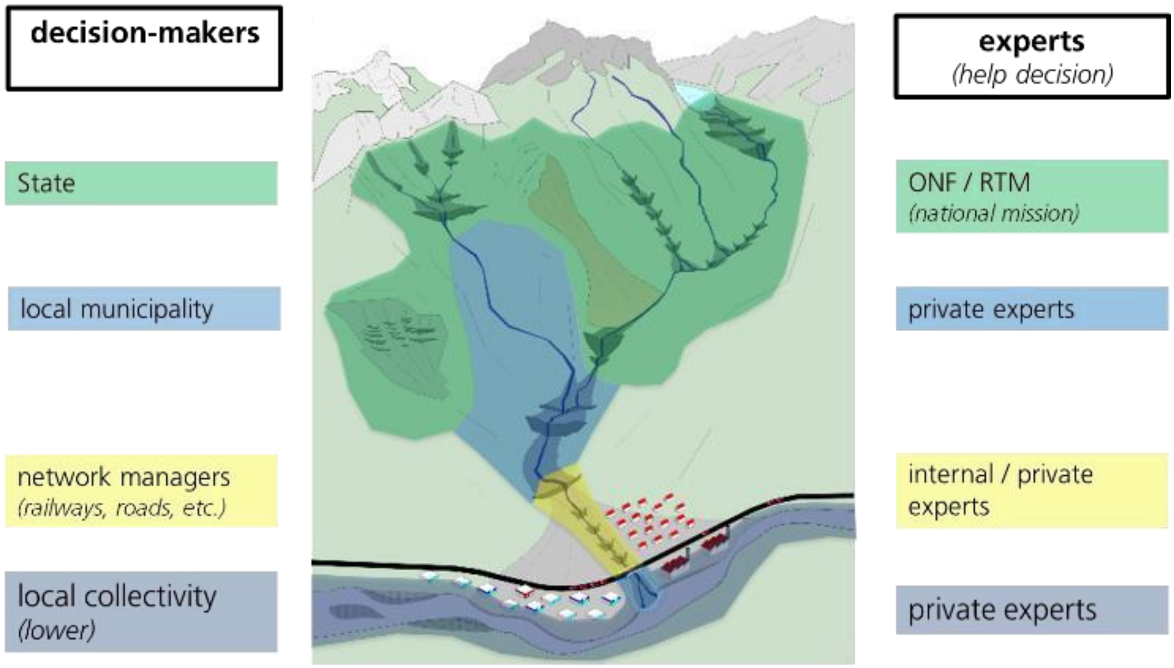



*Figure 24 : Torrential risk management stakeholders in torrential watersheds*

[28] Plans Communaux de Sauvegarde

[29] Gestion des Milieux Aquatiques et de la Prévention de Inondations

## 4. How do forest management and technical/bioengineering works coordinate, and collaborate for the mountain watersheds management?

Multifunctional forest management is carried out by the ONF in public forests and by private owners, accompanied by the CNPF, in private forests.

Technical protection measures (civil engineering or forestry engineering works) are designed and implemented by technical services, at the service of decision-makers.

Therefore, depending on the situation of the land and the legal responsibility for the risk, there may be different situations.

- In state-owned RTM forests and other forests with a protective function, the decision-maker is the DDT, representing the State-MASA on the territory. The works are managed by ONFRTM. The forest manager is the ONF management department. If the forest has a protective effect, the ONF management department asks the ONF-RTM for its opinion on the level of risk and decides on the silvicultural itinerary to be adopted to ensure that this level of protection is maintained, in compromise with the other functions to be ensured.
  In general, clear-cutting is not permitted in these forests.
  To encourage the renewal of priority stands in mountain areas where the stands are old, a budget has been set aside by MASA under the RTM policy, which therefore complements the implementation of civil engineering works.

- In the case of forests, whether private or public, some may have the legal status of forest for protection against natural hazards, but this is rare. In general, it's a question of land authorization to install protective structures in forests. The application for authorization must be made by the future project owner to the landowner. The forest management of the land must then take into account the presence of the structures, so as not to damage them during felling operations, their upkeep and, in particular, with the landowner's authorization, the felling of nearby trees which, if they fall, could damage the structures.

- In the field of flooding, GEMAPI introduces the need to reconcile the management of aquatic environments, which can be found in forests and are sources of biodiversity, with the implementation of technical prevention measures. The "gemapi" authority is then responsible for coordinating the implementation of these different actions, with the aim of reconciling these different issues, as in the case of multifunctional forest management.

- In the field of boulder falls, after several tests, forest screens (steel screens anchored by existing trees) are being developed to provide greater protection (a few hundred kJ) than forest screens alone, given the size of the boulders, but less than boulder screens (several thousand kJ).

# 5. How « protective forests » are identified and designated

We refer here to the national report prepared for the 32nd session of the WP MMW, in 2019: "French National Report – The Protective Functions of Forests in Mountain Watersheds in the context of a Changing Climate". Here are the main points.

## 5.1. What is a "protective forest" in France

In France, the expression "protective forests" is very large because it includes forests which have a role in the control of natural hazards (avalanche, erosion, etc.) but also forests which have an important ecological or social role and which must be maintained because of this. However, all of these forests do not have a protective function (i.e., does not protect the population or human infrastructures against natural hazards).

Here, in the context of the European Forestry Commission's Working Party on the management of mountain watersheds (WPMMW), we can consider that protective forests correspond to all forests with a protective function. Mountain forests limit erosion, stabilize the snowpack and decrease the speed of rock falls. Moreover, we can speak of protection only in the case where forests limit a risk. Then, a large part of mountain forests (but only mountain forests) can be included in the definition.

## 5.2. Protective functions of Forests in Moutain Watersheds

Protective forests have multiple protective functions. The three principal functions are:

- Limiting soil erosion and concentration of solid materials in torrents. Erosion is a natural phenomenon, but it is important to limit its dangerous effects (loss of soil, transport of large solid materials in torrent floods, etc.). Forest is a good way to fix the soil and then to reduce erosion. This was, at first, the reason of the creation of the RTM policy and is still the major role of protective forests.
- Preventing from avalanches. Forests can prevent the snow from moving by capturing the snow in their branches and the stems. However, they are not able to stop an avalanche already in movement.
- Limiting or stopping rock falls. Thanks to their stems and their branches, trees can intercept the rocks smaller than 1 $m^3$ and decrease their speed or even stop them.

To prevent all these risks, different forests characteristics are necessary: great stem density and basal area protect from rock falls, evergreen species prevent avalanches and plant coverage reduce erosion.

## 5.3. Assessing the protective function of a forest

The protective function of a forest can be assessed for two situations:

- to identify which forests are likely to play a protective role against natural hazards.
- to identify the level of protection against natural hazards that a forest should provide: this is the issue when assessing the protection function in the context of multifunctional forest management.

### 5.3.1. Identifying forests likely to have a protective function

This assessment is carried out over large areas and is based on large-scale modeling of rockfalls and avalanches, which are then cross-referenced with GIS layers, including land use.

In France, if this has not yet been done in the field of avalanches, INRAE's Mountain Ecosystems and Societies Laboratory (**LESSEM**) has developed a model (Sylvarock) for the indicative mapping on a slope scale, of rock related hazards and forests likely to have a protective function. This model was first applied to the entire Alpine Arc (Interreg Espace Alpin ROCKTheAlps project), using data available on a European scale, before being rolled out to the whole of mainland France, using more precise national data[30].

Based on available GIS layers, the principle is to identify potential starting zones, to consider an average block of 5 $m^3$, to use a block propagation model, to identify if on the trajectories, there is at least one stake (a road, a dwelling) and if there is a forest between the identified starting zone and the potentially affected stake. If this is the case, then the forest is considered likely to have a protective function. Resulting susceptibility maps have been elaborated, with this approach.

This approach must therefore be seen as:

- a preliminary identification approach.
- limited to boulder falls. It will be deployed for avalanches but appears difficult to reproduce for erosion and the contribution to torrential floods.

### 5.3.2. Forest protection level assessment

Once susceptibility has been established, it is necessary to assess the level of protection that a forest really provides.

Whereas the assertion of a protective function of forests has been subjected to debate for a long time, now, thanks to multiple works, its insertion is possible. A **hazard Control Index (IMA** in French for "Indice de Maîtrise d'Aléa"), created thanks to the RPP program launched in 2005, is noted in the management plan. The index quantifies the protective role of forests on a scale from 0 (no efficiency of the vegetation in regard to the hazard) to 6 (maximal efficiency) and aim to determine the suitable silvicultural operations, for maintaining the protective function of the forests. Only 12% of RTM stands have been defined with a high protection potential. The determination of the IMA of these forests and their renewal is prioritized.

Since 1860, natural hazards prevention in mountains is subjected to territorial planning policies. "Mountain guides of silviculture" present the national strategy for mountain forests and good practices during timber marking, logging, and other silvicultural operations. These guides have a specific part related to protective forests, classified by type of natural hazard and species. For each natural hazard and specie or group of species, the technical sheets of the guides describe the global objectives, differentiate the situations (the localisation of the forest in the slope, its evolution, resistance, etc.) and recommend adapted silvicultural interventions.

[30] Dupire et al. (2022). Cartographie indicative à l'échelle départementale des aléas rocheux et des forêts à fonction de protection

For public forests, State and municipalities are the most important actors in protective forest governance in France. They decide if they think useful or not to fund silvicultural works in protective forests. Then, the ONF oversees the management of them.

Even if forests are prone to protect the population and human infrastructure from natural hazards, in some cases, negative aspects of forests in areas at risk are observed. These cases are scored with a negative IMA. For examples, the presence of trees in an avalanche path: if the trees do not resist, they can increase the risk by adding large solid elements to the snow flow. Moreover, trees or branches can create logjams in torrents and create other hazards.

During the Interreg project IV which took place during the period 2007-2013, systematic mapping of forests with a protective function was carried out in the urban area of Grenoble, in the Northern Alps. The resulting map (Figure 1) shows the efficiency of the forest in regard to rock fall and avalanche hazards. This case study is quite representative of the role of protective forests in the high elevation mountains of France (Alps and Pyrenees).

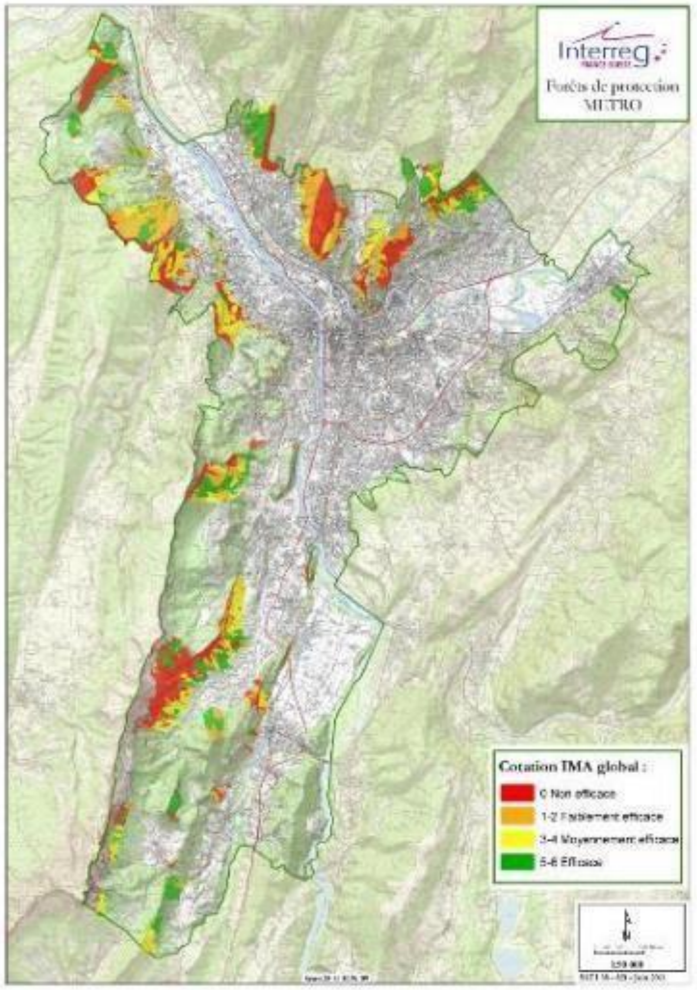



*Figure 25 : Map identifying and quantifying the protective function of the forests, in the limits of the urban area of Grenoble. (Source: Interreg IV). Red: low function; orange or yellow: moderate function; green: high function.*

Here again, the application of the hazard Control Index (IMA) has been recalculated for boulder falls. However, IMA calculation methods are defined for other natural hazards. However, discussions are underway to better assess the function of protection against natural hazards in mountainous areas.

The actual assessment of the IMA is based on current GSM Guides, which do not take into account the effects of climate change. Tests are therefore underway using ONF climate change models on mountain watersheds. This makes it possible to highlight the "risk zones" where existing tree species are threatened in the medium term. By cross-referencing with the areas at risk, defined in the Priority Stand Renewal survey (2007), we were able to identify a current IMA and, taking into account the results of the previous modeling, a medium-term IMA. This test has been carried out in the HautesAlpes watershed and needs to be rolled out across an entire territory.

In connection with the assessment of the state of forests and their adaptation to future conditions in the mountains, the methods for defining this medium-term IMA and the revision of the GSMs required to take account of this analysis and therefore of climate change, should be reviewed by 2025.

# 6. Financial sources for the management of mountain watersheds

In France, the general system is that the forest owner is responsible for the works undertaken in his property and can call on funding from other partners (the State and local authorities in general). The same principle applies to works to protect against natural hazards, with the proviso that the project owner may be different from the landowner but requires the latter's authorization to be able to intervene. In the absence of agreement, a declaration of public utility (DUP) is required to establish and impose a public easement on the landowner.

## 6.1. Forest management

For forests, the financing of actions depends on the status of the forest:

- **in state-owned forests**, ONF, subsidized by the State: currently, the national budget allocated to state-owned RTM forests for the maintenance of structures is around 10 M€/year (a sharp 15% increase over the last two years), to which must be added the engineering time provided by ONF-RTM services.
- **in public authority forests**, the public authority bears the majority of the cost, and may receive state aid if the forest has a protection status or for DFCI actions.
- **in private forests**, the private owner bears most of the cost, but may be eligible for state aid if the forest is under protection status or for DFCI actions, as well as aid from local authorities (commune or community of communes, Department, region).

The major problem of financing, whatever the status of the forest, is the fact that mountain forests are often difficult to manage and wood production is limited by the steep slopes (especially at high elevations). Then, the management of these forests is expensive and less attractive. This is why, in RTM state forests, the French National Forest Organisation (ONF) only receives around 600 to 700 000€ for the whole measures.

## 6.2. Natural hazard prevention

The local authorities are in charge of the implementation of prevention measures against natural hazards, from the moment that the security of the people is at stake therefore, mainly in the buildings.

Depending on the subject, it may be the municipality or a community of municipalities who wish to have the competence for the prevention of natural risks other than floods, or against soil erosion. In the area of flooding, GEMAPI has imposed the transfer of responsibility for flood prevention, from the municipal level to the higher intermunicipal level.

One source of funding for local authorities is the **GEMAPI tax**, limited to a maximum of 40€/year/inhabitant.

In all areas of natural risk prevention, whatever the type of hazard and including flooding, the French government can subsidize several actions through the **Barnier Fund**, which is replenished by home insurance policies, based on the principle of national solidarity.

Depending on the region, local authorities such as departmental and regional councils can direct part of their funding towards preventive measures against natural hazards, carried out by local authorities.

It should be noted that, by financing the maintenance of protection measures in state-owned RTM forests, the State-MASA contributes to the financing of natural hazard prevention in mountain areas.

In addition, with climate change and the national policy committed to leading the ecological transition, European and State funding is being structured: the recovery plan (2021-2022), or “France 2030” aimed at encouraging the renewal of stands through planting, or the Green Fund aimed at accelerating the ecological transition in territories and in particular at limiting the effects of climate change, of which the increase in natural risks are a part. Until now, these financing schemes have been of short duration, and need to be structured in order to be implemented on a sustainable basis.

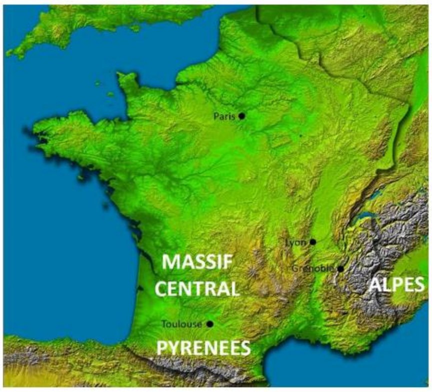
Office National des Forêts

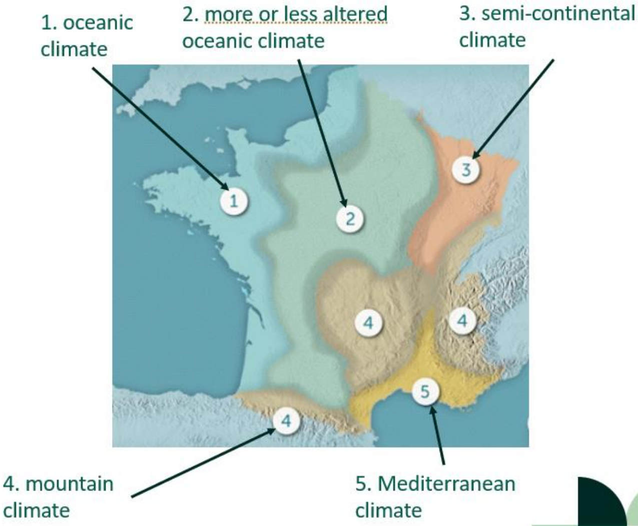
# Management of mountain watersheds in a climate change perspective: from the Alps to the Mediterranean areas

## FRANCE

September 27th, 2023

## The climates in France



## Climate change main issues in mountainous areas

**trends in climatic precursors:** depend on mountain range and altitude + gaps in knowledge

- **mean T°C** — ↗ spring & summer; ↗↗ in mountains
- **number of days of heat waves** — ↗ Pyrenees + Mediterranean rim
- **average rainfall** — ↘ winter (mainly Pyrenees); ↘↘ summer (Mediterranean rim)
- **extreme daily rainfall** *(T=20 y.)* — ↗ 20% autumn (Mediterranean rim); ↗ thunderstorm rainfalls
- **extreme snow-fall** *(T=100 y.)* — if A<2000 m: ↘ all mountains; if A>2000 m: ↘ Northern Alps & ↗ Southern Alps

## Climate change main issues in mountainous areas

**Trends in climatic precursors :** depend on mountain range and altitude + gaps in knowledge

**Clear trends on natural hazards**

- Snow avalanches: ↗ reaching bottom of valleys; ↗ wet snow events
- rockfalls > 2500 m: ↗ frequency
- Glacial & periglacial hazards (*N. Alps*): ↘ ice covered surface, but heterogeneous; ↗ No. and size glacial lakes ⟹ ↗ torrential risks

**unclear trends on natural hazards**

- Torrential floods (incl. Debris flows)
- Landslides
- Rockfalls < 2000 m

**Clear trends on forests**

- Drought & water stress dieback ⟶ decline.
- Growth conditions: ↗ in mountains, but other limiting factors.
- Accelerating decline by parasites.
- Forest fires: ↗ frequency & intensity; ↗ risk areas (incl. Mountains); ↗ risk season (april-october).

**unclear trends on forest**

- Variable vulnerability
- storms

## Current policy instruments and forest management…

- **Multifunctional management of each forest (≠ dedicate management)**
  - **Potential functions**: production, protection against natural hazards, biodiversity, welcoming the public
  - **Objective**: to **develop a compromise** between these functions, given each forest

tools

| Forest | Strategy level | | | | Guidelines | |
|---|---|---|---|---|---|---|
| | National | Regional | | Forest | Regional | Mountains |
| Public | National Forest and Wood Plan (PNFB) | Regional Forest and Wood Plan (PRFB) | Regional Planning Directive and Scheme (DRASRA) | Public forest management document | e.g. Adapting public forests to climate change in PACA (2021) | Mountain silviculture guidelines (GSM) |
| Private | | | Private Forest Management Plan (PSGFP) | | | |

- **Forestry in natural risk management**
  - ***green zones* in risk reduction plan (PPR)** with specific management
  - potential protection against natural hazards → **adapted silviculture (GSM)**
  - **mountain forests** are **vulnerable** → need for **specific management actions**
    - ✓ *under exploitation → accelerated ageing* → ***Priority Stand Renewal (RPP)*** *actions since 2007*
    - ✓ *under pressure from wild game (deer)* → ***hunting plans*** *(ONF + hunting federations)*
    - ✓ ***exposed to natural hazards*** → ***forest fires*** *and* ***storms*** *prevention and resilience*

## … changes to address climate change issues in mountain watersheds

- **Forest fire prevention (DFCI)**

overseen by the MASA (Ministry for forests)

- **July 10, 2023 – law** to reinforce prevention and fight against intensification and extension of fire risk
- New : « Météo des Forêts » (Forest weather)

- **Changes in forest management**

Climate change **effects are highly uncertain** → **Strategy** based on **2 pillars**:

- continuing to **acquire and disseminate knowledge** → Observatory of French Forests
- developing the **capacity to adapt** → **« Mozaic Forest »** as a new forest management tool (2022)

- **Developments in natural hazard prevention State strategy**
  - **disseminate knowledge**: Géorisques
  - **promote local multi-risk strategies and governance**
    - ✓ Glacier and Periglacial Risk Prevention Action Program (PAROPG) – only Alps
    - ✓ Territorial Strategies for Mountain Risk Prevention (STePRiM)

## Institutions and services that manage mountain watersheds

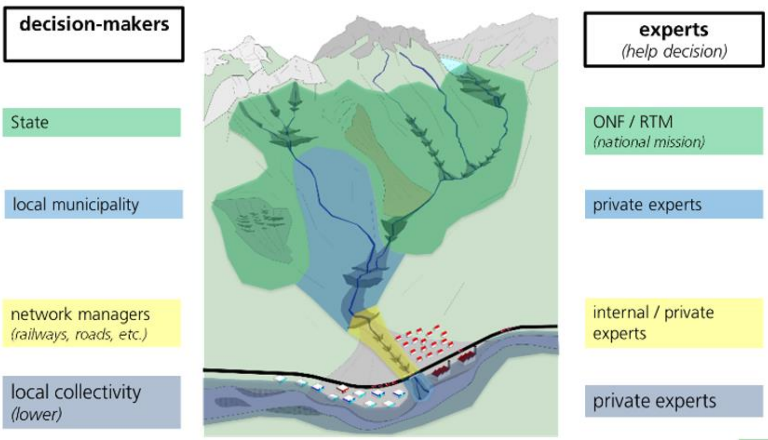
- **Natural hazards management, including forest fires**

| Services | | Prevention | | Alert | | Crisis operation |
|---|---|---|---|---|---|---|
| | | Forest | Natural hazards | | | |
| State | National | MASA *(Min. agriculture)* | MTECT *(Min. environment)* | *floods* | SCHAPI | |
| State | Local | DDT | | *floods* | SPC | Préfet DPFM |
| Public Establishments | | ONF-RTM & DFCI *(Implementation)* INRAE *(research)* | | Météo France *Weather forcast, snow avalanches, forest fire* | | |
| Public Establishments | | CNPF *(private)* | | | | |
| Local authorities | | Mayor GEMAPI authorities *(floods)* | | | | Mayor SDIS *(fire fighters)* |

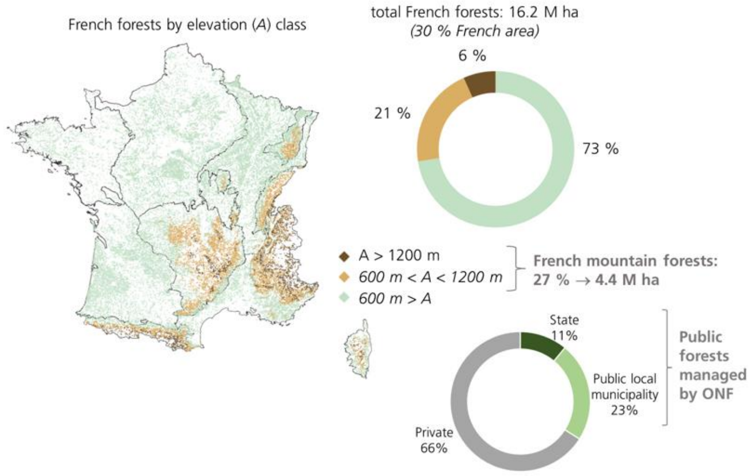
## Institutions and services that manage mountain watersheds

Example:

stakeholders in a torrential watershed for flood protection management



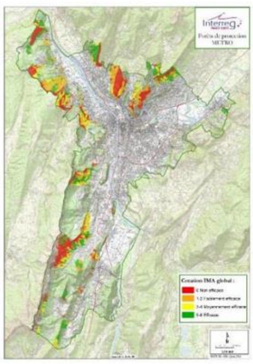
## … short reminder on the repartition of forests




## « Protective forest »

- **Definition**
  - **French definition** is very **large:** protect (natural hazards) + must be protected (biodiversity, social)
  - **Protective function against natural hazards**:
    limit erosion / stabilize the snowpack / decrease the speed of or stop rockfalls

- **Assessment of the protective function**
  - **Identifying forests likely to have a protective function**
    → rockfalls: GIS approach on an extended area; model developped by INRAE's LESSEM (Sylvarock)
    → preliminary approach – will be developed for snow avalanches
  - **Forest protection level assessment**
    → Hazard Control Index (IMA) – for all hazards
    → Preliminary assessed in forest management documents according to GSM
    → Need to be reviewed, notably to consider climate change effects




Rockfalls IMA in the urban area of Grenoble
*(Source: Interreg IV)*

## Forest management and technical/bioengineering works

- **In forests with a protective function** *(inc. state-owned RTM forests)*
  - Overseen by the State government (MASA)
  - Bioengineering works
    - ✓ in general, ONF → no clear-cutting allowed
    - ✓ a specific fund for renewal of priority stands: ONF-RTM
  - Technical works: ONF-RTM

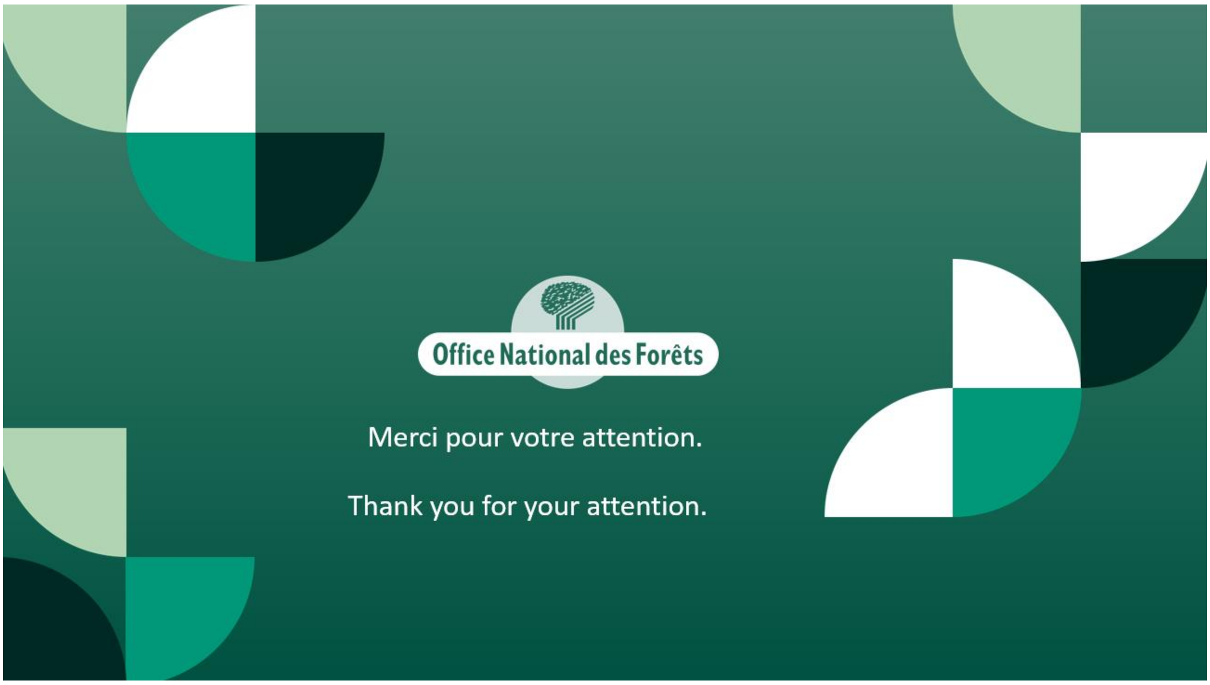
- **In other forests**
  - Bioengineering works: ONF (public) or private with help of CNPF (private)
  - Technical works by technical stakeholders with land authorization for installation

## Financial sources for the management of mountain watersheds

- **Forest management**
  - **State-owned RTM forest**: wood sales + fundings by the State
  - **Public authority forest**: wood sales + local authority + State funds (protection status, DFCI actions….)
  - **Private forest**: wood sales + State and local authority funds

  → main problem in mountains: **wood production and sales are limited by the steep slopes**

- **Natural hazards prevention**
  - **Floods**: GEMAPI tax (≤ €40/year/inhabitant)
  - **All natural hazards**:
    - ✓ State Barnier Fund – replenished by home insurance policies (national solidarity)
    - ✓ State-owned RTM forest: technical measures are 100% State funded
  - Climate change and national policy commited to **leading ecological transition** → specic funds
    - ✓ Post-Covid Recovery Plan (2021-2022), then France 2030: for renewal of stands through planting
    - ✓ « Green fund » to accelerate the ecological transition in territories
  - Depending on the location, **local authorities funds** (departmental or regional councils)


Office National des Forêts
Merci pour votre attention.
Thank you for your attention.

# Germany – Bavaria

Germany – Bavaria[1]

Richard Heitz[a] and Karl Mayer[b]

[a] Bavarian State Institute of Forestry

[b] Bavarian Environment Agency

**Management of mountain watersheds in a climate change perspective: from the Alps to the Mediterranean areas**

About 50 percent of the Bavarian Alps – that is 260.000 ha – are covered by forest, of which 60 percent is protective forest against natural hazards like avalanches, rockfall, landslides, mud flows and floods.

According to the Bavarian Forestry Planning Framework "Waldfunktionsplanung" 85 percent of the alpine mountain forests are part of torrent catchments. This further underlines the outstanding role of protective forests in the context of torrential hazards, as forests can significantly moderate run-off peaks and solids cargo and by that limit the hazard of floods and torrential events.

Important factors of the protective function are protection against soil erosion by roots and canopycover, improvement of soil infiltration, increase of total water storing capacity via humus accumulation and deep rooting, water-recycling to atmosphere, recharging of storing capacity and retardation of catchment run-off via interception, transpiration and physical water-vegetation-interaction. Thereby, the contribution of the single factors varies dependent on the specific conditions of site and event.

Climate change challenges protective function of forests in two respects, raising the hazard potential by more frequent and more extreme events and putting additional pressure on the forest ecosystem itself challenging it´s resistance, resilience, adaptivity and functionality by rapidly altered and more extreme site conditions including natural disasters like storms, snow gliding, bark beetle infestations and (so far with less significance for the northern edge of the alps) forest fires. According to climate experts the Alpine Region will be and already is especially affected by climate change.

*What policy instruments and forest management is your country implementing and developing to address climate change issues in mountain watersheds?*

In Bavaria forests are managed by owners. 53 percent of the alpine mountain forests are owned by the State of Bavaria, 43 percent by private and 4 percent by municipial owners. In case of the state forest the Bavarian Forest Enterprise (Bayerische Staatsforsten BaySF) is in charge of forest management and committed to exemplary management practices. BaySF have established special guidelines for the management of mountain forests ("Bergwaldrichtlinie") within the Bavarian Alps. The silvicultural mission statement within the predominant montane altitude zone is the natural mountain forest with Norway Spruce, European Beech and Silver Fir as main species. The forest management further aims to an uneven-aged and diverse structure with large understory areas of advance tree regeneration. This structure is believed to provide highest multifunctionality, stability and resilience against disturbances and adaptivity to climate change. In case of conflicting

[1] Note: all details in the text refer only to the forest area and torrent catchments within the Bavarian Alps

interests, protective function is given highest priority and necessary management measures to ensure or restore this protectivity are carried out also on sites without regular forestry.

The Bavarian Forest Administration provides consultation and funding to meet the challenges of climate change and to maintain and develop protective forests. Due to the extra demands of forest management in mountain regions there are elevated funding rates, such as for thinning, tree planting, bark beetle control and improving forest access to assist forest owners in managing their protective and mountain forests.

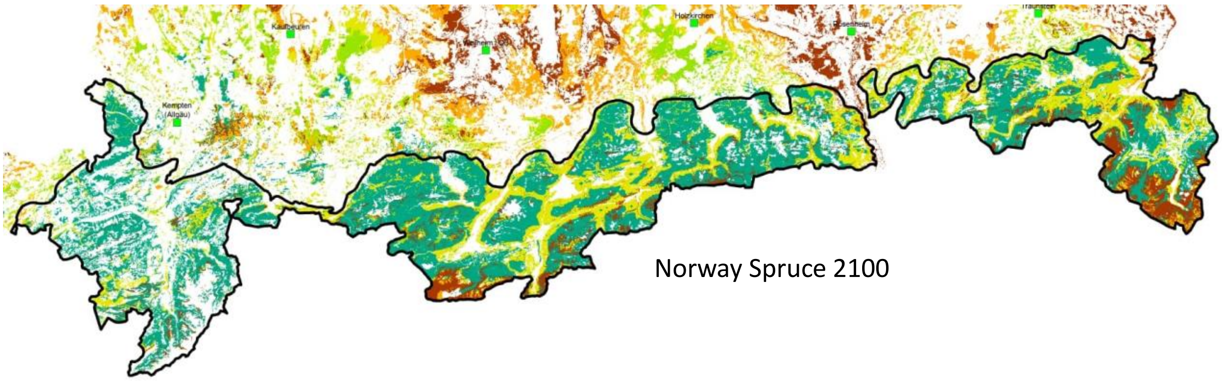
There are State support programmes to promote climate-adapted forest conversion in general, open to protective as well as to non-protective forests, e.g. Bavarian Forest Conversion Offensive 2030 ("Waldumbauoffensive 2030").

In selected regions of the Bavarian alps the State Programme on Mountain Forests ("Bergwaldoffensive" BWO) aims at adapting private and municipal forests to climate change, focusing on a participatory approach to bring together stakeholders from all concerned fields and to overcome challenges.

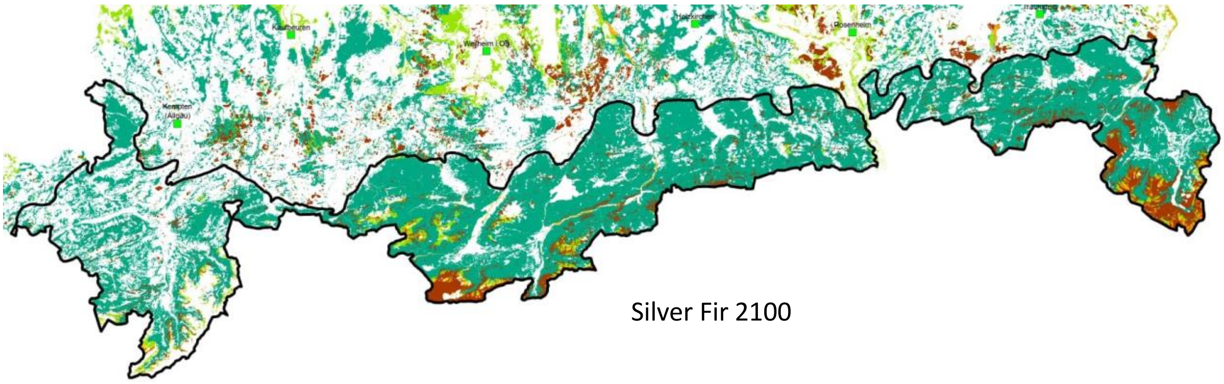
In the special case of dysfunctional protective forests there exists a programme to restore those forests ("Schutzwaldsanierung"). This programme has been running for over 35 years based on decisions of the Bavarian State Parliament in 1984 and 1986 and currently covers 10 percent of the alpine protective forest area of Bavaria (around 14000 hectares). In addition, the programme provides expert knowledge and financial and personal support to forest owners for the restoration of protective forests. The restoration of protective forest is a responsibility of the Bavarian Forest Administration.

For consultation purposes scientific advisory material is provided for climate change adaptation addressing the fitness and risk of tree species in climate change based on species propagation models, e.g. guidelines on the choice of tree species in climate change.

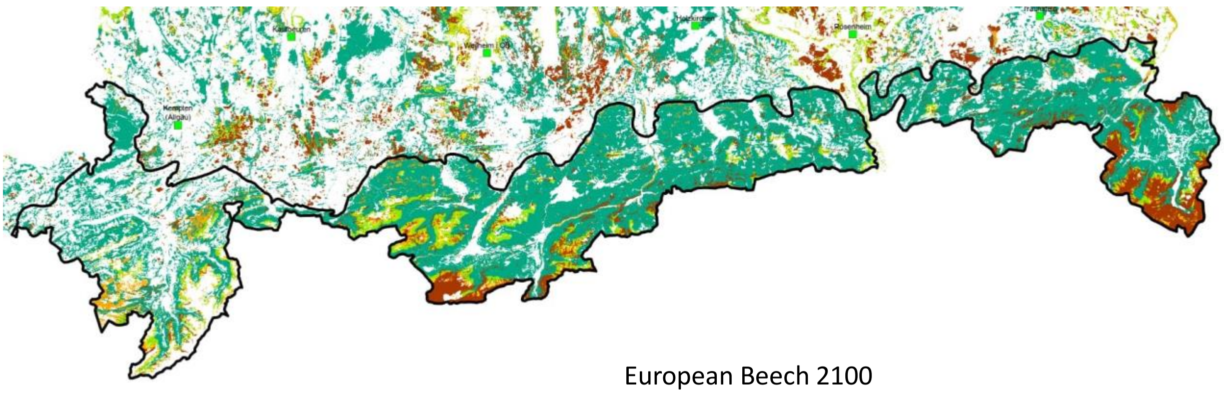
As shown in figure 1, still in 2100 a considerable small risk is predicted for the dominant tree species of the natural mountain forest ("Bergmischwald") Norway Spruce, Silver Fir and European Beech for large parts of the Bavarian Alps with a moderate climate change scenario (WETTREG 2006 SRES B1), based on a species distribution approach. So – in contrast to lower parts of Bavaria - the natural tree species composition including Spruce at least as part of the mixed mountain forest would face a good perspective in the Bavarian Alps still in climate change, if we manage to avoid more excessive global warming. Some upwards-migration included and expected.
Figure 1: Predicted risk for dominant tree species of the mountain forest in climate change till 2100 with a moderate warming scenario (WETTREG 2006 SRES B1)



Norway Spruce 2100



Silver Fir 2100



European Beech 2100

- Very small risk, possible as dominant tree species
- Small risk, possible as dominant tree species with high amount of admixture
- Aggravated risk, possible as admixture with moderate share
- High risk, possible as admixture with small share
- Very high risk, possible as admixture with very small share

According to that, the reconversion of pure coniferous forests into climate-tolerant mixed, uneven-aged forests with sufficient regeneration remains a major challenge for protective forest management.

There is ongoing research on the topic of climate adapted tree species composition to further improve the scientific basis of management decisions, for example WINALP21, a BavarianTyrolean cooperative leaded by the University of Applied Sciencies Weihenstephan-Triesdorf with special focus on the alpine region.

*What is the structure and function of the institutions and services that manage mountain watersheds?*

The Bavarian Forest Administration is headed by the Bavarian State Ministry for Food, Agriculture and Forestry. There are 32 regional Offices for Nutrition, Agriculture and Forestry (AELF), 6 of them with responsibility for the alpine region, among other tasks providing consultation and funding to forest owners and taking sovereign tasks. Three of the "alpine" AELF (Kempten, Weilheim, Rosenheim) host as subunits the Specialized Offices for Management of protective Forests (Fachstellen für Schutzwaldmanagement"). Those are especially responsible for the restoration of protective forests. The Bavarian State Institute of Forestry is a special authority within the Forest Administration providing scientific support of strong practical relevance.

The Bavarian Forest Enterprise is an Institution under public law owned by the State of Bavaria and responsible for the management of the Bavarian State Forest.

Headed by the Bavarian State Ministry of the Environment and Consumer Protection, Water management units in the 7 district governments, 17 State Offices for Water Management ("Wasserwirtschaftsämter") and Offices of the countries (71) and country-free Towns (25) are responsible for water management and flood control including risk and hazard management and torrent control to protect human infrastructure. The water departments of the Bavarian Environment Agency (Landesamt für Umwelt) as advisory authority give expert support.

*How do forest management and technical/bioengineering works coordinate and collaborate for the mountain watersheds management?*

There is a long history both of forest management and torrent control within mountain catchments. In case of torrent control of about 150 years, in case of forestry much more. During this time the relation has changed. Starting from 1872 and during more than 100 years of torrent control also the restoration and reestablishment of forests within torrent catchments under control has been assigned to the new established offices for torrent control and construction, from 1902 followed by two specialized offices for torrent control in Rosenheim und Kempten ("Sektionen für Wildbachverbauung") and from 1953 by the regional Bavarian Water Offices. In the context of forest decline, the restoration of protective forests in general been assigned to the forest administration and to the Specialized Offices for Management of protective Forests (Fachstellen für Schutzwaldmanagement") established in 1989.

In accordance with the integrative demands of torrent management there is a close cooperation between the water and forest authorities with reciprocal participation at all administrative levels. As a recent example of an integrative and participative approach, the integral torrent development concept (IWEK = Integrales Wildbachentwicklungskonzept) will be explained in brief:

With the long history of torrent control, now the maintenance of buildings and the adaptation of the protective system to climate change, altered protective goals and demands are a major challenge. The actual protective constructive assets are evaluated to more than 1 Mrd. Euro (54.000 protection buildings, 16.500 dams). The goal is a sustainable protective system of optimized functionality and cost-efficiency integrating constructive measures, bioengineering, land use and nature protection.
The IWEK-procedure has been developed by the water authorities as responsible for hazard and risk management under involvement of forest, environment and construction authorities and goes through the following steps:

- Evaluation of actual state: analysis all relevant torrential processes, functionality review of existing constructive measures
- participation of forestry, agriculture, nature conservation, municipalities on an administrative level; ○ e.g. forestry: assessment of forest situation and forecast including risks of disturbances, climate change as well as planned measures of restoration, improvement and adaptation
- Creation of guiding principles and mission statement
- Planning of alternative courses of action to realize the functional goal HQ100 + 15% climate change surcharge
- Optimization and selection of the most sustainable and economic solution using a matrix of variants approach
- Final package of measures including cost calculation and timeline

*How do you identify and designate protective forest?*

In general, protective forests are defined by the Bavarian Forest Act. According to Art. 10 Abs. 1 BayWaldG (Bavarian Forest Act):

'Protective forest is forest

- at higher altitude and on ridges of the Alps and lower mountain ranges;
- on sites with risk of karstification or erosion;
- which prevents avalanches, rock falls, landslides, floods, soil drift and protects riverbanks.'

Some protective functions (avalanches, soil protection, drinking water protection) have been mapped within the Forest planning framework ("Waldfunktionsplanung"). With renewal of the planning framework and the availability of geodata the inclusion of torrent catchments and areas/forests with special function for water retention is intended.

There have been some scientific approaches to map protective forests as dependent on legal definitions and with special consideration of damage potential under development, but not yet ready for administrative application.

Especially for the protective forests with special function for water retention a methodical harmonization and innovation might be necessary. Hence, an international exchange on that topic is highly appreciated.

For example, the currently ongoing mapping of areas endangered by torrential hazard as demanded by European legislation could help to promote risk assessment and prioritization of management measures on the catchment level.

*What are the financial sources and amount for mountain watersheds management in your country?*

Public sources of forest funding are

- financial support for forest management for private and corporative owners. Also, Bavarian Forest Enterprise can receive subsidies for special measures of public interest (bGWL).
- project funds like for BWO
- regular public funds e.g. for the forest restoration program

Since 1986 more than 13.5 million deciduous and coniferous trees were planted to restore protective forests. Each year around 1.8 million Euros are invested in protective forest restoration.

For forestry there are no statistics allowing for a special analysis of expenses for forest management accountable to watershed management. Such an analysis on one isolated aspect is hindered for example by multiple hazards overlaying and due to synergistic management measures not accountable to one isolated aspect. Besides, an international comparison probably would also require a harmonized approach of calculation.

The water authorities are responsible for numerous torrent watersheds of about 7.560 $km^2$ in total all over Bavaria. About 5.340 $km^2$ are part of the alpine Region. For torrent protection maintenance and torrent protection measures e.g. around 37 million was invested in the year 2022.

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# Hungary (observer)

# Country report Hungary
## 2023


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Source: http://www.vne-waterways.eu/fileadmin/media/meetings/presentations/070713VN_Seminar_Hungary_-_VKKI_Water_Management_in_Hungary.pdf

Hungary is situated within the drainage basin of the River Danube in the lowest part of the Carpathian Basin, most of the important headwater areas are in the neighbouring countries

**7 neighbouring countries**

**Flood plains cover close to one-quarter of the country's territory, affecting 2,5 million inhabitants in 700 settlements**

# Hydrology of Hungary

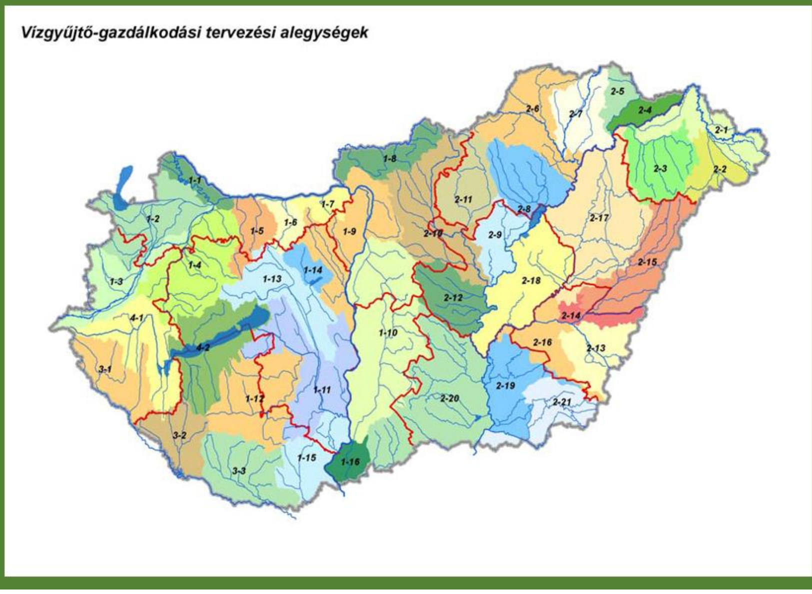
- Most of the Hungarian rivers come from the higher regions of the neighbouring countries, only a few of them have their origins in the country.
- The two main rivers – **Danube and Tisza** – also originate from outside the country and they leave Hungary as well.
- The smaller and bigger rivers build up a network of quiet brooks, middle size rivers, wild-waters and big rivers.

- Hungary has several natural lakes including the greatest lake of Central Europe, Lake Balaton which is a famous tourist destination.
- Lake Hévíz, the largest thermal lake in the world (47,500 square metres in area) is located in Hungary as well.
- The Lake Cave of Tapolca is an important sub-surface lake.
- Major lakes include:
  - **Balaton 596 km2**
  - **Tisza Water Reservoir) 127 km2**
  - **Fertő 75 km2**
  - **Velence 26 km2**

# RBMP

- country (93,030 km2)
- - 4 sub-basins (River Danube– 34.730 km2, River Tisza – 46.380 km2, River Dráva –
- 6.145 km2 and Lake Balaton – 5.775 km2)
- - 42 planning sub-units.

River basin management subunits



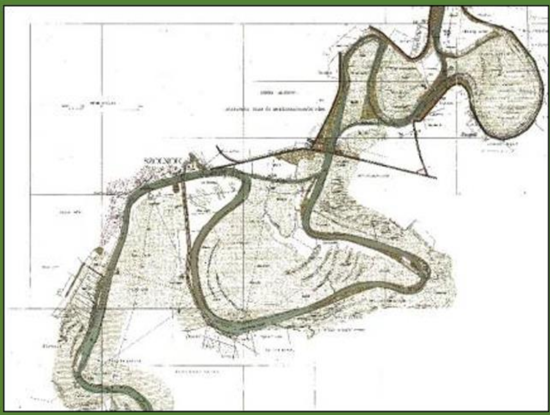

# The most difficult issue: flooding and inland waters

Source: http://www.hirado.hu/Hirek/2011/06/26/09/_Talpunk_alatt_mozgott_a_gat__az_arvizi.aspx

## Waterlogged areas of the Carpathian Basin before water regulation in the XIX. century

Source: http://www.kincseslada.hu/aktualis/content.php?article.362

- **Flooding on the River Tisza in the past decades has caused great destruction** and consumed huge amounts of material resources, making it vital to carry out a fundamental rethinking of defensive systems.
- **Increasingly extreme weather conditions**, a reduction in the length of the normal rainy season and sudden torrential downpours have combined to cause major flood waves on the rivers of Hungary, even during the most severe droughts.
- **Climate change!!!**



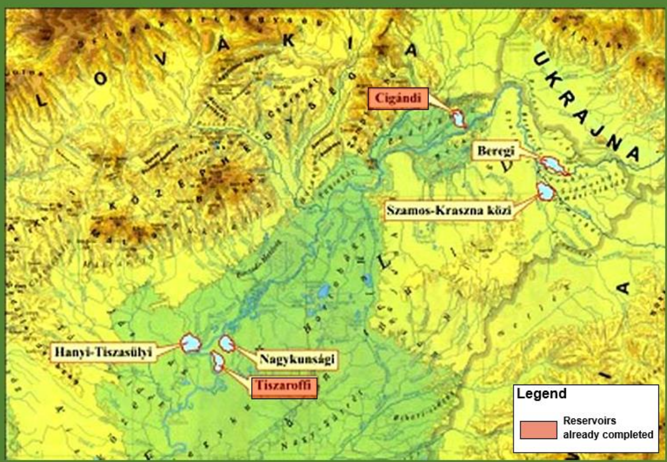
Water management in Hungary is traditional. Article XVII. of the Act of the year 1807 already dealt with the water regulating board.

The first Water Act came into force in 1885.

- Until the turn of the century, flood control was based mainly on **increasing the height of embankments**.
- In the face of ever-increasing flood surges - between 1998 and 2001 there were four extreme floods on the River Tisza, with water levels rising, on occasion, more than one metre higher than previous records (standard flood level) - traditional methods no longer represented an effective solution.
- It became clear that **floodwater protection could not be improved by continuing to build higher dykes**.

- Low frequency flood events with dike breach and inundation risk must be controlled by flood peak attenuation measures; between 2005 and 2008, 22 components of the programme were implemented, such as the Cigánd- Tiszakarád and Tiszaroff **emergency reservoirs**, the summer dikes at Tiszadob and Vezseny were reinforced and the outlet lock of the Lónyay main canal was built.

## Floodwater retention reservoirs along Tisza




Source: http://www.nagykunsagitarozo.hu/index.php?name=reservoir

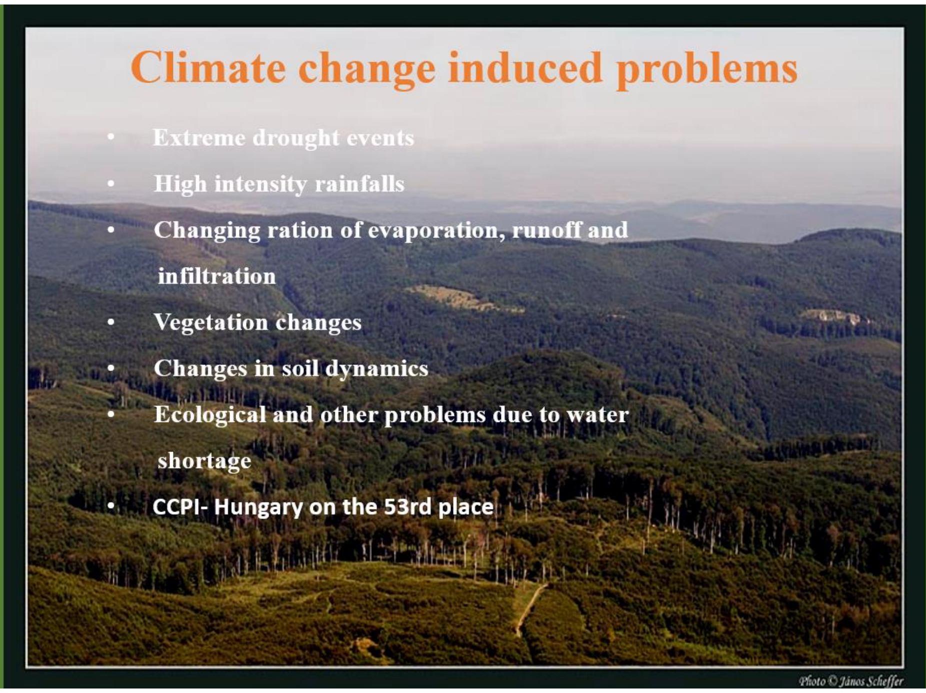
# Headwater catchments

- Most of headwater catchments of Hungarian rivers are in the neighbouring countries
- Headwater catchments is Hungary are in relatively low mountains and in in hilly countries
- The catchments are treated within the framework of RBMP
- Main problem is soil erosion

# The role of forests in flood control

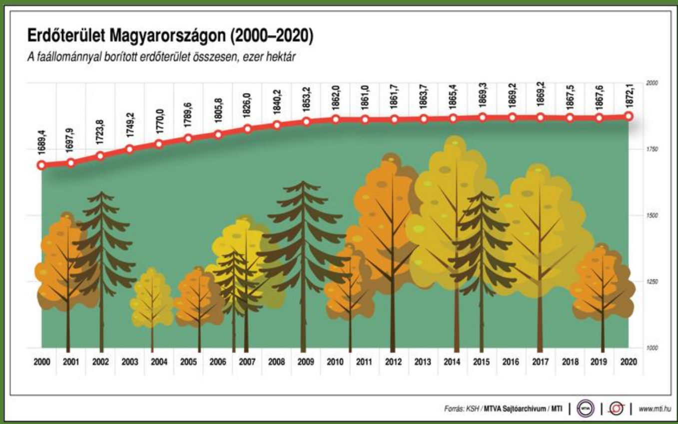
- **During the 1960s river canalization, the draining of the wetlands and deforestration resulted in the loss of absorption capacity during floods** and the increase of soil pollution and erosion in the Tisza region.
- During the last few decades years agricultural production including plant production and animal husbandry has decreased in the Tisza River Basin, so huge areas became fallow land (ICPDR 2008). The risk of further soil degradation and the pollution of the surface and groundwater bodies cannot be neglected in management plans for the basin in the future.

- **Forests have significant effect on the elements of the hydrological cycle** (e.g. interception loss, evapotranspiration, runoff, groundwater recharge) thereby forest cover bears a great importance in water management.
- On the other hand, **the effect of lowland forests on the water balance components (groundwater resources) have been debated** quite intensively in the past among foresters and water managers. Several studies concluded the negative effect of forests on groundwater resources in the Hungarian Lowland based on past afforestation data. At the same time some studies demonstrated small differences in groundwater consumption between various vegetation cover types.




## Forest area increase

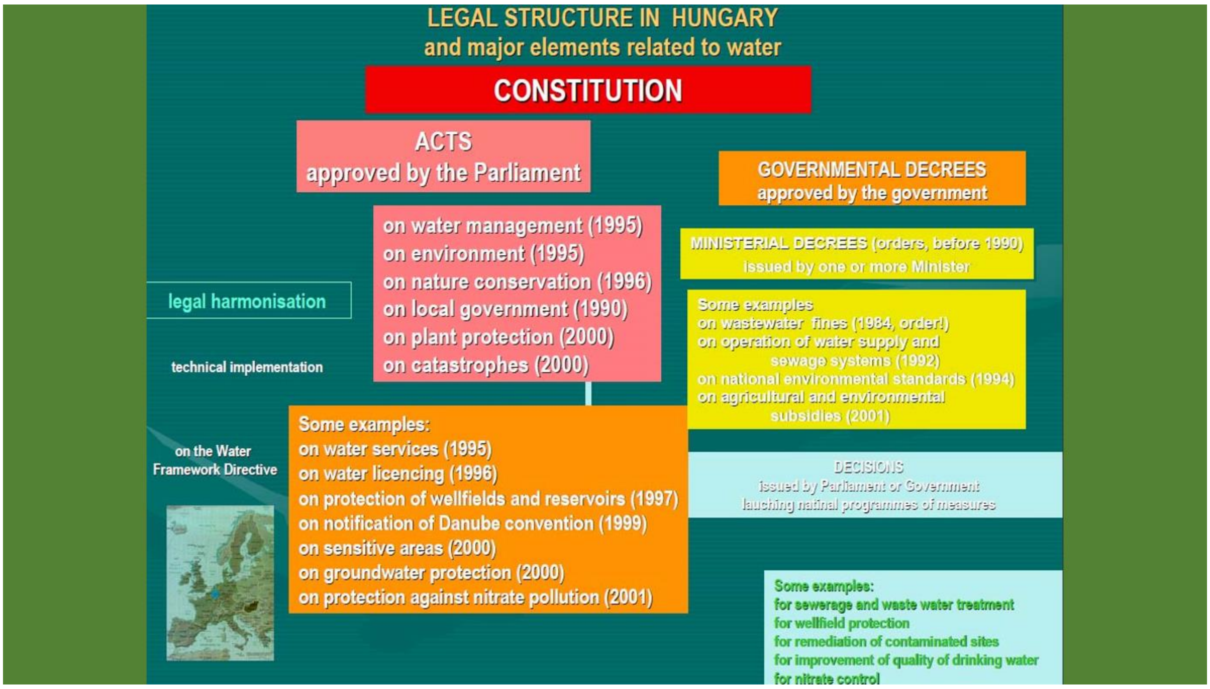
- Country forest area **20,9 % in 2022**
- New program to increase the area of **urban forests** to mitigate negative consequences of climate change
- In Budapest agglomeration 65 000 ha (12 %) state forest
- Forest area will increase to **27 % by 2030**
- World: 30 %, EU27: 38 %
- Firewood programme : 10 forest meter$^3$ (1,8 m$^3$/year at fixed price) – not in favour of forest increase
- August 2022 – clearcutting is allowed, if nececcary, this new regulation is, however, compensated by the prohibition of fire wood export




## Agriculture induced erosion in the forests

- This process may reach up to the headwater areas
- Soil erosion is the most important land degradation process on agricultural areas in Hungary.
- 25% of the area of Hungary is affected by water erosion, 16% by wind erosion.
- Role of human impact on agricultural area is crucial
- Agricultural area diminishes, but the agriculture is more intensive

Thanks for your attention

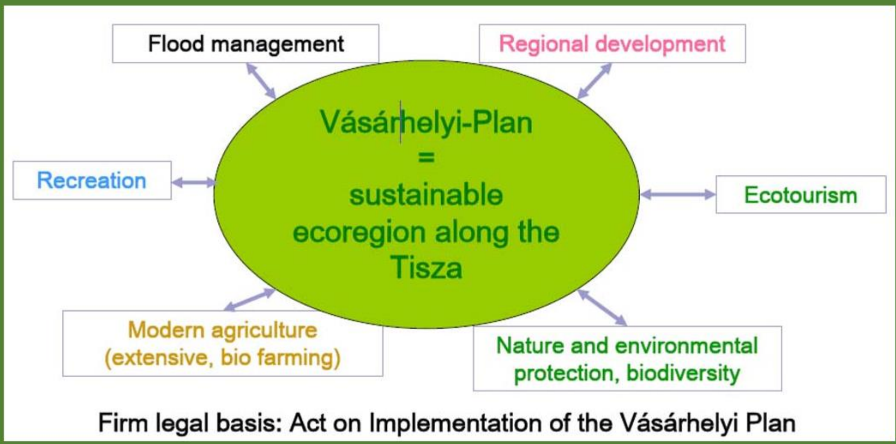


## Implementing the Water Framework Directive in Hungary

- the integrated management of surface and groundwaters,
- protection of both quantity and quality,
- river basin approach,
- combining emission controls and water quality standards,
- economic instruments supporting environmental objectives,
- public involvement.

## VÁSÁRHELYI PLAN – STAGE I. (2004-2007)

- In 2003 the Hungarian government approved of the conceptual plan (Vásárhelyi Plan - named after Pál Vásárhelyi, who developed the complex programme) of enhancing flood safety in the Tisza Valley.
- The aims of the Vásárhelyi Plan
  - creation of a higher level of flood safety
  - improvement of the living standards of the rural- and urban population in the region
  - formulation and introduction of new types of agro-ecological land use in the area of the emergency flood retention reservoirs
  - modernisation of the infrastructure in the settlements along the River Tisza
  - creation of new waterbird habitats.




## VÁSÁRHELYI PLAN
## STAGE II. (2009-2013)

The principles of the project are as follows:

- The floods of the Tisza River must be conveyed primarily in the highwater bed between the flood protection dikes to be built up in accordance with the standards, but at the same time the flow conditions, the conveyance capacity must also be improved with attention to the ecological aspects.

## Danube River Basin Management Plan

- To meet the challenge of ensuring a sufficient supply of clean water for future generations the European Community adopted in December 2000 the EU Water Framework Directive (WFD) - a new and effective tool for water management. Since then All European waters are managed using a river basin approach.
- The best way to protect and manage water is by close international co-operation between all the countries within the river basin – bringing together all interests upstream and downstream.
- The DRBM Plan focuses on the main transboundary problems, so called Significant Water Management Issues (SWMI), that can directly or indirectly affect the quality of rivers and lakes as well as transboundary groundwater bodies:
  - Pollution by organic substances
  - Pollution by nutrients
  - Pollution by hazardous substances
  - Hydromorphological alterations

- The Plan includes visions and objectives for each SWMI as well as a Joint Programme of Measures. In addition, the Plan includes:
  - a description of the significant pressures in the DRB
  - an overview on the monitoring networks
  - an assessment of the ecological and chemical status
  - a final designation of Heavily Modified Water Bodies
  - an overview on exemption according to the EU WFD
  - an economic analysis of water uses
  - a brief overview on water quantity issues and climate changes
  - an outline of public consultation and participation
  - an inventory of protected areas
  - The final version of the DRBM Plan is available since end of 2009 and has been adopted at the ICPDR Ministerial Meeting in February 2010.

## Hungarian memberships in international organisations

- **The International Benchmarking Network for Water and Sanitation Utilities (IBNET) water indicators**
- **GEMS – Water Programme**
- **FAO**
- **FAO AQUASTAT**
- **UNCSD**
- **UNDP WaterWiki**
- **ICPDR**

# Italy

MINISTERO DELL'AGRICOLTURA
DELLA SOVRANITÀ ALIMENTARE
E DELLE FORESTE

EFC WP MMW

Food and Agriculture Organization of the United Nations

**34th Session of the EFC Working Party on the Management of Mountain Watersheds (WPMMW)**

**Management of mountain watersheds in a climate change perspective: from the Alps to the Mediterranean areas**

***Country report - Italy***

**Prof. G. B. Bischetti (University of Milan)**

UNIVERSITÀ DEGLI STUDI DI MILANO

***Free University of Bolzano/Bozen, Italy, 27th - 29th September 2023***

# climate change issues

Climate change is expected to get great pressure on mountain watersheds in Italy:

- Increase in temperature and decrease of precipitation
  - Wildfires
  - Forest health issues
  - Forest evolution towards different and more xeric associations
- Increase in high-intensity rainfall
  - Increase in landslides and debris flow ⇒ higher sediment supply to channel network
  - Increase in peak discharge ⇒ higher erosion and sediment transport capacity in channel network
- Increase in temperature and decrease in snowfall
  - Permafrost melting ⇒ landslide and debris flow
  - Glaciers retreat ⇒ higher sediment supply to channel network

G.B. Bischetti (University of Milan)

# climate change adaptation strategy

- National level
  - National Climate Change Adaptation Strategy
    - National Plan for Adaptation to Climate Change
  - National Strategy for Sustainable Development
  - …
- Regional level
  - regional ad
- Local level
  - Local adap

- Mainly general documents
- Estimation of the impact of CC on forests and mountain areas
- Currently, still gaps in linking documents' statements into specific actions plans for mountain watersheds

G.B. Bischetti (University of Milan)

# Organizational model of the institutions and services before 1970


- Two Ministires:
  - Agriculture & Forests
  - Public works
- Clear subdivision of competence between FS and CoE
- Strong presence on the territories
- Planning, design and execution directly by the Forest Service

G.B. Bischetti (University of Milan)

## Current organizational model of the institutions and services

- Central State:
  - general address
  - Two Ministries: Agriculture&Forests + Environment
- Regional/Provincial Authorities
  - Ordinary status
  - Autonomous status

G.B. Bischetti (University of Milan)

## organizational model of the institutions and services

- Regional/Provincial Authorities with Autonomous status
  - Continuity with State Forest Service and Corps of Engineers
  - Recently unification of FS and CoE
- Regional Authorities with Ordinary status
  - Several different models with different combinations
  - Fragmentation of organization and actions
  - Gaps and overlaps
  - Large use of «Externalisation» through tenders

G.B. Bischetti (University of Milan)

# Interaction between forest management and technical/bioengineering works

- Different Ministries competent for Forest management and Technical works
- Forest management and technical works generally in charge to different branch of Regional/Provincial Authorities
- Soil and water bioengineering works frequently included into Forest management practices as well into Technical solutions alone or in combination with "grey" works
- Soil and water bioengineering works sometimes used as compensation measures for "grey" technical works

G.B. Bischetti (University of Milan)

# protective forests definition

- National level:
  - LEGISLATIVE DECREE No 34 of 3 April 2018 National code on forests and forestry sectors.
  - "direct protection forest: a wooded area that, due to its special location, provides direct protection of people, property and infrastructure from natural hazards such as avalanches, rockfalls, surface slides, torrential floods and others, preventing the event or mitigating its effect»
  - "Forests with the function of direct protection of inhabited areas, goods and strategic infrastructures, identified and recognised by the regions, cannot be transformed and their land use cannot be changed, except in cases related to imperative reasons of overriding public interest as well as the provisions of Directive 2004/35/EC and its transposing national legislation"
- Regional/Provincial level:
  - Not all Regions (especially those with ordinary status) define the protection forests
  - Generally, no distinction between Direct and General protection functions

G.B. Bischetti (University of Milan)

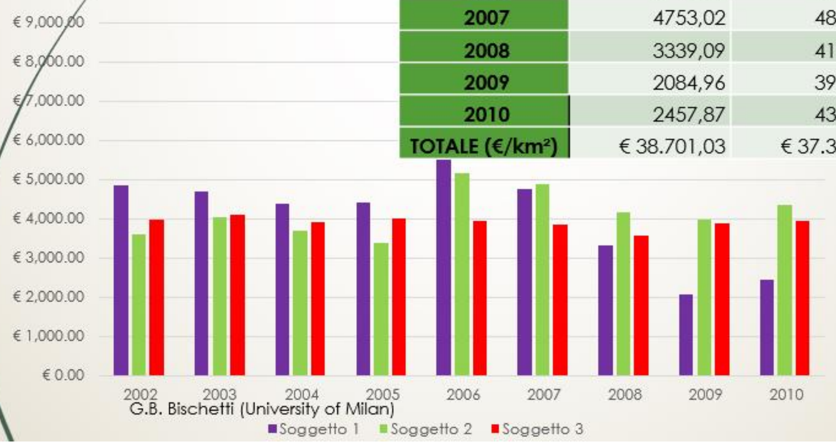
# Main sources of funding for mountain watersheds management

- Environment Ministry to:
  - Regional/Provincial Authorities
  - Mountain Communities
  - Municipalities
- EU funds to:
  - Regional/Provincial Authorities
- Central Government after catastrophic events to:
  - Regional/Provincial Authorities
  - Mountain Communities
  - Municipalities
- ...

G.B. Bischetti (University of Milan)

# Amount of funding for mountain watersheds management

| year | Soggetto 1 | Soggetto 2 | Soggetto 3 |
|---|---|---|---|
| 2002 | 4847,60 | 3621,88 | 3974,62 |
| 2003 | 4697,63 | 4033,72 | 4099,23 |
| 2004 | 4383,70 | 3711,81 | 3910,00 |
| 2005 | 4419,52 | 3384,38 | 4015,36 |
| 2006 | 7717,64 | 5167,70 | 3967,10 |
| 2007 | 4753,02 | 4888,23 | 3847,24 |
| 2008 | 3339,09 | 4181,29 | 3575,85 |
| 2009 | 2084,96 | 3970,09 | 3891,37 |
| 2010 | 2457,87 | 4348,40 | 3939,18 |
| TOTALE (€/km²) | € 38.701,03 | € 37.307,51 | € 35.219,95 |




G.B. Bischetti (University of Milan)

# Amount of funding for mountain watersheds management

| | Soggetto 1 | Soggetto 2 | Soggetto 3 |
|---|---|---|---|
| funding 2002-2010 (€/km²) | € 38.701,03 | € 37.307,51 | € 35.219,95 |
| Landslides density(#/km²) | 5,47 | 0,84 | 0,52 |
| status | Ordinary | Ordinary | Autonomous |
| Approach for works | Tender | Direct | Direct |
| Number of branches | >3 | 2 | 1 |
| Specialisation in mountain watershed management | NO | YES | YES |

G.B. Bischetti (University of Milan)

# Thank you

# Slovenia

Simon Poljanšek, Gal Fidej, Urša Vilhar, Matjaž Guček.

# Country report during the Working Party (27 September); Slovenian management of mountain watersheds in a climate change perspective: from the Alps to the Mediterranean areas

**Introduction to protective forests in Slovenia**

Slovenia is very diverse in terms of climate, terrain and soil, enabling diverse vegetation cover from the Alps to the Mediterranean areas. In general, 60% of the territory consists of forests, covering the majority of mountain watersheds. Forest management plans are made for all forests regardless of the ownership, and they are based on three main pillars: sustainable, close-to-nature and multipurpose forest management, active forest management and the preservation of forests and all their functions. The direct and indirect protective functions are only two of many forest functions. The Forest Act and the Decree on protective forests and forests with a special purpose lay down a separate category of protective forests in order to emphasise their importance. Article 43 of the **Forest Act** defines protective forests as "*Forests in adverse ecological conditions which protect themselves, their land and lower-lying land,…"* and Article 2 of the **Decree on protective forests and forests with a special purpose**, in more detail, as (I): "*forests that protect land from sedimentation, leaching and erosion, forests on steep slopes or water banks, forests that are exposed to strong winds, forests that contain rapid runoff of water in torrential areas and therefore protect land from erosion and landslides, forest belts that protect forests and land from wind, water, drifts and landslides, forests in agricultural and suburban landscapes with an extremely emphasized function of preserving biodiversity, and forests at the upper limit of forest vegetation.*"

The roles of protective forests are described in Article 22 of the **Rules on forest management plans and game management plans**, and more in depth in the Slovenia Forest Service instruction manual for the development of forest management plans, as: "*protecting the site and its surroundings from the effects of all types of erosion processes, in particular ensuring (preserving) the soil's resistance to the erosion phenomena caused by cold, snow, water and wind; prevention of the development (occurrence) of landslides and avalanches; preventing deepening of slope trenches; preventing the deployment of debris; retention of small flowing material and/or preserving the fertility of forest soils. In particular, the forests at the upper forest border, in flood, erosion, creeping or landslide areas determined in accordance with the regulations governing water, on very steep slopes, arid areas, shallow rocky or stony ground have an emphasized protective function.*"

**Recent events in 2023**

The protective function, together with the hydro-meteorological role of forests, is important in Slovenia because of the terrain conditions and annual abundant precipitations with occasional extreme weather events taking place. The last extreme weather event was evidenced in the days around 4 August 2023, when as much as three quarters of the country's territory were affected by heavy rain and severe storms with the daily average rainfall of 100–300 mm per square metre. Extreme rainfall caused torrential, flash and pluvial flooding, numerous landslides and damaged infrastructure. Approximately two weeks prior to the heavy rain, some areas of the country had been affected by hailstorms and strong winds, causing serious damage to forests. In total over 1,200 hectares of forest were destroyed, amounting to over 1 400,000 $m^3$ of fallen or damaged trees. Since it was not possible to perform salvage cut in due time, some of the large woody debris stayed in the torrential areas and riverbeds. Due to the record-high river flow, debris together with mud, silt and gravel blocked streambeds and riverbeds, and contributed to the spilling of water and damage to infrastructure, houses, mechanisation, agricultural lands, fish farm ponds and other immovable property. The damage to forest infrastructure, mainly forest roads, is estimated to €48 million.

**What is the organizational model of the institutions and services involved in mountain watersheds management?**

Without forests, torrential characteristics would be strengthened considerably, and landslides occurrences more frequent. This was recorded in the past centuries in steep deforested areas. For this reason, the protective function has been integrated in the forest management plans for decades. The concept of forest management planning in Slovenia is a hierarchically organized system at several levels. Strategic national guidelines have been laid down in the National Forest Programme since 2007. The programme builds upon forest management policy, which was defined in the Forest Act in 1993. An important tool of the forest policy are the regional forest management plans (14 plans), which are prepared every 10 years simultaneously for the entire territory of Slovenia. More detailed forest management plans are the forest management plans of Forest Management Units (231 FMU). Regional forest management plans and forest management plans for forest management units contain a delineation of the protective function, the state of the forest, management goals with guidelines, measures and restrictions to reach the goals. An important goal in forest management plans is the long-term maintenance and strengthening the role of protective forests. The lowest level presents the silvicultural plan, which is the implementation plan of the forest management plan of the forest management unit. There is no differentiating between different forest categories, for this reason there is no specific planning instrument for protective forests.

Within the process of adopting forest management plans, forest service collects opinions of forest owners and several other stakeholders: Slovenian Water Agency, Ministry of Natural Resources and Spatial Planning, and Ministry of the Environment, Climate and Energy. Forests vulnerable to fires, avalanches, landslides or flooding forest areas are graphically presented within forest management plans.

**Interaction between forest management and technical/bioengineering works**

Forest management of protective forests in Slovenia is mainly passive due to extreme site conditions, low profitability, very dangerous working conditions, ownership structure and scarce skidding trails and forest roads. Many protective forests are therefore today homogeneous, even aged, mainly in older developmental stages and without sufficient regeneration (Diaci, 2012). Ageing of the stands and the lack of proper management presents higher susceptibility for natural disturbances, which will, in the future, represent a major threat for maintaining a long-term stability and protective role of these forests in Slovenia. New regional forest management plans therefore contain an important strategy to intensify the management of protective forests to enhance the protective function of forests.

A specific problem in the management of protective forests is also the influence on torrents by course woody debris, originating from forest management or natural forest dynamics. They are, mostly due to difficult access and insufficient financial resources, not always properly managed, supervised or controlled. As a result, flooding can cause log drift and logjam in infrastructures. Solution to this challenge lies in learning from best practise examples of other countries, connecting all essential stakeholders and in properly amending legislation that would give more authority to the public forest service. Currently, the Slovenia Forest Service covers the entire area of forests with district foresters. They are present in forests daily, so they can quickly detect different events in forests in torrential areas. Unfortunately, an effective connection between foresters and the Slovenian Water Agency, responsible for torrent control has not yet been established at the system level. Therefore, there is still a lot of a room for improvements.

**What kind of approaches and measures is your country developing and implementing in mountain watersheds to address climate change issues?**

Climate change issues are generally addressed within close-to-nature management, where forest management mimics natural dynamics and promotes natural regeneration of site appropriate species. Focus is now on active forest management to establish the structure of forest that will provide the protective function in a long term.

Changing site conditions and disturbances may lead to reduced resistance of some key tree species to pests and diseases. Due to climate change, the frequency of extreme weather events increased, which presents a major threat for protective forests. More frequent natural disasters can result in larger bare areas where erosion processes, landslides and faster drainage will occur. Therefore, forest management in torrent areas should pay special attention to soil erosion, both in terms of construction and maintenance of forest infrastructure and tailor-made silvicultural measures. If not properly addressed, the situation can, in the long term, lead to a decrease in the productive capacity of forest stands and to a reduced provision of hydrological, protective and other ecological functions of forests.

Challenges are addressed by ongoing research to enhance the stability and the protective role of forests, to increase the knowledge, and to establishing forest policy or forest dialogue, aimed to provide the conditions for the implementation of silvicultural and other measures.

Research funds, which are granted by the ministries and the governmental agency for research and with protective forest as a subject, were intensified in the last 10 years, focusing on the delineation of areas with the protective function; assessing the forest's protective effect against avalanches, rockfall and debris-flows; and silviculture measures for maintaining the long-term protective function. The majority of such research was conducted by the University of Ljubljana - Biotechnical Faculty, and the employees of the Slovenia Forest Service and the Slovenian Forestry Institute.

There are several ongoing projects that address and increase knowledge on managing protective forests to establish the structure of forest that will provide a long-term protective function.

The national project »Design of a platform and guidelines for forest management in torrent areas«, led by the Slovenian Forestry Institute and funded by the Ministry of Agriculture, Forestry and Food (MAFF) and the Slovenian Research and Innovation Agency for 3 years, aims to fill the gap in forest management in torrent areas. Forestry in Slovenia needs guidelines and tailor-made measures for forest management in torrent areas that take into account: (1) silvicultural measures to emphasise hydrological and protective forest functions, (2) to reduce the risk of woody debris along and in torrents, and (3) the specificities of forest road and skid road construction in forested torrent areas.

The main objectives and purpose of this project are as follows:

- To define the term " forested torrent areas" and to develop a method for identifying forested torrent areas in Slovenia,
- To develop a method and criteria for the classification of forested torrent areas in Slovenia,
- Determining how maps of forested torrent areas for Slovenia can be produced,
- Elaboration of guidelines and measures for forest management in torrent areas,

- Elaboration of a proposal for (co-)financing of forest management measures in torrent areas for forest owners by the Public Forest Service of Slovenia,
- Conducting research in the field of erosion control with proposals for mitigation structures that reduce the risk of erosion,
- Development of guidelines or starting points for an amendment to the Forest Act that would provide a legal basis for erosion control and measures in forested torrent areas.

The preliminary results of this project present development of the methodology for identifying torrent areas in forests in Slovenia. In cooperation with experts in the field of torrent control and public service providers from forestry and water management, researchers have defined criteria and a methodology for classifying forested torrent areas according to their susceptibility to erosion. In addition, the methodology for mapping forested torrent areas in Slovenia is currently being developed and first maps of forested torrent areas have been produced in the selected pilot area. The aim is also to define the necessary spatial data layers and a criterion that will enable the integration of the spatial representation of torrent areas into forest management planning at the national level and into the information systems of the MAFF, the Slovenia Forest Service, the Ministry of Natural Resources and Spatial Planning (MNRSP), the Water Directorate, Slovenian Environment Agency and other stakeholders.

The project work is done in cooperation with stakeholders and the public, representatives of ministries (MAFF, MNRSP), Slovenia Forest Service, experts in the field of water management, experts in the field of torrent control, public service providers of water management, state-owned company for state-owned forests SiDG, University of Ljubljana, etc.

On a broader perspective, climate change actions reflect in mitigation actions with carbon sequestration efforts. As part of the project Forests for Future (part of the European Climate Initiative -EUKI), the Department of Forestry and Renewable Forest Resources and Slovenia Forest Service are looking for ways of managing the forests to optimize carbon sink in Slovenian forests. The basic goal of the project was to find adapted ways of managing Slovenian forests to maintain or even increase carbon sinks in them while actively managing forests at a similar level as at present. The project used the Slovenian model of forest development to simulate the development of different types of forests, taking into account different forest management scenarios. The results of the simulations were judged with an optimizer; in an individual forest type, they found a way of forest management that optimizes carbon sink. The optimal method enabled the maximum possible absorption of carbon dioxide, while actively managing forests without endangering the production, economic and other roles of the forest. The results of the project proposed adapted management methods and recommendations for the formulation of forest policies, as well as guidelines for forest management planning at the national level. Forest management adjustments was discussed in workshops and passed on to forest planners and operational foresters. At the same time, the results of the project at dissemination events were also passed on to larger (and smaller) forest owners.

Project "Forest EcoValue" focuses on alpine forests, which are threatened by abandonment, climate change and territorial degradation that progressively lead to a decrease in the provision of forest ecosystem services. In extreme sites of alpine forests, forest maintenance costs are high and often cannot generate a sufficient economic income for the public and private owners. For this reason, the project proposes sustainable business models for forest maintenance based on regional circular, green and bio value chains. In Slovenia, the Municipality of Tržič will be included into the project as a pilot region. In the region, a large share of forest areas is declared as protection forests that protect against natural hazards. In the project, different tools will be developed: 1) the definition of the most suitable measures (silviculture, infrastructure) for improving the protective effects of these forests; 2) the measures will be financially estimated and the alternative (no measures, no forests) will also be estimated; 3) the most suitable business model will be developed among the main actors (state, municipality, owners, stakeholders) to ensure the implementation of the needed measures and the long-term maintenance of these forests. The project will involve public and private sector.

The ongoing project "MOSAIC" focuses on hazard-resilient and sustainable protective forest management coping with climate changes' multiple dimensions, which is essential for managing climate-related risks. In order to support regional and Alpine climate action plans, the project aims to collect, harmonize and share data, models on Alpine climate-related disasters and trends. The project partners strive to raise awareness among foresters, risk managers, decision makers and the public through an Alpine network of forest living labs.

The project is based on the fact that an increase in climate-related disasters is often the result of compound events, a combination of multiple climate-related hazards (e.g. drought, wind, insect gradation) that contribute to socio-ecological risks, cause damage and thereby reduce the positive effects of forests. By researching these events, we aim to get a full assessment of the risks caused by climate change. Healthy and resilient forests provide key ecosystem services that support human well-being and play a key role in mitigating the effects of climate change. Therefore, sustainable forest management for resilient and healthy forests is crucial for risk management associated with climate change.

As part of the project in Slovenia, we would like to find out which measures and procedures are most appropriate to use in protective forests, so that they will remain resilient and healthy and will ensure all their functions. For this purpose, we will select a test area (forest living lab) and set up a demonstration plot, which will serve as a research and demonstration facility where we will test various measures and ecosystem solutions to reduce the risk of natural disasters. Solutions and measures will then be presented in a catalogue with illustrations and examples of good practice examples. The knowledge that we will acquire will be useful in forest management planning. Through field workshops and so-called integration forums, we will spread new knowledge, results and the importance of the project among foresters, planners, silviculturists, nature conservationists, decision-makers and other stakeholders.

In general, the knowledge transfer between researchers and practitioners is most important for the development in managing protective forests, therefore Pro Silva Slovenia and Slovenia Forest Service organised a workshop in February 2023, entitled "Management of protective forests and forests in protected areas". The aim of the workshop was to present challenges and propose solutions for the improvement of management of protective forests and forests in the Triglav National Park, which will strengthen the ecological connectivity between different forest habitats. 59 researchers and practitioners attended the workshop and exchanged experience and future challenges regarding the management of protective forests during the workshop and field trip.

**What are the sources and amount of funding for mountain watersheds management in your country?**

Funding from state budget is included in several tasks of forest service and in support to forest owners. Also some measures in protective forests are co-financed, which enable forest owners to compensate higher management costs, connected to challenges and limitations. The funds for the implementation of protective forests functions are part of regular silvicultural measures, and are intended for measures of damage reduction and forest restoration, with a special goal of limiting damages by natural disturbances (sleet damage, windbreak, and gradations of the bark beetles). Another biotic factor, influencing protective forests, is game. For example, browsing rate and success of forest regeneration growth is measured on permanent sampling plots periodically (every three years). However, monitored data are summoned on certain areas across the whole country and not linked to specific forest type or function.

**Conclusion**

Taking into account the increasingly obvious consequences of climate changes, protective forests are becoming very important, yet neglected part of ensuring protection against natural hazards. The system for decreasing risks against natural hazards in Slovenia has great potential for improvement, especially in the field of management of protection forests, as well as managing torrents and spatial planning. The challenges in management of protection forests under climate change are being addressed by various strategies and projects, helping to transfer knowledge into practice and in ongoing process of constant improvement of management of protection forests.

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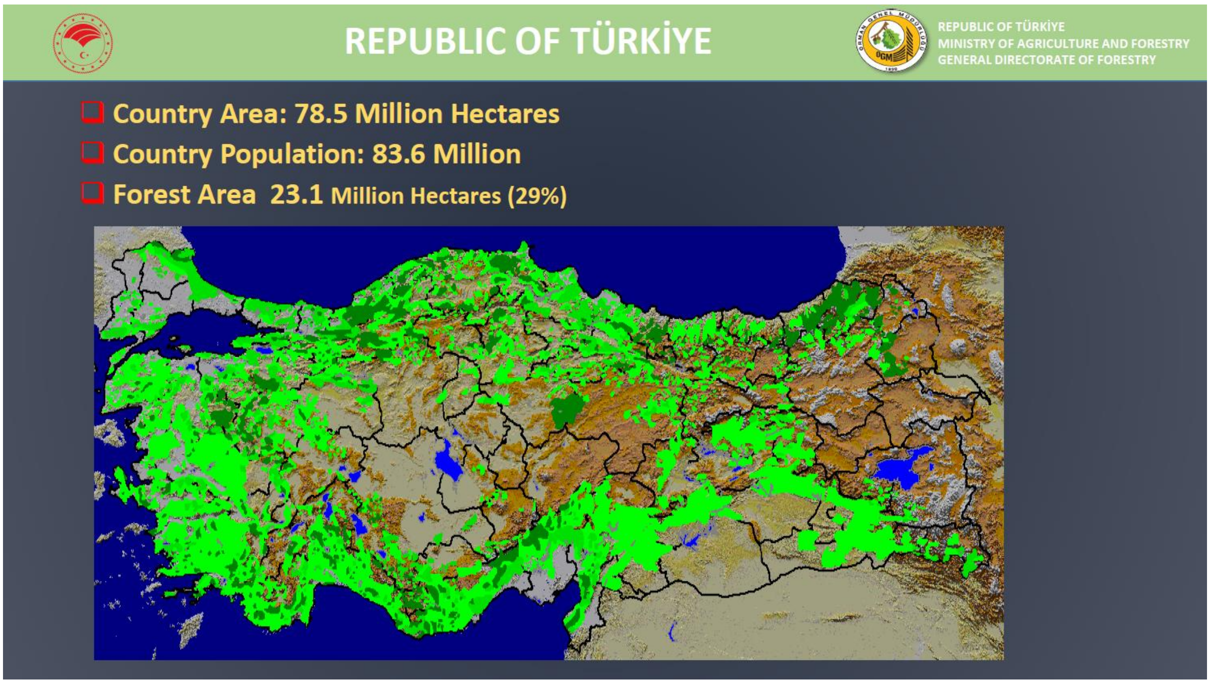
# Türkiye


REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY
THE MANAGEMENT OF MOUNTAIN WATERSHEDS IN TURKEY
Sıtkı ERAYDIN-Gülçin MERGEN
Soil Conservation and Watershed Rehabilitation Department GDoF


REPUBLIC OF TÜRKİYE
REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY
Country Area: 78.5 Million Hectares
Country Population: 83.6 Million
Forest Area 23.1 Million Hectares (29%)

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

## Turkey has different ecosystems in terms of climate, topography and soil characteristics.

Average Altitude: 1.232 m
Ortalama Yükseklik: 1.232 m

62.5% of our country is sloping more than 15%

29% consists of medium and high mountainous areas

27% consists of high mountainous areas.

56% of the country consists of medium -high mountainous terrain

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

Turkey's forests have been managed according to ecosystem based multi-functional management plans. Functions for each forests units in the forest management plans are identified according to Sustainable Forest Management (SFM) Criteria and Indicators. Functional forests related to climate change issues in mountain watersheds include: **(Protective functions of forests)**

PROTECTIVE FUNCTIONS OF FORESTS

- Forests Based On Nature Conservation
- Forests Based On Soıl Conservatıon And Erosion Control
- Forests Based On Climate Protection
- Forests Based Hydrological Functions/ Water Conservatıon Forests.
- Natural Dısaster And Infrastructure Protectıon Forests

# IDOP-CRFP

## CLIMATE RESILIENT FORESTRY PROJECT

Forest General Directorate successfully implements the Climate Resilient Forestry Project (CRFP) with important objectives, including enhancing national and international coordination systems before and during forest fires, increasing technical capacity, conducting national and international training programs, creating new carbon sinks in burnt or endangered areas, and enhancing forest carbon monitoring, reporting, and verification capabilities.

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

In Turkey, the institutions responsible for managing mountain basins and their functions typically encompass areas such as the environment, forestry, water resources, agriculture, and rural development. Mountain basins have important ecological and economic functions, including the conservation of water resources, erosion prevention, biodiversity preservation, and sustainable rural development. Here is a general overview of the institutions responsible for managing mountain basins and their functions in Turkey:

**Directorate General of Forestry(OGM):**

- OGM manages the forest resources of mountain basins concerning the sustainable management and protection of forests.
- It carries out functions such as erosion prevention, afforestation, and rehabilitation of forests.

- **General Directorate of Water Resources and Irrigation (DSI):**
  - DSI is responsible for preserving and managing the water resources of mountain basins related to water resource management and sustainability.
  - The sustainable use of dams, reservoirs, and water resources falls under the jurisdiction of DSI.
- **Ministry of Environment and Urbanization:**
  - The Ministry of Environment and Urbanization oversees and manages mountain basins concerning environmental protection and the sustainability of natural resources.
  - Its responsibilities include monitoring water quality, air quality, and environmental impacts.

**Ministry of Agriculture and Forestry:**

- The Ministry of Agriculture and Forestry works to ensure the sustainability of agriculture and support rural development in mountain basins.
- Functions include erosion control, the development of agricultural policies, and the planning of agricultural areas.

- **Directorate General for Nature Conservation and National Parks:**
  - It operates with the goal of preserving natural areas and biodiversity in mountain basins.
  - The management of national parks, nature reserves, and conservation areas falls under the responsibility of this directorate.
- **Local Governments:**
  - Municipalities and provincial administrations support the local-level management and development of mountain basins.
  - They contribute to infrastructure, environmental protection, and rural development projects

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

# MANAGEMENT OF MOUNTAIN WATERSHEDS IN TURKEY

**For the management of mountain watersheds in Turkey, coordination and collaboration between forest management and technical/bioengineering efforts are primarily overseen by the General Directorate of Forestry (OGM). The OGM is the main institution responsible for the sustainable management of the country's forest resources. Below, you will find more information on the key actors and cooperation mechanisms involved in this process:**

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

## MANAGEMENT OF MOUNTAIN WATERSHEDS IN TURKEY

1. **Forest Regional Directorates:** There are a total of 30 forest regional directorates in Turkey, responsible for regional-level forest management and conservation. Mountain watersheds fall within the purview of these regional directorates. They implement activities in the field, safeguard forests, and manage them sustainably.
2. **Provincial Directorates of Agriculture and Forestry:** In each province, there is a Provincial Directorate of Agriculture and Forestry. These directorates oversee the management and conservation of forests at the provincial level and collaborate with the OGM. They play a significant role in the management of mountain watersheds.
3. **General Directorate of Land Registry and Cadastre:** The General Directorate of Land Registry and Cadastre becomes involved in matters related to land ownership and usage within the boundaries of mountain watersheds. Collaboration may be necessary for determining the boundaries of forest areas and their usage.

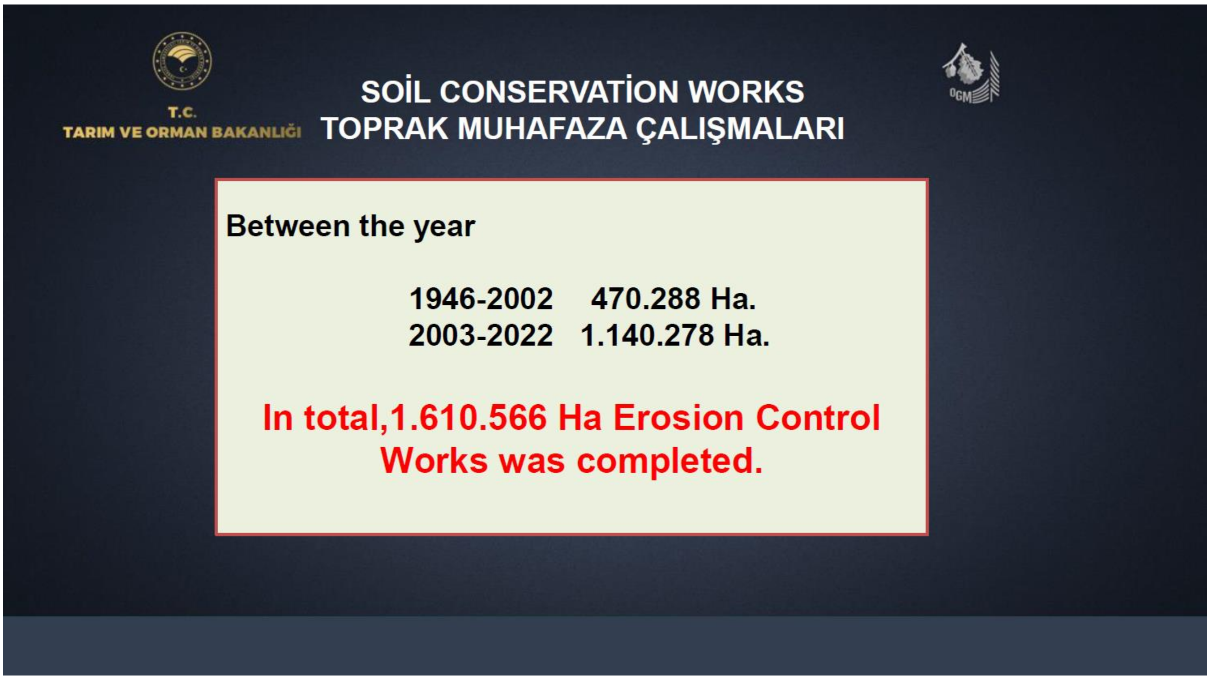
### TECHNICAL AND BIOENGINERRING WORKS

OGM organizes and carries out technical and bioengineering studies aimed at sustainable forest management and employs expert teams for this purpose. These teams provide guidance on issues such as forest structure, erosion control, afforestation programs and other technical details.

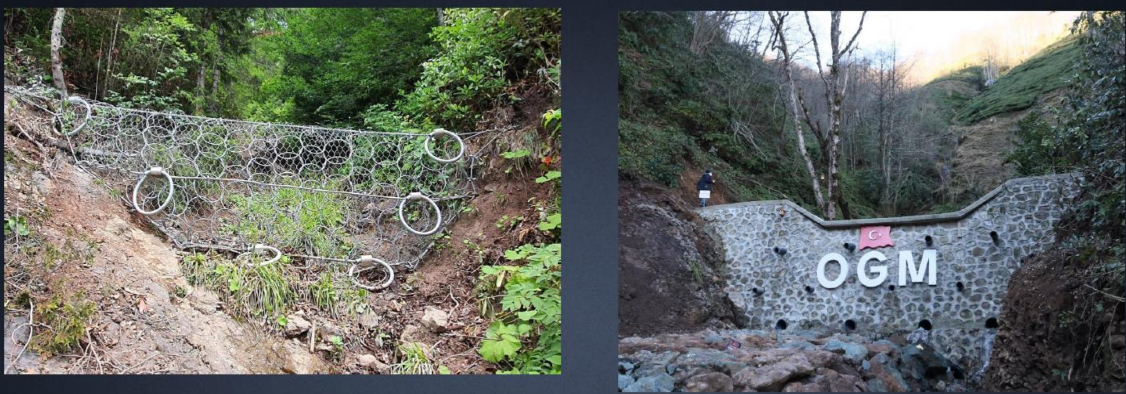
## EROSION AND UPPER WATERSHED FOOD CONTROL ACTIVITIES

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

**Erosion-control activities have been performed in 1,6 million hectares so far in Turkey.**
**Türkiye'de bu zamana kadar 1,6 milyon ha alanda erozyon kontrol çalışması yapılmıştı**


T.C.
TARIM VE ORMAN BAKANLIĞI
SOİL CONSERVATİON WORKS
TOPRAK MUHAFAZA ÇALIŞMALARI
OGM
Between the year
1946-2002 470.288 Ha.
2003-2022 1.140.278 Ha.
In total,1.610.566 Ha Erosion Control Works was completed.


EROSION AND UPPER WATERSHED FLOOD CONTROL ACTIVITIES
REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY
Slope Improvement Facilities
Streamer Terrace
Workers' Terrace
Stone Cord
Mesh Fence
Bushy Terrace
Terrace with Mini Excavator


Since 2019, as a result of budget allocations, flood control efforts were initiated, and work was carried out in an area of 40.608 hectares between 2019 and 2022. For future work in flood basins, it will be carried out within the scope of an action plan. Between 2019 and 2022, a total of 107 Check Dams, 12 Debris Flow Barriers, 21 Gabion Sills, 25 Mixed Sills, and 4 Box Culverts were constructed. Within this framework, The Flood Control Action Plan will be developed by the end of 2023."

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

# PROTECTİVE FORESTS

"The definition and design of protective forests involve a multi-faceted process that takes into account their functions, biological, geological, historical, and cultural characteristics, as well as social factors."

Here are the key steps in this process:

1. **Determining Forest Functions:** Forest management planning committees identify the functions that are crucial for protective forests. These functions encompass ecological, economic, social, and biological aspects, and include roles such as preserving biodiversity, erosion control, water resource management, carbon storage, and recreation.
2. **Assessing Biological Characteristics:** In the design of protective forests, the preservation of ecosystems with high biological diversity, such as old-growth forests, is essential. Factors like preserving the habitats of rare species and providing sustainable habitats for endemic flora and fauna are considered.
3. **Examining Geological and Historical Features:** The geological and historical characteristics of forests are also important in the design process. Factors like soil types, geographical location, geological structure, as well as historical forest usage and changes are evaluated. This data provides valuable insights for the future sustainability of the forest

- **4.Considering Cultural and Social Factors:** Forests are not just biological and ecological entities; they are also cultural and social assets. Traditional uses by local communities, local cultural values, and the community's relationship with the forests are taken into account during the design process, promoting community involvement and sustainable forest management.
- **5.Developing a Conservation Strategy**: After gathering all this data, a conservation strategy for protective forests is formulated. This strategy outlines how specific areas will be protected, usage restrictions, forestry practices, and monitoring requirements.
- **6.Continuous Monitoring and Evaluation:** To effectively manage protective forests, continuous monitoring and evaluation are essential. This helps assess how well the forests are meeting conservation goals and allows for strategy adjustments when needed.

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

# THE FINANCIAL RESOURCES FOR THE MOUNTAİN WATERSHEDS

"The financial resources allocated for the management of the country's mountain watersheds can vary from year to year, depending on the budget period and government policies. The relevant directorates under the General Directorate of Forestry and the Ministry of Agriculture allocate budgets for forest management and the preservation of mountain watersheds. However, the budget amounts can fluctuate annually and may be influenced by other factors."


EROSION CONTROL AND REHABILITATION
REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY
SOIL CONSERVATION
500 MILLION TONS/YEAR
1970
500 MİLYON TON/YIL
2021
154 MILLION TONS/YEAR
2023
130 MİLYON TON/YIL
130 MILLION TONS/YEAR
OGM
İZMİR/Bozdağ
BATMAN/Hasankeyf


SUCCESS IN AFFORESTATION
REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY
Kerpe, Kocaeli - 1973


SUCCESS IN EROSION CONTROL
REPUBLIC OF TÜRKİYE
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GENERAL DIRECTORATE OF FORESTRY


SUCCESS IN EROSION CONTROL
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GENERAL DIRECTORATE OF FORESTRY
Works performed with machines - Terraces
Makineli Teraslardaki çalışma performansı

REPUBLIC OF TÜRKİYE
MINISTRY OF AGRICULTURE AND FORESTRY

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MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF FORESTRY

# THANK YOU!

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