1

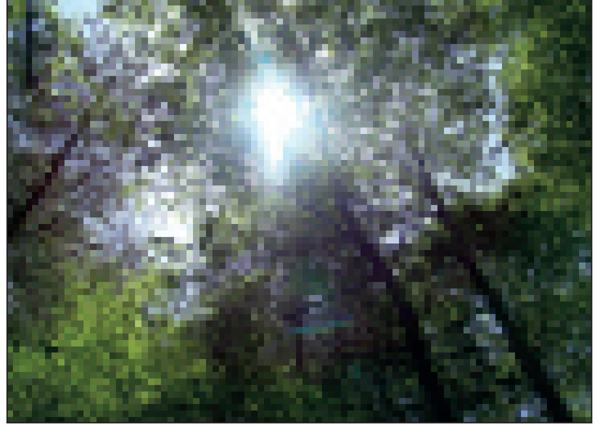
The real value of European forests

The forests and woodlands of Europe play a crucial role in the mitigation of climate change. More than 13 billion tonnes of carbon are locked away in the 70 million hectares of trees growing from Wales in the West to Slovakia in the East.

This vast forest area can help limit the climate change related temperature increase to 2°C and minimise its negative effects.

Climate change and the extreme weather conditions it brings are already causing major impacts across Europe. It is ever more critical that Europeans work together to ensure that forests can adapt to face the new challenges — droughts and flash floods, severe heat and frost, fires and insect and pest outbreaks.

The real value of European forests



The FUTUREforest project has brought together teams of specialists from seven regions across Europe who have looked at those threats and also the opportunities for climate change mitigation measures.

They have drawn up a framework to guide policy makers towards key decisions which will ensure a healthy future for European forests and enable them to adapt, providing society with continuing vital services.

Protecting society from flooding disasters

The average cost of flood damage in Europe over the last few decades amounted to approximately €4 billion per year.

- 2007– UK €4.3 billion
- 2002 – Germany, Czech Republic and Austria €17.4 billion
- 2000 – Italy, France and Switzerland €89.2 billion

Trees reduce the impact of heavy rains and flooding. Using trees as part of upstream soft engineering flood prevention schemes can provide sustainable, green options to counteract increasing flood risks. Trees also help keep towns and cities cool!

Clean drinking water for all

In Europe, almost 100 million hectares of forests are designated for water and soil protection. Forests are a crucial part of the landscape water cycle. They improve water quality by preventing erosion and filtering pollutants and sediments.

Capturing carbon – protecting the planet

European forests currently capture 236 million tonnes of carbon every year - equivalent to 9 per cent of Europe's annual greenhouse gas emissions.

By increasing the carbon stocks of European forests and locking up carbon in timber products, the forest sector massively contributes to climate change mitigation by removing CO_2 from the atmosphere.

Saving the soil, preventing landslides and erosion

Trees prevent soil erosion, land slides, avalanches, and desertification especially in mountainous and semi-arid areas by limiting run-off, holding the soil in place and decreasing wind speed.

Forests play a crucial role in preserving and improving soil fertility. They deepen and enrich the soil with their root systems, increasing the weathering of rocks and adding organic matter.

4 million jobs and support for the rural economy

Currently, 3.9 million people are employed throughout the forestry sector including the wood, pulp and paper processing industries - a number that is decreasing by roughly 7 per cent per decade. Investment to support and promote the forest sector and its products will stabilise and strengthen local economies, regional networks and improve social conditions particularly in rural non-industrialised regions.

Building a sustainable future – with timber

The thermal insulation qualities of wood are:

- 15 times better than concrete
- 400 times better than steel
- 1770 times better than aluminium

Every cubic metre of wood used as a substitute for other building materials saves around 2 tonnes of CO_2. This is made up of the CO_2 stored as carbon in the final product, and emissions avoided because of the lower energy consumption involved in manufacture.

Unique home to thousands of plant and animal species

Forests provide some of the most diverse habitats for a vast range of species. One single oak tree in the forest will be home to countless different plants and animals. Maintaining and improving this biodiversity is key to ensuring the resilience of our future forests.

2

FUTUREforest – 'Voice of the Regions'

The forests of Europe have a vital role to play as we face up to the challenge of climate change.

Europe needs a framework for national and regional policies that allows forests to do more to reduce the negative effects of climate change, provide better protection from natural disasters and boost rural economies.

Forest owners, decision makers and society must take action now to ensure that adaptation – and mitigation – is given top priority.

But this can only happen if there is a major investment in funding and new practices to ensure that forests are ready to withstand increasing natural threats.

How forests can do more for Europe

Given the right support and direction the 'green lung' of Europe can provide even more benefits for generations to come.

Following three years of inter-regional exchange, the partners of FUTUREforest have jointly drawn up a prioritised key list of essential issues that must be addressed immediately.

Innovation in policy

New policies – legislation and financial support schemes created in consultation with all stakeholder schemes - must play a much stronger role in the adaptation process.

FUTUREforest has already proved how different regions and stakeholders across the regions can exchange innovative concepts and create frameworks for effective political tools.

Support for forest owners and legal changes to encourage sustainable forest management and provide greater flexibility are needed to ensure healthy European forests which can deliver multiple benefits throughout this century and beyond.

Better communication

Climate change will considerably alter the natural environment in most European regions. Practitioners and society know much less about the complex nature of the expected developments than most experts imagine.

Urban-based decision makers do not fully understand rural regions and foresters do not effectively engage in political processes.

Foresters must start to better communicate their experience with - and knowledge of - nature and the protection of forest ecosystems.

The forestry sector must establish closer links to politicians, policy makers, and opinion formers to ensure a better understanding of sustainably managed forests and their benefits.

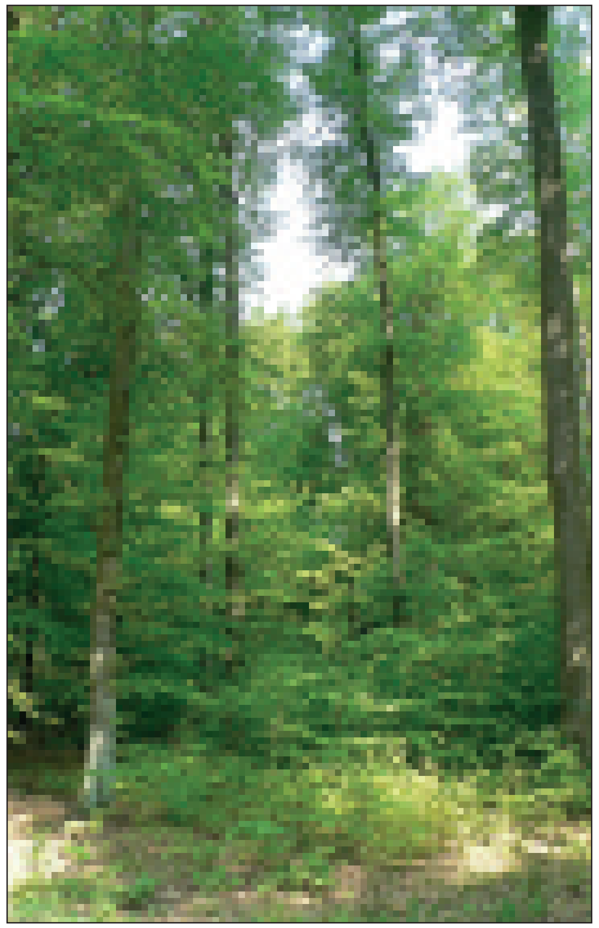
Tackling natural risks

Droughts and flooding, pests and diseases, fires and storms will increasingly threaten forest vitality and stability, reducing the protection of soil, water, towns and villages.

Practical forest management and scientific research must be strongly focused on improving risk prediction and the identification of vulnerability zones.

Monitoring and evaluation of often highly interlinked risks must be compulsory to allow rapid, effective counteractive measures. National monitoring systems should be continuously improved and harmonised between EU member states.

Emergency plans should also be compulsory for each risk, prioritising civil protection and damage limitation. Forest agencies need to develop greater capacity for crisis management.



Urgent action is needed - doing nothing is often the most expensive option. Pro-active, preventive risk management must immediately become an integral part of land and forest management planning to increase forest ecosystem resilience.

Integrate water management

More extreme weather conditions mean some regions will experience a water surplus - but most others can expect water shortages.

European regions with humid climatic conditions will have to consider how to manage excess water. Regions with high risk of drought will need to improve water retention within forests.

Forest practices including species choice and silvicultural management must protect water resources especially in regions most at risk, such as the Mediterranean.

Clear indicators of drought risk across each region must be established and the capacity of forest ecosystems to store water must be better understood.

The role forests play in the landscape water cycle and management of water resources must be publicly recognised. The Water Framework Directive should be used to help balance multiple regional demands. Foresters can and should contribute to river basin management plans.

All relevant stakeholders must be involved in decisions on water management to find acceptable solutions and to co-ordinate forestry, agriculture, and water policies. Forest owners should benefit financially for the continued provision of ecosystem services such as flood prevention and drinking water.

Adapting forestry

Nature knows best. Integrating natural processes into forest management offers one of the most effective methods of achieving economic and ecological success.

Highly structured diverse forests offer a wider range of forest management options compared to even-aged monocultures – a major advantage in the face of future uncertainties. Climate change increases the rate of change and so there needs to be scientific support for the adaptation process.

A wealth of different forest management measures are identified in this report which should be implemented according to each region's needs.

Sustainable forest management is the most cost effective way of increasing forest resilience to climate change threats and providing multiple benefits to society.

Protecting biodiversity

The true value of the millions of species supported in our forests has not yet been fully understood.

Existing national schemes of forest health and biodiversity monitoring must be integrated into a pan-European network. This should be used to study the long-term effects of climate change on biodiversity and to evaluate the effect of different types of forest management.

Silvicultural systems that create diversity of tree species, age classes, structures and micro-habitats within forest stands and landscapes must be promoted and incentivised.

Forest owners should be encouraged to choose measures which favour biodiversity, to restore and maintain forest corridors for species migration and to develop or restore endangered habitats.

But forests should not become purely nature reserves; they must also be maintained as multifunctional systems using sustainable forest management.

Biodiversity should be one of the key goals of forest management, making forests resilient to the effects of climate change. Forest management plans must include measures to protect and increase species diversity.

Saving forest soils

In a changing climate, forest soils are threatened by deforestation, changing temperature and moisture, loss of fertility and by increased pressure from land use.

Soil is the only non-renewable resource and so the protection, restoration and improvement of soils are essential to sustainable forest management.

More research is needed to understand the effects of different silvicultural practices on soil fertility and carbon dynamics. Forest management should aim at improving soil fertility and maximising soil carbon stocks.

Areas at high risk of erosion, carbon loss, landslides and compaction must be identified during landscape planning procedures and made part of specific management plans.

Forest managers and owners need to understand the importance of soil management and protection. Incentives should be developed for promoting soil-conservation in forest management through site-adapted species selection, low impact machinery use and erosion prevention.

"It should be a key priority to maximise timber processing and finishing in the country where it is produced to maximise local economic benefits"

Promoting forest products

Adaptation measures to climate proof European forests can either be financed by selling forest products or by public subsidies.

Marketing sustainably produced timber and non-timber forest products needs to be a priority.

Unmanaged forests - particularly small woodlands - need to be brought into management for carbon sequestration and provision of renewable materials.

Forest Ownership Associations, incentivisation schemes and improved forest infrastructure should be used to achieve this.

The promotion of new markets for timber, fibre, wood fuel and other forest products can generate new income to forest owners.

Diversification into non-timber products and services should also be incentivised.

Increased use of timber and other forest products should be supported and secured to improve carbon storage and maintain or establish a healthy forestry sector, particularly in rural areas.

Improve carbon sequestration

Forest carbon capture, storage and substitution of fossil fuels or high-carbon construction materials with wood are critical to climate change mitigation.

Active forest management must aim to increase carbon storage in timber and forest soils. Loss of carbon due to deforestation and disturbances needs to be minimised by legal regulation and risk management. Afforestation is one of the most effective ways to increase forest carbon stocks.

Forest management also needs to focus on maintaining or increasing forest soil carbon storage. The soil is a carbon pool that is just as important as tree biomass, but will be affected by climate change in yet unknown ways.

European and regional incentives for the substitution of steel, concrete and plastic with timber must be created. The substitution of energy sources such as oil, gas and coal with non-construction grade timber should also be incentivised.

The political framework must credit forestry for its substitution benefits and carbon storage in harvested wood products. Carbon accounting rules for forest management must be improved and take into account carbon loss due to natural disturbances.

3 Mitigating climate change and benefits to society

Forests are long-lived systems that are shaped according to the expectations of one generation, but have to fulfil the needs of later generations. Many of the trees in today's forests will not be cut before 2100. Some oaks which are harvested today have been planted when France needed masts for its sailing ships. Forests near cities are currently highly welcome leisure grounds, but have been planted a long time ago for the hunting pleasure of dukes and kings.

What will the future look like? For what purposes may the timber be used and how will it be processed? How will climate change affect European forests and woodlands?

Shaping the future of Europe's forests

Imagining the future is especially difficult when it is far beyond a human lifetime. Nevertheless, current forest policies and silvicultural measures shape the forests of the future.

How can sustainable forest management be realised? How can the needs of future generations yet unknown to us be met by means of today's policy decisions?

The future doesn't evolve merely by chance. It is not a fate that has to be accepted but rather the result of many decisions and actions. The future is man-made.

From today's perspective, numerous aspects are particularly important for designing future-oriented forest policies:

- Climate change
- Globalisation and international markets
- New perspectives and technologies for wood utilisation
- Land use conflicts
- Demographic, societal and cultural changes

The Interreg IVc project FUTUREforest has dealt mainly with the challenges of climate change. In cooperation with scientists, practitioners, policy makers and government co-workers in forestry, adaptation strategies, political instruments and management tools have been exchanged and developed by partners from seven European regions characterised by different forest types as the basis for future-oriented European, national and regional forest policies.

The changing climate

Increasing temperatures are likely the most obvious sign of the changing climate. During the last 100 years, the average global temperature has risen by 0.7°C. The ten hottest years since the beginning of meteorological monitoring have occurred after 1990. As a result, extreme weather events occur more often, precipitation patterns are changing, glaciers are melting, and the arctic ice shield is getting thinner and thinner.

Without immediate and strong action to considerably reduce greenhouse gas emissions, global temperatures will increase by as much as 6°C until 2100.

Currently, 20.6 billion tonnes of CO_2 are emitted every year. These emissions mainly originate from electricity production (32 per cent), industry (22 per cent), and transport (18 per cent). More than half of the emissions are generated by OECD countries, out of which the European Union is responsible for 4 billion tonnes.

To ensure adequate living conditions on earth, the global temperature increase needs to be limited to 2°C, and the atmospheric CO_2 concentration to 450 ppm. To achieve this, global CO_2 emissions must be decreased by 80 per cent by 2050.

Forests can change the climate

Forests and woodlands play an important role in the climate regulation. During photosynthesis they capture atmospheric CO_2 and transform it to solid carbon in forest biomass, litter, and later to soil organic carbon. To produce one ton of timber, 1.9 tonnes of CO_2 must be transformed — forests are natural carbon pumps and stores.

Globally, forests and woodlands cover about one third of the land area, i.e. around 4 billion hectares. They account for about 90 per cent of the annual exchange of carbon between atmosphere and land and contain carbon stocks equivalent to 4,500 billion tonnes of CO_2. This is more than the total carbon contained in the world's oil reserves. Forests are therefore an important part of the answer to climate change.

However, forests and woodlands also substantially suffer from climate change. In Europe, Mediterranean forests are most negatively affected, followed by the continental forest areas. Less precipitation and longer drought periods stress the plants, which may then be attacked by insects and pests, resulting in drastically reduced growth rates or tree death.

Forests are truly European

In historical times, Europe was mainly covered with woodlands. In the course of history, this natural resource has repeatedly been over-exploited. An understanding for the concept of sustainability has only been developed with the birth of forest science in central Europe during the 18th century. Ever since, European foresters have shaped European forests to the present day according to cultural and societal expectations.

Policy and climate change

As a result of change, new challenges have always been tackled by scientific research, policy and communication. The understanding of the necessity to integrate different areas of policy has awakened along with the concept of sustainable development as a basis for human survival.

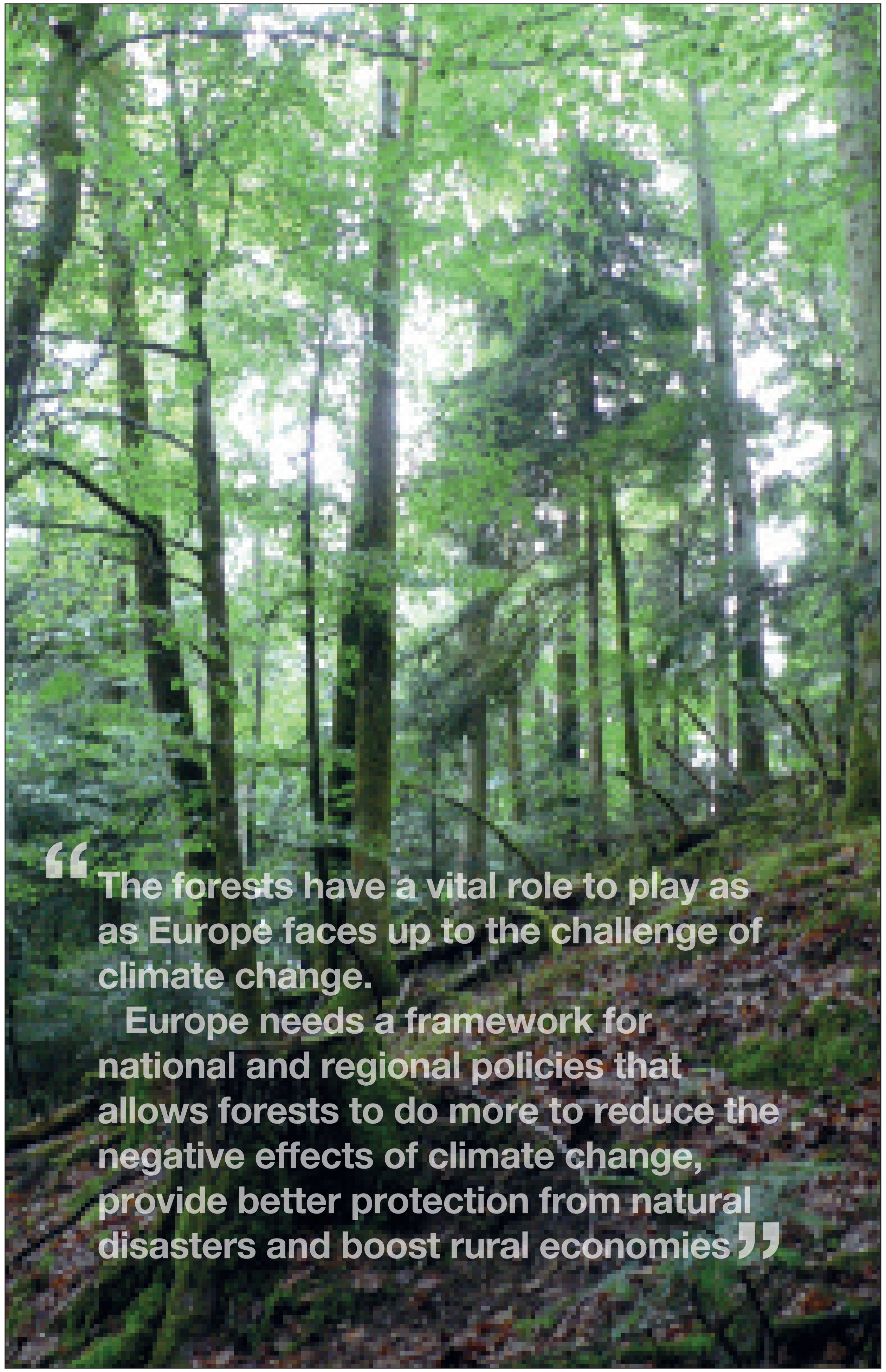
Policy needs to address issues such as regional development, tourism, agriculture, water management, biodiversity, soil protection, forestry and climate change.

In 1997, 40 of the largest industrial countries have committed themselves in Kyoto to reduce their CO_2 emissions by 5.2 per cent until 2012 in comparison to 1990. Surpassing this goal, the 15 member states of the former European Union have decided to reduce their CO_2 emissions by 8 per cent, with individual states committing themselves to as much as 21 per cent. The current European Union wants to reach a reduction of 20 per cent by 2020, and has announced an additional 10 per cent reduction if other industrialised nations are ready to considerably strengthen their efforts.

Beyond these commitments, European and regional policies require considerable adaptation to address the expected effects of climate change in an efficient way and to allow for immediate action targeted at the most severe problems. FUTUREforest has searched for instruments of integrated forest policy to better cope with the structural changes to come.

In light of the importance of rural areas for resource availability and sustainable development, policies for rural areas must receive a higher attention than currently. Forests and woodlands with their particular ecological and social potential for climate change mitigation have to be acknowledged as essential landscape components and their functionality redefined. New forms of communication and solutions are needed — both locally and on the European level.

FUTUREforest has worked towards changes in forest policy, forest management and society by sensitising rural and metropolitan spaces in Europe for this new common understanding of the role of forests.



"The forests have a vital role to play as as Europe faces up to the challenge of climate change.

Europe needs a framework for national and regional policies that allows forests to do more to reduce the negative effects of climate change, provide better protection from natural disasters and boost rural economies"

4

Forests of the regions – now and looking forward

The seven regions of the FUTUREforest project – Auvergne, Brandenburg, Bulgaria, Catalonia, Latvia, Slovakia and Wales – are each very different. From the dry hills of Bulgaria and Catalonia to the wet uplands of Wales temperatures, topography and forest management can be very different.

This chapter gives a snapshot of how each of the partner's forests are now and also looks at how they are preparing for the future – sometimes in surprisingly very similar ways.

Forests of the regions – now and looking forward

4.1 Forests in Auvergne

Today and tomorrow

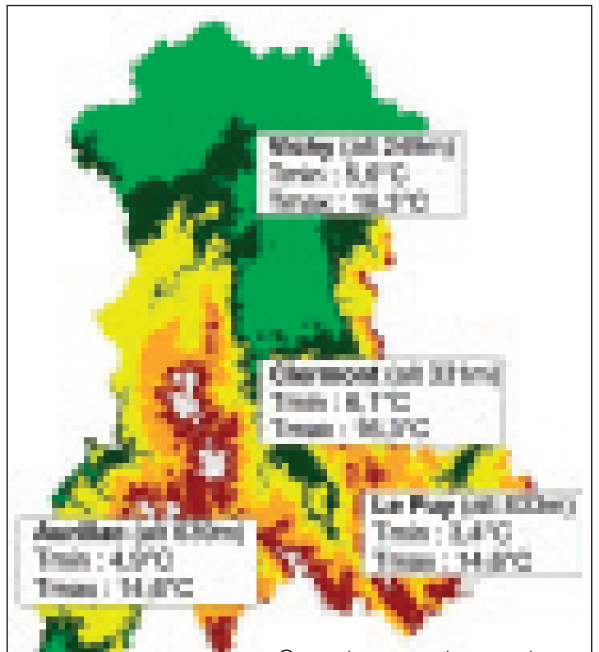
The Auvergne region is located on a part of a 500 million year old massif named "massif central" which contains numerous extinct volcanoes. The highest altitude is 1886 m – the Puy de Sancy - and the lowest about 300 m. This creates a wide range of relief: mountains, deep valleys, volcanic plateaus in the south and in the centre, and plains in the north.

Because of its particular location, the Auvergne is influenced by several different climates:

- Continental in the east and north-east
- Oceanic in the west
- Mediterranean in the south
- These influences are modified by the altitudinal effect of the topography.

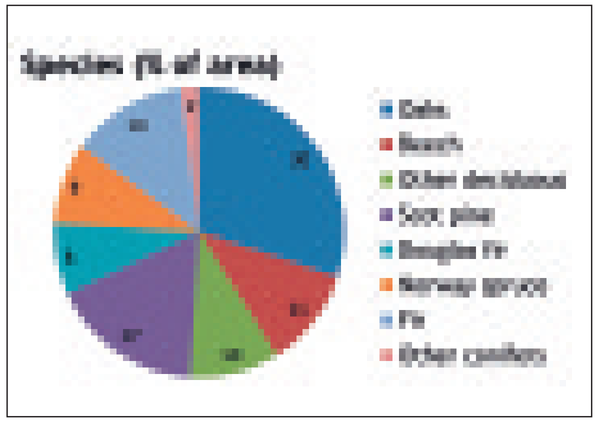
During the last 150 years, the Auvergne forest has doubled in area. Nowadays, forests in the Auvergne cover an area of 694,000 ha – amounting to 27 per cent of the region and 5 per cent of the entire French forest. The current afforestation rate (27 per cent) is similar to the French national average.

Public and private forests amount to 113,000 ha (16 per cent) and 581,000 ha (84 per cent), respectively, with 9 per cent of the entire forest area under protection.



Current average temperatures in Auvergne

Average precipitation in mm (1971-2000)		
Location	**January**	**July**
Vichy (249 m a.s.l.)	49.6	65.2
Clermont Ferrand (331 m a.s.l.)	28.7	53.6
Aurillac (639 m a.s.l.)	96.4	70.6
Le Puy en Velay (633 m a.s.l.)	41.2	53.4



Climate change effects

Europe is confronted with sanitary crises or exceptional climate-related events.

Decay and mistletoe attack
Decay and mistletoe presence have increased in silver fir forests in the south of Livradois-Forez, a region where Silver fir is very important. Numerous decays were observed and large areas were seriously attacked by mistletoe. The decay has a multifactorial origin and is associated with southern exposures. Climate change will therefore be an aggravating factor. The lack of forest management in the area leads to over-mature forests, which are more prone to decay and mistletoe attack. Forestry must be adapted to face these problems, particularly the decay. Forest management should become more dynamic and regular.

New distribution of pests and diseases: the example of the pine processionary moth.
The area damaged by the Pine processionary moth in France has steadily increased: it's moving north and to higher altitudes**.**

More frequent extreme climatic events.
France had to face 4 major storms (in 1982, 1999, 2009 and 2010) and 1 serious drought (in 2003) during the last 30 years. These events caused considerable damage and the forest industry was severely impacted. Thousands of hectares were destroyed and billions of cubic meters of wood had to be harvested and urgently sold. Often, this damage is followed by important sanitary problems which cause almost as severe additional damage.

Where we will be in 2050

Today, even if the extent of the expected climatic changes is uncertain, scientists agree that there will be indeed a change of the climate in France by the end of the century.

The IPCC - Intergovernmental Panel on Climate Change - elaborated several scenarios of potential development of greenhouse gas emissions. The scenario B2 - a moderate emission scenario – translates to the following changes for France by 2100:

Temperatures in 2050
(in °C; in brackets: change from 1971-2000)

Location	January		July	
	T min	T max	T min	T max
Vichy	0 (+0.4)	5.7 (-1.5)	19.3 (+6.6)	32.4 (+6.6)
Clermont Ferrand	0 (+0.3)	5.8 (-1.5)	18.5 (+5.1)	31.3 (+5.4)
Aurillac	0 (+1.1)	4.6 (-1.8)	14.5 (+2.8)	29.4 (+5.9)
Le Puy en Velay	0 (+2.9)	4.8 (-0.1)	14.7 (+4.1)	30.6 (+6.4)

Precipitation in 2050
(in mm; in brackets: change from 1971-2000)

Location	January	July
Vichy	27.9 (-21.7)	21.7 (-43.5)
Clermont Ferrand	34.1 (+5.4)	15.5 (-38.1)
Aurillac	37.2 (-59.2)	31.0 (-39.6)
Le Puy en Velay	31.0 (-10.2)	15.5 (-37.9)

- A general increase of the annual average temperature of 2-2.5°C), with a particular increase of summer temperatures (<+4°C in the South)
- A change of the precipitation regime, with a sensitive decrease during the vegetation period
- More frequent and greater extreme events such as drought, heat waves, violent rains and possibly storms.

The main consequences expected for forests:
Foresters will have to take into account the changes of conditions such as soil or climate which were considered stable until now.

Movements of species distribution areas

- The phenomenon of decay will become more frequent and more important, especially in vulnerable situations: forest species at the edge of their distribution area, following repeated summer droughts, repeated attacks of insects favoured by warmer winters
- Modification of biotic communities and destabilisation of tree-bioagressor relationships as parasitic species move north
- Modification and shift of natural habitats (RBI, Natura 2000).

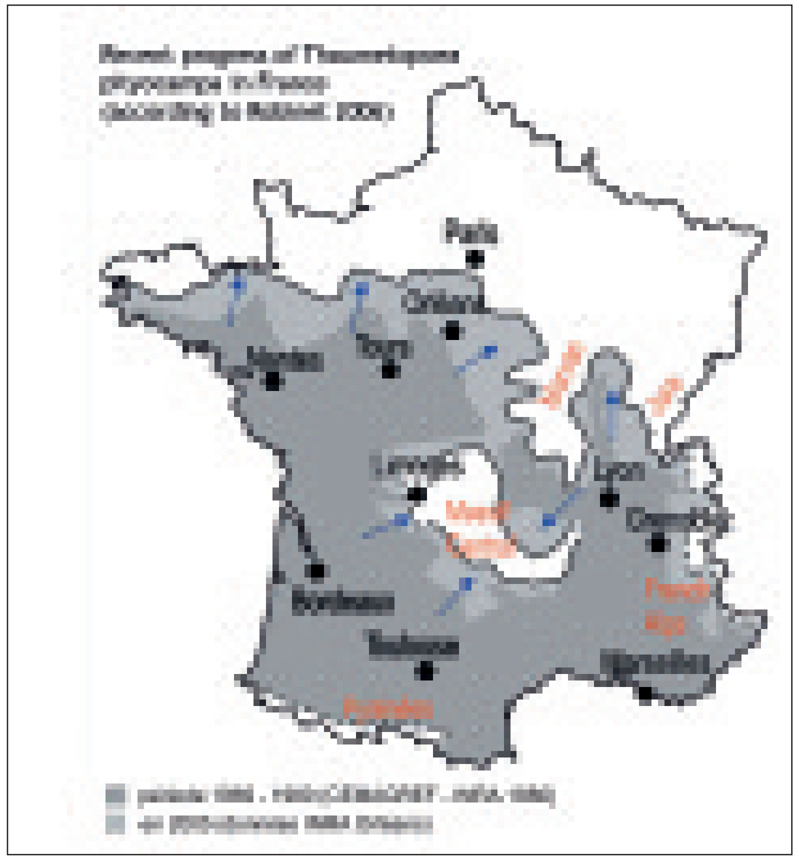
Appearance of new risks

- Increase of the fire risk in regions not at risk until now
- Increased risk of sanitary crisis or stand decay
- Continuing risk of storms, with an increase of the stand sensibility due to increased stand heights and volumes
- Evolution contrasted in the time and in the space of the wood production,
- Complication of harvesting operations: increase of the difficulties of skidding on sensitive soils, because of the reduction of the periods of frost and the increase of the soil water content in winter.

The effects on public forests
The scientific models and field measurements show that the productivity of several species has already strongly increased in the northern parts of France. Several causes contribute to this evolution:

- Global warming and elongation of the vegetation period
- Stimulating effect of the increasing CO_2 concentration in the atmosphere
- Fertilising effect of nitrogen deposition.

This trend could continue until the beginning of the 2100s – but only in places where it will not be offset by increasing water deficit or nutritional imbalance in poor soils.



Foresters have to anticipate climate change
if they don't want to be limited to managing only crisis situations which would lead to the exclusive harvesting of decayed or dead trees. This would considerably disturb the forest sector and the entire wood industry.

Foresters also have to deal with the different adaptation capacity of forest tree species. Hence, decisions taken at the time of the renewal of management documents and when silvicultural choices are made can reduce climate change effects.

4.2 Forests in Brandenburg

Today and tomorrow

Brandenburg is located in north-eastern Germany, in a region characterised by a temperate continental climate. Mean annual temperatures (1951–2000) range between 7.8°C in the north and 9.5°C in the south-east. With only 450–550 mm of average annual precipitation, Brandenburg is one of the driest regions in Germany. During the period of 1961-1998, the average natural ground water recharge tended to decrease on ~75 per cent of the area to an average of ~81 mm per year; a trend that is attributed to the observed increase of temperatures and decrease of summer precipitation during this period.

In addition, Brandenburg is characterised by mostly sandy soils with generally moderate to low nutrient content and water retention capacity. In combination with these soil characteristics, low precipitation rates result in a negative climatic water balance on more than 90 per cent of the area, i.e. more water is being used than recharged. The hydrological situation is therefore considered critical, particularly for tree species with a high water demand.

More resilient forest stands

Being located in the transition zone between climate zones, Brandenburg features a wide range of deciduous and coniferous tree species as part of its potential natural vegetation. However, Scots pine (*Pinus sylvestris*) is currently the most common tree species (ca. 80 per cent), with deciduous tree species stocking on only ~10 per cent of the area. The pine dominated forests in Brandenburg are mostly even-aged single-story stands, which are susceptible to abiotic and biotic damage. In particular, Brandenburg's forests are currently threatened by winter storms, summer drought, forest fire and insect outbreaks (e.g., bark beetles, gypsy moth).

Mixed forest stands are generally more resilient to damage and feature a higher adaptability to change. The conversion of even-aged pine forests to more site-adapted near-natural mixed forests has been one of the most important objectives of forest policy in Brandenburg throughout the last two decades.

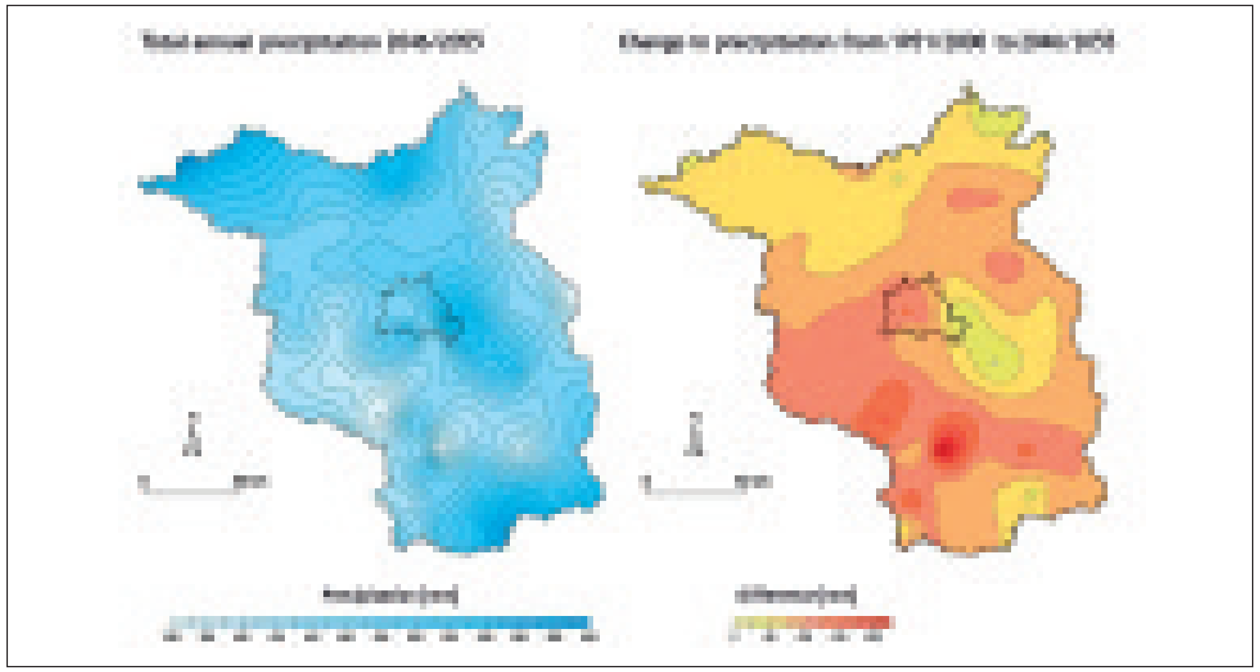
Forest conversion is generally achieved by advance planting of deciduous species such as beech and oak and preserving natural regeneration of secondary tree species such as birch or aspen. The planting of introduced species can be a measure for improving stand productivity (Douglas fir), fire resilience (Red oak), and soil conditions (Black locust), but it is associated with an ongoing critical discussion between forestry professionals and nature conservationists.

Due to the generally high game density in Brandenburg, however, the establishment of regeneration of tree species other than pine is often associated with costly protection measures. A reduction of game density is thus required to facilitate forest conversion in Brandenburg, and to take full advantage of the benefits of natural regeneration.

Increasing demand for timber

The integration of forest ecosystem processes into forest management resulted in the formulation of the 'near-natural forest management' paradigm, which is the essential guideline for forest management in Brandenburg.

The steadily increasing demand for timber for material and energetic use is constantly increasing the utilisation pressure on Brandenburg's forests. In light of the expected climatic changes, forest owners and managers are facing new challenges with respect to ensuring the multi-functionality of Brandenburg's forests.



Climate change impacts

Due to the already dry climatic conditions, negative effects of climate change will likely be observed earlier in Brandenburg compared to other regions in Germany. Regional prognoses of three climate models predict the following climatic changes for Brandenburg throughout the next 50 years:

- Moderate increase of mean annual temperatures of 1.8-2.3°C, with decreasing number of frost days and increasing number of heat days
- Slightly decreasing total precipitation; 10 per cent increase in winter precipitation; 18-22 per cent decrease in summer precipitation
- Increasingly negative climatic water balance, ground water recharge, and ground water and river levels
- Increasing probability of extreme weather events (e.g., storm, hail, heavy rainfall, etc.)

In consequence, the hydrological situation in Brandenburg will likely become highly critical. Lowlands, riverside forests, bogs and fens may lose their functionality and be displaced by drier forest types, thus further contributing to sinking ground water levels and aggravating hydrological problems.

Water availability critical

Water availability will thus become the most critical factor for forests and forest management in Brandenburg.

In combination with high temperatures and extreme weather events, the predicted water deficit will likely result in considerably increased risk of:

- Forest fire
- Drought and heat damage
- Insect outbreaks
- Regeneration failure

In addition, the distribution of tree, plant and animal species is expected to shift particularly in the transition zones between different climate zone likely resulting in increased competition for native species by foreign invasive species. The cultivation of drought-adapted tree species from southern Europe in Brandenburg can help to decrease the risk of drought damage, but will be complicated by the probability of frost occurrence.

Preservation of the forests

The introduction of more drought-resistant varieties of native tree species such a pine or oak is thus likely a more successful approach to maintaining forest functionality.

Particularly on sandy soils in the drier parts of Brandenburg and in heavily damaged forest areas, the regeneration of forests may become increasingly difficult due to the expected heat and drought periods. Timber production as a forest management objective may become secondary to the preservation of forests and their functionality as an ecosystem.

4 Forests of the regions – now and looking forward

4.3 Forests in Bulgaria

Today and tomorrow

The Republic of Bulgaria is situated in the South-Eastern part of Europe. The country's territory is 111,000 km^2. The climate is temperate with cold, damp winters and hot, dry summers. With average altitude above sea level 470 m, Bulgaria features notable diversity with the landscape ranging from the Alpine snow-capped peaks in Rila (including the highest peak of the Balkan Peninsula - Musala, at 2925 meters), Pirin and the Stara Planina to the mild and sunny Black Sea coast; from the typically continental Danubian Plain in the north to the strong Mediterranean climatic influence in the southernmost parts of country.

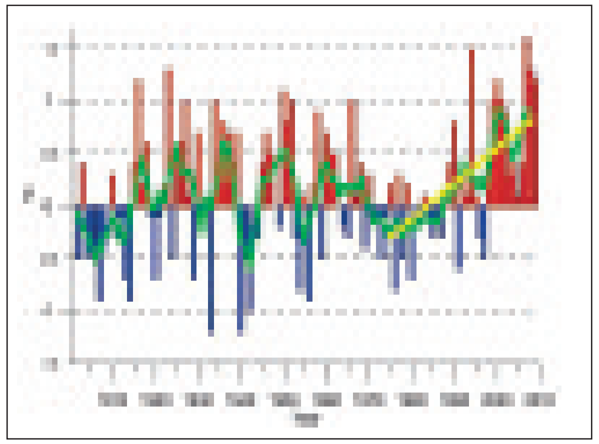
National wealth and identity

The forests of Bulgaria are recognised by the Bulgarian society as part of the national wealth and national identity. Their economic, social and ecological functions are of great importance for the sustainable development of the society and for the improvement of living conditions, especially in rural and mountain areas.

In 2010, the total Forest Fund in Bulgaria covers 4,138 million hectares or 38 per cent of the territory of the country. Broad-leaved forests cover approximately 70 per cent, and coniferous forests 30 per cent. By origin, natural stands make up more than 73 per cent of the forest. The growing stock of the Bulgarian forest is over 642 million m^3 with an average age of 53 years.

At the present moment the scientific community expects the negative impact of climate change to increase in the future. This will have serious negative impacts on nature and particularly on forest ecosystems.

In the course of the FUTUREforest project, the Bulgarian Executive Forest Agency developed the "Program of measures for the adaptation of the forests in the Republic of Bulgaria and mitigation of the negative impact of the climatic changes on them".



Average temperature in Bulgaria during the last century

The trend for warming in Bulgaria is recognisable since the 1970s. Eighteen of the last 21 years after 1990 are with positive anomalies of the average air temperature, compared with the baseline period of 1961–1990.

Extreme weather increases

From 1970 until 2009, average air temperatures increased by 1.2°C. The year 2009 was the 12th consecutive year with above-average temperatures. As a result of the temperature increase, the upper altitudinal limit of broadleaf forest ecosystems has moved to higher altitudes above sea level.

In addition, the frequency of extreme meteorological and climatic events such as heat waves, drought periods and heavy precipitation events increased over the last years.

Climate change is expected to proceed in the coming decades and will likely have serious negative impacts on forest ecosystems in Bulgaria. However, to assess the likelihood and the severity of these impacts, reliable climate predictions are needed.

Climate predictions for Bulgaria were only recently developed. Based on data from the European climate atlas, the FAO climate atlas, the climate guides of the Bulgarian National Institute for Meteorology and Hydrology, the database of the IPCC, DDC, the ATEAM project, the PRUDENCE database, the DIVA climatological database, and over 120 meteorological stations located from 0 to 2925 m a.s.l., climatic conditions were predicted for an optimistic, a realistic, and a pessimistic scenario for three 30-year periods after 1990 – until 2020, 2050 and 2080.

Vulnerability zones defined

On the basis of these scenarios, so-called "vulnerability zones" were defined – areas which will be significantly negatively influenced by climate change.

These vulnerability zones were defined with regard to issues like water management, soil protection, biodiversity protection, productivity, carbon sequestration and natural risks such as forest fires, storms, pests, and diseases.

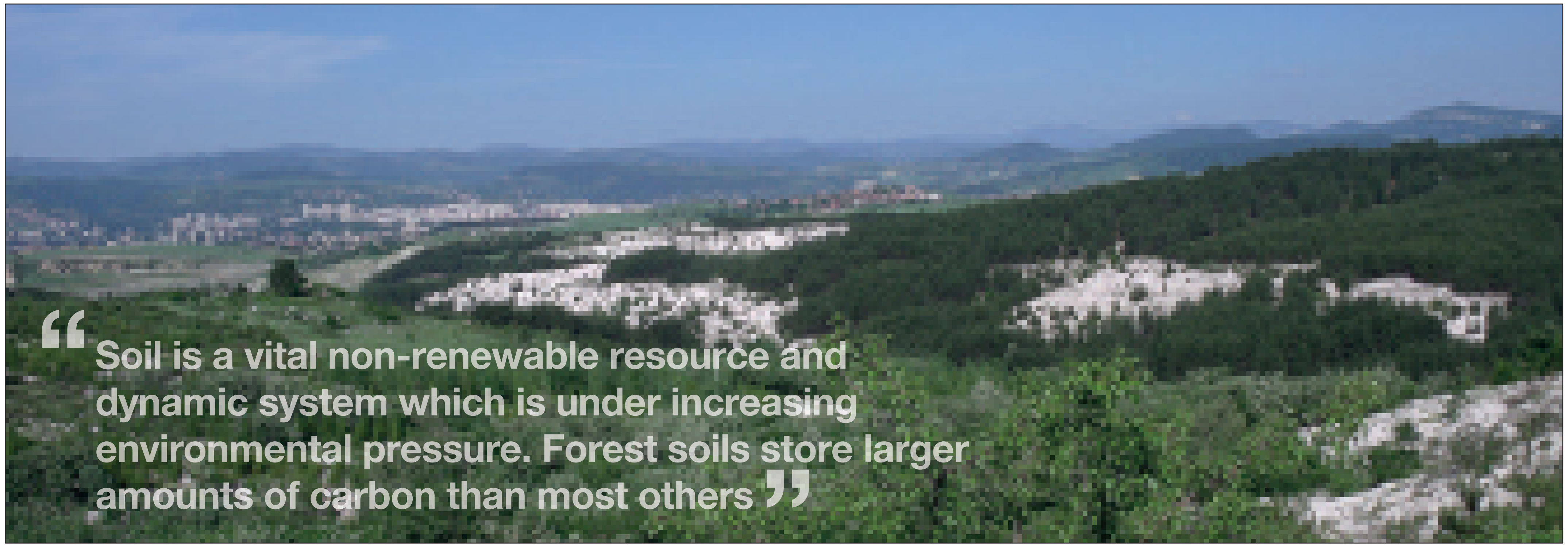
The first map shows the current drought risk in Bulgaria identifying zones with very high (drought index <20 shown in red) and high vulnerability levels (drought index 21-30 shown in yellow).

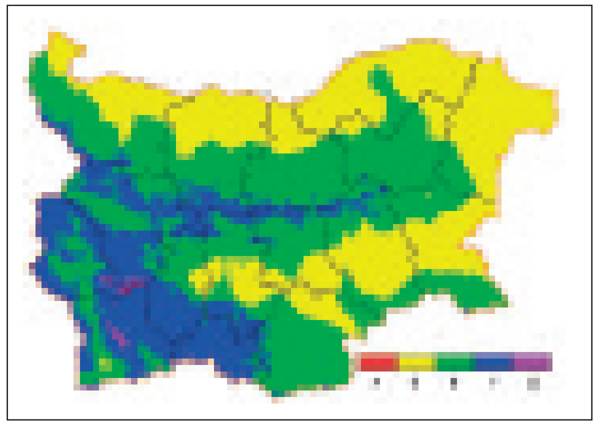
For the first period up to 2020, the realistic scenario shows that in very big parts of Bulgaria, mostly in the lowlands, the drought risk will likely significantly increase due to the expected increase of temperature and decrease of precipitation (Second map: red and yellow zones). The red areas are predicted to have a total loss of forest tree cover.

Increasing resilience

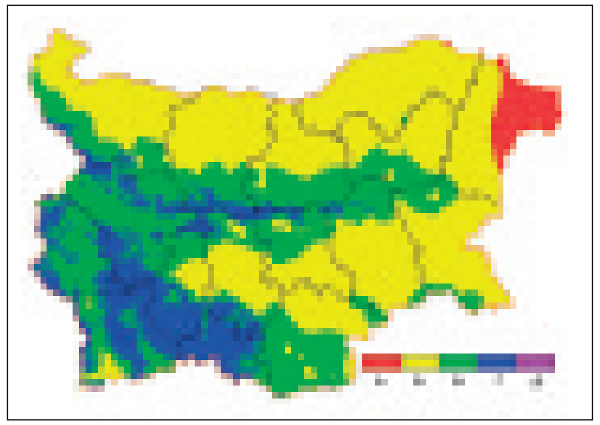
However, the uncertainty of the predictions is illustrated by the difference between the optimistic and pessimistic scenarios (third and fourth map) – and may make all the difference between the regional presence of absence of forests.

Future efforts of forestry in Bulgaria will therefore have to focus on the preservation of our forests by making them as resilient as possible to the expected impacts of climate change.

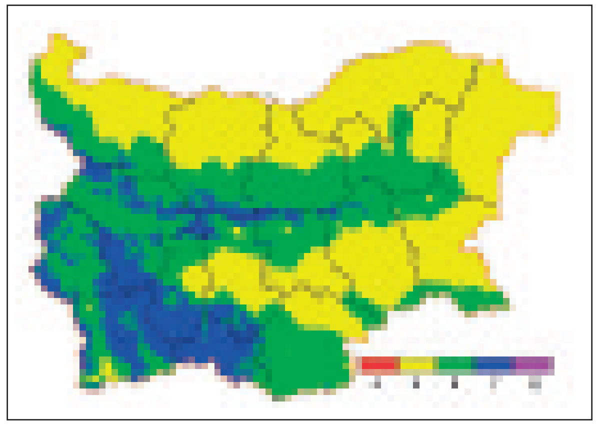


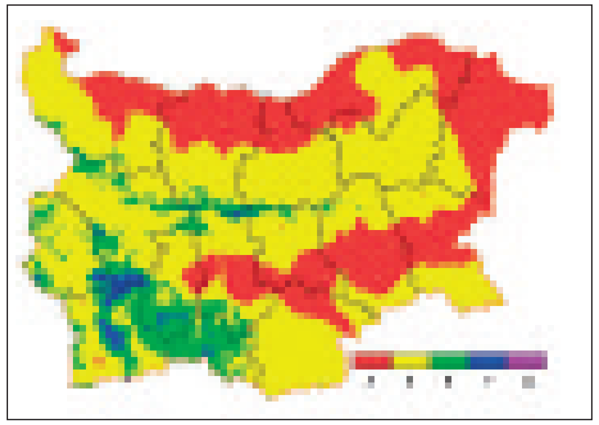


Current drought risk in Bulgaria



Predicted drought risk in Bulgaria in 2020





Uncertainty – predicted drought risk in Bulgaria in 2080 based on the optimistic (upper) and pessimistic (lower) scenario

4
Forests of the regions – now and looking forward

4.4 Forests in Catalonia

Today and tomorrow

A highly forested and diverse Mediterranean region
Catalonia is a Mediterranean region located in the north-east of Spain. The dominant climate is Mediterranean with a wide array of local microclimates depending on the altitude, continentality and topography. Mean annual temperature is 10 ºC (3 to 7 ºC in the inner zones) in winter and 25 ºC in summer. Mean annual rainfall is very diverse: from more than 1,400 mm in the Pyrenees to less than 400 mm in the inner zones. The evaporative demand is above 1,000-1,200 mm, i.e. already higher than precipitation.

Forested area in Catalonia - including not only forests but meadows and bushes - is around 2,000,000 hectares, amounting to 64 per cent of the whole Catalan territory, 65 per cent of which is covered by trees (38 per cent conifers; 27 per cent broadleaved). Within the conifers, the most abundant species are Aleppo Pine (*Pinus halepensis*), Scots Pine (*Pinus sylvestris*) and European Black Pine (*Pinus nigra*). Regarding broadleaved tree species, the main ones are Holm Oak (*Quercus ilex*), Downy Oak (*Quercus pubescens*) and Cork Oak (*Quercus suber*). Around 78 per cent of the forest area in Catalonia is privately owned.

Forestry in Catalonia can only be understood under the multifunctional forestry paradigm, which relies on multiple forest products - mainly timber, cork and biomass for energy, but also pinions and mushrooms - and numerous forest services - mainly conservation and recreation, but also water cycle regulation and carbon storage - although the latter do not have an impact on the economic turnover. Silviculture in Catalonia must make risk management compulsory, especially regarding fire, drought, pests, and extreme events.

Climate has already changed in the last 50 years…
During the 1950-2008 period, the mean annual temperature has risen in Catalonia by an average +0.21 ºC per decade (+0.35 ºC per decade in summer). Mean annual rainfall has decreased by 1 per cent, with a maximum decrease of 22 per cent in spring. 30 per cent of the Catalan area has experienced an increase of “dry streaks” - consecutive days in one year with rainfall less than 1 mm - at a rate of +2 days per decade.

... and this has direct effects on forests
Altitudinal changes of species distribution have already started, as well as phenological changes of the vegetation itself: there has been an extension of the growing season at a rate of +4 days per decade in the last 50 years. This increased evapotranspiration needs, which - together with warming and no increase in rainfall - has brought more intense drought conditions (higher aridity). Plants under such stress are more susceptible to the attack of pests and diseases.

Documented increase of disturbance events - such as large forest fires and wind storms - and decrease of forest carbon stocks (trees use their mobile carbon reserves to overcome drought periods) can also be linked to climate change.

Climate will keep changing
The 2nd Catalan report on climate change (Llebot *et al.*, 2010) summarises the predicted climatic changes for Catalonia in 2050 as follows:

- Temperature: 2 ºC higher
- Precipitation: no significant mean changes but up to 10 per cent decrease in spring
- Drought periods: increasing by +4 days per decade
- Extreme events: No clear trends, except for large forest fires, where risk will increase

The main factors affecting Catalan forests: higher aridity and less productivity
Higher evapotranspiration – due to warming and a longer vegetation period - together with no increment in precipitation results in higher aridity. This will bring changes in physiology, phenology, growth, reproduction, structure and functionality of ecosystems. These effects will vary depending on the species, and will change their competitive capacities and thus their distribution. It will also lead to drier conditions that might increase the risk of fires and pests as a result of reduced tree vitality. Consequently, models project a decrease in productivity in most of Catalonia.

Cork is one of the highest value products of Catalan forests. Its production is highly dependent on climate conditions

Where we will be in 2050

Mountains as biodiversity reserves
Trees will migrate to northern latitudes and higher altitudes, thus the higher mountains (i.e. the Pyrenees) will become true biodiversity reserves. Species extinction and biodiversity loss will be crucial issues in the coming years.

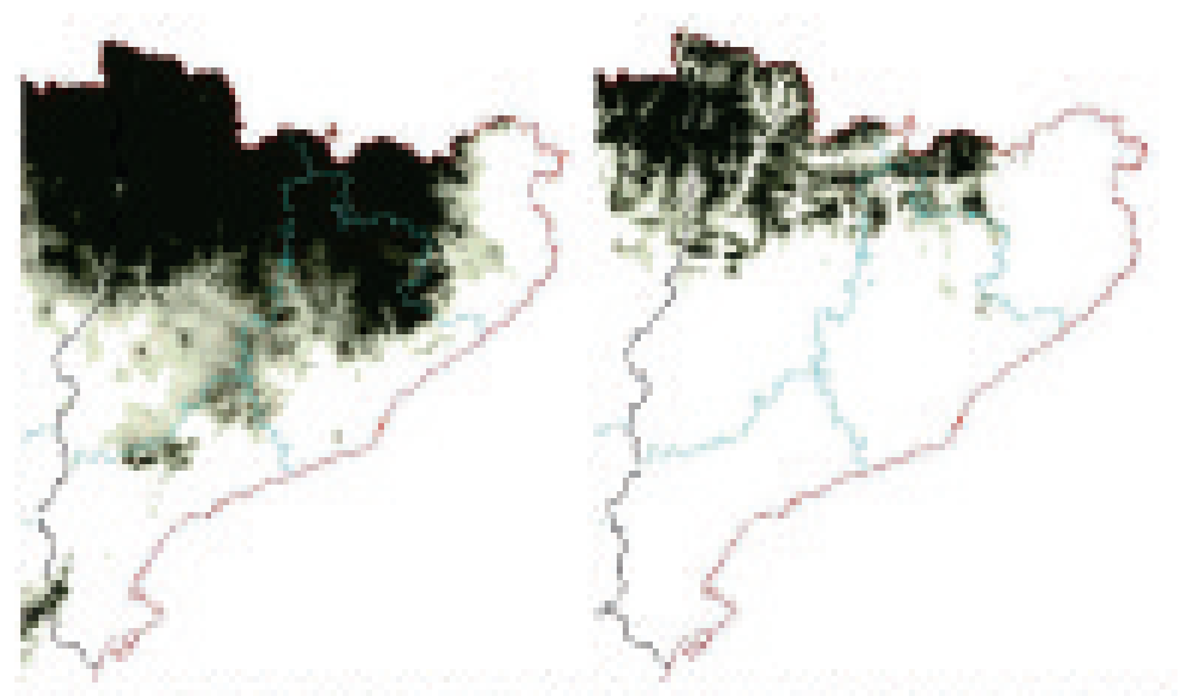
Forests: from sinks to sources of $C0_2$?
In some cases, forests could stop acting as carbon sinks and shift to become carbon sources, because of increased respiration rates due to increased drought. A reduction in the area covered by trees and higher fire damage could also lead to less carbon being sequestrated by Catalan forests.

Reduced area of timber productive tree species
Mountain forests and alpine meadows will become rarer. Species such as Scots pine, black pine or Beech, which are crucial for the Catalan timber industry, will be highly affected by the higher temperatures and longer drought periods; hence their presence will be endangered.

More area covered by Mediterranean species
Lowland and southern areas would become richer in bushy plants and the typically Mediterranean forest may be found higher up in mountainous areas. Mediterranean species such as Aleppo Pine, Holm Oak or European Black Pine will be more resistant and could even extend their area of distribution. The economic consequences of this shift have to be carefully considered: although Mediterranean forests are extraordinarily multifunctional in their products and services today, non-wood forest products and ecosystem services are not yet paid for.

Higher risks (drought, fire, pests)
Drought will decrease the vitality of trees, making them more vulnerable to pests and diseases. Catalan silviculture will have to be more focused on water availability. Forest fire risk will increase and the area under high-fire risk will be extended due to drought, abandonment of rural areas, succession towards young and over-dense forests and less intensive forest management.

Which options for action do we have?
The real impact of climate change in the Catalan forestry will strongly depend on how we prepare our forests. The equation is simple: the more resistant and resilient our forests and our forestry sector are, the more capable we will be to cope with the predicted changes and the uncertainty. This can only be achieved by taking urgent action now in planning forest management at all scales (regional, subregional and forest stand) as well as by developing new technical and political tools to cope with this new scenario.



4.5 Forests in Latvia

Today and tomorrow

Latvia is located in the hemiboreal forest zone, characterised by a mix of broadleaved and coniferous trees species. From the total of 2.96 million ha of forests (46 per cent of territory), Scots pine dominated stands cover 37 per cent, followed by birch (31 per cent) and Norway spruce (17 per cent). Notable areas are occupied by alders (10 per cent) and trembling aspen (4 per cent) ensuring an almost equal distribution of coniferous and broadleaved tree dominated stands.

Despite the previously dominating paradigm to create single-species stands, according to NFI approximately half of the total area can be characterised as mixed stands - with more than 20 per cent of yield from species other than the dominant one. Most pure stands are Scots pine stands located on poor sandy soils that were created after the last glaciation as a result of the gradual shrinking of the Baltic Sea. Portions of the pure Scots pine stands are located also on poor peat soils near swamps - about 10 per cent of Latvian territory consists of peat bogs, swamps and marshes.

Current regulations to favour a mixture of different species in thinning ensure that Latvian forests will also be classified as mixed both at stand and landscape levels in future.

Wind and snow damage

Landscape level mosaic is ensured by a diversity of forest types located on dry mineral soils (58 per cent), wet mineral (10 per cent) and peat (12 per cent) soils as well as drained mineral (10 per cent) and peat (10 per cent) soils.

The most severe damage in Latvian forests is caused by wind, sometimes in combination with snow: the area of stands completely destroyed by these causes during last 10 years exceeds the sum of that damaged by any other cause.

Increases in water level, mostly related to low control of beaver activity, have caused the decline of numerous other animal species known to cause damage in stands to the same extent as forest fires. Also, young forest stands – where moose, red deer and roe deer browse - have increased significantly – their numbers have doubled in last 15 years.

Tree vitality decrease

Browsing damage seldom leads to complete destruction of stands, but can notably impact the vitality of trees and therefore increase their susceptibility to other damage. The same is true for root rot, which is affecting on average 23 per cent TG of spruces.

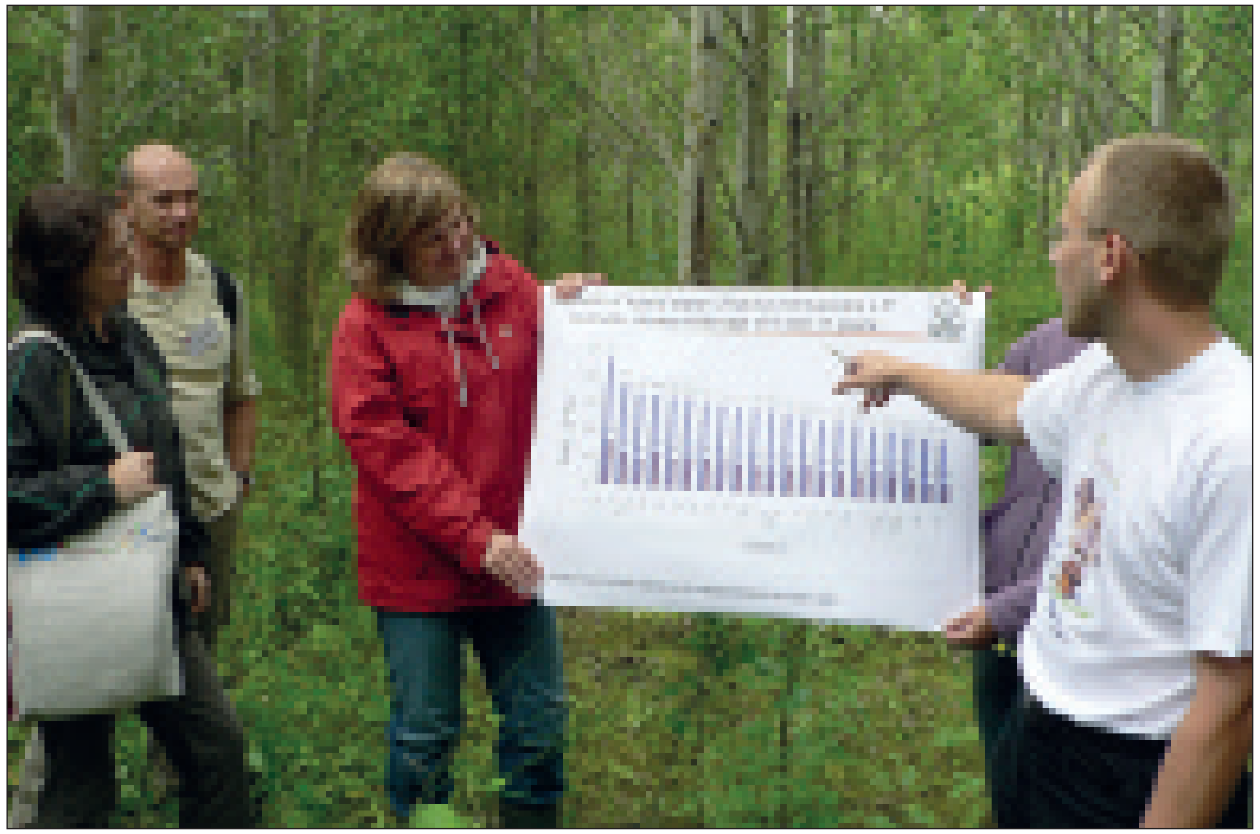
Decreased tree vitality in combination with wind damage is promoting the second largest threat for forest stands: insect damage, mostly caused by *Ips typographus* L., *Neodiprion sertifer* Geoffr., *Ips accuminatus* Gyll.

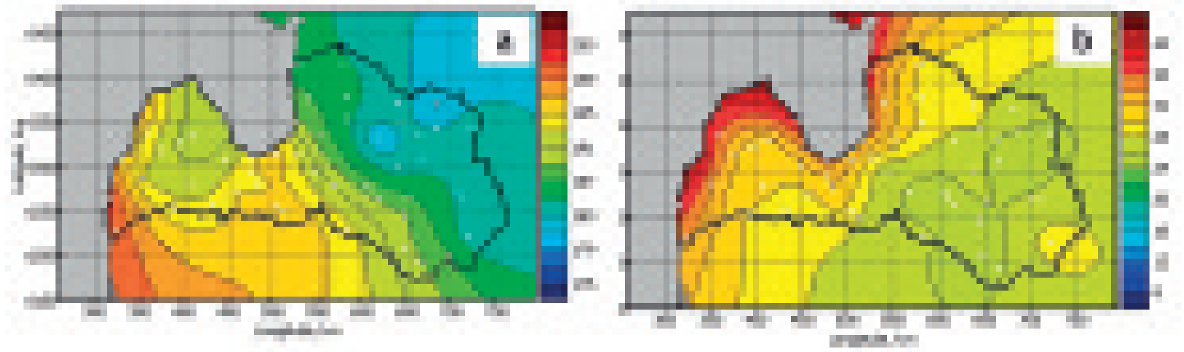
The climate in Latvia is influenced by Atlantic air masses in western parts and continental climate in eastern parts which affects the diversity of flora and fauna. Limits of the distribution ranges of many plant species intersect Latvian territory.

Ground frost decrease affects harvesting

The average temperature in January is -5 °C, in July 17 °C, with an average rate of precipitation 650 mm. The vegetation period lasts for 180-200 days. Already observed increases in temperature have affected the insect threat: new species have caused the destruction of forests in Latvian territory, for example *Lymantria dispar* L. which primarily attacks broadleaved trees.

Limited ground frost has affected the wind resistance of stands as well as forestry operations: soils are frozen less frequently during the winters, therefore harvesting is hardly possible in some areas and may cause notably more root damage, affecting the vitality of trees and spread of root rot.





(a) Average length of vegetation period in 1961-1990 and (b) predicted changes by mid-century (Bethers et.al., 2010)

Effects of climate change

Activities, that in the future could increase stability of trees to wind and that ensure fast development of forest stands, namely, planting and pre-commercial thinning, are carried out to a much lower extent in private forests than in state forests. For example, pre-commercial thinning is conducted on 26,000 ha of state forests but only 6,000 ha of private forests.

According to predictions, the following climatic changes will take place in Latvia within next 50 years:

- Moderate increase in temperature, more pronounced in winter (2.4-3.4°C) than in summer (0.7-2.0°C); winters will become more alike, but between-year differences in summer temperature is predicted to increase
- Average intensity of precipitation (mm per day) and sum of precipitation during the vegetation period is predicted to increase slightly (10-15 per cent), but precipitation will not be evenly distributed – the frequency of long periods (equal or more than 5 days) without precipitation will increase
- The number of cold days ($t < -5$°C) is expected to decrease by 30-50 per cent
- Notable deviations between the models for wind climate can be found, allowing only the conclusion that conditions will not become more favourable for forest management

The combination of the predictions indicates a notable increase in risks for forest management in the future. Favourable conditions for insects will likely increase population size and facilitate the immigration of new species, resulting in higher frequency of insect damage in forests.

Closer cooperation at EU scale is required using early warning systems and research. Further elaboration of integrated plant protection methods need to be developed, accepted and used in forests.

The public value of the forest far exceeds the material value of the timber - therefore ensuring the vitality of forests stands is a very important goal.

Increased future drought risk requires investments in the development of infrastructure for efficient fire prevention and control.

Forest management – the next step

Climate change is also likely to cause difficulties with forest regeneration, and planting with material of high genetic and physiological quality should be encouraged. Using different provenances of common species with desired properties needs to be considered as an option for further adaptation.

Next steps in forest management – early thinning – should especially be encouraged (using support mechanisms) to ensure higher stability of trees in future, and therefore also higher resistance.

Dynamic changes in climatic conditions will also require dynamic concepts of nature protection, elaborated at EU scale, to ensure, that rare species are protected in areas, where future conditions allow their survival. It also requires a close look at the definition of “exotic species”, based not only on current but also future climatic conditions.

For example, *Fagus silvatica* might as well be considered naturally suitable for Latvian conditions according to the predictions of climatic conditions by the end of the century.

Current location of areas (marked in yellow) where temperature and precipitation regime is similar to that predicted in Latvia by the end of the century.

4.6 Forests in Slovakia

Today and tomorrow

The Slovak Republic (SR) is located in Central Europe and has a total area of 49,034 km². It belongs to naturally diversified landscapes: the west and north are covered by the Western Carpathian Mountains and large lowlands cover the south.

According to global climatological classification, the Slovak Republic is located in the temperate climatic zone with precipitation equally distributed throughout the year. The Atlantic Ocean influences the western part of the Slovak Republic and the continental influence is typical for the eastern part. The Mediterranean climate influences mainly the south of the central part of the Slovak Republic with higher precipitation in autumn.

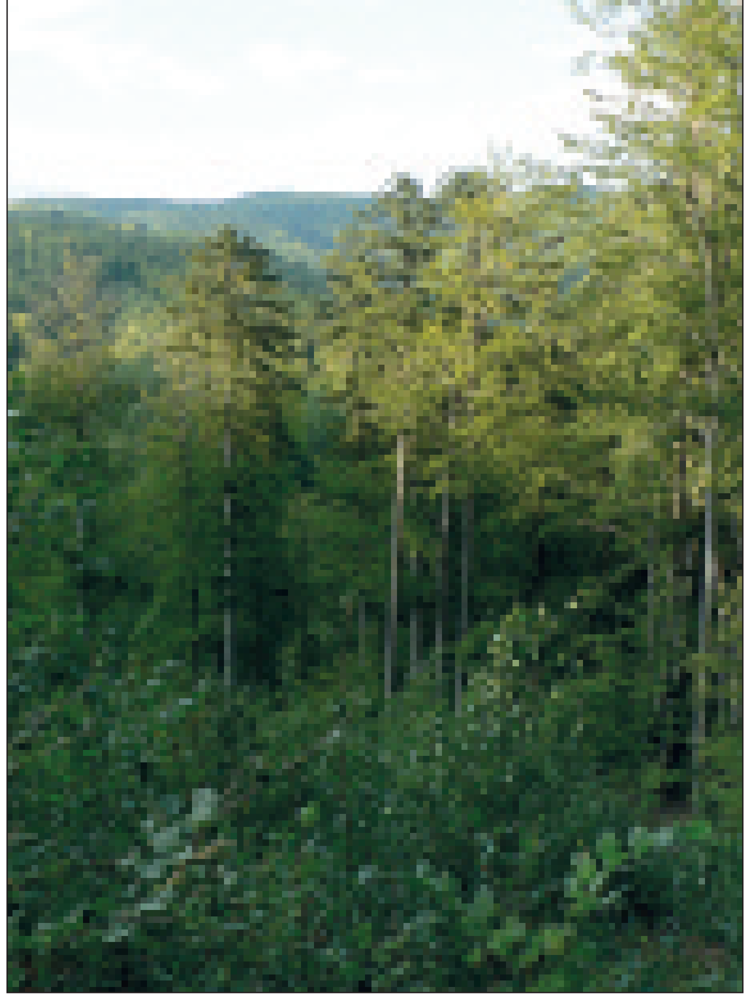
Gradual desertification

During the period of 1881-2008, a 1.6 °C increase in average annual air temperature and a 3.4 per cent decrease in annual precipitation on average were recorded in the SR. The precipitation decrease was above 10 per cent in the south of the SR, and it was sporadically up to 3 per cent in the north and north-east of the country. A significant decrease in relative air humidity up to 5 per cent and a decrease in snow coverage were recorded almost throughout the country (a moderate increase in highlands). There is evidence of gradual desertification, particularly in the south. However, no significant changes of sun radiation characteristics were observed, except for temporal decrease in 1965 – 1985.

Assessing potential impacts

In most of the Slovak territory, the occurrence of drought periods concentrates in spring and autumn months. In the summer, mostly in June and partially also in July, drought periods are rare. However, in the south of the Danube lowland, drought periods can occur with similar probability year-round. In other regions, this is not possible due to the relatively frequent occurrence of thunderstorms in summer. The frequency of drought periods is lowest in locations where precipitation is regular, namely in the north-west and the north of the SR. Apart from frequent precipitation, high rainfall totals are also recorded there.

The annual precipitation regime in the most south regions of the SR gradually begins to resemble precipitation regimes in southern Europe. It means sporadic but sometimes very intensive thunderstorms,



rainfalls or short-term abundant rain in summer and more rainy weather in autumn. The increase in drought periods in January is also very interesting.

In order to provide a qualified assessment of the potential impacts of climate change on the health and vitality of Slovak forests, a number of climatic models have been developed to determine the climatic amplitudes of the natural distribution range of tree species in Slovakia as well as the amplitudes of their factual distribution.

Where we will be

Climatic scenarios predict:

Forest in lowlands and uplands (zone 1 to 3)

- Disappearance of communities with the participation of spruce and fir, onset of xerothermic oak forests
- Higher threat by drought and fungi
- Expected flood damage particularly in floodplain forests
- Occurrence of systematic mass outbreaks of bark-beetles due to dry and hot weather
- Intensive invasion of non-native bark beetles from the Mediterranean in southern areas

Central and mountain forests (zone 4 to 6)

- Termination or marginal occurrence of fir and spruce, development of mixed communities of beech with the participation of valuable broadleaves
- More damage by wind, snow and frost
- Extensive drought damage
- Increase of aggressive fungi species
- The synergistic action of harmful agents will cause widespread mortality of spruce stands

Upland forests (zone 7 & 8)

- Development of mixed spruce-fir stands, shift of the upper forest boundary
- Lack of moisture and re-distribution of rainfall during the growing season as a problem
- Climatic extremes combined with air pollutants will weaken dwarf pine stands
- Proliferation of aggressive species of bark beetles in mountain spruce of zone 7

Massive spread of steppe species

There is already a considerable gap between the bioclimatic conditions on site and the optimal bioclimatic conditions of trees. Currently, 71 per cent of spruce, 82 per cent of fir and 32 per cent of beech are growing outside of the area with their optimal bioclimatic conditions. The biggest changes are expected for beech at the lower boundary of its natural range.

Scientists expect a massive spread of steppe species at the expense of beech forests, an increase of forest fires, particularly in pine stands and the spread of new invasive insect species from the Mediterranean region. Central and upland areas will be damaged by wind, snow and frost. The lack of precipitation will affect the vitality of spruce and increase outbreaks of bark beetles in wind damaged stands.

Increased growth for most species

Alpine forests will be affected mainly by the lack of moisture and the re-distribution of precipitation during the growing season, the expansion of grass species and possible problems with natural regeneration, the physiological weakening of dwarf pine stands and outbreaks of bark beetles.

Approximately 11.5 per cent of trees will respond negatively to climate change, while 34.6 per cent will exhibit no reaction and 53.9 per cent should respond positively to the proposed changes, e.g. by an increased annual increment.

For example, a warming of 3 °C in Slovakia by 2075 is likely advancing the bio-climatic conditions of the upper forest boundary by 400 meters and drastically decreasing the bioclimatic conditions of the alpine vegetation zone.

4.7 Forests in Wales

Today and tomorrow

Wales is located in Western Europe in the Atlantic bio-geographical region, where it experiences temperate winters and humid summers. Average winter day temperatures are 5 °C and average summer day temperatures 19 °C. The region is subject to a maritime temperate climate with high average rainfall between 1,000 mm and 3,000 mm per annum, being generally wetter in the west and in the central upland areas.

Wales has a diversity of soil types; the forested area is principally on poorer soils and characterised by upland brown earths and peaty gleys. The combination of these soil types and the heavy winter rains can lead to the waterlogging of soils, whereas spells of dry weather in summer can cause a shortage in water availability.

Forests and woodlands in Wales cover 14 per cent of the land area, of which 62 per cent is in private ownership and the remainder in public ownership. Much of the forest area in private ownership is unmanaged, semi-natural woodland. The native woodland types are comprised of upland oak wood, mixed lowland deciduous, upland ash woodland, wet woodland and lowland beech and yew.

Sitka spruce dominates production

Approximately two thirds of all Welsh woodland is comprised of non-native species grown in plantations, mainly conifer. The dominant species in these forest types is Sitka spruce - which accounts for approximately 65 per cent of total timber production - and it is mostly planted in monoculture and subject to a management system of clear-cutting and replanting.

Wales' native woodland habitat is highly fragmented and degraded due to lack of management, which severely limits much of the native fauna and flora's ability to translocate and therefore its ability of adapting to climate change. Much of the commercially managed woodland has very limited species and structural diversity and is potentially highly vulnerable to attacks from pest and diseases.

Impacts of climate change

Climate predictions for Wales are provided by the United Kingdom Climate Impacts Programme (UKCIP) with the most up to date forecast giving projections for 2050 and 2080 under a low, medium and high emissions scenario. The figures used below are from the high emissions scenario for 2050, 50 per cent probability (central estimate).

Climate change will have a significant effect on the Welsh climate. Summers will become warmer - predictions indicate a 2–3°C temperature rise for the majority of Wales and up to 3–4°C in the South-East.

Winters will become milder - with a 2–3°C temperature rise and fewer frost days.

Wetter winters, drier summers

These changes will result in a longer growing season and increased growth rates. Productivity is expected to increase by up to 2-4 cubic metres per hectare per year for conifers on sites where water and nutrients are not limiting.

Precipitation will also change with drier summers and wetter winters especially in the east and south of the country. A 10–20 per cent decrease of summer precipitation is expected for most areas, with some areas having up to 30 per cent less rainfall.

Winter precipitation is predicted to increase by up to 20 per cent for most areas, with southern areas expected to experience up to 30 per cent more rainfall.

Extreme events increase

There will also be an increase in the frequency of high intensity rainfall events, which will greatly increase the risk of flooding, landslip, wetter soils, and soil erosion. Additionally, the changes in temperature and rainfall in the summer will increase the frequency of drought.

Excess and lack of water will impact on trees in many ways, including stress, cracking and the increased risk pest and disease outbreaks. Although fewer frost days are predicted, there is still a risk of more frequent extreme weather including late and early frosts that have to be considered.

A number of currently growing tree species are predicted to become unsuitable under the changing conditions.

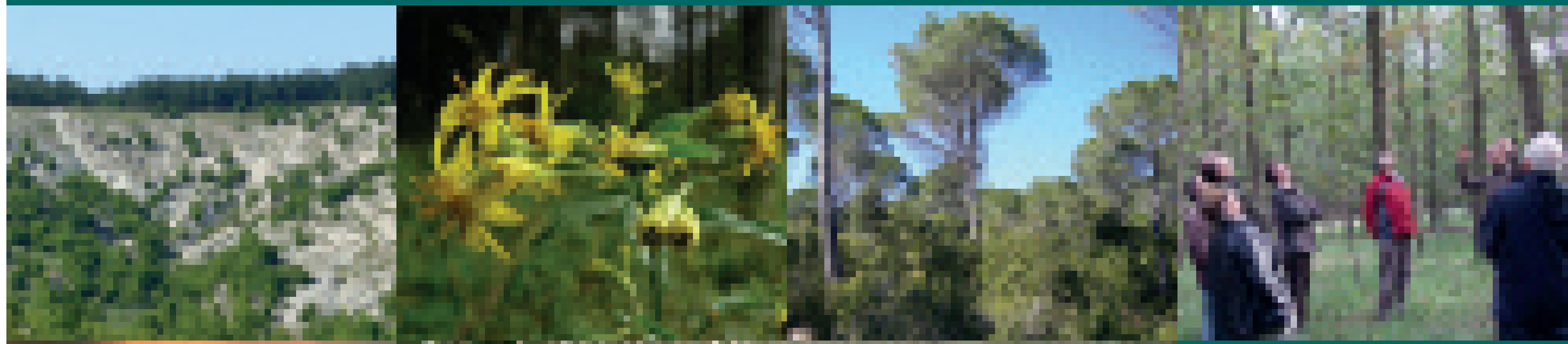
More pests and diseases

The frequency of strong wind events will also increase and result in more storm damage.

Wales is a region very exposed to winds and these storm events, combined with poor site conditions, will limit future silvicultural options of forest management.

Increased incidence of pests and diseases is already occurring in Wales and may become more prevalent with climate change. Further pests and diseases are highly likely to establish in Wales.

The current reliance upon monoculture stands and the limited range of species used in Wales puts the forests at risk of damage.



soil
biodiversity
carbon
knowledge
risks
timber
water

5

The seven challenges for adaptation

Each partner took responsibility for one of the seven climate change challenges facing the forests of Europe – biodiversity, carbon sequestration, knowledge transfer, natural risks, soil protection, timber production and water management.

Working together across the regions the following reports and case studies give specific recommendations on how these challenges can be met - using all the latest management techniques and knowledge put together by teams of regional experts during the three years of the FUTUREforest project.

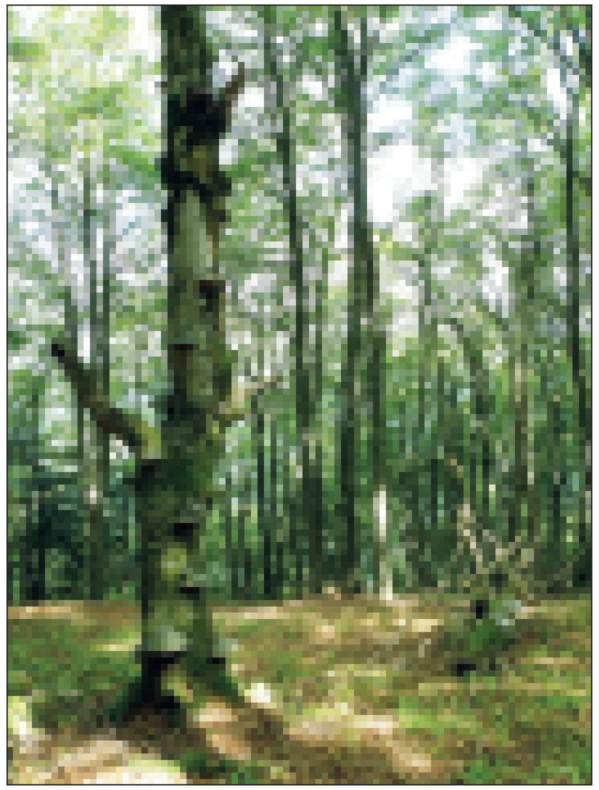
Investing in forest survival

Forests must be resilient to natural disaster - flooding, drought, fire, insect attacks and more - as climate change begins to impact on them. Society needs healthy forests to provide goods and services, as well as helping to mitigate the effects of change.

Scientific evidence strongly supports the conclusion that the capacity of forests to adapt to change (resilience), or recover following a disturbance, depends on the diversity of species (trees, animals and plants including micro-organisms), the genetic variability within species (the diversity of genetic traits within populations of species), and the regional pool of species and ecosystems. This is what we understand to be biodiversity.

Maintaining and restoring biodiversity in forests promotes resilience and is an essential safeguard against expected climate change.

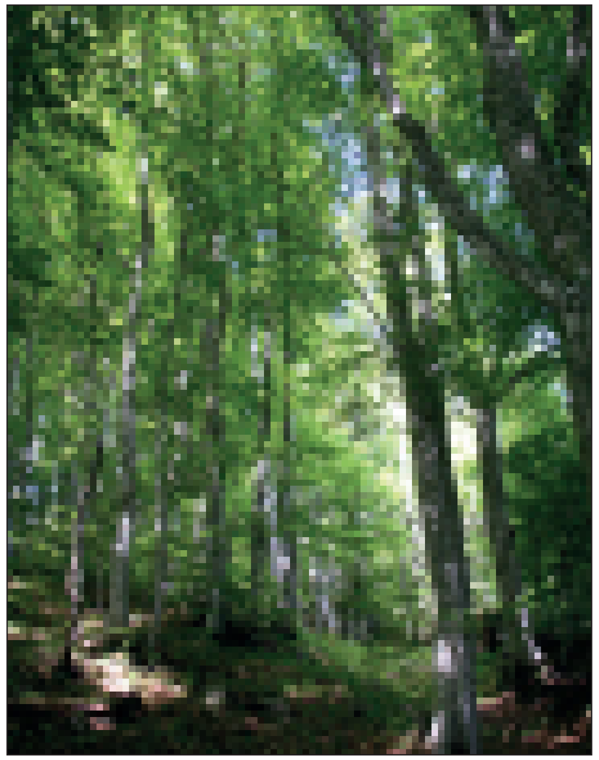
How does biodiversity help forests and foresters?
A more diverse forest has natural defences against pests - for example, in a mixed stand, the Spruce bark beetle (*Dendroctonus micans*) is kept in check by its natural predator *Rhizophagus grandis* which is not present in a monoculture stand of spruce.



Example of tree left for biodiversity

FUTUREforest recommends

1. **Policy makers must understand that forest biodiversity management is key to European forests being resilient to the effects of climate change.**
2. **Economic incentives are needed for land-owners to restore and maintain connectivity between forests, especially between areas of high biodiversity value, and other natural habitats to allow species' migration.**
3. **Silvicultural systems that create diversity of forest structure, age and composition at stand and landscape scale must be incentivised.**
4. **A European network of forest health plots, integrating existing national networks, should be set up to study the variety of forest types and monitor the effects of climate change over the long term. It should also compare the effect of different types of silviculture.**
5. **Older stands of trees need to be retained to improve the level of dead wood in the forests, vital to the diversity of flora and fauna.**



Resilient diverse forest shown during Auvergne study visit

Resilience is also influenced by the size of the forest ecosystem - and by the state and characteristics of the surrounding landscape. Generally, the larger and less fragmented the ecosystem is the better, and a large forest has a wider range of habitats than a small one, resulting in more opportunities for species to respond to change. The more connected habitats are, the easier it is for species to migrate as conditions alter following climate change or to help deal with increased pests.

Increasing biodiversity in planted and semi-natural forests has a positive effect on their resilience and on their health and productivity - including carbon storage.

Biodiversity is under threat

According to many biologists, we have reached the sixth great extinction phase of species on earth. This phenomenon is due to several factors - the extension of urban and agricultural lands, the loss, pollution and fragmentation of habitats and ecosystems. Mankind is now having a significant impact on the environment.

Climate change is expected to accelerate this extinction phase, changing conditions to make the regions unsuitable to some of their native species.

This will have consequences for species' distribution. In Catalonia, altitudinal changes in the species' distribution have already been documented and linked to climate change.

Europe's forests – facing mass extinction?

Altogether more than 50 per cent of species and more than 60 per cent of habitats are in an unfavourable condition in Europe.

27 per cent of mammals, 10 per cent of reptiles and 8 per cent of amphibians, native to forests have been assessed by the International Union for the Conservation of Nature (IUCN) as threatened by extinction at EU level.

Potential forestry impact on biodiversity
Some forestry practices increase the pressure on biodiversity. For example:

- Some regions use a limited range of silvicultural systems leading to limited structural diversity.
- Many of the region's forests have large scale monocultures with a very limited range of tree species.
- Planting of entirely non native species can create risks for biodiversity.
- Large scale short rotation forestry can lead to limited diversity but smaller scale plantings can be beneficial.

FUTUREforest – the way forward

FUTUREforest partners have agreed that the following practices can deliver higher levels of biodiversity in forest ecosystems across Europe:

Where biodiversity is high, measures must be taken to ensure this is maintained.

There must be an increase in diversity of ecosystems, species and genetics by:

- Providing a diverse and complex structure both at forest level - using natural forest processes - and at landscape level

Low resistance capacity to an insect pest in Wales

Crane on the bog meadow (Photo J. Herpel)

Restoration project - Kunsterwiese

BRANDENBURG

For the restoration of forested peatbogs, disturbances of the water cycles have to be identified and appropriate measures of restoration must be taken.

The 'Kunsterwiese' (approx. 3,5 ha) in the Ruppiner Schweiz region is part of the Kunster valley. The Kunster river partly still has a natural course and the valley bottom is almost entirely covered by bogs. However, several drainage ditches are located in the area near the Tornowsee.

The drainage should be completely stopped and peat growth be initiated. Run-off must be rechanneled from the linear ditches to a more spatial run-off across the meadows near the Kunster. Alder forests can develop near the natural sources along the valley edge, and open alkaline sedge marshes can establish.

Measures of peat protection

- Mowing of the area and removal of biomass to ensure nutrient removal
- Complete filling in of the drainage ditches and near all sources with local material
- Limited removal of peat in the centre of the Kunsterwiese to generate material for filling the ditches
- Alteration of the structure near the source by removing the ducts, blocking the ditch and constructing a ford
- Forcing the flooding of the bog area near the ditches by means of barrages or loam plugs

The implementation of measures started in fall 2009 in a cooperative effort of the forest administration and the regional authorities of nature protection and water management.

The modification of the water regime has successfully initiated bog development and growth! In addition, the implemented measures also led to the creation of new habitat for numerous plant and animal species which have returned to this area.

Measures of peat protection thus made an important contribution to increasing the biological diversity of the forest.

5.1 Biodiversity – protecting forest species for the long term

Glastir - Using grant incentives/subsidies to improve forest connectivity

WALES

Farmers and landowners in Wales are given monetary incentives to create and manage new native woodlands through a newly established scheme – Glastir.

This encourages landowners to manage woodland within special habitat networks, restoring native woodland or adapting non-native stands, through replanting options available within the grant scheme.

Up to £4,500 (€5,000) per ha are available for woodland creation over a 3- year period.

In 2003, the Countryside Council for Wales and Forestry Commission Wales, with Forest Research, began research on a Woodland Habitat Network for Wales to inform strategic planning for the maintenance, improvement, restoration and creation of woodland to combat the effects of a fragmented woodland landscape.

The research is based on Wales' existing woodland areas and the profiles of species which are representative of wider groups, based on the species needs and their ability to disperse.

The results provided policy makers and planners with a series of maps showing the potential extent of habitat networks for ancient and broadleaf woodland, which are considered a high priority for conservation action in Wales.

- Maintaining or restoring biodiversity at all scales wherever possible – forest, landscape and bioregional
- Protect, link and expand isolated or disjointed habitats and important populations, populations at the margins of their area of distribution and source habitats. These populations are the most likely to represent pre-adapted gene pools for climate change and could form core populations as conditions change
- Recognise genetic diversity as a key feature of resilience
- Avoid conversion of diverse forests into reduced-species forests.

Connectivity across forest landscapes must be maintained or increased to help species migrate by reducing fragmentation and, where viable, recovering lost forest habitats, expanding the networks of protected areas, and establishing ecological corridors. Invasive species must be controlled, reducing non-natural competition.

A monitoring network must be established to understand the long term climate change effects, comparing a variety of different forestry practices.

All forests should be managed in an ecologically sustainable way that takes into account the predicted future climate - thus reducing the chance of long-term failure by using trees from areas that approximate to future conditions both at provenance and species level.

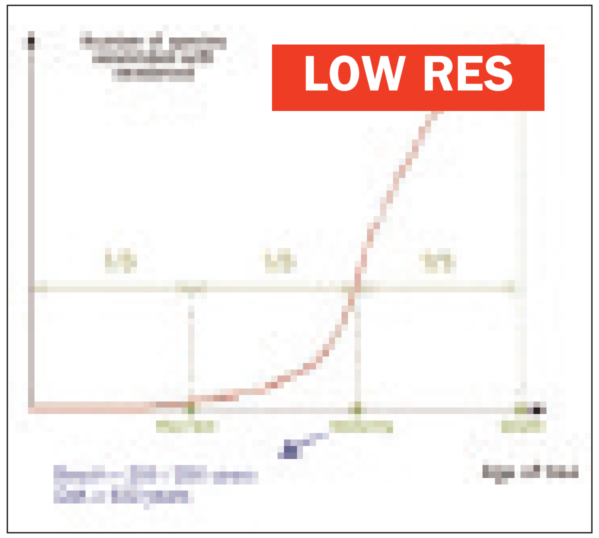
There are already efficient tools to ensure the preservation of optimal forest biodiversity level which are used in the FUTUREforest regions.

Increase or maintain connectivity to help the migration of species

Some species and habitats play a conservation role for others, helping their migration.

It is important to distinguish between:

- Forest biodiversity reservoirs where biodiversity is richer and better represented
- Ecological corridors, used by plants and animals to move from one biodiversity reservoir to another



These two elements are indispensable to allow species to migrate. Without both, many species will disappear, reducing the opportunities for forests to adapt to climate change.

Deadwood and species survival

Up to a third of European forest species depend on veteran trees and deadwood for their survival. 66 per cent of forest species – flora and fauna - are only found in mature forests, but most forests are harvested before they reach maturity.

Deadwood provides habitat, shelter and food sources for birds, bats and mammals and is particularly important to the less visible majority of forest species including insects, especially beetles, fungi and lichens.

Deadwood also plays a key role in sustaining forest productivity and environment, increasing the forests' capacity to adapt to climate change.

Despite its enormous importance, deadwood is now at a critically low level in many European countries.

Biodiversity reservoirs in public forest management (French Forestry Office)

AUVERGNE

To maintain forest biodiversity, it was decided to take action throughout the French public forests and to increase the proportion of aging trees:

- Select ageing areas, small stands (0.5 to 3 ha) to retain beyond harvesting age and apply silvicultural methods that differ from strictly productive ones.
- Select and retain small old forest stands (0.5 to 3 ha) and leave to evolve freely until their physical end, that is, until the collapse of the trees.
- At Stand scale, retain standing and lying deadwood, locating and conserving trees that are indispensable to the survival of threatened species.
- Strengthen the Strict Biological Reserve (SBR) network. This special status introduces additional protection and financial help for the most exceptional public forest areas. In an SBR logging is prohibited, and forests can evolve naturally. SBRs are true “nature laboratories”. They provide an opportunity to observe and study nature's answer to climate change. It also allows foresters to consolidate and improve silvicultural management and better protect biodiversity.

Pipistrellus pipistrellus

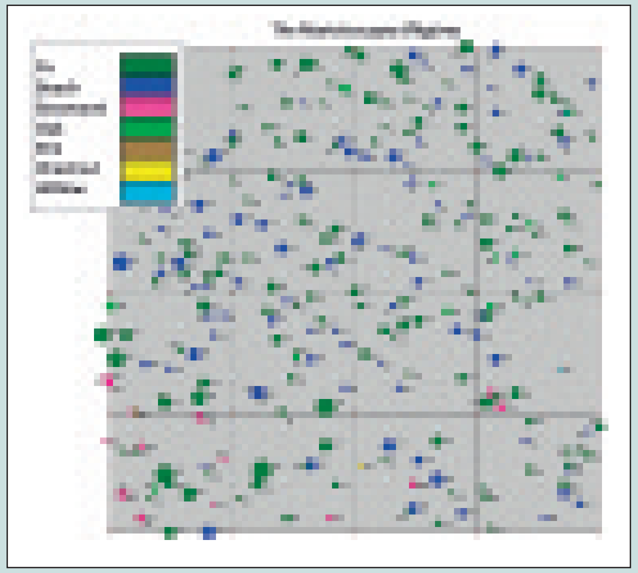
The Algère's Marteloscope - learning to manage for 'plastic' forests

AUVERGNE

The Algères forest has rich and varied tree species - conifer, oak, beech, lime, maple - under traditional management. The site shelters very rare species of saproxylic beetles which are biological indicators of the quality of French forests, many usually found only in forests which have been protected for centuries. This confirms a forest *continuum* for centuries, providing a large volume of dead wood for these beetles to survive.

Experts are concerned about these rare and fragile species and believe it is necessary to adapt forest management to preserve them.

The CRPF (Regional Centre of Forest Property), in partnership with the AFI (Association Irregular Forests) has set up a marteloscope. This is a field based tool for management training in irregular stands, taking into account climate change. It enables foresters, owners, environmental experts, scientists and other users to understand and analyse the impact of measures with respect to silvicultural, economic and ecological parameters. It can also be used to raise awareness of the importance of forest management.



Tree species distribution map of the Algères Marteloscope

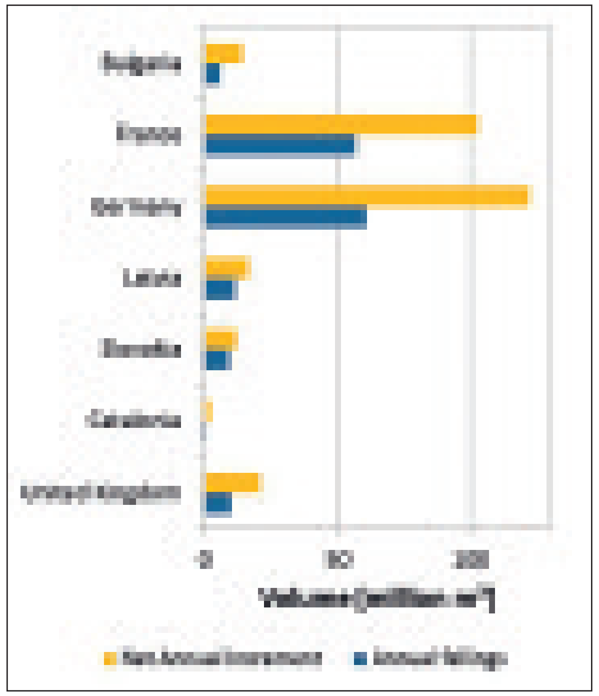
5 The challenge for adaptation – 5.1 Biodiversity – protecting forest species for the long term

Europe's biggest carbon store can do more

European forests currently contain 13.6 billion tonnes of carbon in tree biomass, deadwood, and litter and an estimated 9.3 billion tonnes in the soil beneath them. Forest biomass in the EU countries contains almost 10 billion tonnes of carbon - about nine times the total emissions in the EU.

Every year, European forests naturally remove 236 million tonnes of carbon from the atmosphere – equivalent to almost 89 per cent of the annual transport emissions in the whole of Europe in 2007.

If managed sustainably, European forests have a potentially massive role in helping to mitigate the effects of climate change.



Balance between net annual increment and annual felling in selected European countries

We must however:

- Increase the forest area under sustainable forest management.
  The IPCC concluded that "a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber fibre or energy from the forest, will generate the largest sustained mitigation benefit".
- Protect the existing forest area from deforestation to avoid loss of carbon to the atmosphere.
- Increase afforestation where viable.

FUTUREforest recommends

1. **Sustainable forest management must be used to optimise carbon sequestration in timber. This will ensure protection of forest soil carbon stocks and reduce loss of carbon due to disturbances.**
2. **Ensure that strict national controls on deforestation are maintained.**
3. **It is essential that the increase in forest cover in Europe should continue.**
4. **Develop European and regional incentives for the substitution of steel, concrete and plastic with timber.**
5. **Incentivise the substitution of energy sources such as oil, gas and coal with non-construction grade timber.**
6. **Restoration of afforested deep peat by re-wetting where viable.**

Europe needs to acknowledge the full mitigation potential of its forests, which includes the use of wood biomass for fuel and wood products and recognising the social and environmental role of forests identified within other chapters of this document.

Risks to European forest carbon stocks

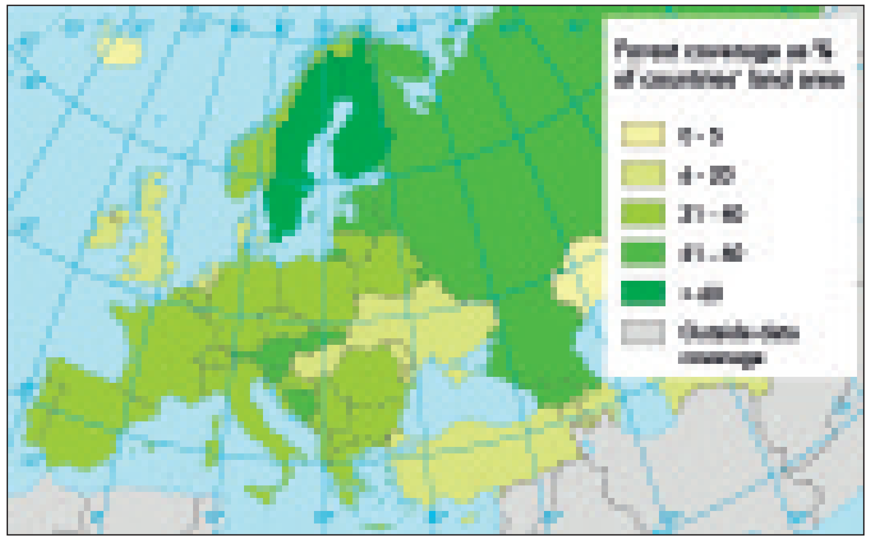
Although the total European forest area is increasing, some areas are at risk from deforestation, which will release large amounts of carbon to the atmosphere. This trend is strengthened by the increasing frequency and intensity of wildfires and insect outbreaks due to climate change. Some southern European countries are currently showing the greatest loss of forest area.

Forest fires release large amounts of carbon

Avoiding forest carbon loss

Improving legislation against deforestation and subsequent change of land use type can help to keep European forest cover at a constant level, protecting forests from conversion to agricultural, residential, or industrial land.

New intelligent risk management systems can help combat large-scale forest damage caused by the more extreme weather conditions associated with climate change - see Chapter 5.4. At a European scale, sophisticated risk networks such as the European Forest Fire Information System may further minimise the loss of carbon from these ecosystems.



Forest cover in Europe

Preservation of forest soil carbon stocks can be achieved by:

- Reduced drainage in the course of forest operations.
- Forest management measures aiming to minimise soil disturbance.
- Restoration of forested peatlands as efficient long-term carbon sinks where viable.

Managed forests capture more carbon

It is essential that more unmanaged forests and woodlands are brought into management. Currently only 62 per cent of the annual timber growth in Europe's forests is being used so the biomass utilisation rate could increase in European forests without threatening sustainability.

European forest carbon stocks are currently increasing. As these forests mature, however, they will reach a level of saturation where they stop accumulating further carbon. The harvesting of timber as part of active forest management is crucial for maintaining the 'carbon pump' functionality of forests.

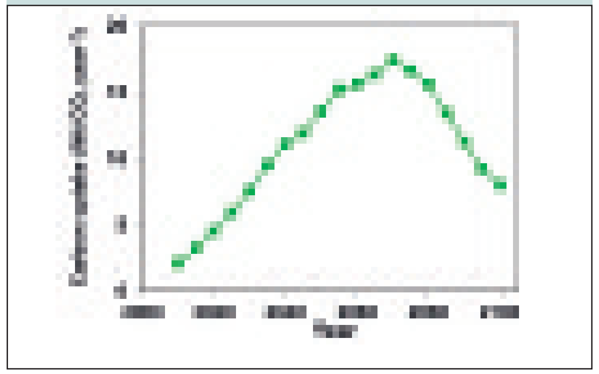
Young forest stands have the highest rate of carbon sequestration, which slowly diminishes with increasing tree age. Carbon sequestration in old unmanaged forests stops as the CO_2 absorbed by the trees is compensated by the respiration and decomposition of litter and deadwood. Managed sustainably, harvested mature trees are replaced by younger trees with higher growth rates maintaining the forest 'carbon pump'.

Increasing carbon capture by afforestation

WALES, UK

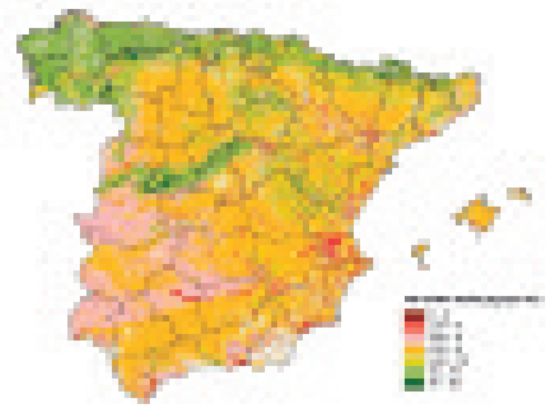
The past 20 years has seen an almost complete halt in afforestation in Wales. By 2009 less than 500 ha/year were being planted. However in 2010 a commitment was made by the Welsh Government to plant an additional 100,000 ha of woodland over the following 20 years - increasing Wales' woodland area by over 30 per cent. The newly planted mixed forests will provide multiple ecosystem benefits and considerably increase Wales' forest carbon stocks. Wales wants to increase production of timber and wood fuel from sustainably managed woodlands.

The UK has also developed the 'Woodland Carbon Code' which defines the standards for voluntary carbon sequestration projects that incorporate core principles of good carbon management as part of modern sustainable forest management.



Predicted accumulation of carbon based on the 1990-2010 afforestation rate and increased afforestation from 2010 to 2050

5.2 Forests - the natural carbon pump of Europe



Map of the soil carbon inventory conducted in Spain within the Balengeis project. Source: CEAM

Assessing forest carbon stocks

CATALONIA

Catalonia has used two different approaches to estimate the forest carbon sink:

- The Ecological and Forestry Inventory of Catalonia (IEFC), by the Center for Ecological Research and Forestry Applications (CREAF) during the period 1988-1998, was one of the first to include carbon stocks
- The Spanish National Inventories II (1989-90) and III (2000-01) were conducted on a systematic network of permanent plots, and allow estimation of carbon sinks.

According to the second report on Climate Change in Catalonia, 1,134,972 ha of Catalan forests accumulated 49 tonnes of carbon per ha, of which 21 per cent are oak forests, 19 per cent Scots pine forests, and 13 per cent Aleppo pine forests. Another 5.6 tonnes per ha are stored by the ground vegetation of those forests.

Extensive research efforts have been made in Catalonia, mainly by the Center for Ecological Research and Forestry Applications (CREAF) and by the Forest Sciences Center of Catalonia (CTFC). Both organisations participated in many international projects.

More forests store more carbon

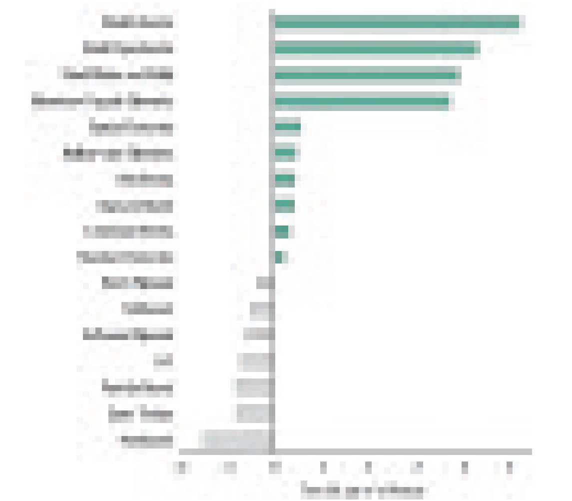
Forest area in Europe has been continuously increasing over the last decades and should be further increased where land is available for conversion. An increase in overall forest area will result in increased removal of CO_2 from the atmosphere and, in the long-term, provides a highly cost-effective reduction of greenhouse gas emissions compared to other alternatives.

Changing the management of Europe's forests

The carbon capture potential of existing forests can be increased by good forest management through measures such as choice of tree species, structure, age and harvesting methods.

Annual average growth rates can be increased by selecting tree species that fully use the potential of a given forest site. Different varieties and genotypes may grow faster than current tree species. In the long term, mixed forests can be more productive and also less prone to risks than single-species forests thus capturing more carbon.

Management and harvesting systems also affect rates of carbon loss and uptake, but knowledge about these effects is still limited. Although large amounts of carbon may be lost following clear-cutting due to increased decomposition and erosion, the lost carbon may be quickly recaptured by the next generation of site-adapted tree species. Some management systems such as 'continuous cover forestry' are particularly suitable for protecting forest soil carbon stocks and ensure continuity of carbon capture.



Net CO_2 emissions (in tons/m³) of building products (from World Resources Institute, 2008)

Timber in construction can lock carbon away for generations

Encouraging the use of timber

Wood products can store carbon for over a hundred years. When used to produce energy, its life-time as a carbon store is relatively short as most of the contained carbon is released during burning. Unlike fossil fuels there is no net increase in atmospheric CO_2 when wood biomass is used for energy production, because the CO_2 emitted is compensated for by that removed during growth – if the timber is from a sustainably managed forest.

Using harvested timber instead of carbon hungry materials such as concrete, steel or plastic not only reduces net emissions but transfers the carbon in the timber into long-lived carbon pools such as construction, flooring, or furniture.

Forest carbon accounting

Carbon storage can be increased by forest management, which should become a mandatory component of carbon accounting.

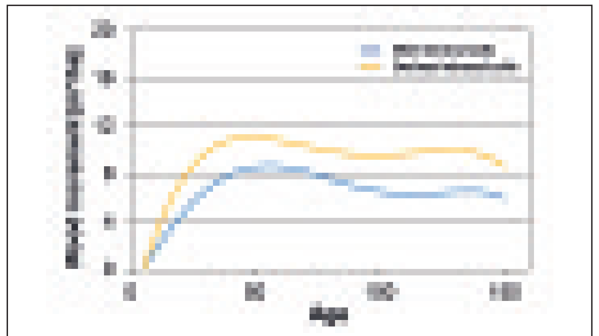
Currently, emissions and removals from afforestation, reforestation, and deforestation *must* be reported, while the accounting of forest management activities is optional.

Under the Kyoto Protocol, industrialised countries, the so-called Annex 1 countries, may use CO_2 removal from the 'Land Use, Land Use Change and Forestry' Sector to meet their greenhouse gas emission reduction targets during the first commitment period (2008–2012). Carbon sequestered by forests can offset emissions from the industrial, agricultural and other sectors.

Regulations to credit forestry

Current carbon accounting rules do not recognise the effects of climate change on forest management. Increased frequency and severity of floods, drought, fire, pests and other damaging events under a changing climate may result in huge CO_2 emissions. Countries in high-risk areas such as Spain may fail to meet their emission reduction targets due to emissions caused by natural disturbances.

Current accounting regulations also fail to credit forestry for substitution benefits and carbon storage in harvested wood products, because emissions are counted at the time of harvesting. Accounting of emissions when they actually occur – such as wood burning and disposal of furniture would recognise the function of wood products as mid to long-term carbon stores.



Comparison of gross annual increment of forests on drained and wet mineral soils

Increasing timber availability and carbon capture

LATVIA

Increasing general forest productivity by

- Planting of highly productive varieties of forest tree species
- Improvement of forest structure
- Public co-financing of investment projects in forestry such as tree breeding programmes

Promotion of afforestation with support from

- European Union Structural Funds financing more than 50 projects from 2004–2006, including the planting of 3,637 ha on unmanaged agricultural land
- The European Agriculture Fund for Rural Development (EAFRD) with more than 2,300 projects submitted for 2007–2013; supported activities include establishment of forests on unmanaged agricultural land, cultivation of natural forests, cultivation of young forest stands, replacement of low-value forest stands, restoration of site production potential, and assistance with forest protection

Increase of forest carbon capture by

- Intensified forest management measures such as soil preparation and planting of selected seed material to increase wood increment and thus CO_2 capture
- Maintenance of existing forest drainage systems to maintain wood increment in living biomass in drained areas

5 The challenge for adaptation – 5.2 Forests - the natural carbon pump of Europe

Floods, fire and landslides – the threat to lives and homes

Changing climate conditions are already beginning to impact on Europe's forests and society through increasingly severe weather conditions.
These bring more catastrophic events of different intensities across the European forests.

Drought can be followed by torrential rainfall bringing floods which put lives at risk, damage the forest, villages and towns. Tinder dry woodlands are vulnerable to forest fires. Trees are put under stress making them more vulnerable to pests and diseases.
When dealing with these natural risks the cost of prevention is presented as an obstacle to taking action.
However, FUTUREforest has found that the cost of prevention is much lower than the costs of damage. Catalonia for example spends 40 per cent of its forest management budget on restoration and repair of damage.
Climate change now makes it essential that we should better understand risks and prevention – we must convince policy makers that prevention is better than cure.
Already in some regions timber salvaged after wind, snow or insect damage is up to 50 per cent of annual felling. A FUTUREforest study visit to Slovakia found that the rate of salvage felling for the 2000 – 2008 period was more than 49 per cent.
Normally foresters plan where they fell timber, but with the increasing effects of climate change on forests they are forced to react to catastrophic events.

FUTUREforest recommends

1. **Pro-active, rather than re-active, risk management is needed. Prevention should be prioritised above control and restoration. The focus should be on increasing forest ecosystem resilience. This is especially urgent regarding forest fires in Southern Europe.**
2. **Urgent action is needed. Doing nothing often leads to the highest costs and restoration is not always possible.**
3. **Risk management has to become an integral part of land and forest management planning. All risk factors are interlinked and must be considered holistically.**
4. **Monitoring and evaluation are essential and must become compulsory. National systems have to be improved and harmonised between the different EU member states.**
5. **Improved crisis management within the forest agencies is vital.**
6. **Emergency plans should become compulsory for each identified risk, prioritising civil protection and damage limitation.**
7. **Subsidised insurance schemes for forest owners should be considered.**

Natural risks are on the increase

In the "Natural Risks" working group at the Barcelona FUTUREforest conference many risks affecting forest zones were identified and their actual and future importance was analysed.
The main risk factors are initially analysed individually in this chapter but it must be remembered that they are often inter-linked and it is crucial to assess them together. The project addresses these complex interactions in Chapter 6.

Red band Needle blight in pine

All risks are highly interlinked

Five main interlinked risks

Drought

Field observations already show that the risk of drought has increased, especially in zones such as the Mediterranean where the water deficit is already critical.
To evaluate the drought risk complex indicators must be considered including longer growing periods, changing seasonal water availability, long term stress and high evapotranspiration. In Brandenburg and France beech tree populations suffered a severe reduction in growth due to drought in 2003.
Drought effects are directly related to pests and diseases - commonly known as abiotic factors - and are linked to the risk of forest fires.

Pests and diseases

Pests and diseases are considered the most serious threats to European forests according to the FUTUREforest partners. The area affected by pests and diseases increased by 64 per cent from 3.1 million ha in 2005 to 5.1 million ha in 2010.
Some pests and diseases are endemic throughout Europe and these must be monitored to establish the level of threat. Other major issues are the migration of specific diseases or pests within Europe and the introduction of new pests and diseases. The most damaging pests are European spruce bark beetle (*Ips typographus*), different species of *Phytophthora* and, the pine wood nematode (*Bursaphelenchus xylophilus*).
The predicted increase in temperature will alter pest life cycles and lead to massive population increases. Changes in plants or insect phenologies could lead to previously non-hazardous organisms becoming serious pests.
Some parasites are used as climate change indicators - the increased spread of Pine processionary moth (*Taumetopoaea pityocampa*) for example is thought to be extending its range as a result of the changing climate.

Forest fires

Fire risk is currently highest in the Mediterranean area but risks of forest fires will increase in all parts of Europe including areas traditionally thought to be of low risk. This is particularly due to longer drought periods throughout all of Europe.
In 2010 more than 285,000 ha of forests were burned.
Rural abandonment and the reduction in land management add to the risk of forest fire, increasing the intensity of forest fires due to increased vegetation cover.
Although fire is a natural factor in Mediterranean ecosystems, its increased magnitude and recurrence has become catastrophic, now totally dominating forest management policy in some regions.
The increased resources dedicated to forest fire control are aimed at quick intervention to limit the burned area. The main focus is on forest wild fires that burn more than 500 ha which make up less than 0.5 per cent of the total number of fires. These fires are responsible for more than 75 per cent of the burned surface in Catalonia.
For example, in July 1994, two forest wild fires, became one big fire and burned 45,000 ha of land (including 31,000 ha of forest). The fire started in a period where 31 other active small fires were burning and caused two deaths, with 6,500 people evacuated from 60 different towns.
Other important impacts of forest fires include fires include soil loss, habitat loss and the increased risk of flooding and loss of accumulated carbon all may have.
Other socioeconomic aspects are the loss of timber, restoration costs and landscape damage.

5 The challenge for adaptation – 5.3 Risk management – prevention is better than cure

5.3 Risk management – prevention is better than cure

Extreme rainfall, erosion and torrential phenomena
Increased heavy rain fall combined with human activities, such as deforestation or building houses in flood zones, increase risks to society, the environment and the economy.

Intense precipitation creates soil erosion, taking materials downstream and depositing them in low lying areas. These phenomena are influenced by topography, soil quality and vegetation cover. Torrential storms can cause catastrophic damage, with violent floods, high amounts of erosion and threats to human lives and infrastructures.

In 1996 an extraordinary storm caused 87 deaths in a camp site near a gully in Biescas (Huesca, Spain).

The effects on the wider economy could become significant with huge payouts by insurance companies.

Strong winds
Climate change is expected to increase the frequency of storm events. According to the European Forest Institute (EFI) and UK Forest Research data, wind currently causes more than half of all forest damage in Europe.

Wind damage is a complex interaction between wind speed, storm duration, topography, site and stand conditions. Tree height, water-logging and recent thinning are strongly related to wind damage.

Wind damage has increased in Europe over the last 50 years. For example, in 2010, more than 2.6 million ha of forests were damaged by storms. The Klaus Storm of 2009 caused 31 deaths, toppled 45 million m^3 of timber, and the timber price reduced from 45 to 10€/ m^3.


Forest fire in Catalonia (Photo by Richard Martin)

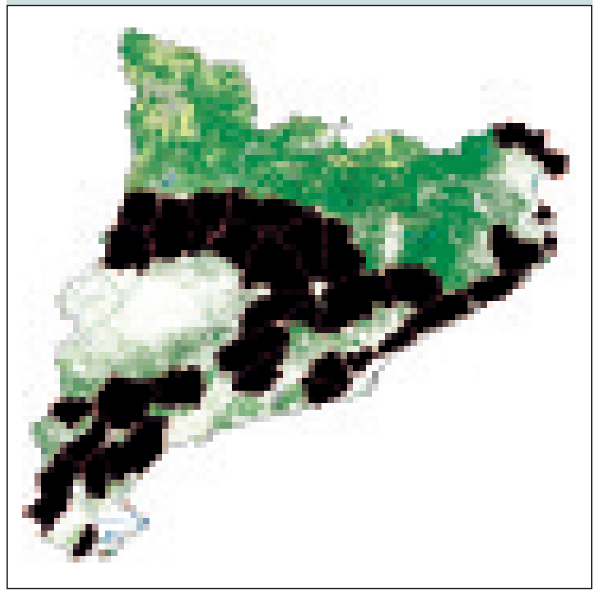
Improving forest fire prevention in landscapes

CATALONIA

To more effectively combat forest fires and integrate forest fire planning at a landscape scale, high risk zones have been identified based on forest type, terrain, vegetation type, climate, fire history, and geographical features such as natural fire breaks – rivers or rock outcrops – and artificial infrastructures such as road or agricultural areas

Within these areas, the aim is to break up the territory and establish infrastructures which support fire fighting such as water reserve networks, approach roads, fire breaks and low fuel density areas.

Planning at the scale of these risk zones allows the integration and prioritisation of planned actions at smaller scales, such as properties, housing development zones or municipalities.


Priority protected areas defined in Catalonia

Taking action to reduce the damage

Acting against drought
To minimise drought damage, future scenarios have to be considered using different species, provenances or clones adapted to drier site conditions. Possible actions are outlined in the FUTUREforest good practice guides.

Controlling the spread of pests
Consistent and reliable information on the health of European forests is urgently needed in order to fight these risks. Moreover, a consolidated, valued and uniform methodology on the European permanent plot network is needed.

Another vital issue is movement control of reproductive plant material. For example, the increase in world trade is seriously affecting trees in the British and Irish countryside as deadly pests breach border controls. They are making their way across the world, hidden in timber packaging used to transport imported goods. Potentially even more dangerous is the trade in live plants which can bring with them foreign pests against which our own trees have little or no resistance.

Each of the FUTUREforest partners has different approaches. Natural regeneration or an increased genetic diversity of planted material from a wider geographic source is being considered. Foresters could also consider using progenies with improved pest resilience that will be most suitable when planning and managing their forests.

To prevent damage by pests and diseases and other disturbances, resilience and health of forests has to be improved by active forest management. Increased diversity of species and structures will help develop resilience.

Fighting forest fires
Even though fire fighting and subsequent restoration measures are necessary, the FUTUREforest team believes future strategy must be focused on prevention. The high cost of fire-fighting equipment also makes preventative management a viable alternative.

Essential preventative measures need to include:

- Improved legal measures for protection of urban areas, security zones on road margins or under electric lines, and limiting certain operations at specific times of the year
- Publicising the danger through advertising campaigns
- Integration of forest fire risk into forest planning and planning at the landscape level
- Mapping - a common forest fire mapping system on a European scale should be considered, bringing together best practice and knowledge from all regions
- The use of controlled burns and livestock grazing to create these must be funded and prioritised according to risk. These will minimise flammable material.
- Improved access to high risk areas, creation of security zones and water point networks.

Development of a coherent National strategy is essential to help local administration, forest owners and the local population. All stakeholders should be involved in the planning of preventative measures. There should be support including adequate funding, training and other resources for professional fire teams. Prevention and emergency plans have to be co-ordinated and procedures agreed.

After a forest fire, urgent action should be prioritised – natural regeneration should be evaluated and promoted before planning reforestation. In existing natural regeneration the forest species must be resilient and adapted to future predicted climate change. Soil protection issues may be vital in areas denuded of vegetation and deadwood from the fire may be used to help build temporary dams in such situations.

Addressing torrential phenomena
Damage can be reduced by increasing forest cover in specific areas to regulate water flow, minimise soil loss and reduce flooding. Risk mapping is essential for both landslides and flooding. Infrastructures within forests should be designed to withstand future extreme events.

Forest design, species and structures should consider flood prevention as an essential element of the forest planning process. Other risks related to extreme phenomena are flooding and landslides. These risks are explained in Chapters 5.4 and 5.6.

Changing management practices to protect forests from storm damage
Single tree stability is the key to creating windfirm forests and can be achieve by careful management of tree density. In Wales, the windiest and wettest region in FUTUREforest, foresters believe that well thinned forests will reduce storm damage.

Forest stability can also be increased by promoting use of site adapted species with deep root systems.

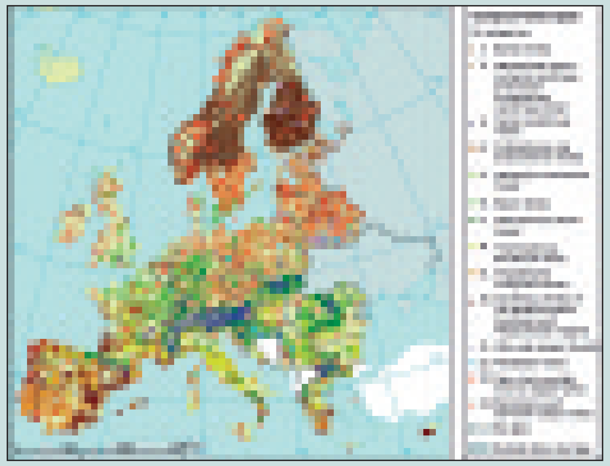
Monitoring the health and ecological condition of forests

ALL REGIONS

In 1985, an integrated ecosystem monitoring system was set up by the International Co-operative Programme about forests (ICP-Forest) to monitor and evaluate forest health at the European scale.

This network encompasses 5,700 plots in over 40 European countries and over 140,000 trees which are evaluated every year. For more than 20 years, data on soils, biodiversity, pollution, and other ecological parameters has been collected using the same methodology.

The data is available for forestry institutions and research centres and may be used to predict migration of pests and diseases as a result of climate change. The monitored changes in forest health can also help identify priorities for action to help forest ecosystems adapt to new climatic and socioeconomic conditions.


Plot map of the ICP forest monitoring network

Soil erosion – the real cost to Europe

Soil is essentially a non-renewable resource and a dynamic system which performs many functions and delivers services vital to human activities and ecosystems survival. Over recent decades, there has been a significant increase of soil degradation processes, and there is evidence that they will further increase if no action is taken.

Soil Framework Directive Proposal
Soil is under increasing environmental pressure. Soil erosion alone costs the European Union millions of euros a year. It damages houses, roads, railways, and other infrastructure, causes sedimentation of reservoirs, loss of life, decreased profits from land based industry and releases carbon.

FUTUREforest recommends

1. **Areas at high risk of erosion, carbon loss, landslides and compaction should be identified and integrated with landscape planning procedures**
2. **Tree species should be selected to match the site characteristics and protect the soils**
3. **Increased awareness of soil management and protection must be initiated amongst all forest owners and managers through communication and incentives**
4. **Soil protection and enhancement are essential to all aspects of forest management**
5. **Research must be intensified to understand better the consequences of different silvicultural practices and the dynamics and storage of soil carbon.**

Soils are essential to the vitality of forestry and forests play an important role in protecting the wider society and environment.

Foresters have a long history of helping to stabilise and protect the soil. But now, as climate change brings more extreme weather events, Europe is facing new challenges which forestry can help provide the answers to.

The value of good soil management must not be underestimated in the future management of our forests, including improving the understanding of the value of the forest in protecting soils outside its boundaries.

The soil is an irreplaceable dynamic living resource that underpins the whole forest ecosystem. Soils provide many functions including:

- Biomass production and tree anchorage
- Storing, filtering and transforming nutrients, substances and water
- Providing a biodiversity pool, such as habitats, species and genes
- Physical and cultural environment for humans and human activities
- A source of raw materials
- Acting as a carbon pool
- An archive of geological and archeological heritage

Globally more than twice the amount of carbon is held in soils as in vegetation and is generally stored in larger amounts in forest soils than those under other land uses.

New forest programme developed following FUTUREforest policy

BULGARIA
The Bulgarian Executive Forest Agency has developed an important *"Programme of measures for the adaptation of the forests in the Republic of Bulgaria and mitigation of the negative impact of climate change on them"*.

The FUTUREforest project provided an excellent series of policy recommendations on issues important in Europe related to forests and climate change which were used as the basis for this work as part of Implementing Strategic action 7.2 from the Bulgarian "Strategic plan for the development of the forest sector 2007-2011".

The programme is also relevant to Target 30 of the Bulgarian government programme - "Improvement in the protection and support of the adaptation of the Bulgarian forests to climate change".

The new programme has been adopted at expert level and is distributed in English among the project partners and all other stakeholders. Its main results include detailed analyses of forests and climate change, including forest soils and climatic scenarios for 2020, 2050 and 2080 (high and low). Vulnerability zones are identified and concrete measures for these zones, including for the protection of the soils, are developed.

On the basis of this programme the Executive Forest Agency implemented an updating of the "Classification scheme of the types of forest soil in Bulgaria".

This practical policy tool was presented to all project partners. Its main role is to support forest management planning, by giving information about appropriate soil habitats and most appropriate forest tree species choices.

The stability of this carbon pool is of primary importance in optimising the contribution of woodlands to climate change mitigation.

But pressures from human activity, such as inappropriate agricultural and forestry practices, industrial activities, tourism or urban development, are damaging the capacity of soil to continue performing its crucial functions.

Soil protection essential to sustainability
Soil degradation has strong impacts on the wider community including water, human health, biodiversity and food safety.

During the FUTUREforest project, experts from partner regions agreed that erosion by water or wind, the loss of soil biodiversity, the change in the carbon pool, the worsening of the water storage and filtering are major risks to our forests - and that climate change will increase these risks in the future.

The failure to protect soils will undermine sustainability and the long term economic basis of the forest sector in Europe.

The project has identified many problems and a number of proposed political, scientific and practical solutions, presented in policy tools, instruments, documents and good practices.

Forest soils under threat

The soils of Europe vary dramatically, with different regions having very different characteristics, fertility and vulnerability to climate change. In many the expected temperature rises, combined with increased periods of drought, will significantly increase the water deficit in soils.

The most serious impacts will be observed for sandy soils with low water retention capacity, and in some cases for heavy clay soils with subsequent cracking, shrinking and swelling as result of drying and rewetting periods.

Southern Europe faces the highest risk of extreme soil droughts. In Northern regions the opposite problem may occur – climate change may in some cases increase precipitation.

Risks to landscape predicted
Global warming and rising CO_2 concentrations in the atmosphere may enhance forest growth in temperate zones, which in turn could increase soil organic matter through greater plant litter input.

Conversely, increasing soil temperatures are predicted to stimulate microbial activity and therefore increase decomposition and loss of soil organic matter, thus reducing carbon stocks.

In all regions climate change is predicted to increase the number and severity of landslides, flooding and soil biodiversity loss.

During the FUTUREforest study visits project partners identified the most important priorities for soils and forests:

Soil protection and enhancement are essential to all aspects of forest management and is essential for climate change mitigation.

Long term forest planning is vital to avoid degradation of the soil's structure and fertility. This is most important with regard to water storage.

Forest soils contain vast quantities of carbon, in most cases more than the trees and sustainable forest management can protect this carbon store.

The dynamics and storage of soil carbon under different soil types and forest ecosystems must be understood better.

Water measures

CATALONIA
During 2009 and 2010 in the municipalities of Meranges and Girult (La Cerdanya, Catalonia a special project used good practice in the protection of people, material goods and infrastructures.

It included the construction of several consolidation dams and the improvement of torrent beds to prevent flooding following intense rainfall.

More than 9 ha in the surrounding area was planted with trees - afforestation which will help rapid vegetation cover that will fix the soil and will also reduce erosion.

Acidification is an issue for forest soils in Northern EU countries, with impacts on water quality and should be considered in forest management.

Forest operations must always consider the impact on soil degradation, erosion and compaction.

A better understanding of the long-term consequences of forest operations in terms of carbon release is needed.

Protecting forest soils

During the work of the FUTUREforest Conference working group at Barcelona on "Soil Protection" a number of recommendations and solutions, common to all European partner regions were agreed.

Leading European experts in the field of forestry, soil protection and climate changes were involved in the development of a number of specific solutions:

- Forest management must be adapted to help reduce the potential negative impacts of climate change on soil function.
- There should be a new political initiative at EU level on soil protection in Europe
- The most appropriate tree species to match the habitat and protect the soils should be selected as climate change begins to impact.

5 The challenge for adaptation – 5.4 Saving our soils – the value of good management

5.4 Saving our soils – the value of good management

- Forest fire prevention must be considered in afforestation and forest management. In forest areas subject to fires, soil protection is a major issue.
- Soil preparation for forest regeneration and afforestation must be properly planned and implemented using best practice to avoid soil degradation.
- There must be increased awareness of soil management and protection amongst all forest owners and managers.
- We must understand better the long term consequences of different silvicultural practices and the dynamics and storage of soil carbon.
- Improved guidance for woodfuel in terms of soil protection is essential.

Soil-conservation actions

BRANDENBURG

At the Forest Research Centre Britz there is continuing research into the influence of climate on the growth and condition of forest stands. It has developed a sustainable model for the relationship between the climate elements, different soil conditions, growth and health of the forest stands that will assist in mitigating the affects of climate change on soils.

There are already a number of preventative soil conservation measures in Brandenburg, implemented primarily in state-owned forests, which are certified up to Programme for the Endorsement of Forest Certification (PEFC) specifications, which means that management of the forest needs to involve soil-conserving actions.

These include, amongst others:

- As a basic principle, forest operations must avoid excessive vehicle movements over forest soils.
- Creation of a robust, permanent infrastructure for forest harvesting.
- Use of forest machinery that minimises damage to forest soils.
- Forest infrastructure using concrete or tarmac will be undertaken only when absolutely essential.
- Whole-tree harvesting, removing all brash and stumps from a site is not always an acceptable forest practice.
- Clear-cutting which leads to open-land conditions should be avoided wherever possible.
- Soil cultivation should be minimised wherever possible during forest establishment.

Restoring Peatbogs

WALES

Historically Forestry Commission Wales planted on any land available to meet the nation's timber needs. This was often poor value agricultural land on peaty soils.

Now we are more aware of the value of these areas as they perform a range of ecosystem functions, including habitat provision, carbon storage and sequestration, regulation of water and nutrient retention.

The plantations of conifers have lowered water levels, allowing soil erosion, the release of carbon into the atmosphere, loss of water storage capacity and reduced biodiversity provision.

The policy in Wales is now not to plant up areas of deep peat and much work has been undertaken to restore peat bog habitat in some areas, such as Penaran, Dolgellau, North Wales.

Through the 'LIFE Active blanket bogs in Wales' project the site was restored by removing the conifers and blocking the drainage ditches.

The conifers were felled, brashed and put into the nearest drainage ditch to decay.

Every 12 m (or less, depending on gradient), vegetated peat dams and runoffs have been created to raise the water table of the bog and allow excess water to flow off across the bog surface. This results in erosion and peat loss reduction and an increase in peat-forming sphagnum mosses. The cost was £1.60/m for this blocking work.

5.5 Sustainable timber and non-wood forest production

Money and jobs - timber production in Europe

Forests and woodlands represent a vast renewable economic resource - covering 44 per cent of the land in Europe - that is significantly under-utilised.

If sustainably managed, they have the capacity to provide more timber and biomass without compromising other ecosystem services.

Development of the local timber processing industry and annual felling could double the economic benefits from the forestry sector, increasing rural employment and contributing to a major reduction in Europe's carbon footprint.

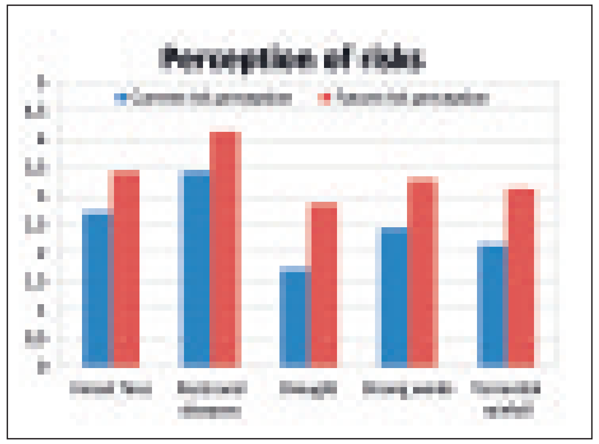
Timber for construction

This timber reserve should be used to replace materials such as steel, concrete and plastics, all of which require large amounts of fossil fuel for their production.

Replacing them with timber for use as construction, furniture or fuel can contribute to the reduction of Europe's carbon footprint – vitally important in the face of climate change - and boost rural economies.

Overall forest timber production, measured as the ratio of annual felling to annual increment declined from 1950 to the beginning of this century.

The percentage of the total annual increment that is harvested varies from as little as 18 per cent in some regions (Catalonia) to approximately 80 per cent in other regions (Brandenburg), far below the maximum sustainable potential.



Share of annual increment that is harvested annually

FUTUREforest recommends

1. **Build new markets for timber in construction through promotion and incentives.**
2. **Promote schemes to encourage the use of wood fuel as a renewable energy resource when other uses are not viable.**
3. **Improve infrastructure to provide access to forests and woodlands for forest operations for which subsidies may be needed in some regions.**
4. **Forest owners should be supported - legally, technically and economically - to help them diversify into marketable non-wood forest products and services such as pine nut and fungi collecting, cork production and recreation.**
5. **Help and encourage the establishment of Forest Ownership Associations that bring together small woodland owners to help increase management of smaller woodlands.**
6. **Encourage FSC/PEFC accreditation schemes to increase emphasis on maintaining or increasing production.**
7. **Encourage the production of forest management plans both at regional and stand level.**

Private forests - undermanaged and uneconomic

With a proportion of state-owned forests ranging from 23 per cent to 89 per cent, the direct political influence on forest management is relatively high. This is guided by an increasingly urban electorate, which has a limited understanding of the need to produce timber and the associated benefits to European society. These conditions in turn, underline the urgent need for education and encouragement of the use of wood products.

More support needed

Private forest owners play a key role in forest utilisation. On average 58 per cent of forests in Western Central and Eastern Europe are privately owned. But more than 86 per cent of all private forest holdings are less than 5 ha in size. These forests are generally uneconomic to manage because potential income is low and irregular. Large forests with fragmented ownership and lack of skills have further complications.

The production of non-wood forest products (NWFP) is often hindered by the lack of technical knowledge as well as economic and legal support to the producers.

In combination with decreasing profitability of forest operations due to increased average wages and other overheads these facts have reduced the efficient use of forests for timber production. More frequently, forest property is now viewed as valuable for providing a number of other, often non-timber services such as recreation, hunting, or environmental benefits. These are all legitimate goals of forest owners, but the cumulative effect decreases availability of timber – sometimes dramatically - as a renewable resource.

Climate change – forests can do more to mitigate

FUTUREforest recognises that Europe is missing out on a significant opportunity to help mitigate the effects of climate change because it is under-utilising its forest timber resources:

1. The EU is currently heavily reliant on a range of products such as steel and concrete in construction that could be replaced with timber, a renewable, carbon-neutral resource.
2. This massive renewable resource has significantly more potential for biomass production to replace fossil fuels than is currently being realised.
3. The required adaptation to climate change and the associated risks can only be achieved by maintaining forest productivity and health through active forest management.

The forest sector currently contributes up to 4 per cent of GDP and 4.5 per cent of employment across the European regions.

Development of the local timber processing industry and annual felling could double the economic benefits from the forestry sector.

Major obstacles to economic opportunity

The most important issues for timber production, as recognised in consensus within the seven partners of the FUTUREforest project, are:

Difficult access
Large areas of forests remain unmanaged due to poor infrastructure. As further development is often constrained by financial resources, EU and national scale investments are required.

Access to these currently inaccessible areas will also be increasingly important to allow for risk management measures to tackle increasingly frequent and severe forest fire, insect outbreaks and diseases.

Fragmented ownership
The fragmentation of forest ownership combined with the problem of identifying individual small private forest owners seriously affects management and production.

Owners and state fail to recognise the opportunity that small woodlands present to increase the economic well - being of rural areas.

Solutions:
1. Forest owner associations should play an important role in providing knowledge and services to private forest owners. Their aim should be to increase the profitability of forest management and therefore the interest of forest owners in managing even small forest areas. However, less than 5 per cent of private forest owners are organised in associations. This process needs to be supported and encouraged.
2. Public forest administrations can be directly involved in organising and assisting with the management of private forests, as practiced in the Auvergne.

Multi-purpose forestry – but who pays?
The provision of a wide range of functions and objectives may constrain timber production. But these multiple services and benefits – biodiversity, social and flood control – are not yet fully recognised or compensated for. The public, governments, and other sectors such as the insurance industry need to acknowledge and value the benefits and services that forests provide. New mechanisms of financial valuation should be developed to encourage increased and improved forest management.

Underdeveloped home markets
In certain regions, there is insufficient capacity and development of the forest industry as indicated by the high amounts of round wood exported to other regions within, or outside, the EU.

It should be a key priority to maximise timber processing and finishing in the country where it is produced to maximise local economic benefits of the forest industry.

Incentives for production in certification schemes
The proportion of forest area certified according to FSC or PEFC varies between regions from almost zero to close to 100 per cent. Certification often provides incentives for increased nature protection, rewarded in some cases by increased economic benefits for the owner. But more often there are additional costs in accessing specific markets.

Maintaining or increasing sustainable timber production is not always a component of these certification schemes. The emphasis on monitoring forest production capacity must be strengthened to ensure that there is no loss of production in certified forests.

Resilient forest plantations
CATALONIA

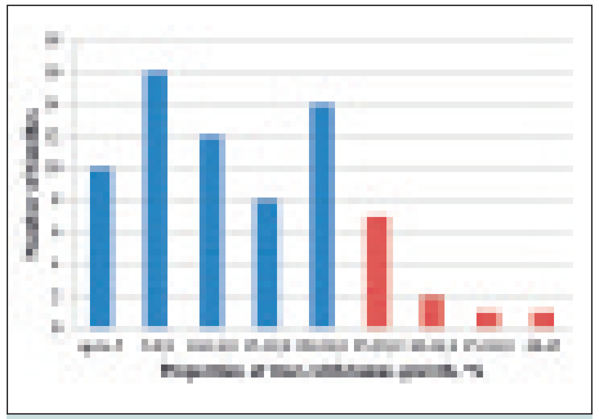
Forest production is already facing major constraints in many Mediterranean regions. In Catalonia, timber production is only possible on a small proportion of the total forest area due to steep slopes, shallow soils and frequent fires.

Local timber harvesting only meets 12 per cent of the region's timber demand. Only 1.5 per cent of the forest is intensively managed using non-native species such as poplars, Monterey pine (*P. radiata*), or Douglas fir, and techniques like clear-felling and artificial regeneration. The rest of timber production comes from extensively managed naturally regenerated forest stands.

The tiny amount of land devoted to plantations produces about 15-20 per cent of the regional timber harvest, which in turn can reach an estimated 30-40 per cent of the overall value. For this reason, measures to prevent and control the consequences of climate change effects in these plantation areas are already being implemented. Any effect on them could have an economic impact that would be devastating for the Catalan timber sector.

There is also great potential for plantation forests, if managed appropriately, to increase the local production of wood resources and development of related industries, while not compromising other important goals of forest management.

Cedar (Cedrus atlantica) plantations could be an option for the basic soils of Central Catalonia given its higher resistance to lower water availability



Improved planting material
LATVIA

Increased vitality and quality of young stands planted with improved forest reproductive material in Latvia

Recently increased lamas - end of year - growth in Scots pine has been seen in Latvia, related mainly to an increase in length of vegetation period over the last 30 years. Lamas growth notably reduces the potential quality of timber and an increased risk of autumn frost damage. Studies carried out in progeny trials reveal notable differences between sets of progenies from a single mother tree in the proportion of lamas growth.

This indicates that selection of proper seed trees for direct seeding or as parents for plant production is an option to reduce the severity of quality loss.

Forest production and resilience to climatic change

The FUTUREforest project has identified that different approaches to forest establishment exist and that a mixture of strategies is necessary in light of the challenges that lie ahead.

A series of forest regeneration strategies are required to maintain or improve timber production in the face of predicted climate change:

1. Introduction of new genotypes, provenances or even species, as well as clones and other new types of forest reproductive material, where appropriate.
2. Research into new genetic material looking at disease and drought resistance, timber quality, and productivity.
3. Regeneration policies and incentives that will increase forest resilience by increasing species diversity and improving forest structure. Regions differ greatly in the practices they use, ranging from 100 per cent planting to 100 per cent natural regeneration. This is due to regional forest tree breeding programmes, availability of seed orchards, costs of establishment and game browsing.
4. Utilising a wider range of forest management systems that will increase structural diversity of forests. This will lead to increased biodiversity (Chapter 5.1.) and improved resistance to threats from pests and diseases.

5 The challenge for adaptation – 5.5 Sustainable timber and non-wood forest production

Financial incentives

AUVERGNE

In order to be eligible for state or public communities funding, private owners are requested to commit to sustainably manage their forest by implementing an administration-approved management document.

The tax system has also become one of the main tools for forest state policy, especially for private forest. Indeed, private forest owners can have access to tax benefits when making investments and committing to sustainable forest management:

Income tax

Under certain conditions, owners have the possibility to deduct up to 22 per cent of the investments made in their forest from their income tax. Eligible investments are property extension and forest work, and one of the conditions to be eligible is the sustainable forest management agreement.

While forest owners are generally taxed according to the value of their land, they can be exempt from this property tax when choosing to renew their stand either by planting or by natural regeneration (within 50 years for broadleaved, 30 years for conifer, and a quarter of the tax for irregular forests). It also implies a diminution of the income they declare on their income tax sheet.

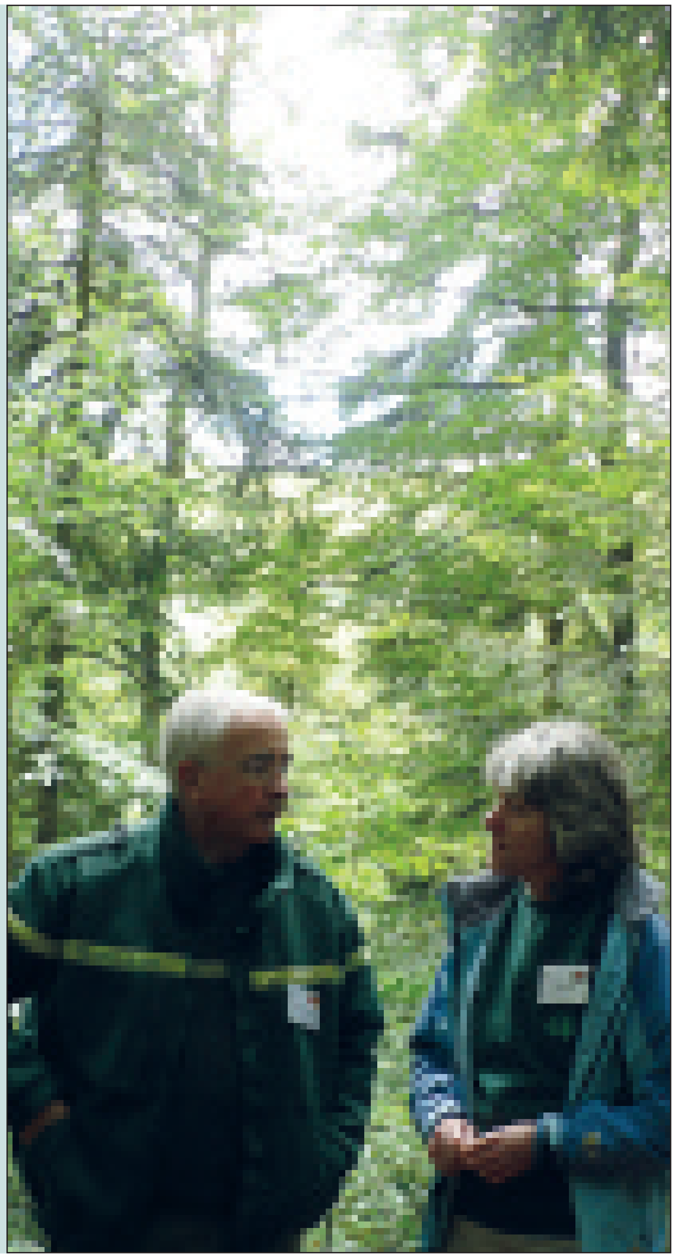
Consumption tax

Owners registered with the tax services benefit from a lower rate on the value added tax which is deducted from the cost of supplies and forest work - 5.5 per cent instead of 19.6 per cent.

Property tax

In cases of inheritance or donation, only one quarter of the value of forest goods is taxed. The same applies to taxation in the name of the “wealth tax”. The only necessary condition is the implementation of the sustainable management document, which is a 30-year commitment.

These tax adjustments are not automatically applied and must be requested from state services.



Non-timber Forest Products (NWFP) are extremely vulnerable to climate change as their production is very closely linked to the seasons so extreme weather events can cause high levels of damage. For instance, in Catalonia in 2003 cork, which is one of the highest value forest products, could not be harvested due to drought.

Compensatory measures and developing climate change adapted silviculture focused on these NWFP are two of the measures that need to be implemented in areas where NWFP are the management target.

The importance of timber and NWFP production is underestimated at EU level.

There is the capacity to boost the productivity of European forests whilst not compromising its ability to provide a wide range of other social and environmental services and benefits.

This will significantly
- Boost rural economies
- Increase rural employment
- Contribute to the reduction of Europe’s carbon footprint

Drought and flooding – dual ecosystem threats

Water is essential for all life on Earth. Many countries rely on forests to provide a reliable and clean supply of drinking water - for example 85 per cent of Bulgaria’s drinking water comes from its forests.

Forests and forest management play a vital role in protecting water quality, managing water resources, alleviating downstream flooding and combating desertification. These ‘ecosystem services’ provided by forests are threatened by climate change.

Already there is evidence of more frequent flooding and a growing imbalance between freshwater supply and demand, leading to increased water shortages. Water shortage in Catalonia is considered one of the main risks of climate change, with an estimated impact of 7 per cent on the Gross Domestic Product of the region.

Sustainable water management is becoming increasingly critical as the water environment faces growing pressures from urban development and climate change – it must be right or we risk impairing this essential resource with severe consequences for society.

FUTUREforest recommends

1. **Forestry practices, including species choice and silvicultural management must be designed to protect water resources especially in regions most at risk, such as the Mediterranean.**
2. **There must be a co-ordinated strategy between forestry and water policies. All relevant stakeholders – including landowners – must be involved in decisions on water management. The different pressures on water – energy production, agriculture, forestry and urban development – must be recognised.**
3. **The Water Framework Directive must be used to balance the multiple demands and opportunities for water on forest land. Foresters should contribute to river basin management plans.**
4. **Society should recognise the important role in the management of water resources forests play and needs to contribute financially towards the continued provision of ecosystem services such as flood prevention and drinking water.**
5. **New forest planting must be considered as a valuable method of reducing flood risk where appropriate.**
6. **Research is needed to better understand the hydrological implications of different tree species. Clear indicators of drought risk across each region must be established and the capacity of forest ecosystems to store water understood.**
7. **Forest infrastructures – such as dams, roads and drainage – must be reviewed to ensure they can withstand increased frequency of heavy rainfall. This will have economic impacts and will need funding.**

5.6 Water – the key element for society's future

The forests are at risk

Forests offer a major opportunity for mitigating climate change effects. But they are also vulnerable to climate change impacts.

Two critical factors must be understood:

- To ensure forest health and prevent any loss in forest area and for that forest planners must change the way the forests of Europe are designed and managed for more efficient use of water. This needs co-ordination between the forestry and water sectors.
- Water supply and flood alleviation are at risk. These services must be recognised, adequately acknowledged and compensated for by those who benefit from them.

Forests depend on sufficient water to survive.

Europe already experiences a range of climate conditions and forests are generally well adapted to the water regime in each region. But the benefits that forests and forestry provide through water are at risk. There are already changes in water availability and trees across Europe are showing a wide range of symptoms associated with shifts in precipitation regimes.

It is essential for forest planners to change the way the forests are designed and managed to make them more resilient to predicted changes in water availability.

Sustaining society

To sustain European society water quantity and quality must be managed.

Changes to rainfall patterns will affect the existing water infrastructure, including hydropower, structural flood defences, drainage and irrigation systems and water management practices.

Important economic sectors depend on sufficient, reliable water supply will also be affected, especially agriculture and the energy industry which relies on water for cooling in power plants, hydropower or the production of biomass.

Flooding is predicted to become more frequent, leading to loss of life, contamination of water supplies and major damage to property.

Waterlogged soils can lead to poor tree health or even tree death in the forest, as well as damage to the ground from forest operations. In Latvia, for example, predictions are for ground water levels to rise.

However, there is also an increased risk of drought in many regions. A co-ordinated strategy between forestry and water policies is needed.

Managing for water

CATALONIA

In the Holm oak forests of Prades, Catalonia, scientists experimented with thinned and un-thinned plots.

Despite leaf area being reduced in the thinned plots, transpiration remained constant at 84 per cent of the total annual precipitation.

Two years later there was a very dry period of more than eleven months with less than 300 mm of rainfall.

This caused intense die-back in the un-thinned plots however, there was no die-back in the plots where the trees had been thinned – demonstrating that active forest management could help maintain or increase waterflows, while helping mitigate the impact of drought in the remaining forest stand.

Native Spruce Fir loss in Auvergne

Water in the forests too little – too much

The loss of trees from drought is of particular concern for the southern regions of Europe and the seasonal shortage of water is also of increasing concern further north where certain tree species that are known to be drought sensitive**.**

Drought-affected forests are expected to increase across Europe due to:

- Increased climate warming resulting in higher evaporation
- Reduced summer rainfall and more frequent and severe droughts
- Changes in rainfall regimes in relation to growing periods
- Increased winter waterlogging reducing rooting depth
- Longer growing periods increasing tree water use.

The limited rainfall must be optimised in these regions through changing forest management regimes and species.

Clear indicators of drought risk across each region must be established.

Forest adaptation

Foresters must use tree species that will tolerate greater soil drying and changing hydrological conditions. Using a wider range of tree species and provenances tailored to the site conditions is considered the best strategy as climate predictions cover a range of scenarios. A diverse forest will reduce the risk of catastrophic damage.

In some regions silvicultural practices will need to change. Where existing management allows bare earth to become exposed - through clearcutting - a move to continuous cover forestry will help prevent the rapid run-off of rainwater.

Forest management based on improving forest stand resistance and resilience, taking into account water use has four main features:

- The promotion of mixed and uneven aged stands
- Re-evaluation of existing silvicultural techniques and the use of new techniques in plantations using drought adapted species
- Re-evaluation of felling and thinning regimes to increase water-retention by managing the leaf area at tree and understorey level
- Keeping more water within the forest through drain blocking and using woody debris dams

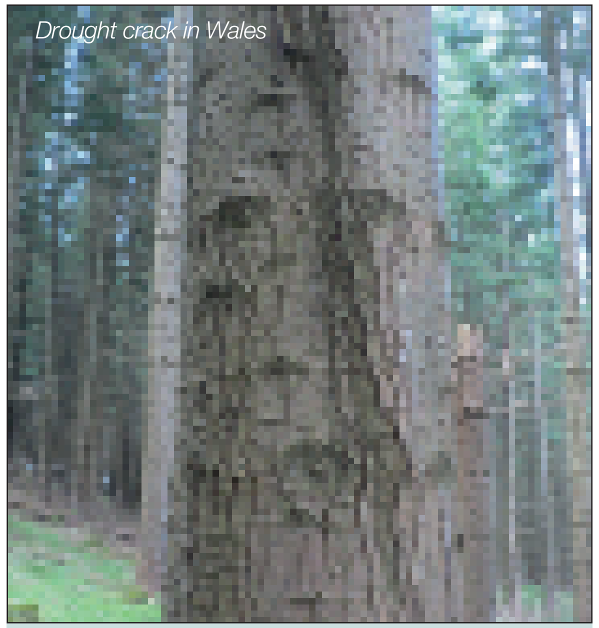
There is a need to better understand the hydrological implications of different tree species in terms of the amount of water used. Some regions already use broadleaved trees to help with water management as they do not require as much water as needle-bearing species.

Forests with soils that are not free draining which are expected to experience increased precipitation, leading to increased waterlogging, will face problems such as site damage from mechanised operations, root rot, poor tree growth, catastrophic wind disturbance and increased disease risks.

This too will lead to poor productivity, damage to the timber and even tree death. Regions must identify areas that are likely to experience problems with waterlogging and adapt their forest management accordingly.

Preparing for the worst

The impact of increased flooding events can be reduced through an improved forest infrastructure with more - or better designed - roads, tracks and culverts to reduce the risk of flood water washing away access routes and scouring at risk areas. It is necessary to identify unstable slopes vulnerable to debris flows and landslides and manage them to reduce these risks through ensuring sufficient vegetative/tree cover.



Drought crack in Wales

Trees used to manage water

WALES

A group of farmers in mid- Wales came together to explore ways of providing a more sustainable, less intensive approach to farming, whilst maintaining or improving economic returns They were initially interested in having longer periods of outdoor grazing for sheep through winter. This required more shelter for the livestock so the farmers began woodland and hedgerow planting and the development of tree shelterbelts.

It soon become apparent that more tree cover, especially the addition of linear features, had a dramatic impact on water flow and erosion potential. Initial research showed that water infiltration rates were up to 60 times greater in areas where stock had been excluded and trees planted, compared to the adjacent grazed pasture.

Models of water flow at field and catchment scale were developed and used to explore a variety of tree cover scenarios. Results indicated that the small scale planting by the farmers had a significant effect at a sub-catchment scale on reducing flood peaks by 6 to 18 per cent.

These lower peak flows reduce the energy of a flood. This leads to less erosion of the stream bed and banks, reducing the amount of sediment in the watercourses. Livestock exclusion through streamside fencing and tree planting, provides an additional important erosion control benefit.

5 The challenge for adaptation – 5.6 Water – the key element for society's future

Preventing floods

There is already more summer and winter flooding. Summer periods of dry weather are followed by intense periods of rainfall, the ground is too dry to efficiently absorb the deluge and the rain runs off rapidly, causing flash flooding. In traditionally wetter months with increased heavy rain falling onto already saturated ground, which also leads to major flood events as there is no capacity left in the soil.

There are various techniques to slow water run off and help reduce flooding to downstream communities, industrial sites and farmland, including planting more trees in appropriate locations, such as within river floodplains.

Trees and forests can delay flood peaks by holding back water, which can desynchronise flows from different tributaries and so reduce flood peaks.

Forest streams also become more retentive with the use of large woody debris dams, which help create multiple channels and backwater ponds that provide better habitat for invertebrates and fish. Slowing the rate of flow also helps to retain more sediment and reduce stream channel and bank erosion.

An additional benefit can be gained by planting trees on farmland where they improve the infiltration of rainwater into the soil and reduce the risk of rapid overland flow contributing to flood peaks.

Ecology and drinking water

Water quality is an important issue and the Water Framework Directive places legal requirements upon each region to improve water quality. It is necessary for both drinking water supplies and supporting the ecology of the aquatic systems. It is important that there is management of riparian zones to protect watercourses from diffuse pollution and improve their overall ecological condition.

The importance of drainage

LATVIA

In Latvia where much of the land is very flat compared to the other regions waterlogging of soils is a particular issue. Active management of forest drainage systems is essential by creating and maintaining forest drains. In other regions the majority of the very wet ground is now used more for biodiversity gain than for forestry.

An increase in groundwater level in managed forest areas would lead to the decrease of forest productivity or even to the total degradation of certain forest areas. To prevent this, improved maintenance of the existing drainage systems and the building of new systems is considered necessary by Latvia's forestry sector.

In Latvia there are 1.5 millions hectares of waterlogged forests, only half of which are drained. Over the last 100 years draining has increased the average stand volume in forests from 100 to 180 m^3 ha per year - nearly doubling production.

Swamp forest areas which make up 30 per cent of the area and have biodiversity value are being retained with no drainage work being carried out.

Appropriate planting of tree species that will help improve the condition of riparian areas within woodlands and new planting of trees to protect water condition within other agricultural land or even in urban areas should be targeted along with;

The use of different silvicultural systems in the regions, such as continuous cover forestry where the existing practice is a clear-cut regime will minimise water flux and reduce nutrient enrichment which will help protect watercourses from deterioration.

Spreading the word on forestry's key climate role

Forest owners and managers must shape forests according to the expected climatic changes**.** Science has already paved the road ahead. For most European regions there are various scenarios of climate change and their associated impacts on forests and other ecosystems.

FUTUREforest has brought together the latest thinking from across Europe on new ways of managing our forests, best practice, current research and new techniques to mitigate and adapt to climate change.

Now, the key is to communicate this wealth of information to the different stakeholders responsible for forests, landscape, nature conservation, biodiversity, society, science, administration, industry and to other stakeholder groups.

Our aim is to identify suitable methods of exchange, dissemination and transfer of knowledge on a regional/local level – vital work without which these cutting edge climate change solutions may never be shared.

Who do we need to talk to?

FUTUREforest believes that the current knowledge on climate change and its impacts on European landscapes is sufficient to allow decisions that define the direction of future development to be made. We know what is likely to happen, but the communication of ideas and knowledge across the regions – and even within the regions themselves – has to be improved.

Our primary target groups are politicians, policy makers, foresters, forest owners, land owners and opinion formers.

FUTUREforest recommends

1. **The forestry sector knows enough about climate change to start making changes now – but needs to bridge the communication gaps between scientists, foresters, forest owners, the general public, policy-makers, politicians, opinion formers and other stakeholders.**
2. **Communication must use a balanced mix of the most suitable tools to target specific stakeholder groups.**
3. **Active local, regional and European knowledge networks need to be created with public funding to bring all stakeholders together to share information and improve communication. Organised field visits can provide a focus for these networks.**
4. **Creation and funding of education programmes for forest owners, children and young people.**
5. **Simple, consistent, common messages need to be developed and delivered outside the forest sector.**
6. **Use 'multipliers' – specialists who have understood and recognise the worth of the material brought together on climate change and forest management - to spread the word.**
7. **Encourage the use of good practice guides such as those already identified by FUTUREforest. Use more regional examples to promote awareness.**
8. **Adequate funding must be made available. Effective communication requires considerable time and effort. Without it, the findings of important projects like FUTUREforest will not be properly understood or acted upon.**
9. **Additional funding is also required to ensure that all important information can be translated so that it can be used by all.**

There are two approaches:

- **The top-down-strategy** - where knowledge transfer is integrated into the forest policy developed by regional decision-makers.
- **The bottom-up-strategy** – where experiences and expectations of forest owners and forest managers slowly 'trickle' upward through the system into policy, a more time and energy consuming approach.

Confronted by a wide diversity of information and knowledge, foresters and forest consultants are often unsure of the right decisions to make.

Forest owners recognise the effects of climate change in their forests, but the knowledge that could help them adapt their practices is often too scientific, too unstructured or simply inaccessible to them.

Today's forest industry relies on currently available forest products. The adaptation of forests to a changing climate will change the availability and quality of forest products, requiring long-term investment decisions and the willingness of industry to adapt production capacity. A forest industry mainly focused on international markets and constant growth is not

able to make these efforts for adaptation.

The wider role of forestry in reducing flooding, carbon sequestration, soil protection, biodiversity, promotion of health and well being is not understood fully by many stakeholder groups.

If communication efforts fail, the socio-economic impact on the rural areas of Europe is likely to be dramatic. We have enough information now to prepare forests for the future – the need is to make sure that the information is spread.

How we used communication

Communication can be:

- **Person-to-person** - conferences, workshops, education, trade shows
- **Print media** - newspapers, specialist publications, flyers
- **Digital** - websites, blogs, social networking, video clips, etc

Person-to-person

Conferences (national and international) – reporting to a wider audience

Four international conferences organised by FUTUREforest communicated key messages as well as current information on project themes: in Berlin, Germany, to launch the work; in Barcelona, Spain, reviewing the study visits; in Cardiff, UK summing up the systematic work, and in Brussels, Belgium, presenting the voice of the regions for resilient future forests.

Conferences bring experts and stakeholders together to discuss, expand and detail current knowledge and sum up the current knowledge from different regions.

International conferences need to address specific topics and should be open to specialists, stakeholders, politicians, policymakers, and opinion formers.

Language barriers can be a problem and sometimes limit the open exchange of ideas and knowledge, which can be resolved by simultaneous translation, as used in Cardiff.

Moderation and documentation is crucial for the success of the conference. Adequate staff/facilitators and a clear understanding of the desired results are essential. Attendees need to know what is expected from them and what they can expect from the event.

Study visits – seeing is believing

FUTUREforest organised seven ‘study visits’ – one in each of the regions – in which experts from every participating project region were able to develop a clear understanding of regional problems at a practical level.

By means of challenging presentations and site visits, current problems of climate change relating to practical forest management were demonstrated and discussed with international experts.

This understanding of the situation of the local forestry professionals allowed for in-depth discussions and the exchange of practical experiences and recommendations for possible adaptive measures. These study visits were also open to all audiences: forestry professionals, students, politicians, policymakers etc.

The study visits provided the key information on which this FUTUREforest final report is based.

Workshops – learning from each other

During the second phase of the FUTUREforest project - “developing together” – five workshops were held:

- *‘Funding and subsidies in forestry’* - Brandenburg
- *‘Forest planning instruments’* - Auvergne
- *‘EU Greenpaper Forest Protection’* - Brussels
- *‘Forest policy instruments’* - Bulgaria
- *‘Forests as carbon sinks (LULUCF)’* - Latvia

These workshops contributed considerably to the exchange of factual knowledge about the forest policy framework of the participating regions, with common statements on current topics of European forest policy being issued.

Trade shows and exhibitions – a showcase for project findings

These events give access to a wide audience but a cost-benefit analysis is needed to see if that audience is likely to be receptive to information on forests and climate change.

The FUTUREforest project team resolved that presentations of this complex and sophisticated topic at ‘normal’ trade shows or exhibitions will reach our agreed target groups only to a limited degree. In contrast, presentations given in combination with professional conferences, forums, or symposia are much more successful when it comes to transferring knowledge to the target groups.

However, in Wales for example, the team collaborated with other stakeholders from the forest sector to provide a presence at the region’s largest agricultural and land use show at reduced cost. Similarly, presentations at other more ‘public’ events were organised in cooperation with sister organisations.

Competitions – encouraging engagement with climate change and trees

A number of competitions organised by several of the partners encouraged entrants to investigate and interpret climate change and its impacts of forests and landscapes. The approach of giving a problem and inspiring students and children, as used in Latvia and Catalonia, to find solutions by means of a scheme of incentives was generally positively received.

Forest education programmes – involving young people

Children and young people were targeted through educational programmes in Latvia and Slovakia, although these ‘stakeholders’ were at the periphery of the agreed target groups. Subjects concerning the forest and timber industry within a certain region were prepared and presented depending on the targeted age group.

Compared to other groups, children and young people can be more easily informed about forests and climate change. Positive results of working with children and young people were recorded although, again, a cost benefit analysis is needed to assess the success of educational programmes.

Silvicultural training – learning together

This highly practical approach relies on training a small number of ‘multipliers’, specialists who then go on to repeatedly educate small groups of foresters using specific silvicultural examples. Against the background of climate change, Forest tending, thinning and other silvicultural measures are discussed during forest field trips.

Silvicultural trainings are suitable for transferring current and new silvicultural knowledge to forest managers.

Print media

Good practice guides – documenting ground breaking practice

Good practice guides developed from discussions between two or more project partners focus on specific impacts of climate change and the different solutions used in the regions. These good practice guides are highly valuable for all participants and provide a wealth of important cross-border information and practical help for

foresters across Europe. The development process and the quality of the final Good practice guides, however, rely on excellent moderation and specific requirements regarding the structure and length of the final documents.

Daily newspapers at different levels – spreading the word

Daily newspapers provide access to a very wide audience, but require simpler messages than other print media. However, the forming of public opinion across the regions is largely influenced by this media type.

Scientists and professionals often present problems and messages in a complicated way, with too much detail. Press releases therefore need to be prepared by media professionals to ensure they make it into daily newspapers without being distorted during the editorial revision process.

Local Forest Plans – working together for the future

AUVERGNE

When local French municipalities group together in territorial authorities, they can create their own local forest policy through “Local Forest Plans”. This allows the association of forestry and timber industry stakeholders, the state administration, and the local authorities to identify and define common objectives of development and the required actions to achieve these objectives.

The success and originality of this approach depends on the co-operation between forest professionals and forest users and on the definition of common objectives. The effects of climate change are now part of the agenda of these Local Forest Plans. In Wales, forest design planning also includes community consultation processes organised by Forestry Commission Wales.

Discussing forest management concepts

5.7 Communication – sharing knowledge and information

Education of forest owners – putting knowledge into practice

BRANDENBURG

Compared to silvicultural training aimed at forestry professionals, the transfer of knowledge to forest owners with limited knowledge of forests and forest management requires a different type of infrastructure and curriculum.

In Brandenburg, for example, the 'Waldbauernschule e.V.' (Forest Owner School), a non-profit organisation, aims to educate forest owners of all types and property sizes. Selected subjects are prepared and taught by instructors who are professional foresters. Following indoor lectures, participants expand their newly acquired knowledge during practical exercises in selected forest stands. These forest owner schools will always rely on public co-funding or subsidies because of the reluctance of owners to pay for the service.

Trade magazines and professional journals – talking to the sector

These journals are highly focused on their respective target audiences and present an excellent way of communicating new knowledge, developments and discussions. Due to this focus, however, the information is not noticed by all stakeholders or land users.

Flyers – a first step to knowledge

Flyers are a standard method for distributing information, which should be offered to an audience with further explanation. A well-presented flier can be a door-opener to a project by providing background and contact information. The limited space requires a simplified presentation of complex issues.

A generic flyer was produced in English giving details and contacts for the project. The artwork of this was made available to all partners for translation and print. In Wales alone, more than 5000 copies have been distributed.

Brochures – learning more

Brochures can provide more in-depth information on a given subject to a target audience. Pocket size brochures in particular are an efficient way of knowledge transfer and dissemination.

Digital media

Websites – knowledge on the net

The FUTUREforest website is an excellent medium to make knowledge available to a large number of target groups and provides a central information resource. However, websites need to be continuously updated and administered, which requires considerable time.

The accessibility of information presented in a website to all target groups remains an unanswered question, particularly among foresters with limited computer technology and insufficient internet access in rural areas.

Video clips – project work on the screen

During the study visit in Chorin, Germany, the Brandenburg FUTUREforest team produced a video clip on forests and climate change in Brandenburg. This video clip was to be presented on trade shows and exhibitions and for other events of the FUTUREforest project. Although the clip is suited for appealing to a large audience due to its interesting content and attractive design, it turned out to be unsuited for trade shows and exhibitions due to acoustic issues and lack of brevity.

Marteloscopes – virtual forest planning

AUVERGNE

Silvicultural demonstration sites called 'marteloscopes' have been set up and operated by the French Forest Administration ONF and the centre of private forest owners (CRPF) in Switzerland, the UK, and France. They are based on selected forest stands that have been fully inventoried for tree species, non-tree vegetation, and ecologically relevant structures. A database is then linked to models, classification schemes, and, potentially, to imaging software.

Foresters and forest owners implement virtual silvicultural intervention schemes in the stand. The consequences of each virtual intervention are analysed by the modelling software. Impacts on timber volumes, quality, and value as well as on water regime, biodiversity and potential risks are assessed.

Marteloscopes are the perfect tool for visualising the consequences of silvicultural measures and for evaluating the effectiveness of corrective measures. The approach can easily be extended to include aspects of climate change and is destined to become a valuable tool for communicating the need for and the road to resilient and vital forests in Europe.

Television and radio – reaching the crowd

These media provide access to a very wide audience and are very powerful. While simplified messages are generally required, regular telecasts or broadcasts can disseminate more in-depth information on a particular issue.

For example, in Latvia, a regular telecast addresses climate change and its effect on the forest in Latvia, presenting information on climate policy and climate change science in Latvia and the world. Efforts will be made to include results from the FUTUREforest project in this telecast, particularly the practical examples of how successful management can reduce the impacts of climate change on forests.

Social networks – new technology, new opportunities for the future

The use of 'social media' such as Facebook, Twitter or Xing for the dissemination of information on forestry and climate change is currently discussed in forest journals. FUTUREforest set up a Facebook page, but with very limited success. A media seminar staged by INTERREG IVC identified that very few professionals are currently using this method of communication.

Communication is the key

The success of all political actions, newly developed adaptation measures, and adaptive management schemes will depend on the successful communication of knowledge, recommendations and objectives to the relevant stakeholders.

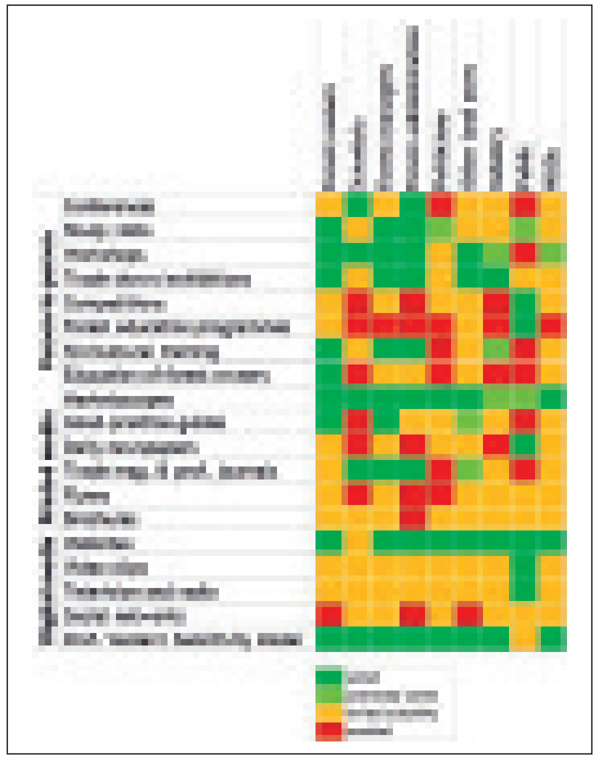
Regardless of the selected communication tool, communication is therefore the key to ensuring that forests and forestry are ready for the challenges of climate change.

Sensitivity model – communicating complexity

BRANDENBURG

The *Sensitivity Model Prof. Vester®* is a computerised planning and management tool for analysing and understanding complex systems. This tool was for the first time applied to the climate change-forestry-society system by the FUTUREforest project. The adaptation of the tool to forestry initiated an intensive discussion process with numerous experts and stakeholders from all regions. They defined the main variables of the climate change-forestry-society system, and helped identify its key drivers.

FUTUREforest continued the adaptation of the sensitivity model to develop a FUTUREforest Policy Simulator, an educational computer game that playfully illustrates the complex issues around climate change and forestry to a wide range of non-forest professionals. For more details see chapter 6.



Suitability of communication tools for selected target groups

6

Searching for order within complexity

Forest ecosystems are extremely complicated and can be difficult to manage effectively taking all the seven climate change challenges identified in the previous chapter into consideration simultaneously. Accounting for all aspects such as timber utilisation, landscape water regime, recreational requirements topography, soil types and weather patterns can become too complex for the human brain to grasp.

FUTUREforest has developed a new system which brings these inter-actions together, Crossing boundaries between forestry and cybernetics using the *Sensitivity Model Prof. Vester®* to identify the key drivers of this ‘climate change forestry – policy’ system.

Making connections – forestry relationships made simple

Interpreting the role of variables

FUTUREforest has developed a new system which makes it possible to bring together all the complicated interactions between the various forest functions.

This unique and innovative tool enables foresters to make valuable judgements on how our forests are managed for optimum multi-purpose benefits.

The provision of habitat for a wide range of species, the protection of soil and water resources and the sequestration of carbon in timber and soils are ecosystem services which are all inter-related.

For example, the planting of trees to reduce soil erosion and downstream flooding - chapter 5.6 - will also increase carbon sequestration and potentially provide harvestable timber to be used for substituting high-carbon materials.

However, diversification of forest stands will decrease the risk of abiotic and biotic damage (see chapter 5.3), but this increase in biodiversity could reduce timber production and the economic value of the forest.

Capturing complexity

Due to their complexity, forest ecosystems cannot be easily managed. Accounting for all aspects such as timber utilisation, landscape water regime or recreational requirements, can become too complex for the human brain to grasp.

Current tools of system analysis may help to integrate and understand the inter-connections. Crossing boundaries between forestry and cybernetics, the FUTUREforest project applied the *Sensitivity Model Prof. Vester®* to the complex system 'climate change – forestry – policy' to identify the key drivers of this system (http://www.frederic-vester.de/).

In a first step, 27 key variables in a FUTUREforest developed 'climate change – forestry – policy' system were identified. Using a series of workshops and expert interviews organised by the lead partner, these variables were aggregated into 10 cluster variables to reduce system complexity while still representing all components. An indicator was selected for each cluster variable.

Initial set of 27 variables

Mean annual temperature	Quality of soil
Soil water availability	Water management
Annual wood increment	Sequestration of CO_2
Use of timber in society	Forest industry
Employment in the forest sector	Income generated from forestry
Non-timber forest products	Harvested wood products
Number of tree species	Non-tree biodiversity
Forest structure	Genetic potential
Harvesting intensity	Forest regeneration
Legal framework for forestry	Public funding for forestry
Leisure and recreation	Ecosystem goods and services
Abiotic damage	Biotic damage
Risk management	

Regional status quo

This set of variables, their definition and scaling, was used for a series of workshops held in 5 of the 7 FUTUREforest regions:

- Auvergne
- Brandenburg
- Catalonia
- Latvia
- Wales

In each workshop a diverse group of local experts captured the regional *status quo* of each variable to identify and illustrate regional similarities and differences. For example, the harvested percentage of mean annual timber increment varies considerably and ranges from 20 per cent in Catalonia to 80 per cent in Brandenburg. In contrast, the proportion of forest area that is damaged by disturbances is currently quite similar in most regions.

Identifying key variables

Based on an evaluation of the strength of all possible relations between the 11 variables, the *Sensitivity Model Prof. Vester®* can be used to determine the role each variable plays in the system. Based on its interdependencies each variable is evaluated with respect to four key roles - active, reactive, critical, and buffering - and depicted in a diagram:

- **Active variables** - levers to initiate changes
- **Reactive variables -** indicators
- **Critical variables -** risk factors
- **Buffering variables** - inert elements

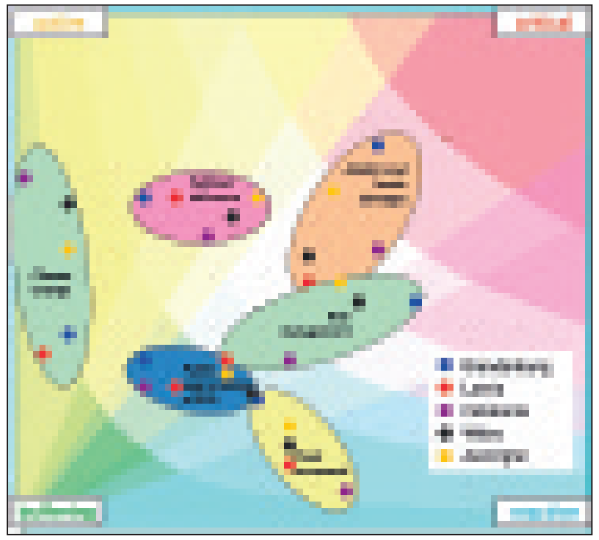
Derived cluster variables and indicators

Cluster variable	Description/Indicator
Climate change	Increasing concentration of atmospheric CO_2, increasing temperature, and changing precipitation regime
Abiotic and biotic damage	Percentage of forest area damaged by any abiotic or biotic damaging agent
Annual wood increment	Mean annual increase of wood biomass (i.e., amount of carbon sequestered in wood)
Biodiversity and potential	Diversity of plants and animals, including native and introduced species, and indicator of the site potential accounting for soil water holding capacity, structure, chemistry, etc.
Public appreciation of ecosystem goods and services	Indicator of the financial appreciation of the goods and services that forest ecosystems provide to society
Public influence	Legal framework for forestry and public spending on forestry (administration, subsidies, etc.)
Forest structure and composition	Forest structure and tree species composition as resulting from forest management (e.g., harvesting techniques, silvicultural systems, genetic diversification, methods of regeneration) - the forester's silvicultural toolbox
Forest utilization	Harvested percentage of annual wood increment as an indicator for the forest industry and utilization of timber and non-timber forest products
Risk management	All measures of risk monitoring, risk assessment, prevention, abatement, and restoration
Water management	All measures of active water management (i.e., water retention and water discharge)

Regional similarities

Most of the cluster variables have similar roles in each of the FUTUREforest regions.

Climate change is generally seen as a variable that is driven by external factors – from non-forestry sectors - and can only be influenced to a limited degree.



Variables with similar roles in the regions

The changing climate leads to increased risk of forest damage (Chapter 5.3). The proportion of damaged forest area is therefore considered a critical risk factor in all regions. In regions like the Auvergne and Brandenburg - where forestry contributes considerably to the regional economy and precipitation patterns are expected to drastically change - abiotic and biotic damage is regarded as highly critical. In consequence, the active impact of risk management is also perceived as particularly high in these regions.

More damaging events and deteriorating growing conditions are expected to result in reduced wood increment. Mean annual wood increment functions as a sensor for the overall vitality and condition of forest ecosystems.

The strongest consensus was on the political influence and public appreciation of ecosystem goods and services. The willingness of the public to pay for non-marketable goods and services provided by forest ecosystems is thought be generally low and ranked as an inert element.

This reflects the difficulties experienced throughout Europe when attempting to increase public appreciation and initiate financial compensation of forest owners for the generated services.

In contrast, the analysis identified political influence as the most powerful lever in the system 'climate change – forestry –policy'. This influence may be exerted through regulative (laws, guidelines, etc.) or financial (administrative funding, subsidies, etc.) pathways.

The current model did not distinguish between legal force and financial incentives, however. Results from the regional discussions showed that these two approaches have different effects in regions with varying degrees of democratic centralism, property rights, and free market economy. Finding the optimal balance between legal instruments and financial incentives for achieving defined objectives of forest policy therefore requires more detailed analyses at the regional scale.

Forest structure and composition is the second most active variable in all regions but Catalonia, where the focus is predominantly on forest preservation. In the other regions, forest management and the resulting mix of tree species and stand structures is a powerful tool to positively influence abiotic and biotic damage, wood increment, or diversity and potential. At the same time, forest structure and composition is also strongly influenced by other variables, making it a potentially destabilising component.

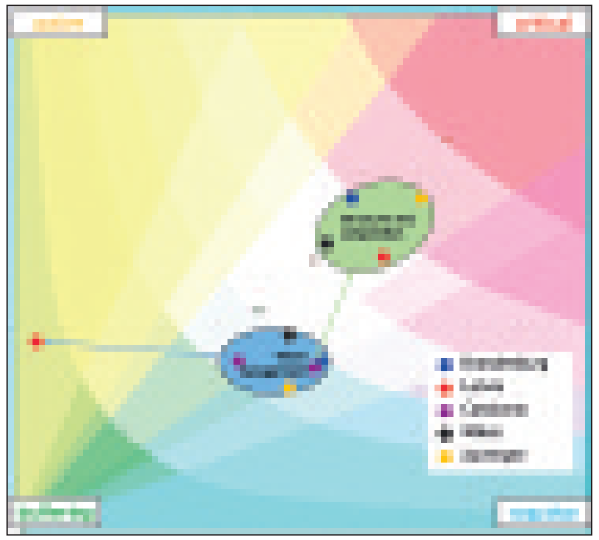
Active forest management is thus not only a key to the maintenance of healthy and multifunctional forests but also to the entire 'climate change –forestry – policy' system. Another variable featuring a different role in one of the analysed regions is water management. Measures of water retention and the prevention of torrents following drought make it a variable that is closely related to risk management in most of the regions (Chapters 5.3 and 5.6). In contrast, the removal of excess water from forests to allow for harvesting dominates water management in Latvia, where precipitation is plentiful and not predicted to considerably decrease due to climate change.

Workshop in the Auvergne, France

Regional differences

FUTUREforest participants expected similar interactions and processes between forests, forest management, politics, industry, and society throughout Europe. However, the evaluation of the role of two cluster variables varied widely between the analysed regions.

Biodiversity and soil protection are often considered keys to maintaining healthy and resilient forests. However, measures for directly enhancing these characteristics are scarce as they are mostly a function of tree species composition, forest structure, water management, etc. Consequently, diversity and potential is a buffering element in most of the regions. However, in Wales and the Auvergne, where insect outbreaks and forest pests have increased over the last years (Chapter 4), diversity and potential are evaluated as critical components that need to be monitored.



Variables with differing role in one region

Results showed diversity and potential to play differing roles in the regions. Protecting biodiversity was the main issue in the Auvergne, while soil protection dominated the discussion in species-rich Catalonia. It is therefore recommended to split this variable into two separate variables for further analyses.

However, soil conditions, tree species diversity, and the diversity of plants and animals are tightly interconnected which necessitates the integration of biodiversity management into forest management.

The successful adaptation of forests to climate change depends on the implementation of integrated forest biodiversity management concepts.

Forest utilisation – the share of the annual wood increment that is harvested and utilised – represents the productive and economically most relevant function of forests. As such, it is regarded as a buffering component in Latvia and Brandenburg, where timber production is a major forest function. Surprisingly, it is evaluated as a strong lever in Catalonia and Wales, where forest utilisation is quite low. Forest utilisation in these regions is considered the key to incentivising private owners to manage their woodlands and forests.

A larger share of managed forests will increase forest carbon sequestration and timber availability and facilitate the implementation of measures to adapt forests to changing climate conditions.

Public and private forest owners across Europe must engage in active sustainable forest management, particularly in regions with vast areas of unmanaged forests.

Public forest owners in particular play a key role as role models for sustainable forest management. They need to recognise their responsibility for providing adequate and comprehensive guidance and support to all other forest owners.

In light of the benefits of active forest management – carbon sequestration, timber production, forest protection, etc. – European society itself needs to demand more active forest management and an increased utilisation of European forests.

Targeting adaptation

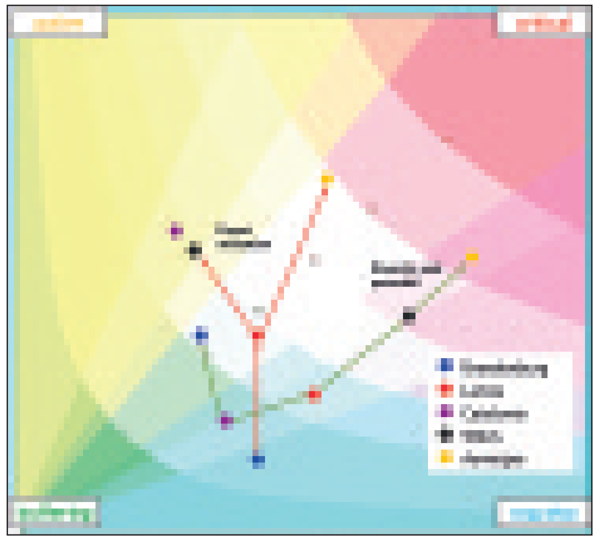
Climate change is an external driver of the system 'climate change – forestry – society', forcing it out of a balanced state and into an adaptation process. The rate of change and the condition of key components will determine the fate of the system: collapse (deterioration of forests, deforestation, etc.) or adaptation (shift of forest types, etc.).

Based on the *Vester*® analysis, the system features more negative than positive feedback cycles, indicating a high buffering capacity. However, the rate of climate change may exceed the rate of adaptation. Targeted actions are required to stabilise the system.

As the most interconnected variable, political influence stands out as the strongest lever to initiate changes to components which are currently obstructing forest adaptation.

Protection and enhancement of biodiversity, improved risk and water management, promotion of sustainable forest management, incentivisation of timber utilisation – these are developments that can be initiated through political action.

The regional differences of the interconnection and role of some variables shown in this analysis result from



Variables with differing roles

different political systems, different ownership structures, different public opinion, different historical developments, and lastly, different degrees of concernment with respect to the impact of climate change. On the one hand, Latvia expects increased growth rates due to warmer temperatures with little change of risks. At the other extreme, in Mediterranean Catalonia, the climatic changes will considerably increase the risks to forests, possibly resulting in the deforestation of regions that become too warm and dry.

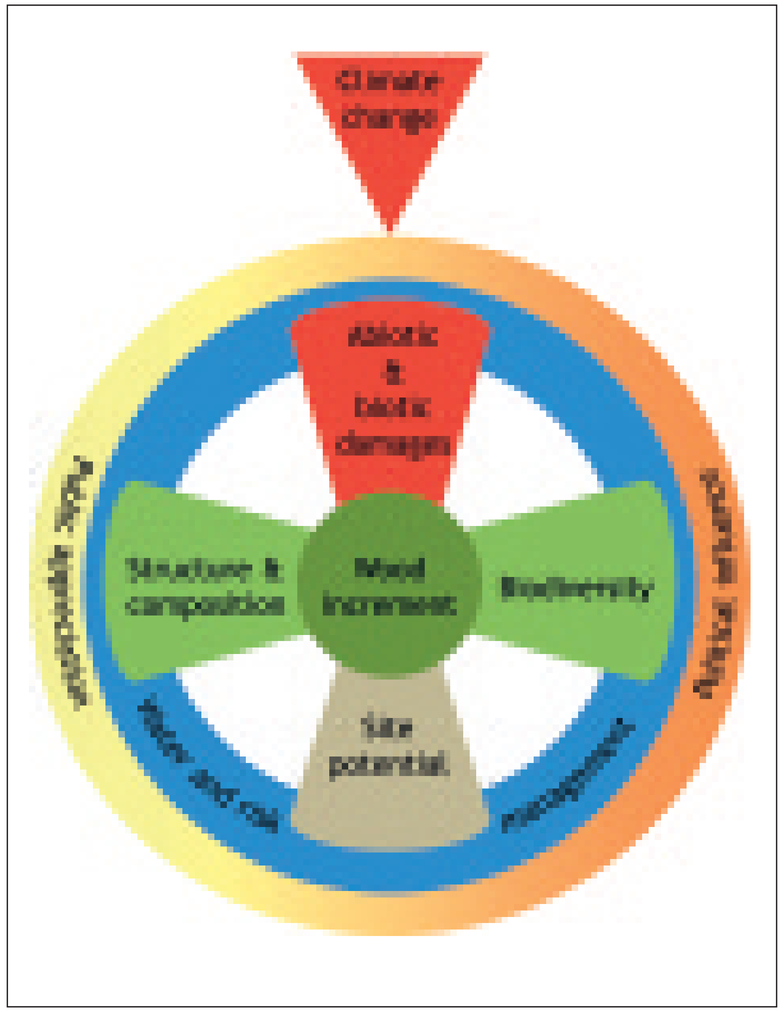
These differences prohibit generalised recommendations for political action. European Union legislation and funding schemes need to recognise these regional differences!

The combination of framework legislation with respect to overall visions and goals (e.g., forest preservation) and funding schemes incentivising desired developments and targets will leave the regional (forest) authorities with the freedom to select the appropriate political instruments for their regionally specific conditions.

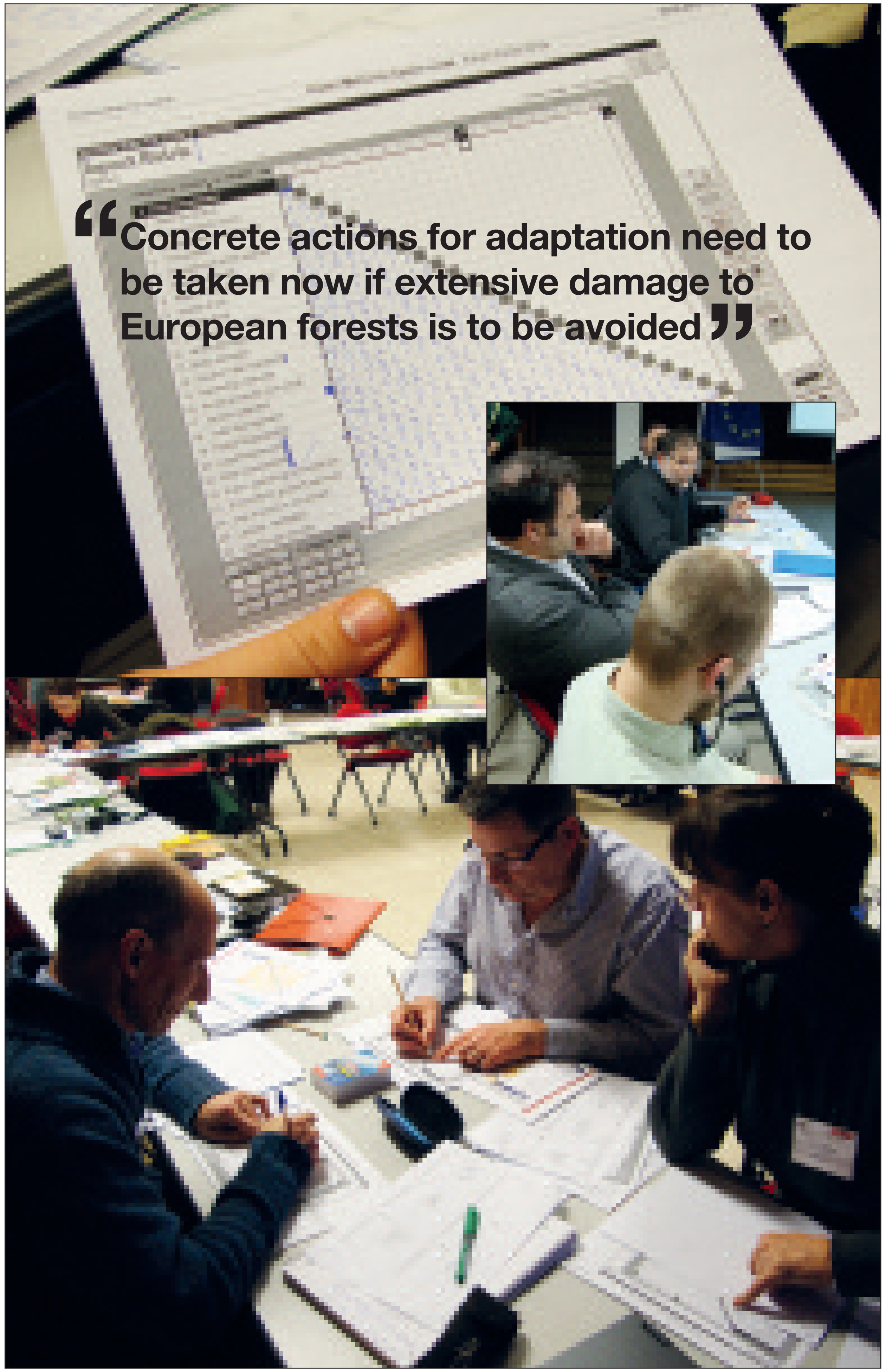
Data on climate change and the associated challenges that foresters and forest owners face are sufficiently clear – concrete actions for adaptation need to be taken now if extensive damage to European forests is to be avoided.

The integration of regional perspectives and experiences into a European strategy for adapting our forest to climate change will not only improve the chances for maintaining resilient and multifunctional European forests, but also for vital and diverse regional economies.

The success of any political action will, however, depend on the successful communication of its objectives to the public and all relevant stakeholders.



Capturing complexity



> “Concrete actions for adaptation need to be taken now if extensive damage to European forests is to be avoided”

7

Looking to the future

So which way now for the future of Europe’s forests? FUTUREforest project leader Georg Wagener-Lohse gives his own personal perspective on the findings of the team – and outlines a way forward.

He believes that the regions should continue to work together, sharing their knowledge and experience. Farmers and foresters should join forces and all land use integrated. Marketing and compensation issues and legal frameworks need to be addressed – taking into account projected climate change.

But most of all he is convinced that healthy forests and woodlands are essential to a healthy Europe.

Initiating change

General principles

FUTUREforest has discussed aspects such as water management, species diversity, soil quality and carbon sequestration, which go far beyond matters of traditional forest management but are increasingly integrated into multi-functional forestry.

Forests and woodlands are essential to European self-perception despite regional differences with regard to climate, soil, species, utilisation and public appreciation.

The preceding chapters clearly show how European forests and the forestry sector will be affected by climate change and what actions of adaptation must be taken.

Policy changes were shown to be an efficient option to initiate adaptation processes. Apart from the detailed political instruments provided in Chapter 8, certain more general principles and instruments should be considered at regional, national and European levels.

Strengthening the regions

United but different – this European principle acknowledges the individuality of the European regions as a creative source for adapting to changes. Subsidiarity calls for adaptation measures to be implemented by the smallest, lowest or least centralised competent authority, thus ensuring that appropriate actions will be taken at local, regional, national and European levels while granting regional authorities a maximum of freedom.

To date, forestry has only been the subject of European policies in exchange processes between member states (Forest Europe) and general policy documents written by European directorates (European Forestry Action Plan). Climate change is a challenge that requires new concerted actions – such as the EU Green paper on forest protection developed by the DG Environment in a participative process. Bottom-up approaches may also provide valuable instruments to increase the political weight of rural regions at the European scale.

Forestry – balancing production and protection

Forest policies are often developed by urban-based decision makers, which may not be familiar with the complexity of forest ecosystems. Conservationists, who often demand protection without production, seem to have an understanding of undisturbed nature that practically does not exist anymore in Europe.

Foresters must increasingly engage in regional, national and European political processes to communicate how sustainable forest management and timber harvesting can help to protect forests and forest species.

Although forest reserves are essential for the conservation of certain species or habitats, many forest functions such as carbon sequestration or erosion protection are only fully delivered in managed forests. This

Georg Wagener-Lohse

concept of multi-functional forestry is part of the European heritage and must become the basis for European forestry and silviculture.

The seemingly obvious contradiction between forest management – the economy - and conservation – the environment - that is often propagated disappears when considering the role of timber harvesting in funding forest protection and adaptation.

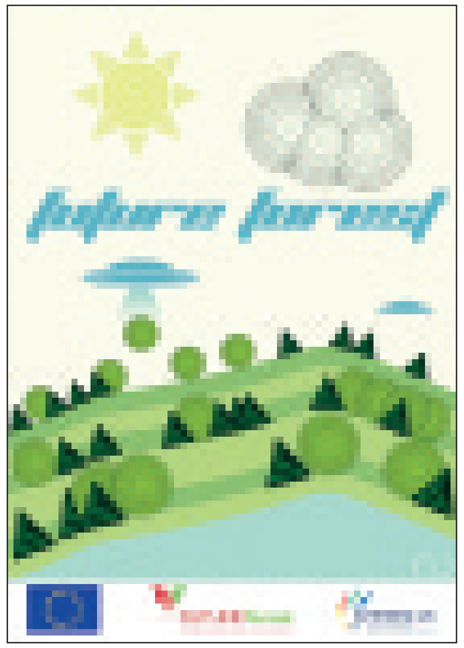
Foresters and farmers – joining forces

Rural areas are the European backbone providing essential environmental and ecological services to the entire society. As forestry and agriculture dominate rural areas throughout Europe, they often form intricate land use mosaics. Natural processes - water flows or erosion - and organisms cross borders between forests and fields.

Agriculture and forestry are thus tightly interlinked – and quite often farmers are also forest owners - a fact that is not reflected by the separation of agricultural and forest policy, administration and planning. While forestry only plays a minor role in EU legislation and funding schemes, a huge political and economic European agricultural framework exists - spending more than 50 per cent of the European budget. At the regional scale, there are often separate administrations for agriculture and forestry and other land use types - complicating the development of integrated schemes of climate change adaptation and neglects what appears to be a natural alliance between foresters and farmers.

The role of forestry in politics and planning must be strengthened – and agriculture and forestry should join forces to represent rural regions in an increasingly urban society.

The reform of the common agricultural policy is an ideal situation to find new principles to enable rural areas to play their role better that go far beyond high yields or subsidising agriculture. Binding public payment to the basis of serving the societies needs for sustainability and expanding the second column of financial support is the right direction. Forestry should become much more a part of this philosophy than it is today. Supporting bottom-up approaches in rural development like LEADER are essential to reach these demanding goals.



Integrating all land uses

Forests are also relevant to the economy and energy sector, the conservation and environment sector, spatial planning and human welfare. However, these aspects are often separated between different departments of government at European, national and regional levels with little involvement of foresters in many of these individual departments.

Reliable long-term partnerships between foresters and all other land users and planners – farmers, spatial planners, conservationists, tourism experts, energy experts and economic developers - will be required to maximise the benefits forests contribute to rural landscapes and economies.

Integrated land use planning is the key to negotiating land use conflicts which are expected to increase as climate change progresses. Spatially explicit priority areas for each land use type have to be identified to find the optimal sustainable balance between social, economic and ecological interests.

Balancing marketing and compensation

Large forest areas are privately owned, contributing to family income or fulfilling other functions such as production of fire wood. At the same time, private forests are also expected to accommodate public interests and to provide a range of services such as air and water purification, recreation and landscape aesthetics – an expectation that is formulated as “property entails obligations” in some countries.

Society therefore has an interest in enabling forest owners to deliver services to the public. Forest owners who cannot pay for adaptation measures required to maintain or improve the deliverance of these services by marketing their timber need to be financially supported.

Ideally, all non-marketable goods and services provided by forests should be compensated by society - particularly in times of low timber prices and a rapidly changing climate. However, a strong timber market with prices that account for the climate change mitigation effects of wood products will be much more beneficial to the forest sector than large-scale subsidisation schemes.

A European emission trading scheme could be a basis for accounting sustainability benefits. The CO2-bank developed in Northrhine-Westfalia offers an opportunity to integrate wood products due to their sequestrated carbon dioxide into this scheme. Carbon dioxide based taxes which some member states use could be another instrument when put on materials with high CO2 emissions during production processes.

Incentives for change

In the European free-market economy, sustainable production is rarely financially rewarded. Public incentives can only be interim strategies to encourage sustainable forest management and increased timber utilisation.

In the long-term, however, sustainably produced forest goods and services - potentially certified using a common scheme - need to provide higher economic benefits than currently. Voluntary certification schemes such as FSC and PEFC could be a first step towards higher revenues of sustainably produced goods and – potentially – compensation for non-marketable goods and services.

Adapting legal frameworks

National and regional forest laws need to be adapted to the challenges of climate change. Although regional differences prohibit generalised recommendations for political action, EU framework legislation can provide a common vision for sustainable forest management and funding schemes that allow regional authorities to select and fund regionally appropriate measures of adaptation.

A binding directive however should more strongly emphasise the role of productive forests and bear clear evidence that sustainability is not just a synonym for nature protection but for true durability based on economic success for social cohesion and functioning environment.

National or regional based rules for forest management usually represent the state of the art of silvicultural practices based on scientific evidence that was valid years ago when political implementation processes were initiated. Climate change has become more and more obvious during the last years and the scientific discussion on useful solutions for adaptation needed some time to gain a certain maturity. Adaptation should start now to make forest management climate proof and to add the elements of risk management that are described in this document in relation to new rules in water management and soil protection that need to be defined by environmental policies.

Improving knowledge

In light of the observed rate of climatic change, research is urgently needed to support and guide the adaptation process. However, funding for research is often dictated by short-term politics and is not in accordance with the time scale of forestry.

Observing the reaction of forest ecosystems to climate change and evaluating possible adaptation measures requires long-term financial commitment. Research should increasingly integrate practitioners to draw upon their expertise and on-site observations and quickly communicate new insights. In all member states more communication is needed to motivate owners of small forest land to improve their skills and the well being of their forests.

Implementing FUTUREforest recommendations

FUTUREforest has brought together a comprehensive list of the political instruments it believes can provide a framework for change that will benefit the forests – and the people – of Europe.

This listing on each of the aspects of the project provides recommendations for actions at European, national and regional level.

Biodiversity

European level

- Evaluate the state of conservation of biodiversity using a European network
- Integrate stages of habitat degradation under the 92/43CE 'Habitats' directive.
- Commitment to the Convention on Biological Diversity
- Implement a legal framework on climate change, forest management and biodiversity

National level

- Establish a Strict Forest Reserve network representative of the variety of habitat types to monitor the long-term effects of climate change and compare with the situation in managed stands
- Develop a list of key parameters to be monitored
- Develop recommendations on biodiversity in public forests

Regional level

- Provide incentives and subsidies for private owners to promote biodiversity
- Create an education programme for forest managers and workers to promote good practice
- Include indicators of species diversity in forest inventories should include

Carbon

International level

- Provide improved accounting rules for forest management
- Ensure that accounting rules provide incentives for long-term mitigation and equally credit all mitigation options
- Address emissions from extreme weather events, wildfires and insect outbreaks caused by climate change
- Account for carbon storage in wood products and the substitution of materials and fossil fuels by timber
- Develop standardised methods for assessing forest carbon stocks

European level

- Develop credit schemes to encourage carbon-oriented forest management

National and regional level

- Promote campaigns to encourage the use of wood biomass
- Create education programmes for foresters and forest owners to promote management practices that maximise forest carbon storage

Risk management

European level

- Develop European emergency plans for each risk
- Develop clear and concise guidelines for strategic and practical interventions. This is especially urgent regarding forest megafires
- Harmonise national forest health monitoring networks to facilitate exchange of data and knowledge between EU member states

National level

- Integrate risk management into landscape scale planning processes
- Integrate disturbance models into growth simulators to evaluate alternative management options and associated risks

Regional level

- Integrate risk assessment and management into forest inventory and planning
- Promote safety training for forest workers in salvage logging after windthrows
- Promote insurance schemes for forest owners
- Promote capacity building at forest agencies on risk assessment and crisis management
- Enhance information management through sustained support to existing systems (monitoring networks, databases, etc.)

Soils

European level

- Develop a European and regional land use strategy to maintain the sustainable carbon balance in ecosystems and prevent soil carbon loss after land use change

National level

- Improve national policy documents including programmes, plans and guidelines with specific measures for management of high-risk areas
- Identify risk areas and threat levels for erosion, carbon loss, landslides and soil compaction
- Review and update forest site inventories at national, regional and local scales for better selection of tree species under expected climate conditions
- Determine and improve the effectiveness of different techniques of erosion control to ensure stabilisation and protection of forest soil cover
- Develop funding schemes for soil protection measures
- Create long-term soil monitoring networks

Regional level

- Improve recommendations for best forest management practices of soil protection through cost-benefit analysis
- Incentivise selection of appropriate tree species for increasing soil carbon sequestration, improving soil fertility and biodiversity

Timber

European level

- Provide financial support for the installation of forest infrastructure to facilitate forest management and to minimise risks of mass outbreaks of pests and diseases
- Provide continuous, targeted support for the development of private forest owner associations
- Develop grant schemes to support the timber processing industry in rural regions, to ensure competitiveness of EU forest products and to stabilise rural economies

National level

- Balance the designation of protected forests by designating forests with a mainly productive function
- Develop guidelines for tree species selection according to site, climate, and management objectives
- Promote the use of forest reproductive material with proper physiological and genetic qualities
- Support for establishment of short rotation plantation with proper forest reproductive material on marginal lands
- Adapt taxation systems to promote active forest management

Water

European Level

- Ensure commitment of all EU member states to the water framework directive and put into place the recommendations which would enable water body improvement
- Coordinate policies regarding forests and water
- Fully integrate adaptation measures into existing EU water legislation and policies, for example, the development of the catchment management under the Water Framework Directive (WFD)

National Level

- Support the adaptation of the forest sector through research and funding schemes
- Establish payment schemes for environmental services (PES), identify the services and the clients and ensure public compensation for areas with no direct clients of hydrological services
- Implement communication programmes to inform river basin management bodies and other institutions responsible for water management
- Promote 'Green Infrastructure' as a crucial component of the adaptation process

Regional Level

- Develop grant schemes to support tree planting for water interception in catchments and restore buffer strips along streams
- Integrate measures of water management into the forest planning process

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