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MANAGING STATE
FORESTS RESPONSIBLY

EUROPEAN FORESTS: TACKLING CLIMATE CHANGE

Best practices from state forest management organizations

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This booklet was prepared by the EUSTAFOR Working Group on Climate Change.

Photo: BaySF

"The optimal way to keep forests resilient and adapted to climate change is through sustainable forest management."

FOREWORD

More than one third of Europe is covered by forests, providing a wealth of economic, environmental and social benefits for all Europeans. 30% of European forest land is government owned and is managed by state forest management organizations (SFMOs), 36 of which are members of EUSTAFOR. This ensures professional and knowledge-based sustainable and multifunctional management of this natural asset, for the benefit of all Europeans.

Forests are rich ecosystems that remove carbon from the atmosphere by storing significant carbon stocks, including in forest soils. They regulate ground and surface water flows, protect microclimates and infrastructure, as well as offering recreational and aesthetic value to society. The optimal way to keep them resilient and adapted to climate change is through sustainable forest management (SFM).

Managing forests sustainably means managing and using forests in such a way that future generations will benefit from forests as much as, and possibly even more than, we do now. Their biodiversity, productivity, capacity for regeneration, and vitality are maintained while leaving all interconnected ecosystems intact.

It is estimated that EU forests and the forest-based sector currently contribute to overall climate change mitigation by absorbing about 13% of the EU's total emissions[1]. In order to maximize the potential of forests to regulate climate, they must be actively and professionally managed to make them "climate-fit". SFM aims to provide biomass, timber, non-wood resources and other ecosystem functions and services, which can lower greenhouse gas emissions and contribute to adaptation. However, climate change also has a significant impact directly on forests. Extreme weather and climate events, as well as an increase in pests and diseases, have caused severe damage to forests throughout Europe.

Therefore, SFMOs must continuously seek to provide solutions to multiple, and at times diverging, interests and constraints. Forests that are managed sustainably and with a multifunctional focus today will maintain their potential to fulfill their relevant ecological, economic and social functions well into the future.

Through this booklet we would like to bring you a wide range of SFM practices implemented in European state forests to cope with climate change impacts, both in the context of adapting forests to climate change and making them climate resilient, hence maximizing their contribution to the overall mitigation objective. We hope it will also enhance understanding of how Europe's forests can help to accomplish the ambitious objectives of the EU Green Deal and make Europe climate neutral and future fit. In the face of the growing scale of the impact of climate change on forests, both the Member States and the EU must urgently consider mobilizing relevant public support to assist SFMOs in their efforts. This must be done within the Green Deal framework and, more precisely, through the new EU Forest Strategy.

Last but not least, we would like to express our special thanks for the dedicated work of EUSTAFOR's Climate Change Working Group, as well as the valuable contributions of all the authors in this publication.

Reinhardt Neft
President of EUSTAFOR

[1] Nabuurs, G. J. et al. (2015). A new role for forests and the forest sector in the EU post-2020 climate targets. From Science to Policy 2. European Forest Institute.

POLICY PERSPECTIVE

The forests of Europe are critical for climate mitigation, now more than ever

Author

Bernard de Galembert, Plant-based Chemistry Sector Group Manager at CEFIC; former forest director at CEPI

Photo: Piotr Borkowski

With the nomination of the new College of Commissioners, the EU has beefed up its ambitions in many fields, not least of which is that of climate change. The eruption of the Covid-19 pandemic has reinforced the conviction that several policy shifts are urgently needed to restore the health of our planet. Forest management that embraces environmental and climate-related sustainability, economic performance and society's well-being, is a relevant part of the toolbox to use in order to achieve such ambitions.

Biogenic carbon, a critical building block

Photosynthesis – the process by which vegetation absorbs carbon dioxide, water and sunlight to grow – is a natural process billions of years old, that forest owners are optimizing through active management practices. It sustains life on earth with oxygen, food, material, shelter and energy.

Trees that store carbon dioxide (CO_2) can be used in a range of products (from building materials to green chemicals) that further keep CO_2 away from the atmosphere, and nicely replace fossil- and oil-based products and materials.

Thanks to this process, and because about two thirds of the annual increment is harvested, European forests remove some 400 million tons of CO_2 annually – equalling around 10% of EU total emissions – according to the Intergovernmental Panel on Climate Change. Furthermore, the benefit of CO_2 storage in finished wood products probably adds around another 50 million tons.

Policies to boost the contribution of the forest sector to climate mitigation: ask for the menu!

While the European Union has no legal basis for regulating forestry, the climate challenge has triggered the adoption of a number of non-forest policies that, nonetheless, have an impact on the forestry sector.

The most recent overarching one is the **European Green Deal.**[1] This EU roadmap includes a number of policy areas in which forestry may play a critical role: biodiversity conservation and restoration, the net zero carbon ambition, climate adaptation, the circular economy and land-use, land-use change and forestry (LULUCF), being the key ones.

When promoting **A Clean Planet For All**[2], which adopts a net zero greenhouse gas emissions objective by 2050, the EU involves de facto all sectors and activities in the common endeavor. For forestry, it notably translates into yet another revision of the renewable energy directive[3] (a first revision was concluded in December 2018), and of its indirect land-use change component, including the list of eligible feedstocks for biofuels. In this context, the currently valid assumption of the carbon neutrality of bioenergy and biofuels will need to be defended to secure the perennity of investments made over the last decade.

Bioenergy represents some 60% of the total consumption of renewable energy in the EU and forest biomass represents the lion's share of biomass supply (70%). Achieving the target of a 32% share of renewable energy of total energy consumption by 2030, set by the EU, will depend significantly on the capacity of forests and the forest sector to sustainably supply the required amount of feedstock. The revision of the renewable energy directive has fixed this ambition in stone, while pairing it with sustainability criteria for biomass.

A revison of the land-use, **land-use change and forestry (LULUCF)**[4] regulation, adopted in 2018, has also been announced. It sets out the rules for emissions accounting and removals in the land-use sector, including CO_2 storage in harvested wood products, and stipulates that the sector as a whole should not become a net source of emissions (no-debit rule). Today, the generation of energy from biomass in the land-use sector is not accounted for. Will this issue be taken up in the revision? Will the revised LULUCF restrict the harvesting potential of forests, hence putting at risk the possibility of CO_2 storage in wood products, and the substitution of fossil-based resources with renewable ones? Furthermore, when it comes to the accounting of the storage benefit of harvested wood products, the regulation should recognize the merits of the growing number of products emerging from the bioeconomy, for example, textiles, new materials and chemicals from lignin and cellulose.

"The Bioeconomy"! While the bioeconomy is a promising way forward to help the transfer from a fossil-based economy to a renewable-based one, the Green Deal seems to ignore its potential. Fortunately, the Clean Planet For All initiative explicitly lists it as one of the "building blocks" to achieve a climate neutral Europe by 2050. One should, nevertheless, deplore the fact that the revised **Bioeconomy Strategy**[5] of 2018 remains a piece of "soft legislation", hence prompting neither rapid nor bold action.

As much as forest ecosystems are complex, so is policy. No new initiative should be seen in isolation but, rather, together with the consequences and impacts it will have on other existing initiatives.

When presenting the new **Biodiversity Strategy for 2030**[6], policymakers need to consider the consequences it will have on the other policy goals and ambitions that have been adopted. A balance will have to be found between legitimate conservation intentions and the achievement of other objectives, in particular that of a climate-neutral Europe. Depending on the final outcome, it may put the availability of resources for a climate-neutral circular bio-based economy at risk.

Perhaps, rather than the economy being the biggest threat to biodiversity, it is in fact climate change. Floods, drought, fires, storms, pests and diseases illustrate more than ever the scale of the challenge. Over the last months and years, natural catastrophes and pests have taken a heavy toll on forests. Ensuring the **adaptation** and resilience of ecosystems is therefore of utmost importance. The EU climate adaptation strategy of 2013[7] did not adequately address forests. A revision of this strategy has been announced as part of the Green Deal. Let's hope it gives rise to a much-needed set of rules for natural ecosystems, going beyond funding, preparedness and prevention.

Straight jacket vs. enabling conditions

As explained, the coming years will see a proliferation of policy initiatives and revisions under the "umbrella" of the Green Deal. Each of these could have unintended consequences on the others. Building on the conviction that forests – thanks to photosynthesis and sustainable management – are a response to the challenges that humanity is facing, it is critical to implement the best possible forest management practices. These need to deliver multiple benefits at the same time: perennial habitats for fauna and flora, carbon storage and sequestration, renewable and recyclable raw materials and energy, non-wood products, water and soil cleaning services and climate adaptation responses, to mention a few. In short, **well-managed, thriving and healthy forests** are likely to play a pivotal role in mitigating climate change. Forest owners and managers, both public and private, are striving to make their contribution. However, this will not be possible without enabling and supportive policies that address all areas of sustainable forest management, not least that of resilience and adaptation to climate change. And it is important that this be properly acknowledged!

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/DOC/?uri=CELEX:52018DC0773&from=EN
[3] https://ec.europa.eu/energy/topics/renewable-energy/renewable-energy-directive/overview_en
[4] https://ec.europa.eu/clima/policies/forests/lulucf_en#tab-0-1
[5] https://ec.europa.eu/knowledge4policy/publication/updated-bioeconomy-strategy-2018_en
[6] https://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm
[7] https://ec.europa.eu/clima/policies/adaptation/what_en#tab-0-1

RESEARCH PERSPECTIVE

Climate-smart forestry: Best practices in forest climate mitigation and adaptation

Author

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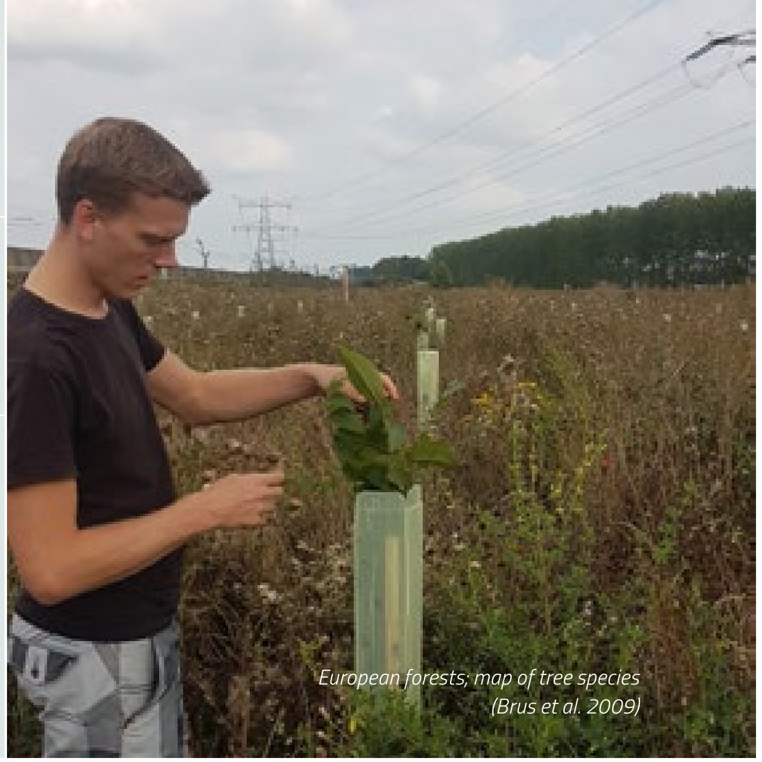


European forests; map of tree species (Brus et al. 2009)

European forests are considered to have been prospering over the last 4–5 decades (FOREST EUROPE 2011). Achieving a multifunctionality in which there is room for biodiversity, as well as providing renewable raw materials and many other functions has been a success. **The forest cover in Europe amounts to around 36% of land area, and growing stock increased substantially between 1990 and 2010.** This wealth of natural resources is subject to a range of different forest management practices, land use planning and policymaking regimes in the different Member States.

However, views on European forest management have recently changed. Climate change is putting considerable pressure on Norway spruce stocks in Central Europe (Nabuurs et al. 2019) with estimates of mortality reaching 200 million m3, biodiversity is under pressure, the Mediterranean area is showing a weak forest sector and harvesting pressure in the Baltics and north is reaching the maxima achievable. While we still foresee that future demand will increase, it is evident that the forest carbon sink needs to be maintained, in the face of climate challenges.

For this reason, a European strategy for unlocking the EU's forests and forest sector potential based on the concept of **"climate-smart forestry"** (CSF) was developed. CSF is a more specific (climate-oriented) form of the sustainable forest management paradigm. The idea behind CSF is that **it considers the whole value chain,** from the forest to wood products and energy, illustrating that a wide range of measures can be applied, to more firmly integrate climate objectives into the forest and forest sector framework. CSF is more than just storing carbon in forest ecosystems; **it builds upon three main objectives: (i) reducing and/or removing greenhouse gas emissions; (ii) adapting and building forest resilience to climate change; and (iii) sustainably increasing forest productivity and income**. Measures can vary depending on local circumstances and needs, from setting up strict reserves, planting new adapted species and provenances, to afforestation, more efficient wood use and better regional collaboration between forest owners, etc.

These three CSF objectives can be achieved by tailoring policy measures and actions to regional circumstances in the forest sectors of Member States.

The current annual mitigation effect of EU forests via contributions to the forest sink, material substitution and energy substitution is estimated at 569 Mt CO_2/year, or **13% of total current EU emissions**. With incentives like tree breeding programmes, planting programmes, forest management improvement programmes, biodiversity protection programmes, carbon funds, wood use targets, etc. (and assuming that Member States and the European Commission seriously tackle climate change) in place at EU and Member States levels, we found that the EU has the potential to achieve an additional combined mitigation impact through the implementation of CSF goals, of 441 Mt CO_2/year by 2050 (Nabuurs et al. 2017).

The Wageningen Environmental Research leads a large number of pilots, together with 36 Dutch partners in the forest and forest-based sector including the Dutch state forest service.[1] Climate-smart forestry is now taking shape in many countries across Europe with various research and implementation projects in place. Also, with the new climate law, announced by Ursula von der Leyen on 11 December 2019, and referred to as the European Green Deal[2], more emphasis will be placed on forests, forest management and the provision of renewables. The success of this initiative will be seen in the diversity of measures proposed, taking into account the state of local forest resources and local needs. Only by achieving shared benefits in nature conservation, soil protection, and the provision of renewables and income, can the mitigation and adaptation measures be successful.

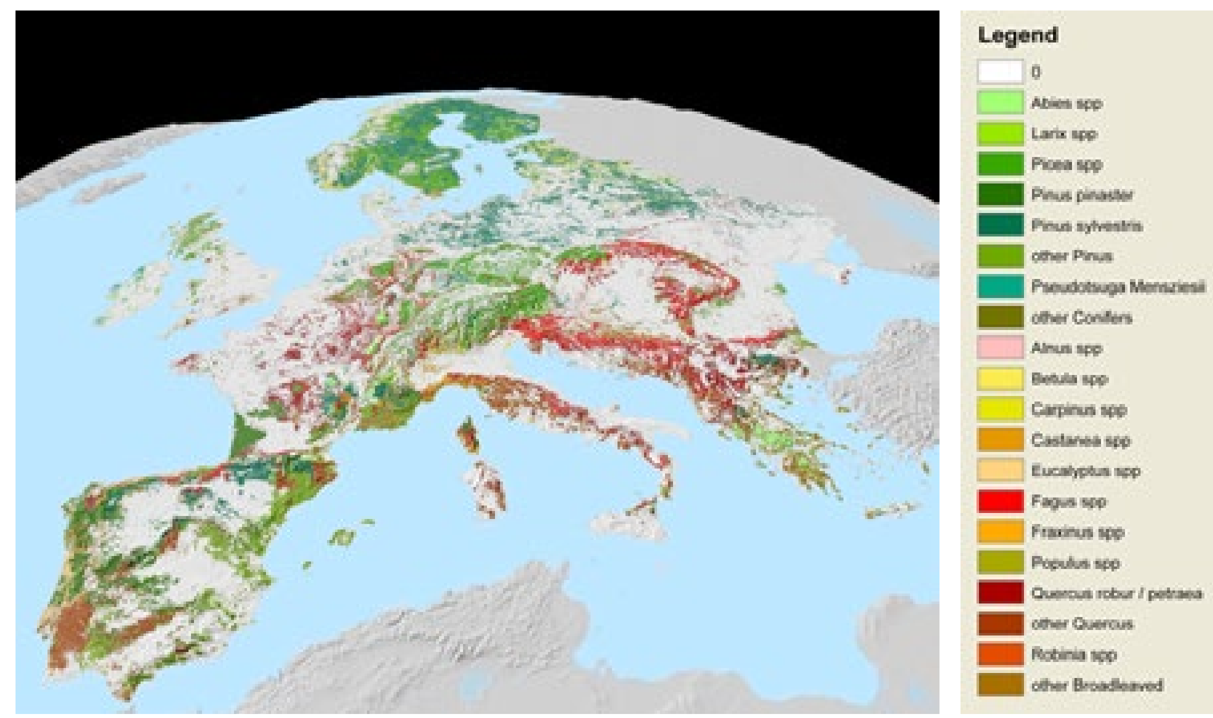
There is no doubt that **closer collaboration between industry and forest owners and managers**, will be needed to make these measures happen, and the larger – and in many cases – public forest owners will have to take the lead. They will need to set the example and make sure that they reach out to smaller owners. However, **the right triggers and incentives** still need to be provided, for example, adapting spruce forest stands in Central Europe to climate change requires knowledge of different species and different management options. It is also necessary that the demand for alternative species is developed and that these species are available from the nurseries.

Furthermore, **better monitoring** will be required as this is the only way to get carbon credits from land accepted under the Paris Agreement. Today, monitoring is too slow and too fragmented. Member States are not sending detailed data to common databases and, thus, estimates of harvesting levels fluctuate and are seen as unreliable. Ongoing discussions about the use of biomass for bioenergy only add to this uncertainty.

In conclusion, there will need to be a joint effort between the European Commission, Member States, industry, research and large public owners to tackle the challenges as outlined above. Only then can climate-smart forestry be rolled out on a large scale and find its way into common practice.

[1] https://www.vbne.nl/thema/klimaatakkoord/

[2] European Commission (2019). Communication on the European Green Deal. https://ec.europa.eu/info/files/communication-european-green-deal_en



Planting and testing new varieties and species will be necessary to adapt to climate change; here, creating a walnut hybrid in the Netherlands.

CASE STUDIES

INTRODUCTION

In this publication, we present a number of case studies showing best practice examples in climate mitigation and adaptation from EUSTAFOR member organizations. Our aim is to demonstrate that European state forest organizations are aware of the challenges posed by climate change and have already taken various practical actions to address them, although there is still considerable uncertainty about the future impact of climate change on forests. Future climate change impact will depend, to a large extent, on the emissions reduction targets and future development pathways chosen by political leaders, which are still evolving and under continuous debate. Moreover, based on past experience, the agreed commitments are often not met. This makes it extremely difficult to plan ahead for the future of European forests.

As managers of the European state forests, EUSTAFOR members are at the forefront of the fight against climate change. Foresters are accustomed to planning over long time spans (decades or even centuries), aiming at finding a balance between different societal demands on the forest, which include environmental, economic and socio-cultural aspects. In forest management planning they have to anticipate future developments in policies, markets, and environments. Climate change is a phenomenon which is especially difficult to predict. Adaptive forest management in the face of anticipated climate change requires foresters to trial and test new forest management approaches in an integrated way. This implies learning by doing, including accepting mistakes which cannot be totally avoided.

Due to the unprecedented scale and expected impact of climate change on European forests, past forest management approaches based on biological automation, natural regeneration and successions, species shifts, and evolutionary trends may no longer work. In other words, time for natural adaptation is running out. The tremendous climate change impact, almost exclusively caused by human interferences, will most probably require new and drastic human interventions in forest management. Examples include the reduction of tree age, and intensive thinning of stands to create robust, climate change-resilient stands with a low height/diameter-ratio and a diverse vertical and horizontal structure, the cultivation and planting of genetically-improved, climate-resilient seedlings, or the human-assisted migration of tree species, i.e. anticipatory planting of tree species outside of their current "natural" distributional range.

European forests cover a wide range of biogeographical regions and forested ecosystems, from the boreal and temperate to Mediterranean zones, as well as mountainous and sub-alpine forests. They are affected by a multitude of climate change-induced phenomena and stressors, such as drought, forest fires, windthrow, snow break, torrential rains, flooding, mudslides and biological calamities. At the same time, they are mitigating climate change by sequestering carbon dioxide from the atmosphere in standing forests as well as in harvested wood products. Last but not least, they are providing a renewable resource which can be used for substituting fossil fuels and energy-intensive construction materials.

Our aim is to demonstrate that European state forest organizations are aware of the challenges posed by climate change and have already taken various practical actions to address them.

Since climate change-related solutions in the forest sector have to be adapted to local conditions and challenges which vary considerably throughout Europe, this publication can only demonstrate some examples taken by European state forest organizations. This booklet presents some of the best practices used by EUSTAFOR members willing to share their experiences with a broader public. The selection of the case study topic was intentionally left to the members, in order to give them a platform to exhibit their current projects and activities. There was neither an attempt to cover all aspects of climate change adaptation and mitigation, including all 3 "S" (sequestration, storage, substitution), nor to avoid any redundancies. Therefore, this publication can only be regarded as a partial snapshot of some of the ongoing activities implemented by EUSTAFOR members in their fight against climate change. A full and comprehensive account of all climate change-related approaches and activities implemented by European state forest organizations is clearly beyond the scope of this publication.

If you have questions or require any further information on the case studies presented, please feel free to contact the relevant member organizations directly. The contact list is available at the end of this booklet.

AUSTRIA

Österreichische Bundesforste AG

Diversity as a prerequisite for climate-fit forests

Skilled forest worker processing wood affected by windthrow in the Bischofshofen forest district. (Photo: ÖBf)

CHALLENGES

Over the past two decades, Austrian forests have been increasingly affected by climate change phenomena such as windthrow, snow break, torrential rains, mudslides, extreme droughts, as well as bark beetle outbreaks.

According to Österreichische Bundesforste's (ÖBf) sustainability reports, the cost of climate change during recent years has been steadily increasing, reaching an annual amount of 41 million Euro in 2019. This includes higher costs for preventing and fighting bark beetle infestations, providing forest protection and timber harvesting, as well as the economic losses caused by increasing amounts of damaged wood. In 2019, about 80% of the annual harvest was classified as damaged wood.

ÖBf is dealing with current climate change impacts through rapid crisis management, maximum flexibility and sophisticated logistics. In order to sustain the company in the long run, ÖBf's management is focusing on diversification, both in terms of making the forests more resilient to the effects of climate change and natural disturbances (i.e. ecological diversification), as well as generating growth outside of its core business – "sustainable forest management" (i.e. economic diversification).

RESPONSES

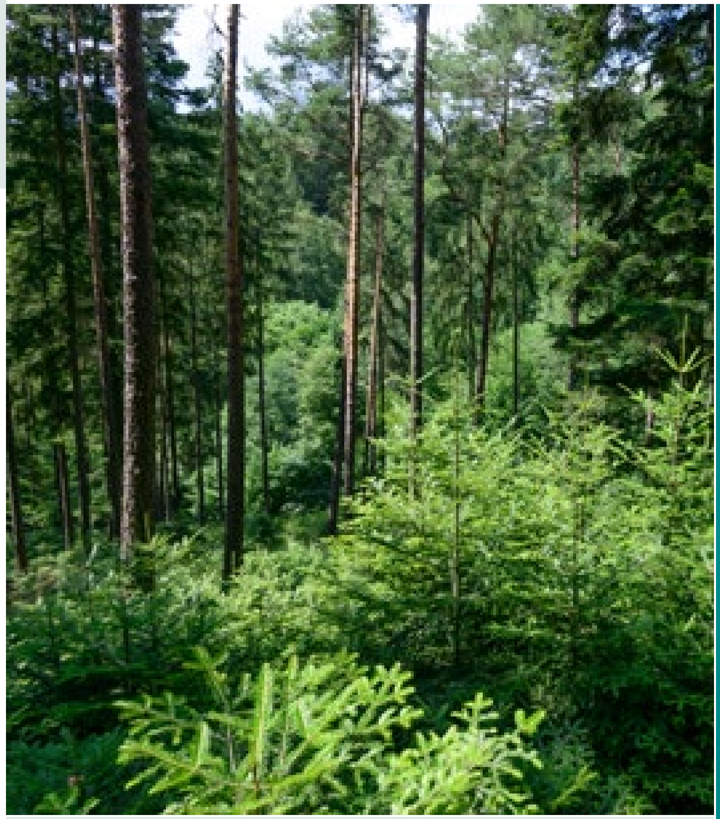
ÖBf's silviculture adaption strategy is based on the development of climate-resilient, species-rich, structurally diverse and close-to-nature forest stands. ÖBf applies active, climate-smart and sustainable forest management in order to adapt its forests to the changing ecological conditions.

Due to increased temperatures, tree species will shift to higher, cooler elevations and thus the species composition of the forest will change. Reduced precipitation and higher temperatures have already been observed in the lowlands of north-east Austria. The increasing prevalence of drought weakens the vigour of spruce, and as a consequence, bark beetles find ideal conditions for mass reproduction. ÖBf is thus reducing the share of spruce in the lowlands and replacing it with more drought-tolerant species such as oak, maple, larch, and Douglas fir. The majority of ÖBf's forests lies in the Alps, at an average elevation of 1,100 metres. In a 2°C temperature-increase scenario, the spruce would still find good growing conditions here. At present, our silviculture experts anticipate a 5–10% reduction of spruce, whose share will further decrease if the expected temperature increase is higher.

Österreichische Bundesforste's forest management strives to nurture healthy, stress-resistant and resilient forests, especially by increasing tree diversity. Each of ÖBf's 104 different sites has a particular species composition target that is based on the potential natural forest vegetation. Higher floral and structural diversity increases the resilience of the forest ecosystem and reduces the risk that entire stands are affected by climate change impacts. The underlying notion is that potential natural forest vegetation will be site-adapted and thus less susceptible to climate change. However, a remaining challenge is that potential natural forest vegetation is also evolving under climate change, and that the time required for natural adaptation may not be sufficient in the future.

Furthermore, we are frequently facing difficulties to naturally regenerate the forest due to widespread browsing damage. Therefore, another climate adaptation measure carried out by ÖBf is to regulate the deer and elk populations, bringing the population density back to acceptable levels through intensified hunting regimes.

A number of pests benefit from climate change. The most dangerous pest is the bark beetle which benefits from a warmer climate and drought conditions. In particular, in the north and east of Austria, spruce trees suffering from drought stress are subject to massive bark beetle infestation. Traditional measures taken by ÖBf against such infestations are rigorous monitoring, setting of pheromone traps, offering "catching trees" as bait, debarking of infected trees and watering of logs.



Mixed forest with natural regeneration of silver fir (Abies alba) in the Waldviertel-Voralpen Forestry Management Unit (Photo: ÖBf)

LESSONS LEARNED

Thanks to a simulation project (ADAPT2 project) conducted in collaboration with the University of Natural Resources and Life Sciences in Vienna (BOKU) which has assessed the impact of climate change on forests under varying climate scenarios, we know now which areas are most prone to climate change hazards. The results of the project have been used to adapt the species composition target for the different sites. Our management response is to increase the share of drought-tolerant deciduous trees, especially through promoting natural regeneration. Naturally regenerated trees are generally better adapted to their environment and more resistant to disease and pests. A positive knock-on effect of this response are company-wide cost savings for plantations.

Still, our knowledge about climate change impacts remains limited. Therefore, in cooperation with the Austrian Federal Environment Agency, ÖBf runs the Zöbelboden research station located in the Limestone Alps (Kalkalpen) of Austria. Over the next four years, this and five other locations will be expanded to become state-of-the-art monitoring stations for ecological and climate change research, with financial support from the Austrian Research Promotion Fund. They will provide important insights into the effects of climate extremes and environmental changes on our forests. The new measurement technology will allow us to monitor more closely the immediate and long-term consequences of climate change as well as to better estimate climate risks.

CZECH REPUBLIC

Lesy České republiky

Reforestation of forests affected by large-scale calamities caused by climate change in areas larger than 10 ha

LESYČR

CHALLENGES

Similar to other countries, the Czech Republic is confronted with diverse climate change effects that have caused an increase in average temperatures and extremes, changes in water balance, vegetation season length (it has been extended) and have favoured an increase in invasive species. This difficult situation has had a direct impact on the practical work of foresters in the Czech Republic. For the moment, we are planting 100 million seedlings instead of 60 million per year, and for phytosanitary reasons, clear-cuts have increased from 10,000 hectares to 40,000 hectares per year. The total annual cutting volume of incidental felling is now over 90%, and the total annual harvesting volume is 50% higher than the long-term average level. The unpredictable climate change developments mentioned pose a considerable challenge to forest management planning.

According to Czech forestry legislation only clear-cuts of less than 1 hectare are allowed. It is mandatory to plant a minimum share of soil-improving and pioneering tree species (broadleaf and fir) in forest stands, with this share representing around 50% of newly planted species.

However, due to climate change it has become necessary to conduct sanitary cuttings of unhealthy forests affected by drought and bark beetle over the past 15 years. As a result, open areas of up to several hundred hectares are now in need of restoration and reforestation. Dying forest stands are primarily made up of Norway spruce, which is dominant in all stands, and which accounts for more than 70% of species. Several tens of thousands of hectares of forest stands in northern and central Moravia, as well as in the highlands around Jihlava, and around Brno, are affected.

RESPONSES

In 2019, the organization developed a detailed strategy for the restoration of calamity areas. Planning was done according to the size of the area, natural conditions, and the possibility for using natural regeneration. The aim is to have at least four tree species with a share of over 20% in the renewed stands. For the reforestation of calamity areas, a criterion needs to be established in order to decide on the best approach for restoration, so as to ensure that the situation is manageable from an organizational perspective, in other words that there are enough seasonal workers and planting material. For large-scale areas, defined as areas larger than 10 ha, it is advisable to develop a so-called reforestation project for the calamity area, consisting of spatial distribution of the clear-cut categories and their physical stabilization in the field.

The following categories have been created:

- Clear-cutting areas without the potential for natural regeneration – for artificial reforestation of target tree species (spruce, larch, Douglas fir, beech, oak) and soil-improving species (especially beech, fir, oak, maple, lime)
- Clear-cutting areas with existing natural regeneration of target tree species, but soil-improving species that have been planted artificially.
- Clear-cutting areas with the potential for natural regeneration for the natural succession of the pioneer species (birch, aspen, alder, willow) and after some time the underplanting of the target tree species. Target tree species are subsequently artificially planted under the "nurse" stands of pioneer species.

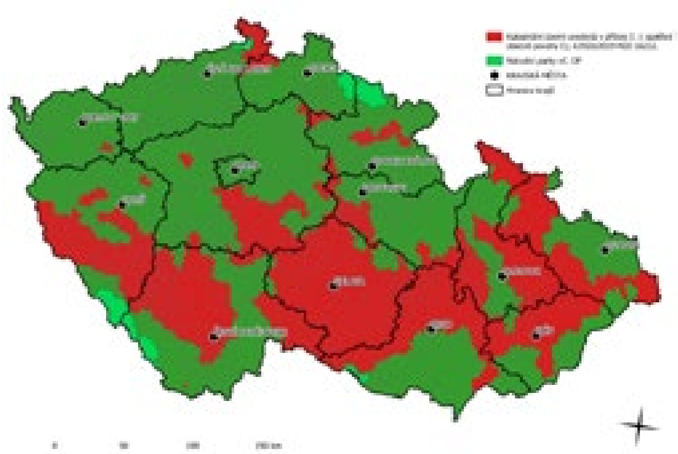


Figure: The Ministry of Agriculture has identified calamity areas affected by bark beetle (coloured red). December 2019.

When choosing the basic composition of suitable tree species for the reforestation of calamity areas, the species composition of the forest stands must respond to the new roles and status of individual groups of trees in the restoration process. The categories to be considered are target tree species, soil-improving species and pioneer tree species. Due to the increased need for fast restoration of forest functions, it is important to use the potential of soil-improving and pioneer trees and keep the forest land covered by vegetation at all costs. The strategy is to support, in advance, the natural regeneration of all trees, including the pioneer species. In the past, these species were removed by the tending of stands. The natural regeneration of spruce is supported, but artificial planting is not being done. It is necessary to differentiate target tree species as a major measure for supporting biodiversity, with regard to natural conditions (habitat, altitude, etc.), stand type and in particular, the degree of damage and decay found in spruce.

The purpose of reforestation projects in areas larger than 10 ha is to:

- Introduce a renewal system for large calamity areas;
- Reduce the regeneration time of forest stands to a minimum – no more than 5 years;
- Categorize clear-cut areas and the division of the calamity surface (size, potential for succession, the presence of natural regeneration);
- Maintain strict respect for natural conditions (habitats, field conditions), spatial frameworks, forest status and development, etc.;
- Create a detailed forest map of the reforestation process (graphic plan) of afforestation areas;
- Perform continuous marking, physical stabilization and maintenance of permanent fields, where there are different types of forest regeneration (artificial regeneration, natural regeneration, succession with pioneer species);
- Allow for adequate game management.

Photo: Lesy České republiky

Trees approximately >10 years old generally have larger canopies and are better for evapotranspiration. And if large areas of these older trees are felled at once, canopy will decrease significantly (having a negative effect on peak flow) and by contrast canopy might increase due to new planting in the catchment (a positive effect on flood mitigation). Roadbuilding, quarrying, windfarm construction, peatland restoration, all reduce the canopy extent in the catchment and as such can have a negative effect and so these factors need to be taken into account during planning. But there are techniques to mitigate the effect of lost canopy including: woodland creation, delayed felling and rescheduling felling coupes, faster restocking (as the forest coupe matures, it will once again have a large canopy) and other Natural Flood Management techniques. Forest planners run future forest scenarios to select the best option to meet the management objectives – including flood mitigation.

Photo: Lesy České republiky

LESSONS LEARNED

Due to climatic changes in Central Europe, forest monoculture stands of all age classes and species are dying at a rapid rate. In the Czech Republic this applies mainly to spruce and pine. The aim is to establish new, stable, species-rich forest stands that minimize the risk of breakdowns in the future. Another expected benefit of this method is the positive results seen in the improvement of site conditions and the reduction of reforestation costs. The aim is to constantly expand the amount of forest covered by tree vegetation, which will ultimately fulfil all ecosystem services.

FINLAND

Metsähallitus Forestry Ltd

Carbon classification in forests as a tool for climate-smart forestry

CHALLENGES

The total area of Finland is 338,000 km² which includes 78% of forested land and 10% water. A third of Finland's land and water area is owned by the state and managed, operated and developed by Metsähallitus, in a way that maximizes the benefits to society in general. The reconciliation of various functions with ecological, financial, social and cultural sustainability lies at the core of Metsähallitus's mission. One third of state-owned multiple-use forests are used for forestry. The rest consists of protected or wilderness areas (40%), or is otherwise excluded from forestry practice.

Forests have a significant role in mitigating and adapting to climate change. As a major forestry actor, Metsähallitus Forestry Ltd sees a need to further its knowledge on how state-owned forests can respond to the demand of both carbon sequestration and storage.

RESPONSES

Metsähallitus Forestry Ltd launched its "Climate Smart Forestry" project in 2017, to identify the importance of forestry sites in carbon sequestration and storage for growing stock. The project also aimed at examining how carbon sequestration and storage can be enhanced through forestry measures. A third goal was to create a carbon-based classification method as a practical tool for planning forest use. The ultimate target was to improve Metsähallitus's ability to make climate-friendly decisions within its forestry activities.

The project examined all forest sites belonging to Metsähallitus Forestry Ltd (5.1 million hectares) which includes forest land, low-productivity land, non-productive land, restricted forestry sites and nature sites. National parks and other areas managed by Metsähallitus – Parks & Wildlife Finland, were not included in the classification. The classification was based on Metsähallitus's forest inventory, soil information, land use information and landscape-ecological data. Areas with similar sink and storage emphasis were grouped together. Some generalization was necessary in the classification, which is why the result may not be entirely accurate for every compartment. The work resulted in seven forest categories. The main category is divided into two groups, based on different types of forest use: carbon sinks and carbon storage. Each group is important as either a carbon sink or carbon storage, but the emphasis varies. Classification is presented as a map layer in Metsähallitus's GIS system and is periodically updated with the latest remote-sensing data.

Minor carboon storage

Understocked, low-productivity land, non-productive land, built-up land and other areas.

- The trees have no significance as carbon slinks or storages

Developing carbon sink

Young growing stands and open areas. Developing into a good carbon sink.

- Small significance as a carbon sink and storage.

Carbon sink to be developed

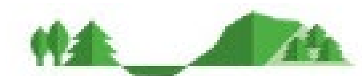
Multiple-use forest where the number and/or condition of trees is not ideal.

- Need for actions to develop carbon dioxide sequestration in the growing trees.

Increasing carbon sink

Multiple-use forest in good condition, a sufficient number of growing trees and timely forestry actions.

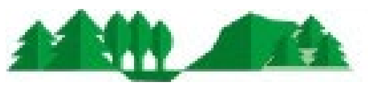
- The best sites for effective carbon dioxide sequestration.



Increasing carbon storage

Areas with young forests where forestry use is restricted for landscape, recreation or game management reasons, such as wood grouse mating displays.

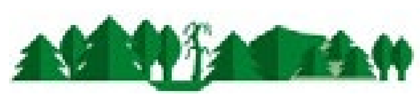
- A good site for storing sequestered carbon in the tree stock. The trees in the area already contain a certain amount of carbon and their ability to sequester more is good in light of local conditions.



Significant carbon storage

Areas with mature forests where forestry use is restricted for landscape, recreation or game management reasons, such as wood grouse mating displays.

- The best site for storing sequestered carbon in trees. The trees already contain a lot of carbon. Their ability to sequester more carbon has decreased.



Stable carbon storage

Areas completely excluded from forestry operations. Mainly various nature sites and other areas outside the scope of forestry operations.

- A carbon storage that developes via naturall processes, storage may also decrease due to rot. No forestry measures.

LESSONS LEARNED

Metsähallitus Forestry Ltd started using the classification method as a decision support tool in forest use planning in January 2019. It was recognized during the project that methods for both enhancing carbon sequestration and carbon storage were already present in Metsähallitus's current forest management practices.

Climate benefits will be achieved by applying the most prevalent forest management practices with the emphasis on climate recognized in the carbon classification. Maintaining the health and resilience of forest stands and further improving the quality of forest management are equally important in adapting to and mitigating climate change. Increasing carbon sequestration in suitable "increasing sink" class forests by means of fertilization, or by utilizing selectively bred seed and seedlings in cultivation, are all worthwhile options.

Carbon sequestration and storage are not solely present in growing forest stock and coarse woody debris. In peatlands, in particular, most of the carbon per hectare is stored in organic soil. In addition to measures for growing stock, ecosystem restoration in previously drained, low-productivity mires can be applied to suitable "minor storage" class sites to promote biodiversity, multiple use and carbon sequestration and storage.

Metsähallitus Forestry Ltd, in cooperation with NRIF (Natural Resources Institute Finland), has carried out a pilot study to create a classification system for soil emissions. For optimal results in climate change mitigation and adaptation, both growing forest stock and soil carbon stock and their development should be considered concomitantly when planning forest management or mire restoration.

Focusing on carbon sequestration in forestry does not conflict with good economical results. However, a strong increase in carbon storage in multiple-use forests can, on the other hand, reduce forestry revenue.

Metsähallitus Forestry Ltd's efforts in mitigating and adapting to climate change consist of more than one or two major changes. Site-specific, good forest management complemented with carbon classification as a decision-support tool, together with science-based developments, make a difference in managing the challenges of climate change.

FRANCE

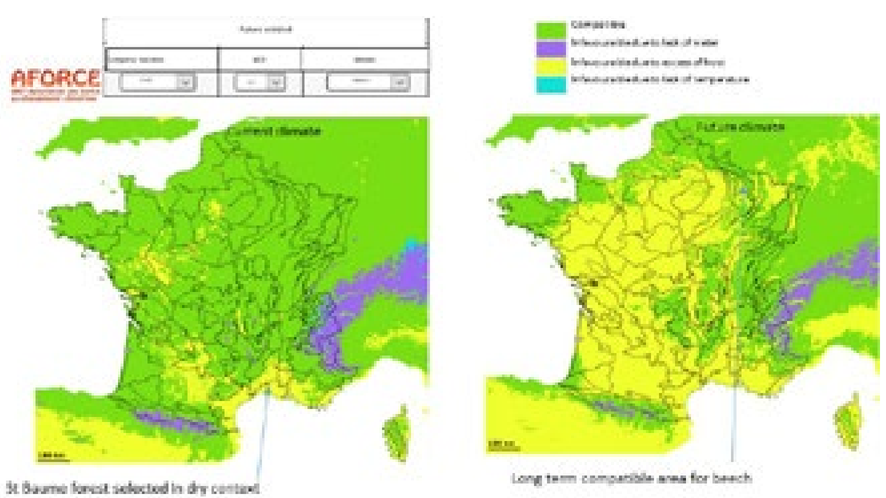
Office National des Forêts

Adapting forest genetic resources in the face of climate change

CHALLENGES

To adapt forest to climatic changes, genetic resources are a good option. Indeed, there is great genetic diversity both between species and within species. The choice of genetic resources was an important issue in the past, to use the best species and provenances for better growth in the area of species production. Nowadays, it has become fundamental. Nevertheless, few data are available to advise which species and provenances are adapted to new conditions in the forest. The climate models predict strong impacts, especially in major areas where oak and silver fir production exists. The climate change context, uncertainties regarding possible evolution, interactions with other drivers (e.g. air pollution, biotic agents) and answers provided by forest genetic resources, mean that the effects of climate change are even more complex and hard to predict. A multiscale approach is needed, combining monitoring, modelling and experimental testing.

Figure 1: Beech area compatibility



RESPONSES

Long-term monitoring is needed to detect, better understand and predict changes in forest ecosystems in response to climate and other environmental variations. RENECOFOR, the French network for the long-term intensive monitoring of forest ecosystems (ICP Forests Level II) collected data from 122 permanent plots, covering a wide range of ecological conditions across France. The input provides reference data to test process-based climatic models in terms of ability, to accurately describe natural phenomena and for forecasting future conditions.

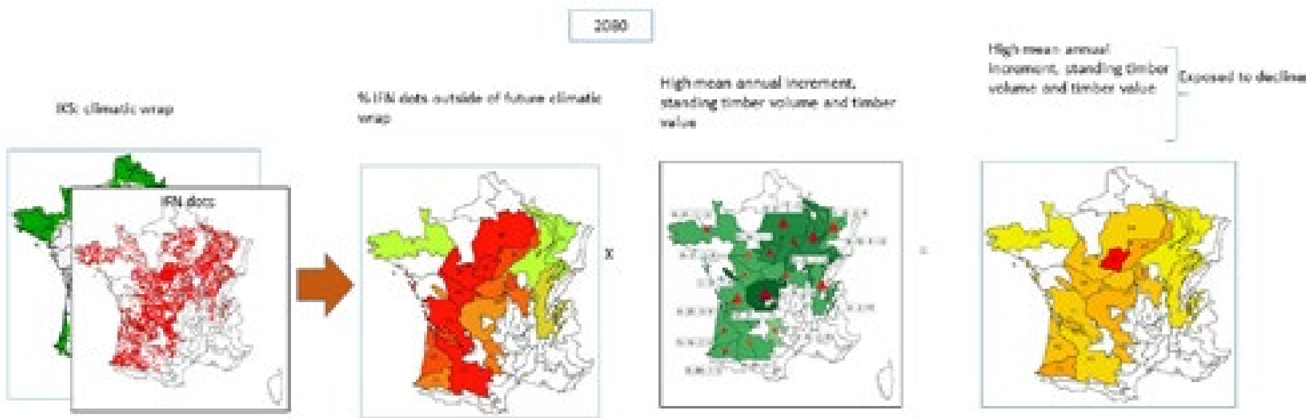
This approach is complemented by a modelling tool of the climatic similarity area (at a spatial resolution of 1 km) for 38 forest species largely distributed throughout Europe. The tool simulates the climatic similarity area of the species at different time horizons (current, 2050, 2070 and 2100) under different representative concentration pathways using EU climate data and three scenarios (optimistic, pessimistic, and medium). It shows the different forest areas where tree genetic resources will either be able to adapt (compatible) to climate change over time, or where they will not (unfavourable).

In order to cope with climate change speed largely exceeding the natural species migration capacity (10 times less), the French forest service initiated a process of assisted migration to address a part of the problem. The driest area provenances were identified according to the model criteria And, therefore, drought-resistant provenances were selected and raised in nurseries. According to the models, seedlings are planted in favourable ecological areas, based on the expected climatic conditions of the future. These genetic resources, considered to be adaptable to drought are planted within the natural range of the species for future hybridization of local resources, in order to increase their adaptability. More than 25 ha of beech, sessile oak and silver fir are already planted as a proof of concept. These tests will be monitored for more than 30 years. This measure to adapt and enlarge the diversity of local species is widely promoted in state forests. Currently, rules concerning seed transfer stipulate that assisted migration is allowed only in the case of sessile oak.

Another measure, developed with the AFORCE network[1], is to identify vulnerable forest areas and modify the species composition. These zones are determined on the one hand by a high mean annual increment, standing timber volume and timber value for main tree species.[2] On the other hand, the climate compatibility models enable the identification of areas where the main forest species will be vulnerable. Overlaying the respective maps/GIS layers, it is possible to identify where adaptation measures must be prioritized. One of the main priority zones is located to the east of the Paris Basin and relates to pedunculate oaks.

For this area, a list of 53 species and provenances is proposed, based on their growth potential (min. 25-30 m) and resistance to future dryer conditions (expected for 2070 or 2100).

These species are pooled in different risk classes, according to the level of knowledge which can guide the forest manager in species selection in terms of risk. The proposal is to introduce the new species into the priority areas by plantation (at least 0.5 ha) to test their performance in different pedo-climatic conditions. This network is also deployed under climate conditions that simulate future climates (2070 and 2100) of the priority area, in order to identify species (including provenances) that can be adapted both to the current and future climate. More than 200 stands will be installed by 2022 along the different climatic gradients in France. The location of all the plantation sites will be recorded using GPS and collected data will be stored in a database. Information such as timber stock and growth will be collected, which will build up knowledge regarding the species ecology. This information will be added to web platform species sheets.



[1] https://www.reseau-aforce.fr
[2] https://inventaire-forestier.ign.fr/?lang=en

LESSONS LEARNED

Since 2005, the French forest service has implemented a process within forest management which takes into account the impact of climatic change.

We have carried out collaborative work with all foresters and participating science projects. To do this, we have developed climate similarity models for different climate scenarios and assisted migration actions, but also species changes based on long-term monitoring. One of the key points highlighted was the quality of genetic resources. This initiative has been favourably received by foresters, policymakers, the media and citizens alike.

GERMANY

Forst Baden-Württemberg

Adaptation and mitigation activities supported by ForstBW

ForstBW

CHALLENGES

To increase the adaptability, resilience and stability of forests to secure the provision of forest ecosystem services for the general public while maintaining sustainably managed forests as an income source for the state.

RESPONSES

Adapt tree species composition to different climate change scenarios and future reference times (2050 and 2100).

ForstBW has developed maps for assessing the suitability of tree species under climate change, in cooperation with the Forest Research Institute Baden-Württemberg (FVA). These maps are used in long-term forest planning and mid-term forest management planning. Since these maps only cover the current main tree species (Norway spruce, European beech, silver fir, sessile oak) additional research is underway to recommend the climate suitability of other tree species, including domestic rare tree species, species from neighbouring countries and non-domestic species. One example of adapting tree species composition that has already been implemented, is the current conversion of climate-vulnerable Norway spruce stands at lower altitudes into stands with higher proportions of Douglas fir, to increase their drought resistance and resilience. Other target species are likely to be eligible for conversion as soon as scientific suitability recommendations are confirmed.

Reduce vulnerability

Current hotspots of forests with high vulnerability have been identified in vulnerability maps and have become the focus for adaptation. Vulnerability in these areas can be reduced by converting drought- and bark beetle-sensitive Norway spruce forests into better-adapted deciduous stands. This is done by converting storm-exposed coniferous forest stands, composed of high and vulnerable trees, into stands with lower tree heights, and to increase the proportion of mixed stands consisting of adapted tree species. Pre-commercial thinnings help to increase the resilience of young coniferous forests by stabilizing the individual trees (more favourable slenderness) and fostering the increment of their diameter. This mandatory measure has been implemented in the silviculture guidelines of ForstBW for Norway spruce stands. Increasing the structural diversity of forest stands has also been introduced as a binding element for all tree species, since it promotes the establishment of advanced natural regeneration which, in turn, increases resilience of forest stands in case of disturbances.

Maintain the axes of genetic exchange

In relation to the conservation of biodiversity and genetic diversity, a network of specially protected habitats was established. This habitat network is predominantly aimed at the genetic exchange of animal species, and has been extended to accommodate the potential biome shift of plant species especially under climate change. Since natural forest edges and natural forest succession areas are somewhat rare habitats in southwest Germany, a special programme was implemented to secure the genetic, species and structural diversity of this particular forest habitat. The spatial connectivity of these habitats provides space for migration and genetic exchange which strengthen genetic and ecosystem resilience under climate change.

Preservation of climate-endangered habitats

Our first focus was the creation of 400 ha of additional forest gaps as special habitats for capercaillies, a mountainous bird species depending on mountainous habitats which include berry bush vegetation and Scots pine trees. A second focus was on the protection of peat bogs and swamps which need special protection measures to prevent them from further drainage and climate-induced desiccation.

Pest monitoring

Many of the specific causes of forest damage such as drought, bark beetle and storms are linked to climatic drivers, and therefore a specific digital system has been introduced to monitor this damage. All damaged areas are registered by local foresters and reported to ForstBW, including spatial information about the amount or aerial extent of damage, as well as the cause of the damage.

Lowering psychological thresholds for adaptation action through education

ForstBW has acknowledged the human dimension to be a potential barrier in climate change adaptation. Therefore, a number of educational events have been organized to raise awareness of the immense proportions of climate change, underline the urgency and need for immediate action, and to demonstrate the effectiveness of different adaptation measures. Additionally, decision support systems have been developed and specifically adapted for different target and user groups.

Timber buildings

ForstBW is supporting a programme to increase sustainable timber use in the construction of various types of buildings. This public programme is implemented by the state and focuses on the advantages of domestic wood as a resource. Such advantages include: a positive carbon footprint and the effects of substitution when compared to fossil-intense alternative resources such as steel and concrete or mineral resources, the sustainable use of a natural, renewable resource, and the contribution to regional value-added chains, as well as to the bioeconomy.

Increased use of hardwood timber for long-lasting wood products

The minor contribution that timber from broadleaved tree species makes to the mitigation of climate change has been a major challenge for some time, due to its high proportion of use in short-lived wood products. Conifer timber represents a much higher share of long-lasting wood products and thus a higher and much more positive mitigation effect. To enhance the mitigation effect of broadleaved timber use, ForstBW is supporting projects and initiatives that focus on the increased use of European beech timber to achieve wood products with a longer life. New technological solutions for this are currently still being researched but, unfortunately, are not yet available. A great deal more investment needs to be undertaken in this area.

Scarlet oak in Black Forest, Germany (Photo: ForstBW)

Firs (Photo: ForstBW)

Beech in autumn (Photo: ForstBW)

LESSONS LEARNED

There is a general lack of consensus both within the forest community and in society in general on which specific climate change adaptation measures are most effective, reliable, and are in line with other management objectives. ForstBW has learned that:

1. It is not only natural science knowledge, but also the transfer of this knowledge, as well as continued education which are essential elements to enable forests to adapt to climate change.
2. Effective measures that have been identified are subject to change, since research continually advances, as a function of climate data permanently evolving.

GERMANY

Bayerische Staatsforsten

Sustainable forest management to tackle climate change

BAYERISCHE STAATSFORSTEN
Nachhaltig Wirtschaften.

CHALLENGES

Forests are affected by climate change. With this in mind, Bayerische Staatsforsten (BaySF) aims to achieve climate-resilient and adapted forests through active, sustainable forest management (SFM) using an integrative approach, taking into account economic, ecological and social demands.

To do this, BaySF has developed strategic goals based on expected socio-political conditions, implemented through the following measures by the Hammelburg forestry district:

RESPONSES

4-tree concept

In order to encourage forest adaptation, it is important to increase the variety and number of tree species. Experience shows that at least four "climate-resistant" tree species should be planned for each stand. For instance, it is important to ensure a certain share of coniferous trees when choosing the combination of different types of tree species for an area, as scientific evidence has shown conifers to be climate resistant. A greater variety of tree species results in a reduced risk vis-à-vis the effects of climate change.

Vertical and horizontal structure

To ensure a multiple structure in forest stands and a variety of tree species, regular thinnings have to be undertaken, and growing stock has to be limited to a specific threshold depending on the climate change risk assessment. Additionally, tree species have to be selected depending on the soil characteristics of the site. This means that each area needs to be developed with a very specific concept in mind.

Management of natural disturbances

BaySF adopts a conceptual approach when carrying out its responsibilities. Everyone in the forestry district is specifically trained and knows how to react in the case of a forest calamity. Measures carried out include the following: systematic search for damaged trees using mobile software solutions, and prioritization during the tree processing phase; wet storage of bark beetle wood (in each region of Bavaria), installation of dry storage areas and consistent and timely chopping of scrap wood; medium-term contracts for harvesting, logistical capacities, and the availability of timber marketing contracts to ensure swift wood delivery from the forest.

Social acceptance

It is essential to obtain widespread social acceptance for our forest management practices, so that we can be sure of a "licence to operate" in the future. To achieve this, BaySF has an information, communication and networking strategy in place, taking into account all aspects of climate change. With this in view, forest excursions are organized, during which the objectives of sustainable forest management in the forestry district are explained to the general public.

Hunting management system

Hunting is an essential element in establishing the targeted, climate-stable regeneration of species. Each forestry district has developed an individually adapted hunting concept, which sets out the use of efficient hunting methods to manage the game populations.

Forest conversion makes forest fit for climate change (Photo: BaySF)

Wet storage in Unternogg (Photo: BaySF)

Environmental protection management

The desired substitution of native forest communities with "new" climate-resistant tree species and an appropriate share of coniferous trees requires a supportive policy framework, which allows for active forest management and control of tree species composition. Measures for the conservation of nature and species alike, are integrated within the forestry sector in the form of a dynamic nature conservation strategy. Each forestry district has established a tailor-made nature conservation concept, specific to their own circumstances, in addition to a description of the current status. They have also drawn up a nature conservation action plan for the next 10 years (based on the existing forest management system). For example, the establishment of wet habitats or concrete deadwood and biotope tree targets may be defined.

Installation and evaluation of trial plots

The Hammelburg forestry district already has 22 hectares of trial plots. Currently, a number of climate-stable tree species are being cultivated on a trial basis in order to gain experience, but research on climate-resilient tree species needs to be further developed.

General measures

Naturally, the Hammelburg forestry district needs to prepare its forests for climate change. For this purpose, numerous measures (in addition to established ones) are being implemented by BaySF:

- Establishment of a BaySF crisis fund, in which each forestry department can participate;
- Creation of more water storage capacities, at least in every forestry district;
- The recruitment and retention of professional forest workers. Skilled labour resources are becoming more and more difficult to find;
- Training in climate change for our own staff, encouraging collaboration with scientific institutions and stakeholders for knowledge transfer;
- Timber flow and utilization management optimized for each forestry department, with flexible mechanisms, as far as possible;
- A comprehensive overview of the protective functions of forests against increasing geo-risks will be examined for existing silvicultural concepts and be part of forest management planning.

In this way, forestry management concepts are coordinated with other administrative bodies and individual assets are weighed up. In line with the forestry principles of BaySF, the forests' resistance to plant and animal pests and abiotic pollutants is promoted primarily through preventive measures (forest protection strategy), in view of the predicted climatic changes. These measures to control and mitigate the effects of climate change are already under way in order to better adapt to invasive species or to cope with emerging complex diseases.

LESSONS LEARNED

BaySF is structuring measures to be taken in line with its responsibilities, regarding the technical, temporal and spatial basis of the expected probabilities of occurrence and effects of climate change.

GERMANY

Niedersächsische Landesforsten

Forest management planning based on site water balances to cope with climate change

Niedersächsische Landesforsten

CHALLENGES

The climate projections for Lower Saxony suggest that there is a good chance of more frequent weather extremes (storms, heavy rain, droughts) in the future. The summers will get drier and hotter, while the winters will get damper and milder. This will lead to altered production bases, changing yield prospects and varied cultivation risks which are primarily the result of the increasing dry-stress risk of the tree species. With the interaction of abiotic site factors, the importance of biotic site factors increases, as for example the risk of bark beetle attack, which has to be taken into account in the tree species selection. The site water balance will be particularly important under future climate change as it indicates the available water supply during the vegetation period and is an index for the water supply of a forest site. The overall water supply capability of the site is obtained from the sum of climatic water balance (precipitation minus transpiration minus interception) and utilizable site water capacity.

In calculating the site water balance, changes in the forecast for regional precipitation are taken into consideration when making climate projections. Due to different combinations of site factors and forest tree stands, different sums of site water balances are to be expected in the future. Consequently, tree species can be assigned to different risk classes, according to their respective ecological qualities or their tolerance to dryness.

RESPONSES

Case study - Norway spruce (Picea abies)

A site water balance of 0 mm is considered as a low dry-stress risk for Norway spruce; the dry-stress risk increases once the site water balance is at -80 mm at mid-level, whilst a water balance of less than -80 mm would be assessed to be at peak dry-stress risk level.

At present, the Norway spruce is the most frequent tree species in the Niedersächsische Landesforsten (NLF) and represents approximately 25% of species present. Due to age class distribution in which the Norway spruce presents a main peak in the 3rd and 4th age class they will soon need to be harvested, to make space for younger (and more site-adapted) trees. Because dry-stress risk starts early, Norway spruce stands will be concentrated in future on the poorer sandy sites of the low mountain ranges of Lower Saxony. Meanwhile, the dry-stress risk is too high in large parts of the lowlands, particularly in the east of the country. Instead of Norway spruce, other species will be prominent in these areas, such as Douglas fir, Scots pine, grand fir and European silver fir. The dry-stress risk for Norway spruce is expected to be too high in 38% of the NLF forest area and, therefore, this species is no longer planned on these sites as a stand-dominating tree species. As a result, the amount of Norway spruce in the tree species distribution planned for 2055, will be reduced to about 20% of the NLF forest region.

Case study: European beech (Fagus sylvatica)

Already at a site water balance of less than -50 mm, the dry-stress risk for European beech is considered mid-level, while a site water balance of less than -100 mm constitutes a high dry-stress risk. The European beech has a high dry-stress risk on approximately 29% of the NLF forest area, however, the share of European beech will nonetheless increase in the NLF from 23% currently, to 27% by 2055. One of the reasons for this are the specifications for protected areas which must be taken into account when considering tree species selection. The European beech is essentially the leading tree species in most forest biotopes within the EU's "Flora-Fauna-Habitat" protection system, mainly in the south of Lower Saxony. Furthermore, the European beech is found to be between 20% and 40% of almost all regeneration target types of the NLF "lion" programme outside of protected areas. Due to the dry-stress risk, however, cultivation of the European Beech will be primarily maintained on sites with a better water supply in the mountain ranges, whereas in the lowlands the share of European beech will not increase, contrary to previous strategies.

(Photo: Niedersächsische Landesforsten)

LESSONS LEARNED

Mixed stands as a target for forest development

The "lion" programme instigated the development of mixed stands at the beginning of the 1990s and its development over the last 30 years means that 55% of the NLF forests are today made-up of mixed stands. Due to age class distribution, primarily in the case of Norway spruce and Scots pine, target diameter cutting of mature timber and regeneration will increase in importance within the next few years. Since this knowledge is applied when ascertaining the dry-stress risk level of single tree species, and forest management practices are closely adhered to, based on the approved principles of the "lion" programme, the share of mixed stands will increase to 88% by the year 2055.

The developments seen during 2018 and 2019 show that not only the modelled predictions will come into play, but also interactions with other harmful organisms have to be expected. In light of this, the importance of the various mixtures of suitable tree species in the course of a yield, as well as risk diversification, is evident.

GERMANY

ThüringenForst

Climate change adaptation and mitigation based on forest conversion of spruce stands in the higher elevations of the Thuringian Forest

CHALLENGES

With the pilot project "Forest Conversion in the Central, High and Ridge Areas of the Thuringian Forest", a research platform was created in the ThüringenForst-AöR state forest in order to develop and demonstrate silvicultural and operational approaches for a practice-oriented adaptation and the mitigation of climate change by today's forests. The project is being implemented in a relatively humid and cool climatic region in central Germany, in the Thuringian Forest (elevation of 600–1000 m). The project focuses on extensive, unstable pure spruce stands mostly originating from unsuitable spruce provenances as well as on the climate change-induced increase in extreme weather conditions in this topographically challenging region. The current spruce-dominated composition of tree species is the result of a historical hurricane and bark beetle catastrophe in the 1940s and 1950s and a snow break catastrophe that followed in 1981. The project is focused on pure forest stands dominated by spruce over 60 years of age, and on already-existing forest rejuvenation from these non-adapted spruce monocultures. Despite the generally successful reforestation efforts in these difficult times, the lack of manpower, suitable seeds and seedlings, climatic extremes, mice and game damage, as well as insufficient tending measures, has resulted in forest stands which are now particularly susceptible to snow breakage, storms, heavy precipitation events, bark beetle outbreaks, and high game populations.

RESPONSES

These forests, therefore, urgently needed to be stabilized against long-term, gradual climatic change and drastic climate extremes, for ensuring and increasing forest productivity and for contributing to climate mitigation. The project is funded by the Federal State of Thuringia and partly co-financed by ThüringenForst-AöR through timber sale revenue. Designed to run for 10 years, the project started in 2013 with the measurable objective of establishing small pilot areas for climate-adapted forests within a total of 8,000 hectares of contiguous state forest, consisting of different age classes. To this end, an average of around 60 hectares per year are actively being converted by sowing and planting typical tree species of mixed mountain forests (e.g. 20-25% European beech, 15-20% silver fir, 5-10% sycamore maple) and by promoting extensive natural regeneration of pioneer and secondary tree species (e.g. silver birch, goat willow, mountain ash).

Near-natural mixed mountain forest with European beech and Norway spruce in overstorey and natural regeneration (Photo: Nico Frischbier, ThüringenForst-AöR)

Snow load and storms can considerably damage spruce crowns (Photo: Mathias Stürtz, ThüringenForst-AöR)

Furthermore, specific tending strategies are being pursued in existing natural regeneration and middle-aged spruce stands which focus on low stand densities and phenotypic selection for ensuring and increasing single tree storm and snow stability. The conversion of lowland to high-elevation spruce provenances is another important project aim. In the snow and storm-prone high altitudes of the Thuringian Forest, the gene pool of the autochthonous, narrow crowned, stable high-elevation spruce is preserved, and its occurrence is promoted.

Through various work packages (e.g. silviculture, technology and wildlife management) the project aims to demonstrate practice-oriented pathways for successful forest conversion and to thus serve as a role model for other forest owners and managers. In addition to the content-related work, extensive public relations activities as well as comprehensive internal and external education programmes are therefore key project tasks. The project is implemented by the Gotha Forest Research and Competence Centre (FFK Gotha) of ThüringenForst-AöR in cooperation with the regional Thuringian forestry offices, the UNESCO-MAB Thuringian Forest Biosphere Reserve, collaborating universities, as well as other regional and supra-regional partners.

LESSONS LEARNED

A total of 225 hectares of forest area were actively converted within the first four planting years, thus positively influencing approximately 800 hectares of directly affected or adjacent forests. Between 2013 and 2017, a total of 12 scientific publications, 10 bachelor's, master's and doctoral theses on topics related to forest conversion were completed and integrated into training programmes. Up to now, through promotion activities such as lectures, excursions with foresters, planting campaigns or multimedia information stands, 45 events have taken place, reaching more than 6,230 people in 2017 alone.

The project "lives and grows" thanks to the intensive support of a regional manager, available funding, strong commitment and an excellent network of scientists, actors and stakeholders. It should be noted that all those involved in the project are confronted with the consequences of climate change in the region on an almost yearly basis, especially winter storms, high snow loads, bark beetle infestations, and impassable water-logged forest soils during the winter harvest. There is no doubt, therefore, of the necessity of this project for climate adaptation and climate protection. In order to build networks and trustworthy cooperation, to generate and test knowledge, to protect and develop the desired forest stands in the long-term, and continuously regulate game numbers, at least 10 years – or preferably 15 years – of project duration and funding will be required.

IRELAND

Coillte

Establishment of native woodlands on cutover peatland

CHALLENGES

Industrial peat harvesting leaves behind bare peat fields which are virtually free of seeds. Without any intervention, significant vegetation cover will eventually develop over time. The slowest areas to vegetate are the more degraded and drier areas; within these, tree colonization may take decades due to the low nutrient status of the peat and the exposed convex nature of the fields. Following the initial establishment of ground cover vegetation, birch and willow will eventually begin to colonize the areas, beginning at the drain edges and continuing in other sheltered areas.

Recently, Bord na Móna and Coillte Nature agreed to collaborate on a project to establish native woodlands on large areas of cutaway bogs which are highly degraded and cannot be rewetted. This project aims to reduce the rate of carbon emissions from the land, create new woodland habitats for wildlife, and create new outdoor recreational amenities. It will also provide an opportunity to grow new sustainable businesses in recreation and eco-tourism in the midlands of Ireland.

RESPONSES

Bord na Móna estimates that around half of the cutaway bogs have the potential to revert to wetlands, and the remainder are likely to eventually revert to scrub and woodland habitat; however, this process could take decades in the case of drier sites. Creating new woodlands, by seeding or planting, can potentially speed up this process and offer a wide range of ecosystem services, including biodiversity, carbon sequestration and recreational uses. In this project, Coillte Nature proposes to seed approximately 1,500 hectares of the most degraded peatland with a mix of native tree species. The mix will be based on birch as a pioneer species, which will be enriched with alder, Scots pine and oak to increase diversity.

Photos: Coillte

LESSONS LEARNED

In a pristine or undrained state, peatlands are sinks for atmospheric carbon and sources of methane. Over millennia, peatlands store vast amounts of carbon, and peatlands in Ireland store at least 50% of the country's total soil carbon stocks. Drainage dramatically alters the carbon balance of peatland, whereby lowering the water table increases the depth of aerobic peat and accelerates peat decomposition. The rate of soil CO_2 emissions depends on a suite of factors such as water table depth, soil temperature, peat type and soil properties.

When considered in the context of greenhouse gas emission reductions, it is desirable to reduce carbon losses from disturbed peatlands and, where possible, to restore the carbon sink function. Industrial cutaway peatlands are cleared of all vegetation and drained to lower the water table and enable peat extraction. Efforts to restore the carbon sink of industrial cutaway peatlands focus on revegetation of predominantly dry areas and rewetting of low-lying areas. While these changes may eventually occur naturally after the cessation of peat extraction, management-based interventions have the potential to accelerate the nature and extent of both rewetting and revegetation.

Although any assessment of the potential greenhouse gas balance of the woodland types envisaged in this project is unreliable, some reasonable conclusions can be drawn:

1. In drier areas (where rewetting will not be particularly effective), the creation of woodland will accelerate the restoration of the carbon sink function and lead to the development of new carbon stocks in biomass, woody debris and litter.
2. This new carbon sink function will offset some or all of the carbon loss from peat decomposition, and the extent to which it does will depend on the relative balance between carbon uptake and loss.
3. It is uncertain if this balance will move towards carbon neutrality over the medium to long term, but the rate of carbon loss will be reduced.

The value of this 1,500-hectare project is potentially very significant. In addition to supporting the Strategy for Native Woodlands, it will complement a number of other important national initiatives such as the National Peatlands Strategy and the National Biodiversity Plan.

The presence of an array of habitats in time will support an increasing number of flora and fauna species. The sheer critical mass of the woodland area will potentially support specialist woodland species that require large woodland areas to sustain themselves. In effect, large "biodiversity restoration" areas will be created, and the project will de facto become one of the first large-scale "landscape reanimation" projects in Ireland.

NORWAY

Statskog

Forest fire challenges and prevention measures

Photo: Skogbrand Forsikring

Photo: Skogbrand Forsikring

CHALLENGES

Statskog and private forest owners in Norway have witnessed an increase in the occurrence of forest fires. The expected changes in climate will add new challenges to forestry and resource management; an increased risk of summer drought makes the forests more exposed to fire and storm damage.

The Norwegian Directorate for Civil Protection (DSB) advised that there were approximately 2,000 forest fires in 2019, and the Norwegian Meteorological Institute has reported temperature changes and an increase in the forest fire threat. We have seen that forest fires are getting larger and more frequent. The challenges are also increasing: lightning-ignited fires may be hard to locate in isolated areas; harvesting machines may ignite fire which increases the importance of their carry-on firefighting equipment, whilst hikers and campers may cause forest fires, too.

Photo: Skogbrand Forsikring

Photo: Skogbrand Forsikring

RESPONSES

Fire prevention

Norway's largest forest insurance company (Skogbrand), Statskog and other forest organizations have been working together to create procedures and plans for forest fire prevention.

Education and information

Statskog organizes courses on forest fires together with local schools. Children learn about the risks and what precautions to take in the forest. At the end of the course the children are honoured as "forest firefighters" and awarded a firefighter cap and a membership card. Skogbrand, Statskog and other forest organizations are also participating in national and regional events with local fire departments and civil defence units.

Local and national information

In areas with an increased risk of forest fires it is important to ensure that visitors are clearly informed of the fire risk present. Local and national newspapers, weather forecasts on television, radio, or on websites and on social media, can be used for disseminating information about the risks and for increasing awareness.

Prevention and understanding of fire risks, in forest management forest fire course

Local fire departments provide a mandatory three-hour forest fire course for all contractors. Approximately 1,000 contractors have completed the course and feedback from participants has been positive. Once contact has been established between the firefighters and participants, it is maintained throughout the fire season and follow-up sessions are arranged every fifth year. The risk of machine-ignited fires has increased because there are ever more machines used in forestry activities. Furthermore, as forestry often takes place in secluded areas, it may take some time for the fire department to reach the fire, adding to the importance of having first response firefighting equipment available with forestry machinery. The forest contractor can, in many cases, extinguish small fires before they develop and pose a greater danger.

Forest machinery equipment

All forest machines belonging to Statskog are equipped with a 25-litre water container, a water can with a sprinkler head, a shovel, a Pulaski tool and a swathe to ensure a quick response to the initial fire.

National guidelines

Norway has compiled national guidelines for forest management, including guidelines for mechanical forestry, field preparation, manual harvesting and young forest management, which are dispatched to forest operators and all the local fire departments.

Resources for fighting forest fires

Better collaboration between institutions is needed, as effective cooperation during a crisis has proven to be crucial. Such cooperation must be based on thorough preparation and rehearsal of routines.

On behalf of the forest owners, Skogbrand participates in a joint project with the Norwegian Institute of Bioeconomy Research (NIBIO) and the Skien fire department. The main aim of the project is to classify the vegetation, based on its susceptibility to forest fires and to use the information to create a risk map. Satellite pictures will be used as the basis for future analysis of the danger of fires spreading, as well as to carry out strategic extinction.

LESSONS LEARNED

Fire prevention must remain the key objective, as the risk of fires is increasing and the consequences will be ever more severe. Norway's topography both helps to prevent forest fires from spreading and poses a challenge to detecting and fighting them, due to the steepness of its mountain slopes. Terrain is not uniformly steep, which requires that proper exercise models for up-to-date competences be implemented, as well as the right resources, both locally and regionally, and also in the case of more flat-level woodland areas. Cooperation and working procedures between the fire department, civil defence units, forest contractors and the local government need to be seamless.

The fire department may consider that saving buildings and infrastructure is a priority, before combatting other types of fire damage. The need to set priorities in the case of saving one valley with more inhabitants, as opposed to another, may be required. Strengthening cooperation between forestry stakeholders and emergency response actors, as well as carrying out joint exercises is of the utmost importance.

Photo: Agderposten

POLAND

Państwowe Gospodarstwo Leśne - Lasy Państwowe

Adaptation of forests and forestry to climate change – small retention schemes and fire protection

State Forests
Poland

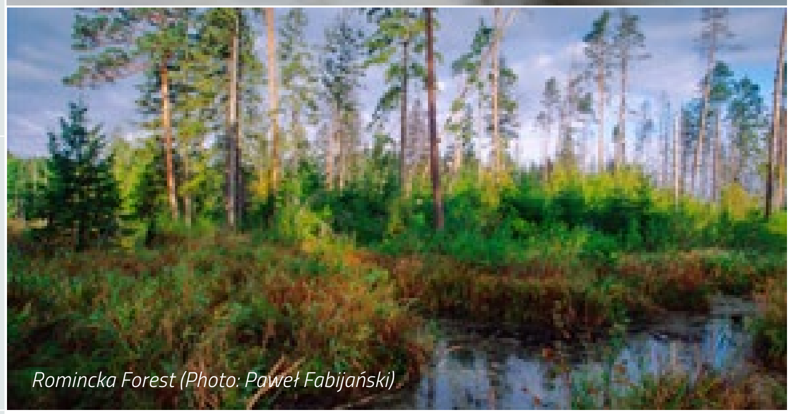
CHALLENGES

Long-term meteorological observations in Poland show that average temperatures across the country are increasing, as is the number of days with heavy rainfall – especially in southern regions. Climate change symptoms in Poland include extended rainless periods, long-term droughts and extreme weather conditions of increasing frequency (e.g. hurricane-level winds).

Water in Polish forests is periodically in short supply, caused by natural factors such as high temperatures and the lack of precipitation over long periods. Long-term water deficit weakens the natural defensive capabilities of many plant species. Trees, in particular, become more susceptible to disease and pests; as a result, they display less resistance to damage brought about by wind, rain or frost. We do not often consider that one of the effects of drought especially harmful to nature, is the decrease in biodiversity.

When the forest is burning (Photo: Dariusz Zatorski)

Fire (Photo: Marcin Tomczak)



Romincka Forest (Photo: Paweł Fabijański)

RESPONSES

In order to support the ecological functions of forests, primarily with regard to water and nature protection, as well as fire safety, State Forests (Lasy Państwowe) have, for some time, been pursuing various projects developing small retention schemes in forest areas. In the context of climate change adaptation, measures are also required in the field of forestry itself – especially in the continuous development and supplementation of firefighting infrastructure. Due to the large scale (the entire area of Poland) these are often very expensive measures. For this reason, they have been supported by EU funds for several years.

Since 2016 State Forests have been implementing the "Forest and Forestry Adaptation Programme to Climate Change 2020". This integrated programme contains an assessment of the measures of forest and forestry adaptation to climate change as well as the effectiveness of existing activities. At the outset, a diagnosis of needs was carried out, whilst sources of financing for new activities were researched, and objectives, activities and expected effects were defined.

Under the programme, three comprehensive adaptations of forests and forestry to climate change projects are implemented:

1. Small retention and protection against water erosion in lowlands.
2. Small retention and protection against water erosion in mountain areas.
3. Prevention, counteracting and reduction of the effects of threats related to forest fires.

Two of the projects will carry out the following activities:

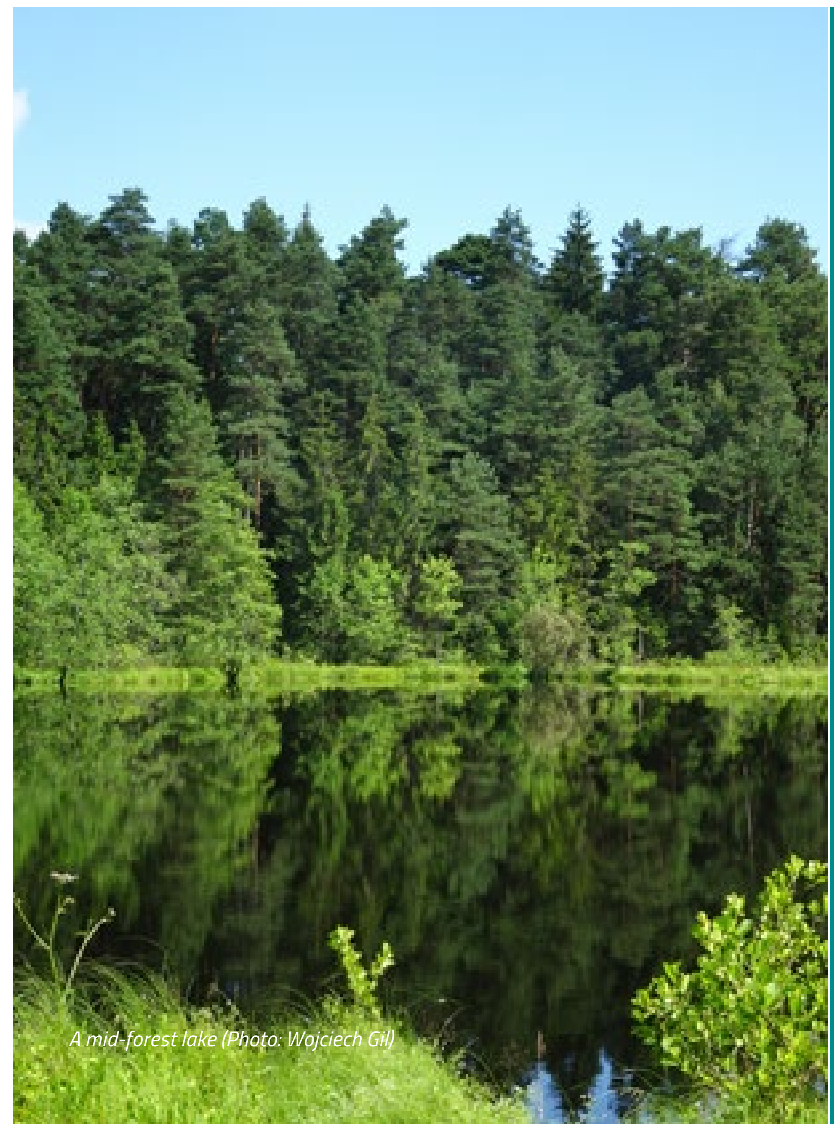
- Regeneration and protection of wetlands and restoration of floodplains;
- Construction, reconstruction or restoration of small retention reservoirs and dry reservoirs;
- Reconstruction or demolition of hydrotechnical facilities (bridges, culverts, fords) not adapted to flood waters;
- Protection of forest infrastructure facilities against the effects of excessive water erosion related to rapid heavy rainfall;
- Construction, reconstruction or restoration of small water-damming devices in canals and ditches, to slow down surface water run-off;
- Construction of facilities conducive to the development of biological diversity, such as fish ladders or cascades and rapids, and the reproduction of natural systems of deep and shallow sections in mountain streams, which are habitats for many species.

A direct effect of the projects' implementation will be the retention of 2.5 million m3 of water and construction/reconstruction/restoration of 2,267 small water-damming devices which will slow down water run-off.

As well as preventing, counteracting and reducing the effects of forest fires, early warning and forecasting systems will be modernized, to include:

- Construction and modernization of five observation posts;
- Purchase of modern equipment to locate and detect fires;
- Addition of equipment for alarm and command points;
- Construction of meteorological stations.

Technical support for rescue and firefighting systems will also be developed in the case of forest fires, including the purchase of patrol and firefighting vehicles.



A mid-forest lake (Photo: Wojciech Gil)

LESSONS LEARNED

Sustainability requires foresters to anticipate the course of natural processes and their effects – a challenging task, as it is impossible to predict everything. Yet, we always take action whenever possible, to prevent negative consequences or at least to limit them.

Small retention measures by State Forests have been consistently implemented over the last 30 years. Thanks to our work, the water balance in the forests is constantly improving. Blocking the run-off of rainwater, its dissipation and accumulation in numerous reservoirs helps us to gain the benefit of supplying groundwater and increasing the humidity of habitats. This way we contribute to strengthening the most important forest protection function: the preservation of natural assets and water protection. As a result of our forest fire protection project we expect the resilience of forests to natural disasters to grow, as well as the effectiveness of the early fire warning system in the State Forests. We also hope to see monitoring of a larger forest area and a reduction in the time required for hazard detection and response, as well as less extensive fires, improved fire protection in areas adjacent to areas administered by State Forests (e.g. national parks, inhabited areas) and a decrease in CO_2 emissions by reducing the quantity and range of fires.

SCOTLAND

Forestry and Land Scotland

Adaptation of Scotland's forests and associated land to help support Scotland's National Flood Risk Assessment

Forestry and Land Scotland
Coilltearachd agus Fearann Alba

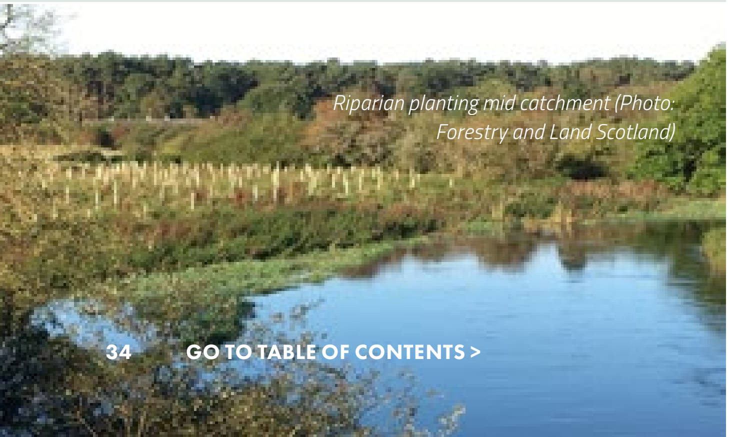
CHALLENGES

Climate change predictions suggest that vulnerable locations – such as domestic properties, transport links, businesses or other infrastructure – will be affected by more frequent and intense, extreme rainfall events, and by subsequent flooding.

The mitigation options are either:

- To build flood protection schemes at the flood point to reduce the likelihood of flooding; OR
- To instigate potential land use changes upstream to help slow and reduce flood peaks at flood points.

Scotland's Climate Change Plan identifies forestry as a way of reducing flooding (as does the UK Forestry Standard) and Forestry and Land Scotland – as a manager of significant areas of land in "at-risk" areas – is well positioned to assist with flood mitigation.



Riparian planting mid catchment (Photo: Forestry and Land Scotland)

RESPONSES

Forests have a part to play in flood management. Their canopies decrease the amount of rainfall reaching the ground, and water that does reach the ground is more likely to soak into the soil rather than quickly run off the surface. As water reaches streams and rivers, trees on banks and on floodplains help to slow its rate of flow. Forestry and Land Scotland (FLS) works with other organizations in a collaborative effort to reduce flooding. FLS shares data and expertise with partners (e.g. Scottish Environment Protection Agency (SEPA), Scottish Forestry, Scottish Water and local authorities) across Scotland – a collaboration that is likely to become more important as flood risk increases in line with climate change predictions.

1) SEPA

Flood Risk Management Strategies (14 across Scotland) are approved by the Scottish government and published by SEPA. The strategies coordinate efforts to tackle flooding, set the direction of future flood risk management, target investment and coordinate actions across public bodies. They explain the reasons for and the impact of flooding in high-risk areas – information that underpins decision-making across flood risk management organizations.

2) Local authorities

Each of Scotland's 32 local authorities draw from the strategies to develop their own Local Flood Risk Management Plans, which detail how and when the actions from the strategy will be delivered locally.

3) Forestry and Land Scotland

Through its understanding of the location of Scotland's vulnerable flooding points in the context of its landholdings upstream, FLS can adapt its land management as appropriate to help mitigate flood risk.

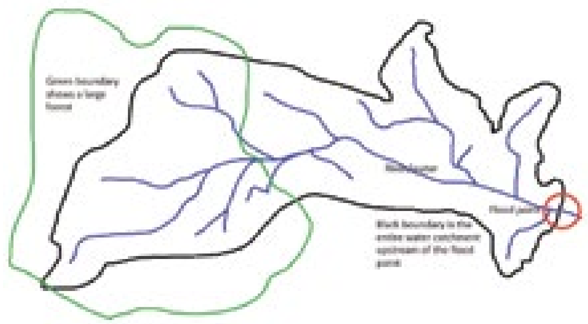


Figure 1. Drawing showing context of the forest and the flood point

Our land management plans detail how an area will deliver its management objectives, including economic, social and environmental benefits; these are reviewed at least once every 10 years. The outputs from the planning include felling and restocking proposals or plans. Management objectives include society benefits and that's when adaptation of forests for mitigating flooding comes in to play. During land management planning, FLS uses all the available data and information to check whether downstream areas are vulnerable to flooding. If any are identified, the Local Flood Risk Management Plans are consulted to find out what natural flood management actions are already agreed, and to explore whether FLS has a part to play in delivering these. Also, during land management planning, where there is a vulnerable location downstream and where there is a high proportion of tree cover within the wider catchment, FLS will check whether its activity is likely to exacerbate or reduce peak flow over the lifetime of the plan.

Research indicates that where more than 20% of a forested catchment is felled or canopy is removed, this can cause a measurable increase in flood peak at the flood point.[1] Trees of approximately 10 years or older generally have established canopies with typically higher evapotranspiration rates compared to grass. And if large areas of these older trees are felled at once, canopy coverage will decrease significantly, which will have a negative effect on peak flow. In contrast, new planting will increase canopy cover and therefore help to mitigate downstream flooding. Roadbuilding, quarrying, windfarm construction, peatland restoration, all reduce the canopy extent in the catchment and so these activities also need to be considered during planning. But there are techniques to mitigate the effect of lost canopy including: woodland creation, phasing/delaying of felling by rescheduling felling coupes, faster restocking (to accelerate restoration of the forest canopy) and other natural flood management techniques. Forest planners run future forest scenarios to select the best option to meet the management objectives – including flood mitigation.

[1] https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk

The flood risk point in the town (Photo: Forestry and Land Scotland)

Woodland creation at the top of the catchment (Photo: Forestry and Land Scotland)

LESSONS LEARNED

When developing management plans for the forests and land there is significant advantage in collaborating with other agencies and organizations who share a common interest. Sharing objectives, information and data to improve land use management, demonstrates how agencies can work together to deliver greater flood mitigation for impacted communities.

SPAIN

Junta de Castilla y León

Restoration of burnt forests in protected areas: adapting and mitigating climate change

1\. 

2\. 

CHALLENGES

On 28 July, 2009, a large forest fire seriously affected (almost 4,000 ha) the Gredos Mountains Natural Park in the Spanish Central System range (Ávila, Castilla y León), which has also been designated a Special Area of Conservation (Habitats Directive 92/43/CEE). The burnt vegetation was mainly comprised of pure Scots pine forests (both natural and planted), completed by pastures and scrublands. The area hosts such emblematic species as the Spanish ibex, wolf, black vulture and imperial eagle. This area has a high climatic continental index, with a strong thermal contrast both daily and yearly; cold winters and dry summers, with rainfall concentrated in spring and autumn. Almost 600 ha of the burnt forest belonged to the regional government (Junta de Castilla y León) and formed part of the Public Utility Forest 134, which is directly managed by the General Directorate for Natural Heritage and Forest Policy. Since 2015, the regional government of Castilla y León has been working together with a private company – Bosques Sostenibles SL – on ecological restoration in the area, adopting solutions using criteria for the mitigation of and adaptation to climate change.

The ultimate goal of restoration is to create a mixed forest that can generate greater stability for the ecosystem and is more resilient to the effects of climate change and other disturbances. The planting of 337,000 native tree species (Pinus sylvestris L: Scots pine, Betula alba L: birch and Sorbus aucuparia L: mountain ash), is expected in an area of about 153 ha. In addition, other objectives have been developed: promoting the fixation of carbon dioxide in the atmosphere through the creation of carbon sinks; recovering the functionality of the forest ecosystem by restoring areas degraded by fire; reducing active erosive processes; improving the quality of water resources; contributing to the preservation of natural and landscape values.

1. Development of plantation after three years (Photo: General Directorate for Natural Heritage and Forest Policy - Regional Government of Castilla y León)

2. Soil preparation with walking excavator (Photo: General Directorate for Natural Heritage and Forest Policy - Regional Government of Castilla y León)

RESPONSES

The restoration action was focused on a north-facing hillside with an average slope of 25% and an average altitude of 1,600 m. A forecast of the climatic features expected in 2100, relative to the context of climate change, has been made for the area The climate change scenarios viewer of the Spanish Ministry for Ecological Transition has been used, taking into account the IPCC's RCP 4.5. This forecast mainly shows a reduction in the number of days with rainfall (128 to 119), an increase of both minimum and maximum average temperatures (1.3°C and 1.6°C), a reduction in freezing days (106 to 80), and a 100% increase in the maximum span of heat episodes. The main restoration action has been the recovery of the Scots pine, that has not been able to regenerate by itself due to its young age, followed by birch and mountain ash plantations in areas with higher humidity or better soils. Prior to soil preparation, a selective scrub clearing is created manually with a brush cutter, respecting the specimens of tree or shrub species which may be incorporated into the main stratum in a future scenario, mainly those providing fruit due to their importance to wildlife. 2,200 plants per ha have been planted, with Scots pine being the most widely used (80%). Genetic origin (as local provenances are the best adapted ones) and morphological quality standards have been major factors in the selection of plants, produced in our own nursery. Since there are wild herbivores such as deer, ibex and roe deer in the forest, protection from browsing is needed. A perimeter fence that allows the plant to be protected in its early years has been installed.

LESSONS LEARNED

A new forest has been successfully installed. The selection of species and provenances has taken into account the most probable future climate conditions in which the young forest will have to age and survive. A mixed forest will also have more chances to combat climate events in the future. Plantation density has been considered optimum in order to achieve a good mycorrhization and so that the struggle for water in the summer does not hinder the planted trees from developing well. Beyond the use of adaptation criteria in the modelling of the reforestation, the action has its own value in terms of climate change mitigation, as a new stand for carbon storage has been created. In fact, the project has been mainly financed by private funding related to mitigation, and the first 35 ha planted in 2015 were registered with the Spanish government's Bank for Carbon Absorption Projects, with a carbon absorption of 12,595 tons for the first 40 years provided. A new dimension in restoration management has opened up, given the current climate change considerations. This can provide a vital new tool to establish better operational practices and for funding opportunities alike.

Photo: General Directorate for Natural Heritage and Forest Policy - Regional Government of Castilla y León

SWEDEN

Sveaskog

Making sustainable biofuels from forest biomass

SVEASKOG

CHALLENGES

Forests and forestry can provide huge climate benefits in a number of different ways. Forest biomass for energy use is to a large extent based on harvesting residues like tops and branches but, at the moment, large amounts of small residues are left rotting due to lack of markets. At the same time, future goals at national and EU level largely depend on the increased use of forest-based biomass. One way to meet this demand can be through increased use and refinement of residual product from the forest industries. Renewable forest biomass in different forms substitutes fossil-based resources.

(Photo: Sveaskog)

RESPONSES

Sveaskog sees the forest as a key factor in an essential bio-based transition towards the circular economy and is therefore taking part in a variety of projects to develop and refine the use of forest raw material. An example of this is the production of diesel from SunPine, which in some 10 years has developed from an innovation project into the full-scale production of biodiesel based on tall oil. Sveaskog has supported the project all along as a part-owner of SunPine.

The SunPine biorefinery

Tall oil, which is the raw material used by SunPine, is a residual product from pulp mills. The original raw material is pulpwood, which is traceable and mainly originates from Swedish managed forests. The tall oil is delivered from various pulp mills to SunPine, where it is heated, and its various components can then be released at different temperatures with the main product being tall diesel. The volume of tall diesel produced today provides a positive climate impact equivalent to an annual reduction of 275,000 tons of fossil-based carbon dioxide emissions. This corresponds to and neutralizes the emissions from 157,672 diesel cars per year.

Apart from tall diesel, SunPine uses the original tall oil as the base for a variety of products, among them bio-oil, crude sulphate turpentine, rosin and district heating. SunPine's bio-oil is a green fuel oil and a renewable alternative to fossil fuel oils for industry. Bio-oil has several development possibilities, such as in the production of petrol or lubricating oils and because it contains sterols, there are also possibilities for developing cholesterol-reducing foodstuffs or medications.

Another renewable product extracted is crude sulphate turpentine which is an extremely malodorous chemical used in the creation of perfumes, where it provides chemical properties that allow fragrant aromatic substances to attach to the skin. It should not be confused with the turpentine used as a paint thinner; however, crude sulphate turpentine is also used in heavy industry as well as in the manufacture of perfume.

Rosin consists of resin, i.e. the sap that flows out of a tree, and has many applications. For example, violinists rosin their bows with it and it can also be used in printing ink, adhesives, paint, and white road markings.

The production processes used by SunPine require cooling, which generates hot water. This in turn is used for district heating. The district heating is used partly in the company's own industrial plant, and partly in other major industrial premises in the region via an extensive district heating network. SunPine supplies around 1,500,000 kWh of green district heating annually.

(Photo: Sveaskog)

LESSONS LEARNED

SunPine's industrial plant is an example of how a variety of new climate-smart forest- based products can be developed. Its entire diversified operation thus illustrates how innovation and new uses of forest biomass may contribute further to resource efficiency and climate change mitigation.

The combined mitigation effect from carbon sequestration in Sveaskog's forests and the replacement of fossil-based materials corresponds to approximately 10 million tons of carbon dioxide annually. The replacement, or substitution effect, represents a significant proportion (around 40%) which can be further increased through the refinement of forest industry residues and efficient use for new products and uses.

CONCLUSIONS & RECOMMENDATIONS

It is estimated that EU forests and the forest-based sector currently contribute to overall climate mitigation by **absorbing about 13% of the EU's total greenhouse gas emissions (GHG)**, and that EU forests could achieve a combined additional effect of 400 million tons of CO_2 emissions reductions by 2030[1]. In order to maximize the potential of forests to regulate climate, they must be actively and professionally managed to make them "climate fit". Sustainable forest management (SFM) improves the ability of forests to maintain and enhance carbon sinks and stocks, including by storing carbon in wood products. Sustainable forest management aimed at providing biomass, timber, non-wood resources and other ecosystem functions and services, can lower GHG emissions and can contribute to adaptation. **There are three main different mitigation options** that can be harnessed:

1. Sequestration: of CO_2 by forest growth thanks to sustainable forest management.
2. Storage: the carbon storage effect of standing forests as well as the harvested circular forest-based products.
3. Substitution: the effects of replacing carbon-intensive and fossil-based materials and energy with forest-based materials.

As the case studies have shown, the human-induced climate crisis has had an unprecedented impact on European forests which have functioned as a significant carbon sink, compensating emissions caused by other sectors. Even remote close-to-nature or old-growth natural forests in national parks or wilderness areas are affected by the climate crisis caused by human activities, and there is a considerable risk that biological processes alone will not be able to cope with expected climate change impacts. In EUSTAFOR's view, it is the key responsibility of European state forest organizations to combat the human-induced climate change impacts on European forests and to nurture climate-fit forests which are able to resist the anticipated, and most likely increasing, aforementioned impacts. This requires **active, climate-smart forest management** by professional foresters in close cooperation with scientists, climate change modellers, the private sector and other stakeholder groups, in contrast to a protectionist approach which just sees forests as a standing carbon sink, increasing the risk of natural disturbances and calamities.

Sustainable forest management has evolved as a forest management concept worldwide and is promoted by European forest policies as well as EUSTAFOR members. SFM lays the foundation for scientifically-based, multifunctional and site-adapted management of European forests, balancing various management objectives. With the increased concern for climate change, new concepts such as climate-smart or carbon-conscious forest management have been proposed, giving more attention to climate change mitigation. However, the fundamentals of sustainable forest management are not in question and will remain, despite the challenges and failures of traditional forest management which was not fully based on the SFM principles employed today. It is thus more or less a question of how to improve sustainable forest management under a changing global climate, than to come up with a totally new forest management concept. In fact, many of the case studies presented build on existing SFM concepts and principles.

> The importance of locally-adapted solutions developed by skilled and experienced foresters familiar with local ecological and socio-economic conditions must not be underestimated.

While the case studies only present a small sample of activities implemented by EUSTAFOR members, it becomes obvious that climate change has a multitude of effects on European forests, spanning various ecoregions and many different forest ecosystems. The importance of **locally-adapted solutions** developed by skilled and experienced foresters familiar with local ecological and socio-economic conditions must not be underestimated.

The case studies provide evidence that forests have a role to play, both in **climate mitigation and adaptation**. Mitigation and adaptation of forests are closely related, and in many cases, mitigation activities will also support the adaptation of forests and vice versa. This is particularly true if the focus is on promoting productive, healthy and climate-resilient forests having a diverse structure and species composition. In fact, there are a number of case study examples promoting diverse, site-adapted and mixed forests being able to withstand

[1] Gert-Jan Nabuurs, Philippe Delacote, David Ellison, Marc Hanewinkel, Marcus Lindner, Martin Nesbit, Markku Ollikainen and Annalisa Savaresi. A new role for forests and the forest sector in the EU post-2020 climate targets. From Science to Policy 2. European Forest Institute, 2015.

climate change impacts. One-sided silvicultural mitigation strategies aimed at merely maximizing growth (e.g. to maximize carbon sequestration by fast-growing species) or stock (e.g. by setting aside forest or increasing the rotation age) will, in most cases, be an inappropriate adaptation strategy. What is needed is younger, healthier, professionally thinned and more robust forest stands.

A proper forest management strategy will strive to nurture species-rich and structurally diverse forests, favouring indigenous, high-value trees with the potential to produce long-lasting timber products.

It is well known that tree species have shifted with changing climate conditions, for example during warmer periods between the ice ages, species moved to higher elevations. Under the anthropogenic climate crisis, the time for tree species to shift is much shorter, requiring assisted migration, i.e. artificially planting species outside their usual distributional range.

The dramatic climate change that is predicted calls for **new approaches and activities**. In the future, it may not be sufficient to just rely on natural regeneration, assuming that natural regeneration is always best suited for a particular site. Planting genetically improved, more drought-prone tree seedlings may be required. Another response is the introduction of non-native trees into mixed forests (e.g. Douglas fir, *Pseudotsuga menziesii*), choosing species that are more drought resistant and at the same time able to grow faster and sequester more carbon than native species.

Forests which are left to grow naturally without any silvicultural intervention may achieve the maximum biomass and carbon stock, however they are frequently very dense and less structured than managed stands. The diameter of the trees is thinner and the height/diameter larger, increasing the risk of windthrow, forest fire and pest attacks. A proper forest management strategy will strive to nurture **species-rich and structurally diverse forests**, favouring indigenous, high-value trees with the potential to produce long-lasting timber products.

In order to address **climate change-related damages and disturbances** (biotic and abiotic), active protection measures by forest protection specialists or entomologists are needed alongside preventive measures. Besides, silvicultural operations such as tending, selective thinning or sanitary cuttings can contribute to more robust forest stands and reduce the fuel load in dry forests susceptible to forest fires. Putting large areas out of production or leaving them for natural succession after fire or insect attack is not recommended, since this will certainly reduce the mitigation effect of the forest. Besides, the importance of hunting to bring the population density of browsing animals to an acceptable, ecologically-balanced level and thus allowing natural regeneration of a variety of native species, must not be forgotten. In fact, many forests suffer from browsing damage which makes the forests more susceptible to climate change impacts.

Forest fires are now an EU-wide concern. In the Mediterranean region, fire is becoming deadlier, while in Central and Northern Europe, unusually dry summers have recently led to forest fires in countries which have historically seen very few. Forest fires not only represent a serious danger for human beings and rural areas, environment and biodiversity, but also a serious threat to the climate change mitigation potential of forests. EUSTAFOR believes that sustainable forest management practices have an important role to play in improving resilience against forest fires, thus reducing fire's impact on climate change. Managed forests often have lower tree density and a lower accumulation of dead/dry biomass, which makes them less prone to fire than unmanaged forests. Regular thinnings are also key for forest fire prevention and can be economically attractive for forest owners and managers, thanks to new developing markets for small dimension roundwood and harvest residues. These practices, in addition to carefully planned and implemented preparedness and prevention measures, contribute to positive long-term impacts on forest resilience, while being adapted to the local conditions of European forest ecosystems.

Conservation of primary forests and propagation of carbon-rich forests should focus on areas which have not been harvested before and which host endangered species or have a high biodiversity, based on clearly-defined criteria. Even from a biodiversity perspective, some silvicultural interventions may be required to foster the growth of endangered plant species.

The EU's Green Deal proposes massive **reforestation programmes** in response to the climate crisis. The Irish case study provides an example of establishing native woodlands on degraded peatlands. However, in many of the more densely forested European countries the potential for new afforestation is limited, due to the scarcity of suitable land and competition from other land uses (e.g. grazing). Besides, new afforestation is costly. With appropriate financial incentives, it should yet be possible to increase afforestation efforts in the future, especially on degraded and marginalized land. Other less capital-intensive options could be assisted **natural regeneration in canopy gaps and enrichment plantings** in bushlands or open woodlands. Moreover, natural successions can be steered with limited human interventions, if conditions allow.

Well-designed EU strategies and financial instruments are needed more than ever. Only healthy and thriving forests can efficiently provide climate-related services.

The case studies present a variety of activities that EUSTAFOR members are already implementing, to cope with climate change. These additional activities are frequently not part of routine management activities and thus have a cost associated with them. Moreover, climate change causes **significant losses** to EUSTAFOR member organizations, which are likely to increase in the future. A case in point is the recent severe damage of **1.2 million hectares** of European forests resulting from extreme weather and climate events, exacerbated by the effect of pests and diseases. Our members report that during the period 2018–2019 more than 36 million m³ of wood were lost, and recovery will require an additional workforce and funding of up to **800 million Euro**, presenting both logistical and financial challenges for many state forest organizations. Well-designed EU strategies and financial instruments are needed more than ever. Only healthy and thriving forests can efficiently provide climate-related services.

EUSTAFOR remains committed to supporting the European forest-based industry to decarbonize Europe by substituting critical or CO_2-intensive raw materials and fossil energy with forest-based alternatives. This requires **ensuring primary raw material supply** from sustainably managed forests, to satisfy the increasing demand for renewable biomass resources and climate-friendly products. An open dialogue with the forest-based industry will be sought in order to enhance productivity and resource-efficiency along the entire value chain, changing raw materials (different/new species, quality) and introducing new technologies and ways of use.

EUSTAFOR supports a future **European Green Deal** that concretely addresses the continuation of the transition to a more sustainable circular bioeconomy. The bioeconomy is a major opportunity to help build a carbon-neutral future in line with the climate objectives of the Paris Agreement, and contribute solutions to help meet the UN Sustainable Development Goals. Sustainably and efficiently produced biomass from the agricultural, forestry and marine sectors ("producing more and better"), and valorizing side-streams and bio-waste can contribute significantly to Europe's climate commitments. A strong **bioeconomy** will create jobs, stimulate growth and rejuvenate rural areas as well as reducing Europe's dependence on imports, while increasing the security of supply. In addition, it can enhance biodiversity through sustainable management of land and resources.

Last but not least, EUSTAFOR members are committed to **reducing their carbon footprint**. Most carbon emissions are caused by wood harvesting and transport, making the case for the introduction of new energy-saving technologies such as presented in the Swedish case and phasing out the use of fossil fuels.

KEY POLICY MESSAGES FROM EUROPEAN STATE FORESTS:

1. European forests and the forestry value chain have important strategic roles to play in climate change mitigation and adaptation.
2. EUSTAFOR supports the integration of European forests into the global climate and sustainable development architecture.
3. Forests must be actively and professionally managed to make them climate-fit and able to cope with the challenges of climate change.
4. Apart from carbon sequestration in living trees, the storage of carbon in forest products, as well as the substitution of biomass for fossil energy and construction materials, must be accounted for in line with an integrated and holistic approach towards the green economy.
5. Additional resources and financial incentives should be mobilized to make European forests more climate-fit and for the restoration of forests damaged by climate change.
6. Forest reference levels should not only be based on historical use and age-class distribution, but also on current policies and market trends.

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EUSTAFOR

A STRONG VOICE FOR SUSTAINABILITY AND USE OF FOREST RESOURCES

The European State Forest Association (EUSTAFOR) represents the voice of European state forest management organizations who have sustainable forest management and the production of wood as major concerns.

EUSTAFOR member organizations provide valuable, professional and experience-based knowledge about the sustainable and multifunctional management of state owned forests in order to support European forestry-relevant policy objectives.

As a forum for European state forest management organizations, EUSTAFOR advocates the positive results of the management of state forests as their contribution to society, particularly in terms of achieving Europe's sustainability strategies.

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