Federal Ministry
of Food
and Agriculture

BUNDESWALDINVENTUR

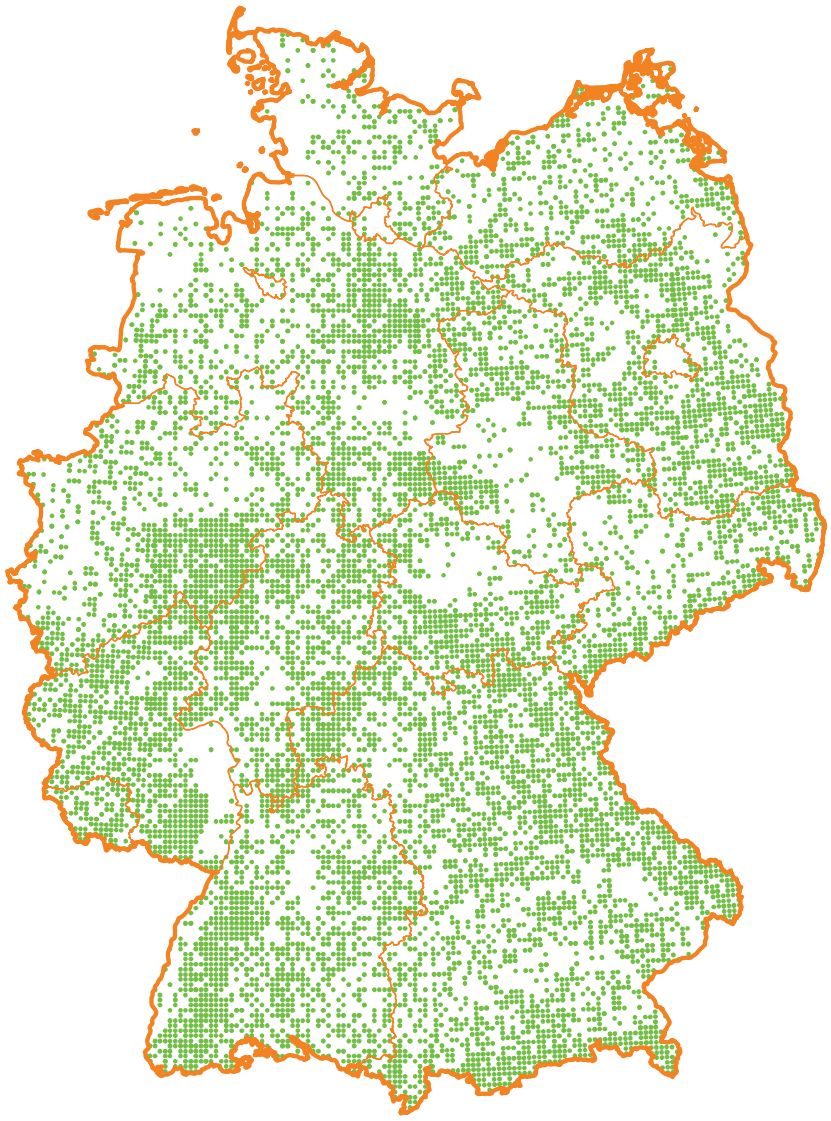
The Forests in Germany

Selected Results of the Third National Forest Inventory

Forest distribution in Germany

Germany
35,720,780 National area
11,419,124 Forested area = **32 %**

All areas in hectares



Schleswig-Holstein
1,579,957
173,412 = **11 %**

Niedersachsen
4,769,942
1,204,591 = **25 %**

Nordrhein-Westfalen
3,409,772
909,511 = **27 %**

Hessen
2,111,480
894,180 = **42 %**

Rheinland-Pfalz
1,985,406
839,796 = **42 %**

Saarland
256,977
102,634 = **40 %**

Baden-Württemberg
3,575,148
1,371,847 = **38 %**

Mecklenburg-Vorpommern
2,319,318
558,123 = **24 %**

Hamburg & Bremen
115,907
13,846 = **12 %**

Berlin & Brandenburg
3,037,573
1,130,847 = **37 %**

Sachsen-Anhalt
2,045,029
532,481 = **26 %**

Sachsen
1,842,002
533,206 = **29 %**

Thüringen
1,617,250
549,088 = **34 %**

Bayern
7,055,019
2,605,563 = **37 %**

Forests

Dear Readers,

The forest possesses many talents. It is a home for animals and plants, an important climate protector and contains a wealth of biological diversity. For us, it is also an important supplier of raw materials. We need timber to build houses and furniture, for the production of energy and for the paper on which this booklet is printed. The forest is, however, also a place of peace and quiet that offers us refuge and recreation in our hectic, fast-paced world. Therefore, the forest is indispensable for all of our lives.

One third of Germany is forested over 11.4 million hectares. The Third National Forest Inventory (NFI) provides good news: Our forest area has remained unchanged. More timber is re-growing than we use. We also have more of it than any other country in the European Union. In spite of high use, our forest stocks rose to 3.7 billion cubic metres. The appearance of German forests is characterized by 90 billion old and young spruces, pines, beeches, oaks and other tree species. The percentage of deciduous trees has risen. The forests have become more diverse and natural in structure. We find more deadwood in them – an important foundation for biodiversity.

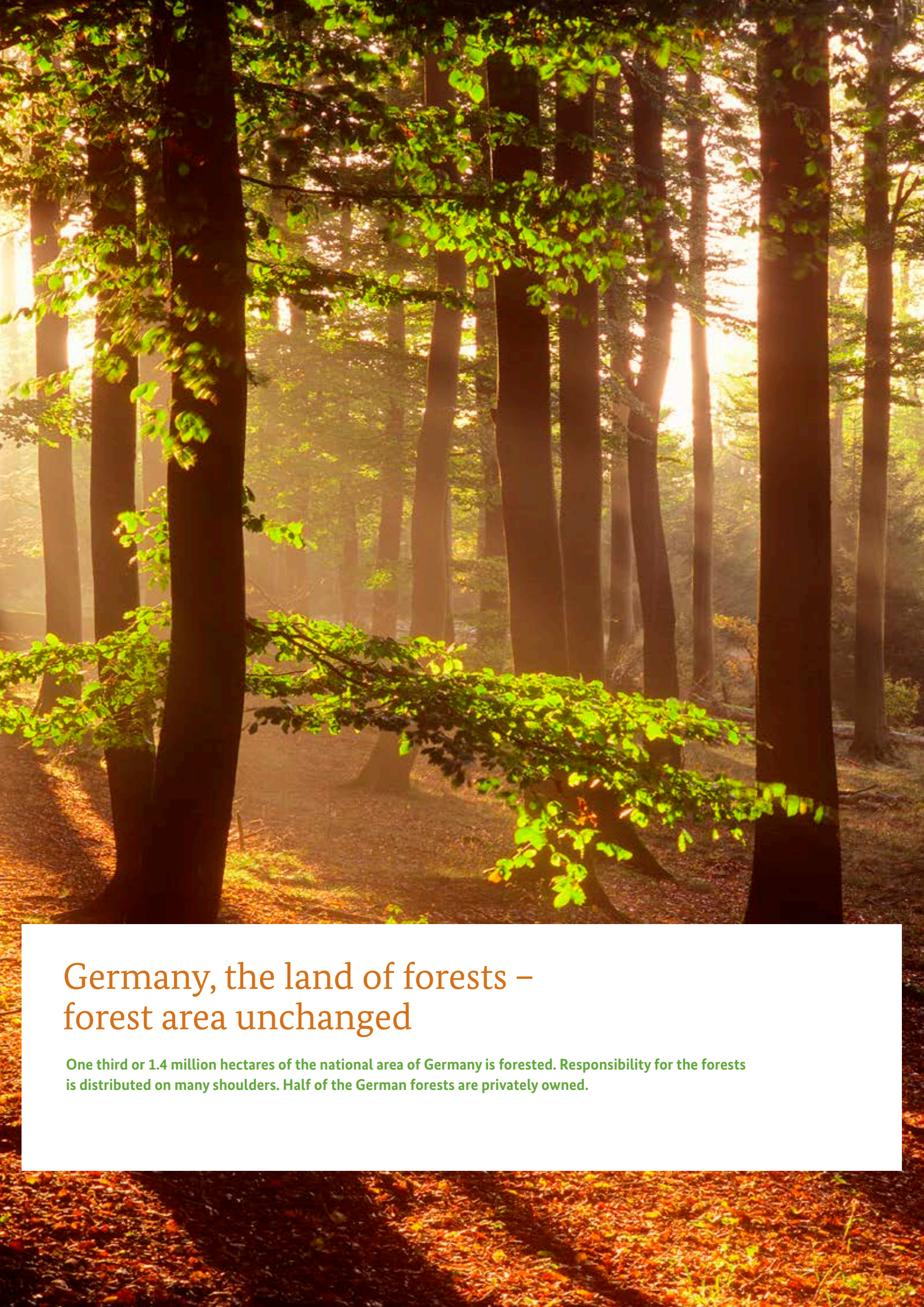
The good condition of our forests is the consequence of the silvicultural actions of many forest owners and foresters and the result of a forestry policy based on balance and sustainability that distributes the responsibilities on many shoulders: roughly half of German forests are privately owned. One fifth of them are owned by municipalities, cities and other public entities. One third belong to the Länder and the Federal government. But the National Forest Inventory also indicates the need for action. One example is the spruce: the NFI confirms that the spruce – an important supplier of raw material for the timber industry – is in decline. We must therefore talk about how much spruce forest we need and what alternatives there are to the spruce in the face of climate change.

The forest should be used in the best possible way without overtaxing it. To make sure of this, the Federal government devised the Forest Strategy 2020. Its objective is to express and harmonize our diverse demands on the forest. This is the only way to maintain our chances for having intact forests for future generations as well. That is why my maxim is “Our forests: utilize and preserve.”

The aim of this booklet is to generate understanding for the forest, forest owners and foresters. It provides citizens with the opportunity to get to know the functions of the forest and appreciate its value. Hence, the booklet is a contribution to sustainable forest management.

Truly yours,

Christian Schmidt, Member of the Bundestag
Federal Minister of Food and Agriculture



Germany, the land of forests – forest area unchanged

One third or 1.4 million hectares of the national area of Germany is forested. Responsibility for the forests is distributed on many shoulders. Half of the German forests are privately owned.

Germany is a densely populated country. Over 80 million people live on 35.7 million hectares. For centuries people have inhabited and cultivated Germany intensively. We use 13 % of the national area for settlements and transportation. 52 % of the area is used for agriculture, making it the largest land use form in Germany followed by forests or forestry with 32 %.

In recent decades, our demands on our standard of living and consumption as well as conservation of the environment have risen. This leads to growing competition between different types of land use.

The facts that the forests continue to take up one third of the national area and their stands are secure are the success of the Federal Forest Act.

Between 2002 and 2012, the forest area changed only slightly. A loss of 58,000 hectares of forests contrasts 108,000 hectares of new forest area. In total, the forest area increased by 0.4 % or 50,000 hectares.

Overexploitation of the forests – no thank you!

Today, the forests in Germany are just as important as ever: They purify our air, produce essential oxygen, safeguard our drinking water and are home to many animal and plant species. In densely populated Germany, they provide space for recreation and to experience nature. Not least, the forests supply our most important renewable resource: timber. They therefore make an important contribution to employment and added value in rural regions.

The fact that one third of Germany is still forested and we can use and enjoy our forests is not a given, as a look at other countries or continents and even back at our own (forest) history shows.

Guardian of the forests – the Federal Forest Act

In recent decades, the Federal Forest Act made a crucial contribution to preserving our forests. Alongside the Länder forest laws, it has regulated how we treat our forests since 1975.

The figures provided by the National Forest Inventory prove that these laws effectively protect the forest from inappropriate treatment, overuse, overexploitation and area loss.

Sustainable forestry preserves the forests

The German forestry sector regenerates, cares for and manages the forest and lastingly makes its diverse functions available to society. It looks back at over 300 years of experience in sustainable handling of forest resources. While in the early days, sustainability referred to the timber supply, forestry further developed this principle with support from science and research. The objective is to permanently and optimally secure the diverse economic, ecological and social benefits of the forest for the use of the present and future generations.

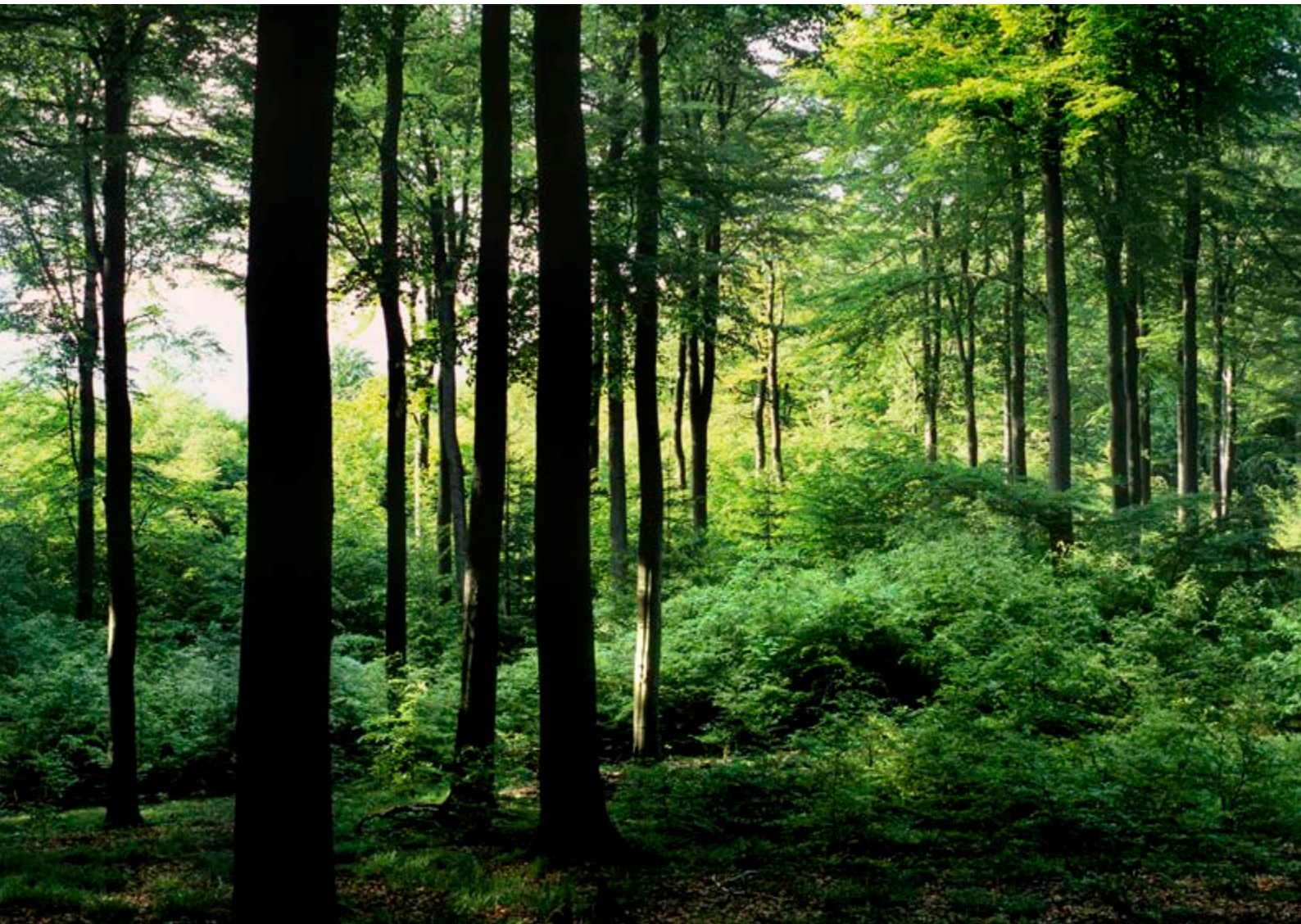
Historic development of the forested area

Since the spread of farming about 7,000 years ago, humans have been increasingly influencing the forests. The intense use of the forests in the Middle Ages and before the Industrial Revolution led, in the early 19th century, to an all-time low in forest cover. The landscape back then was characterized by bare areas and wastelands.

At the same time, the demand for timber for energy production, mining, iron smelting and construction rose. In order to prevent an impending timber shortage, in the 18th century, Hans Carl von Carlowitz and other foresters drew up the principles of sustainable forestry and woodland management. In the course of forestry and land reforms that reshaped the use of many forests, the foresters began reforestation. The pressures of human use on the forests did not lessen until new energy sources such as coal gained in significance and timber was no longer the primary fuel for all sectors of industry.

Gradually, the forests recovered and the forest area increased once again. The last major drain on the substance of the forests was during and after the Second World War. The destruction of war, the blows of reparations and great demand for timber for reconstruction exacted a toll. Mass infestation of bark beetles caused more blows resulting in large felled areas. The reestablishment of the forests was a significant cultural achievement. It was so significant that it was reflected at the time on the verso of the 50-pfennig coin in the form of a woman planting an oak tree.

Thanks to 300 years' experience in sustainable handling of forest resources, we can still use and enjoy them today.



The spruce is sometimes called the “bread tree” of German forestry. It grows comparatively quickly and possesses prime timber traits.

What exactly is a forest?

Botanically speaking, a forest is vegetation distinguished by trees, the area of which is large enough to produce a forest climate. This differentiates the forest from, for example, tree-lined roads, parks and nurseries.

Legally, a forest is any area of ground covered by forest vegetation (Article 2 of the Federal Forest Act). Foresters traditionally call this area “timberland.” This also includes forest areas that are not stocked with trees for a time (gaps and temporarily unstocked areas).

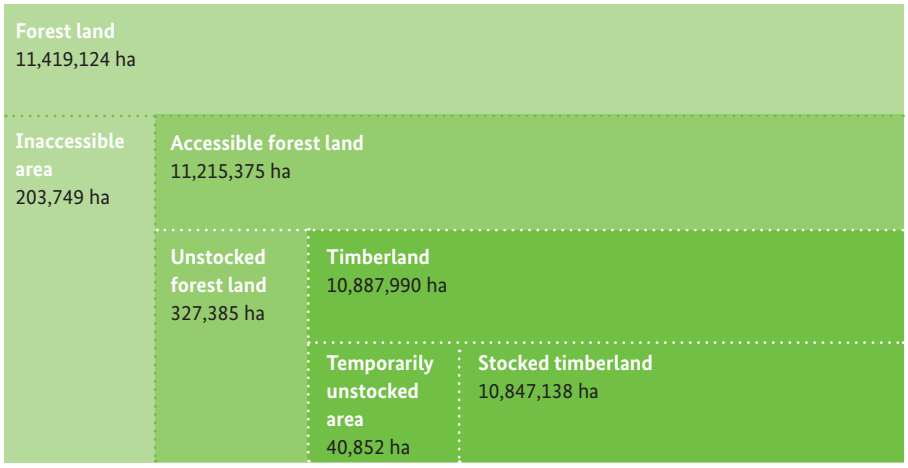
The forest also includes permanently treeless areas such as forest tracks, landings, firebreaks as well as other areas linked to and serving the forest. These areas are called “unstocked forest land.”

The National Forest Inventory is based on the legal definition of the forest. For the sake of a distinct and uniform delineation, areas are also defined as forests when they are at least 0.1 hectares large and 10 metres wide (see Terminology: Forest).

The National Forest Inventory recorded 11.4 million hectares of forests. More than 98 % of these areas are accessible. The inventory teams surveyed data on these areas.

With a total of approximately 10.9 million hectares, so-called “timberland” is the largest area category (95 %). Most of the results of the National Forest Inventory refer to timberland. The remaining almost 328,000 hectares or 3 % of the forest area consist of “unstocked forest land.” It has important functions for forestry (e.g. as landings), for recreation (e.g. forest tracks) and as a habitat for light and warmth-seeking animal and plant species. The diverse benefits of the forest emanate from its entire area.

Forest categories



Hectares = ha

Accessible forest land: This is where the inventory teams surveyed data

Inaccessible area: Not accessible, for example, due to bans on access or hazardous grounds

Timberland: Area permanently serving the purposes of wood production.
This also includes ditches, areas under power lines, areas unstocked for a time (temporarily unstocked areas) as well as roads and paths less than 5 metres wide, as well as areas within, for example, national parks.

Unstocked forest land: Forest areas not considered timberland, such as forest tracks, rides and firebreaks over 5 metres wide, and landings

Stocked timberland: Timberland on which trees grow

Temporarily unstocked area: Timberland on which trees temporarily are not growing

The forests – mainly privately owned

Of the 11.4 million hectares of forest in Germany, 48 % are private forests. The *Länder* own 29 % of the forests, 19 % are communally owned and 4 % are owned by the Federal government.

The regional differences can be considerable. The percentage of private forest ranges from 24 % in Hessen to 67 % in Nordrhein-Westfalen. It frequently predominates in more thinly settled rural regions. The percentage of state forest lies between 17 % in Nordrhein-Westfalen and 50 % in Mecklenburg-Vorpommern. The largest part of today's state forest is made up of formerly sovereign forests and secularized monastic lands. In Rheinland-Pfalz, the communal forests take up 46 %, in Brandenburg about 7 %, in Niedersachsen and Sachsen-Anhalt approximately 9 %. This percentage is often especially high in densely settled urban regions.

The private forests in Germany are largely of small structure and fragmented. Approximately half of the private forest area is shared by holdings with less than 20 hectares. Only 13 % of the private forests belong to holdings with a size of over 1,000 hectares. The ownership structures developed differently over history and from region to region. The small and smallest forest areas in private hands often were created in the course of historic farming settlement or through distribution of estates, distribution of common land or afforestation of agricultural areas. The number of communal and private forest owners in Germany is estimated at two million[1].

Due to the large area owned by the small and smallest forest owners, their forestry consultation and supervision is an important field of forestry policy. The owners of small forest areas are often unfamiliar with the demands of sustainable forest management because of geographical distances, urban lifestyles or their vocations. In addition, the financial revenues from forest management are often negligibly small compared to the total income of the owners. In addition to questions about the use of the renewable resource timber, other aspects that necessitate special attention and support of small private forests by the Federal government and Länder with a view to the social benefits of the forests in future include forest tending, adapting to climate change, control of biotic damages, but also forest nature conservation and biodiversity.

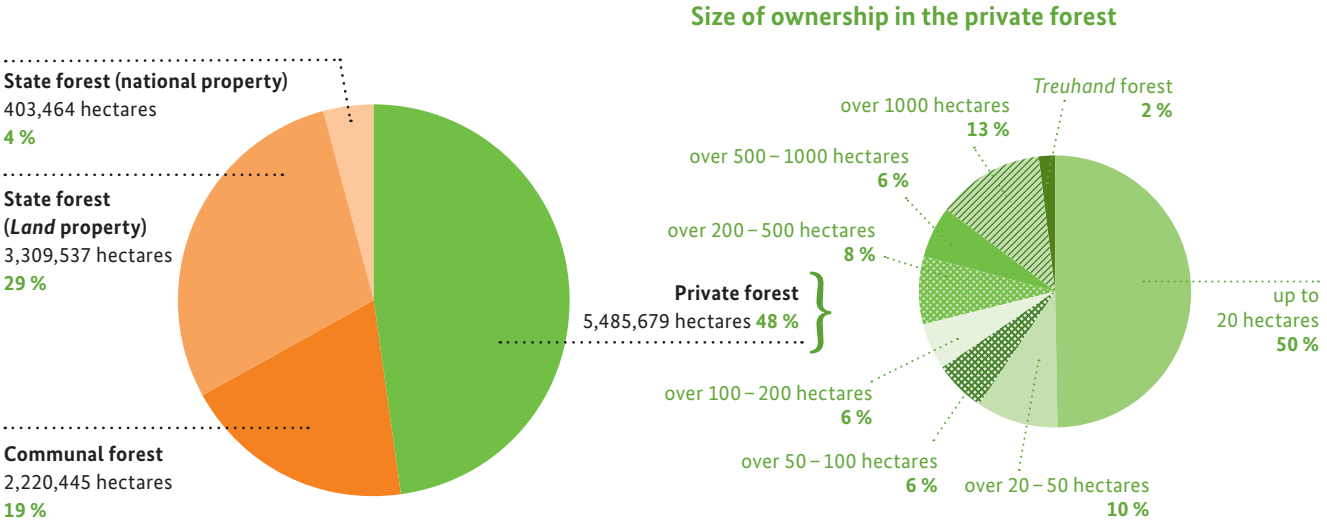
The diversity of forest owners leads to different objectives in the treatment of the forests. Therefore, the forests differ in some parameters such as tree species composition, timber stock or utilization.

Is access to private forests permitted?

Yes, but... On principle, one can only enter private land with the permission of the owner. This applies equally to homes, domestic gardens, company grounds, private roads and agricultural areas. There are exceptions for the forest (Article 14 of the Federal Forest Act). According to these, anyone may enter forests in Germany for recreational purposes as long as these areas are not barred for special reasons (e.g. timber harvest, afforestation area). Entry is at one's own risk. Those pursuing other objectives in the forest (e.g. commercially collecting mushrooms) need the forest owner's permission. The forest owners must consent to entry for recreational purposes. The forest and forest owners appreciate it if, in return, forest visitors behave as guests.

1 According to "AGDW – Die Waldeigentümer"

Forest area by type of ownership



Basis: : Total forest 11,419,124 hectares

Varying forest abundance in the *Länder*

A little less than one third of the national area of Germany (32 %) is covered in forests. Forests are particularly located in places where the climate, soil or terrain is less suitable for farming or settlement. Rheinland-Pfalz (42 %) and Hessen (42 %), followed by the Saarland (40 %), Baden-Württemberg (38 %), Bayern (37 %), Brandenburg with Berlin (37 %) and Thüringen (34 %) have above-average areas of forests related to total area. By contrast, the remaining Länder have forested areas ranging from 29 % (Sachsen) to 11 % (Schleswig-Holstein) (see the inside cover illustration).

Statistical certainty

The National Forest Inventory is the national sustainability monitor for forest management. It illuminates large-scale and significant developments.

Rare events are affected by high statistical errors. Users of this data must be cautious with interpretations. This applies for rare tree species like the fir, small regional units like the Saarland or small evaluation units such as the Federal state forests.

The forest habitat – more biological diversity in the forest

German forests are diverse and provide habitats for many animal and plant species. The spruce, pine, beech and oak are the most frequent tree species in Germany. Deciduous trees, mixed forests and the structure of the crown canopy have increased in size. The forests contain approximately 93 million trees with ecologically significant tree attributes, 224 million cubic metres of deadwood and especially protected biotopes over five percent of the forest area.

Diversified forests can do more: they offer the greatest potential to fulfill the demands made on them. The forest performs a variety of services to society. It contributes to protecting the climate, water and soil, is a habitat for animals and plants, provides space for recreation and to experience nature and supplies timber, our most important renewable resource. Sustainable forestry in Germany acts according to this multi-functionality and safeguards the services of the forest.

Mixed forests that are site-suitable and rich in structure are the objective of forestry policy. They are best suited for our present demands and future challenges. Mixed forests can better adapt to environmental changes and balance out silvicultural risks such as storms, pests and tree diseases. Mixed forests are beneficial for the forest soil and groundwater storage. In addition to an aesthetically pleasing forest, they provide diversified habitats and therefore a prerequisite for species-rich fauna and flora. Diversity in the forest begins with forest ownership. The diversity of the forest owners, their aims, management practices and holding sizes are reflected in the diversity of our forests.

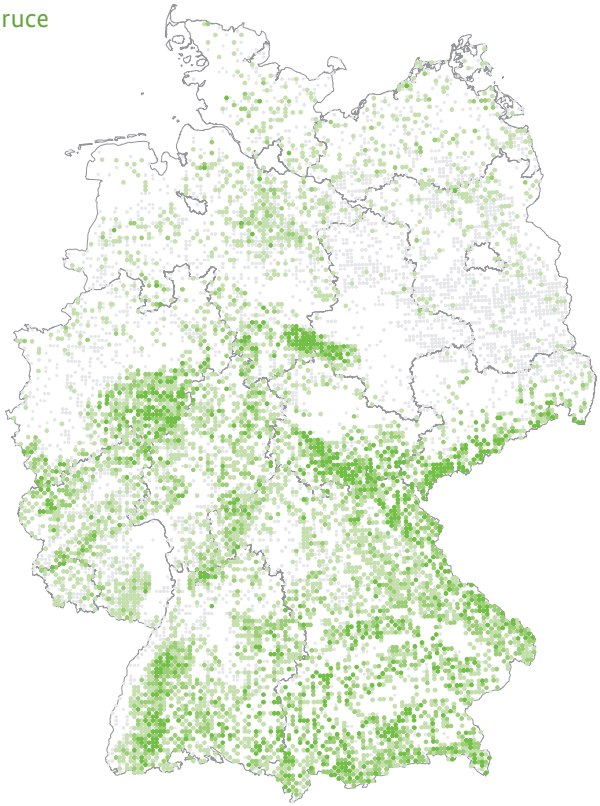
Spruce, pine, beech, oak – the most common tree species

At present, the appearance of our forests is characterized by spruces, pines, beeches and oaks on a total of 73 % of the timberland. These tree species have different regional focuses. The spruce is found in particular from the Alpine foothills to the high altitudes of southern and southwestern Germany and in the uplands of northeastern Bayern to the Thüringer Wald and the Erzgebirge, as well as in Hunsrück, Eifel, Taunus, Westerwald, Rothaargebirge and Harz. The pine stretches mainly across the northeastern German lowlands of Niedersachsen to Brandenburg and Sachsen. It is also found in Pfälzer Wald, in the valley of Rhein and Main and in the Oberpfälzer Becken und Hügelland. The beech occurs mostly in the uplands of the Schwäbisch-Fränkische Alb across the Pfälzerwald, Eifel, Odenwald and the Spessart to Solling. We find the oak in particular in the Pfälzer Wald, the Spessart and the warm low-lying areas of Germany.

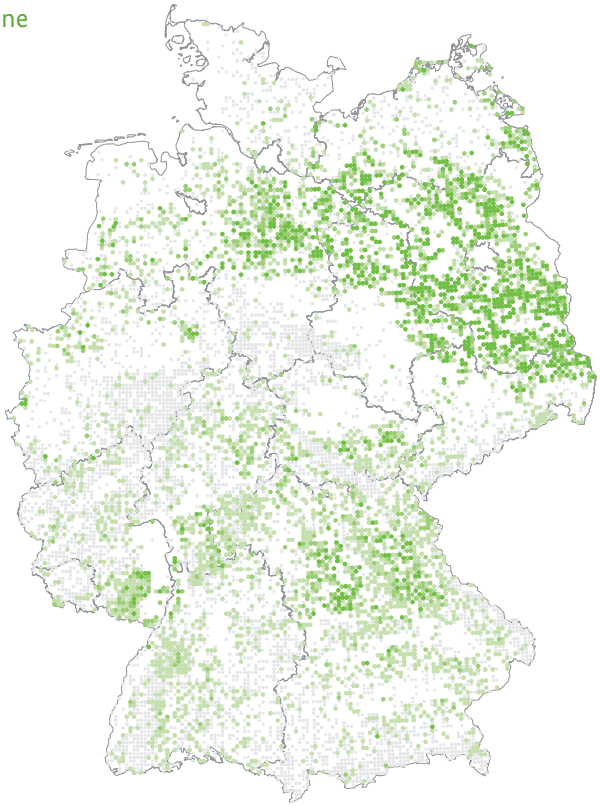
The National Forest Inventory surveyed 51 tree species or tree species groups. Approximately 90 % of the timberland is taken up by 11 tree species. They are, in addition to the tree species named above, the common spruce, common pine, purple beech, sessile oak and European oak, the tree species common birch, common ash, black alder, European larch, Douglas fir and the sycamore maple. The other 40 tree species share the remaining 10 % of the timberland. In spite of their low distribution they make important contributions to diversity, stability, soil maintenance and timber production. They fill in ecological niches, like the Swiss pine in the mountains. Its timber is sought for special uses, as for example, the ash for tool handles, the lime tree for sculpture and the wild cherry for furniture.

Distribution of spruce, pine, beech and oak in Germany

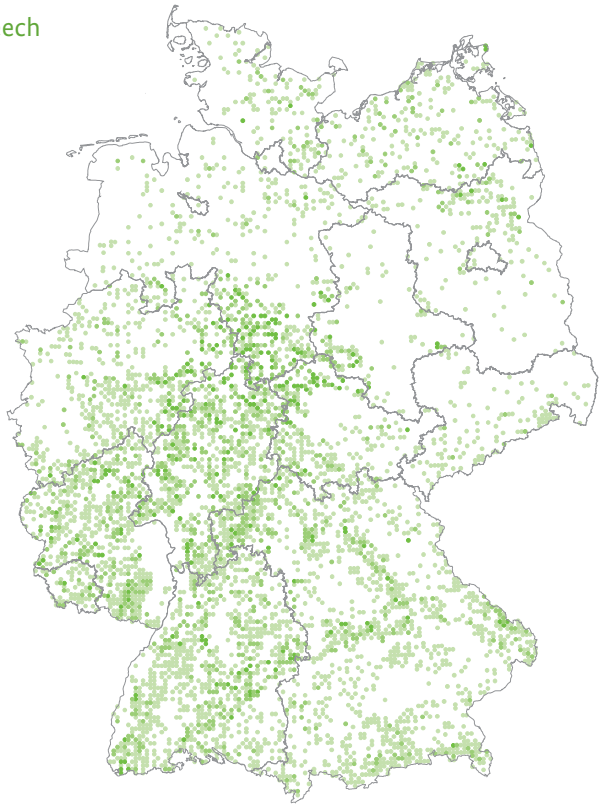
Spruce



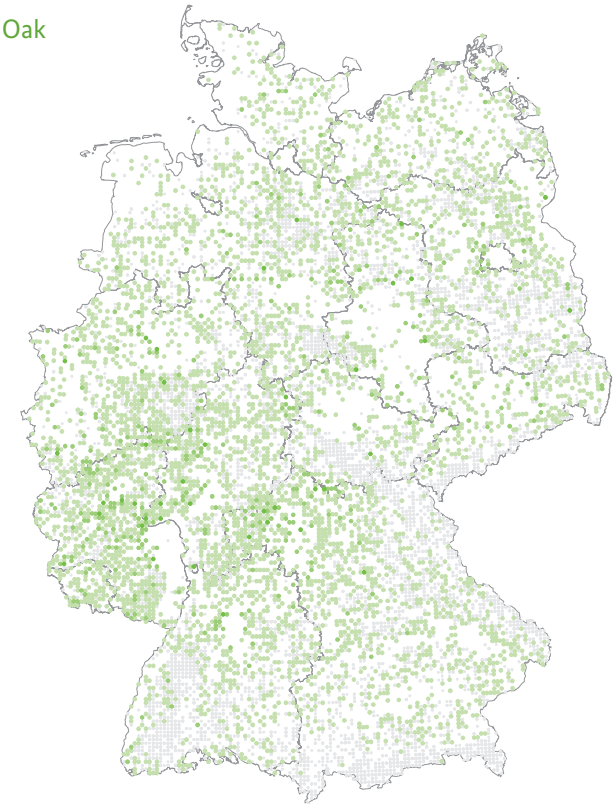
Pine



Beech



Oak



Percentage of tract

up to 1/3 over 1/3 to 2/3 over 2/3 forest tract with other tree species

Area covered by beech tree species or beech forest cover type

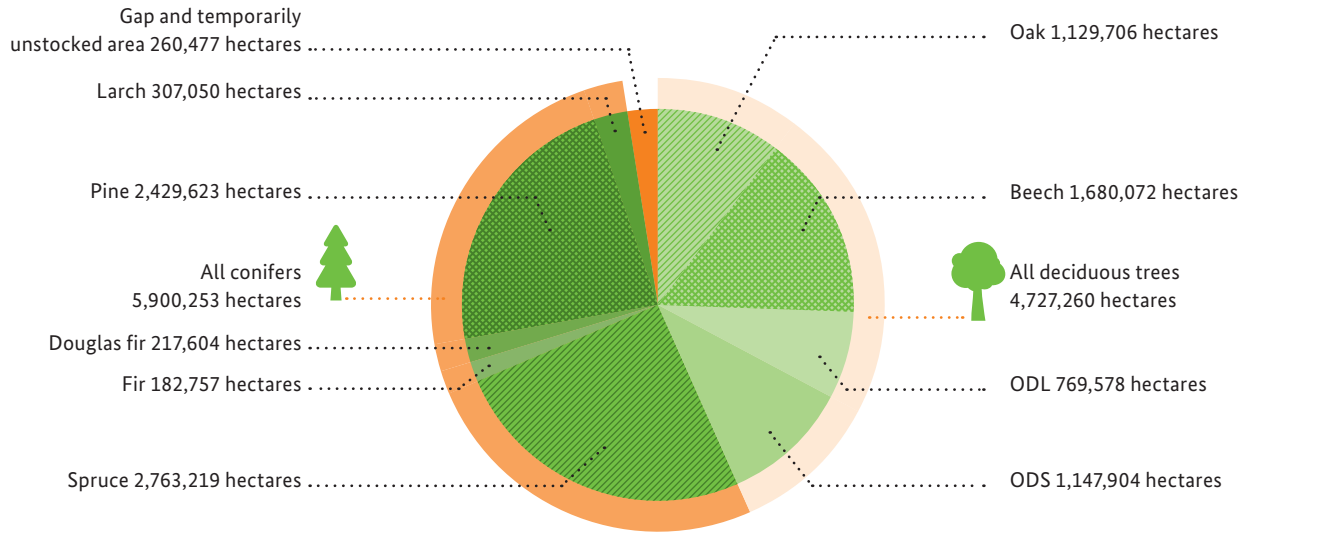
In order to ascertain the tree species areas, the area percentages of the individual tree species in a mixed forest are divided up by "calculated pure stands." Hence, for example, the cited area of beeches contains not only the pure beech forests, but also the share of beeches in the mixed forests. By contrast, the "beech forest cover type" contains all forests in which the beech is the most common tree species – including the blended in areas of other tree species. This is why the beech area of 1.68 million hectares differs from the area of the "beech forest cover type" with 1.80 million hectares.

The rarer deciduous tree species are put together in the groups "other deciduous trees with long life expectancy" and "other deciduous trees with short life expectancy." These are tree species such as the hornbeam, which only rarely dominate in upper canopy layers. Other tree species (e.g. the service tree and wild service tree) can only compete with tree species that tolerate shade, like the beech and spruce on dry and warm sites. In this way, the site and tree species-specific competitive strengths naturally differentiate the tree species composition. In addition, game browsing of young tree growth exacts a toll on the rare tree species in particular.

Humans are another force that shapes the forests. Our silvicultural actions decisively determine what tree species grow in the productive forests. Today's forests testify to both the present and, in particular, the past circumstances, the social needs and the silvicultural decisions made by our ancestors. In past centuries, uncultivated wasteland had to be afforested in order to re-establish the forests and cover timber demand. In this way, the spruce – actually native to the highlands – became widespread, and the pine on poorer sites.

Expeditions introduced non-native tree species to Europe. Compared with our native tree species, these exotic trees play a subordinate role in the German forests. Non-native forest tree species such as the Douglas fir, Japanese larch, red oak, black locust, Sitka spruce, black pine, Mexican white pine, grand fir and others altogether have an area percentage of a little less than 5 %. Cultivating these tree species allows for additional silvicultural alternatives to the number of Central European tree species, which was greatly diminished by the Ice Ages. This aspect is gaining importance in view of climate change. The most widespread, although still low in numbers, is the Douglas fir with approximately 218,000 hectares or 2 %, followed by the Japanese larch (approx. 83,000 hectares or 0.8 %) and red oak (approx. 55,000 hectares or 0.5 %).

Area of the tree species groups



Basis: Timberland 10,887,990 hectares, calculated pure stand

The National Forest Inventory surveyed the trees in the German forests in categories of 51 tree species or tree species groups. For evaluation, they were categorized in nine tree species groups: oak, beech, other deciduous trees with long life expectancy, other deciduous trees with short life expectancy, spruce, fir, Douglas fir, pine, larch.

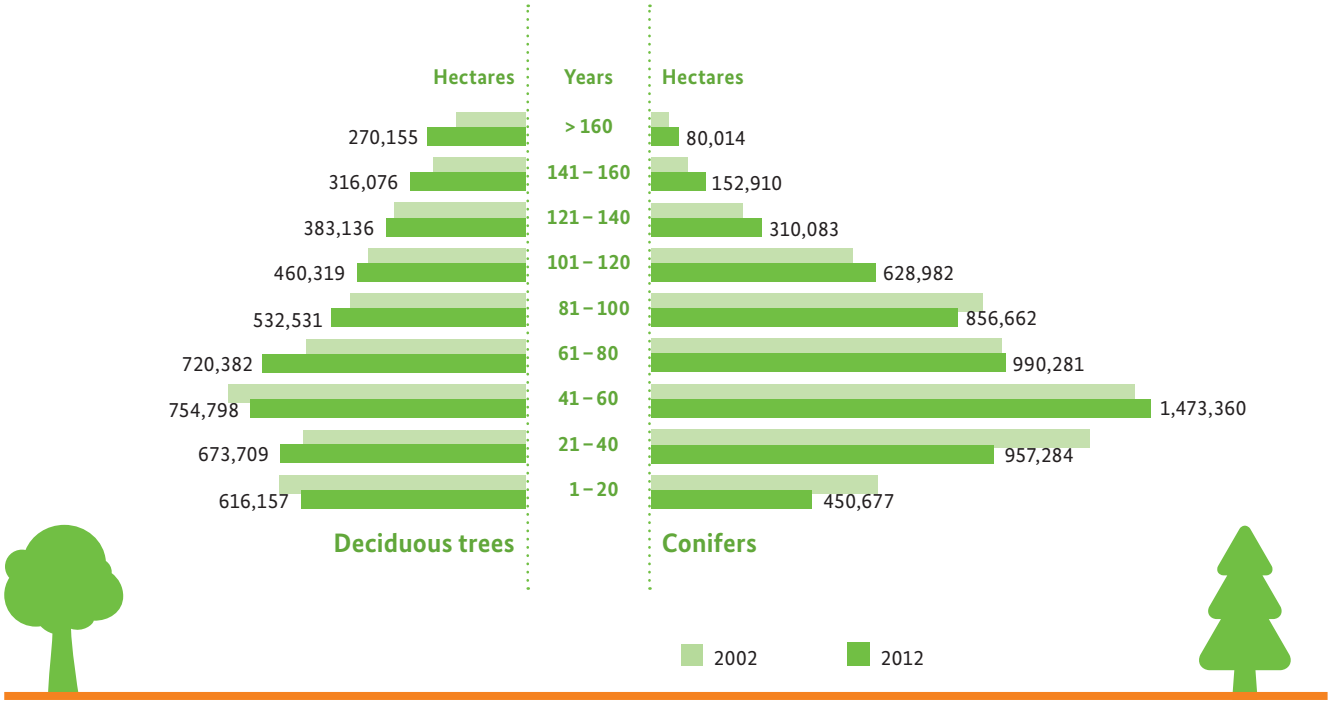
Other deciduous trees with long life expectancy (ODL): maple, ash, chestnut, lime tree, white beam, service tree, black locust, elm.

Other deciduous trees with short life expectancy (ODS): birch, wild service tree, alder, poplar, bird cherry, rowan tree, wild cherry, willow, forest fruit trees.

Forest damage led to rethinking – climate change faces us with new challenges

In the 1980s, the forest damage caused by air pollution led to rethinking the choice of tree species and in particular gave the spruce and fir fewer prospects. In the meantime, the air quality and hence the future prospects for the fir have again improved. The fir is therefore again being cultivated as a silvicultural option and for distribution of risk. At the same time, research of the forest ecosystem revealed the major importance of deciduous trees for forest soils. Deciduous trees are therefore a central element of ecologically compatible forestry. By contrast, some tree species are afflicted by wide-ranging diseases. Those affected for decades now are elms, and ash trees in recent years. Therefore scientists and foresters look for tree species that can adapt to climate change or thrive under the anticipated circumstances, those that bind lots of carbon dioxide from the atmosphere and form species-rich ecosystems.

Age pyramid of the forest



Basis: Calculated pure stand

Increase in older forests

The forest area with stands of old trees is increasing. On average, today's forest is 77 years old and thus four and a half years older than in 2002. The oldest trees on average are the oaks at 102, beeches at 100 and firs at 96 years. The Douglas fir, averaging 45 years, is the "youngest" tree species.

A little less than one fourth of the forest (24 %) is older than 100 years, 14 % is even older than 120 years. The area of old stands over 100 years old grew by 393,000 hectares since 2002.

The age structure of the forests in Germany is the result of the extensive reforestation measures after the Second World War. Never have so many forest areas in Germany had to be reforested as they did in the 1950s and 1960s. These forests are now between 40 and 60 years old.

The numbers of large-girth trees are growing in the forest. These thick, old trees can contribute to biological diversity in a special way because they frequently possess special micro-habitats more than young trees do, such as rough bark, crown deadwood and woodpecker cavities. Many rare species need this. Also, old trees are attractive eye catchers for human visitors to the forest.

Large-girth trees are an increasing challenge for the forestry and timber industry. Modern sawmills and chipper canter mills are built for processing small and medium-girth tree trunks. They can produce high-quality timber-based materials of almost any dimensions from these trunks. Therefore large-girth trees are less and less in demand.

If large-girth trees remain in the forest until they decompose, this raises liability risks for the duty to maintain safety and hazards for working in the forest along roads, car parks and hiking trails. Also, the legal requirements for protecting rare species of such trees can result in possible restrictions for management.

Rise in numbers of deciduous trees

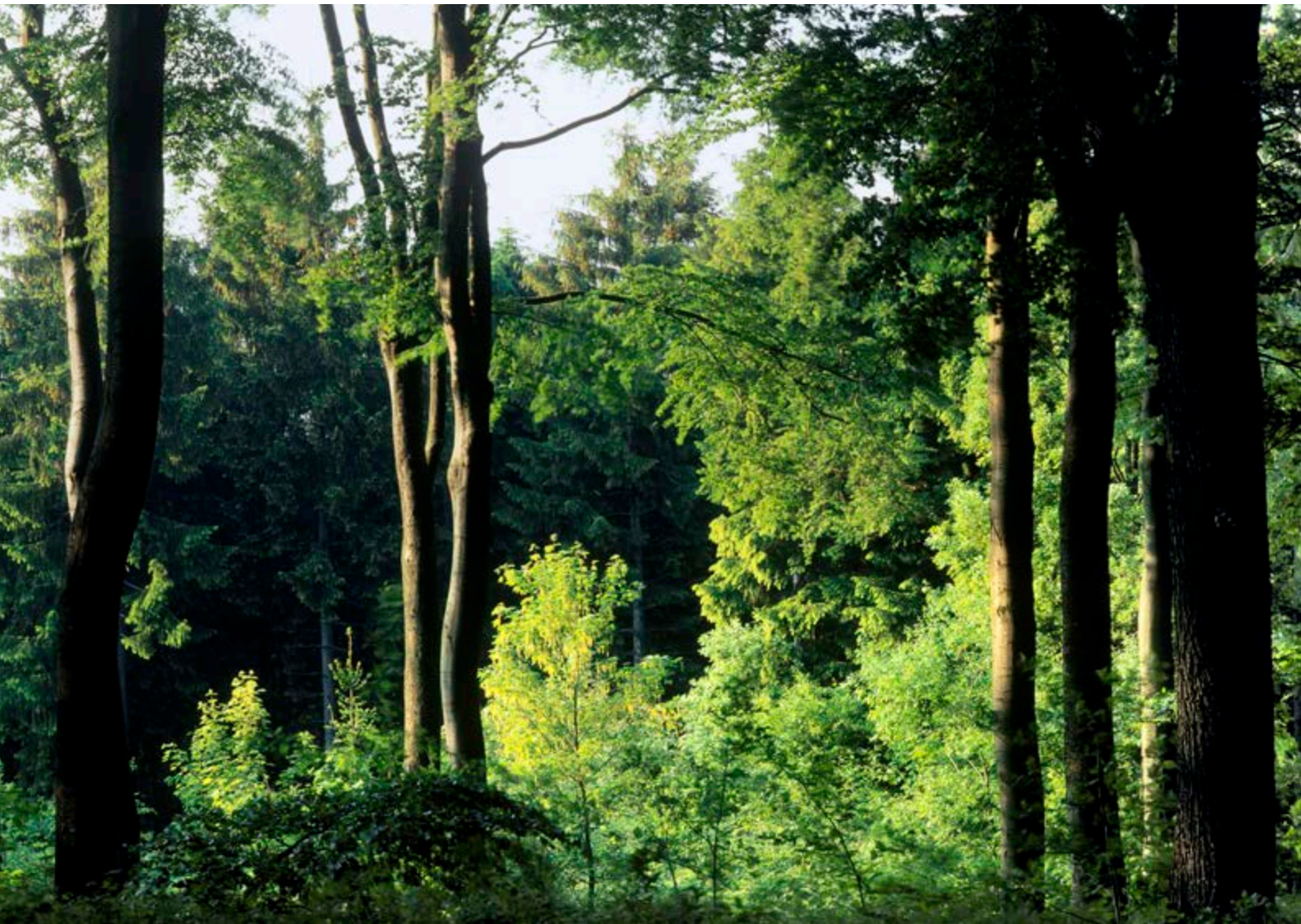
There are again more deciduous trees in Germany's forests. They presently make up 43 % of the timberland. This means that the percentage of deciduous trees rose by approximately 7 % (approx. 315,000 hectares) compared to 2002 and the percentage of conifers dropped by approx. 4 % (267,000 hectares). The difference of approximately 48,000 hectares corresponds to the increase in forest area.

Today's forests are the legacy of history. If left to nature, deciduous trees would dominate the appearance of the forests in Germany. The fact that today's forests are dominated by conifers, spruces and pines in particular, is a consequence of our past.

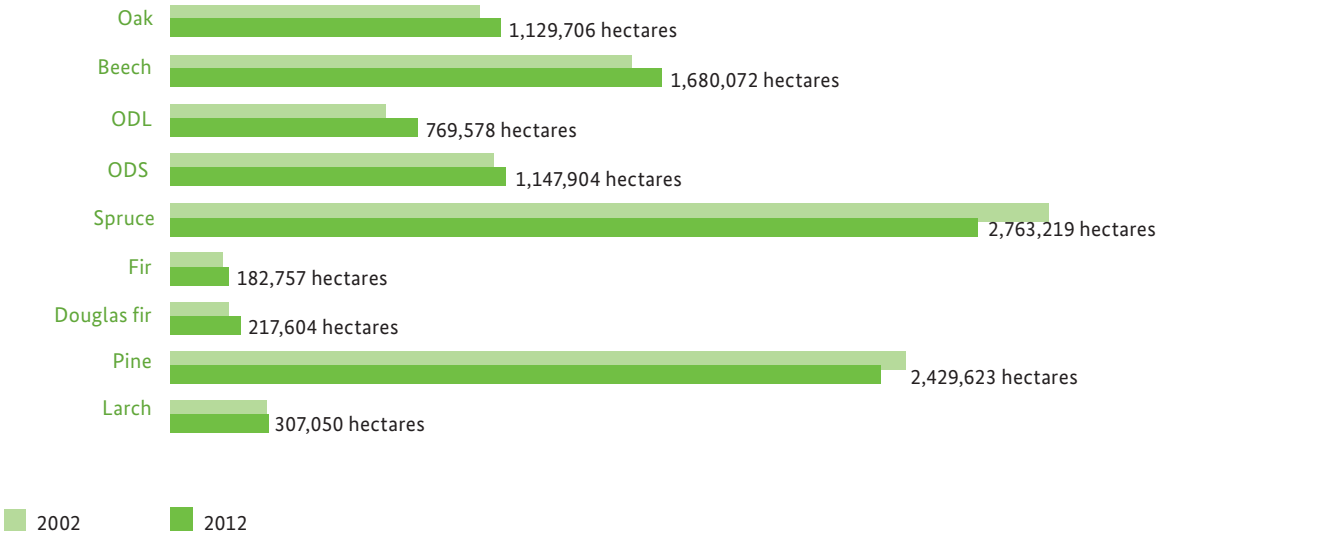
From the Middle Ages until the 19th century, many forests were over-used or cutover (see info box "Historic development of the forested area" on page 5).

As a consequence, in past centuries uncultivated wasteland or large clear-cut areas frequently had to be afforested. Such areas are dominated by conditions that are unbeneficial to forests. Without the shelter of old trees, small trees are exposed to the influence of the sun, wind and frost without protection and at the same time have to assert themselves against fast growing competing vegetation such as grasses, bracken and blackberries. Mice, fungi, insects and browsing by game animals are additional burdens for small trees.

The National Forest Inventory results show more deciduous trees and more mixed forests. The percentage of deciduous trees has risen since 2002 by approximately 7 %. The counter-trend from pure conifer stands to site-appropriate, highly structured mixed forests is meant to prevent the effects of climate change.



Change in forest area by tree species groups



Basis: Calculated pure stand
ODL = other deciduous trees with long life expectancy, ODS = other deciduous trees with short life expectancy

The forest continues to be an important resource.

Only a few tree species, among them the spruce and pine, can deal well with the conditions of a clear-cut area. There were hardly any alternatives to spruces and pines for rapid re-forestation. Sufficient amounts of propagating material were available only for these tree species.

Also, spruce and pine grow quickly and their timber is in demand due to its outstanding properties. This is why spruces and pines became widespread in Germany. Hence, today's forests are, to a considerable extent, the result of the silvicultural considerations and options of our forefathers.

On many sites, deciduous trees have many benefits for the forest soil, for the supply of groundwater, for the diversity of animal and plant species as well as for the stability and adaptability of the forest stands, for example against pests, storms and climate change.

Therefore, the transformation of pure conifer stands – as those that were cultivated in large numbers most recently after the Second World War – into site-appropriate deciduous and mixed deciduous stands is one objective of the forestry policy of the Federal and the Länder governments. It is an element of the forestry directives of many Land forests and has been promoted with major funding in the non-state forests for decades. In this way, the forests will be better able to cope with the anticipated burdens of climate change (see the chapter "The forests as climate protectors – still a carbon sink").

The Federal government and *Länder* have already made considerable investments in order to bring about the forest transformation documented here. In the meantime, many forest owners have practiced ecologically compatible forestry for many decades. With targeted management, they cultivate stabile and ecologically valuable mixed stands with a high share of site-suitable native tree species.

The results of the National Forest Inventory substantiate the success of these measures: Between 2002 and 2012 the area of spruces dropped by 242,000 hectares (-8 %) and the beech area rose by 102,000 hectares (6 %). Already between 1987 and 2002 the spruce area in former West Germany had been lowered by 219,000 hectares (-8 %) and the beech area increased by 151,000 hectares (12 %). This development was intensified further by storm events and drought years.

In addition to the beech, the forest owners also expanded the area percentage of other deciduous tree species. Among the conifers, only the Douglas fir increased slightly by approx. 35,000 hectares or 19 % and the fir by a little under 19,000 hectares or 11 %, while the pine decreased by approx. 85,000 hectares or 3 %. The decline in pines is particularly noticeable in the younger age classes.

Forests are long-lasting ecosystems that develop over decades and centuries. Forestry planning and production periods are correspondingly long. It is therefore natural that spruces and pines – in spite of the development leading to more deciduous trees – will initially remain the two dominant tree species.

Forests more diversely structured

A forest's horizontal and vertical structure, i.e. its tree species mixture and its stratification in the canopy, are important indicators of its structural diversity. A forest in which a variety of different tree species stand next to one another and the crown canopies of a multiple tree layers rise above one another offers diversified habitats for animals and plants. Due to its structural diversity, it can also better react to environmental impacts.

Tree species composition is also a key element of the forest's horizontal structure. German forests are dominated by mixed forests, with 76 % of the area percentage. Pine forests, with an area percentage of 57 % admixture or spruce forests with 71 % are relatively less mixed. All other forest cover types are more mixed.

Over the past ten years, the tree species composition has intensified somewhat. The area of mixed forest cover rose by 5 %.

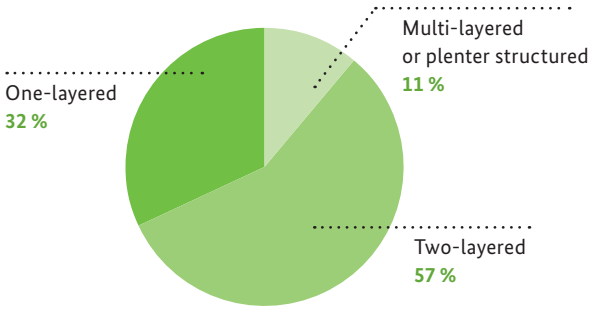
With 85 % of the area percentage of young forest cover, natural regeneration is the dominant form of regeneration in the German forests. Plantings only make up 13 % and are primarily found among Douglas fir forest cover (73 % of Douglas fir forest cover) and in oak forest cover (44 % of oak forest cover). The remaining area (seed, coppice shoots, unclassified) makes up a mere 2 %.

What is a mixed forest?

The term "mixed forest" is not uniformly defined either in general usage or in forestry language. The National Forest Inventory defines mixed forest as a forest in which trees of at least two botanical genera occur, whereby each of them has at least a 10 % area percentage. Therefore, a beech forest with oaks or a spruce forest with firs is also a mixed forest.

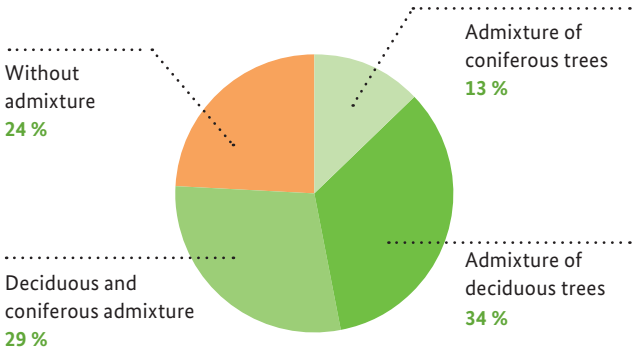
Mixtures of botanical species of the same genus, such as European oak and sessile oak are, by contrast, not mixed forests. When differentiating between deciduous forests and coniferous forests, a deciduous forest is considered mixed if it has a 10 % conifer admixture and vice versa.

Canopy layers



Basis: Stocked timberland

Mixture



Basis: Main forest cover

An intact, diversified natural environment will be able to supply future generations with ecosystem benefits such as renewable resources, clean air and drinking water.

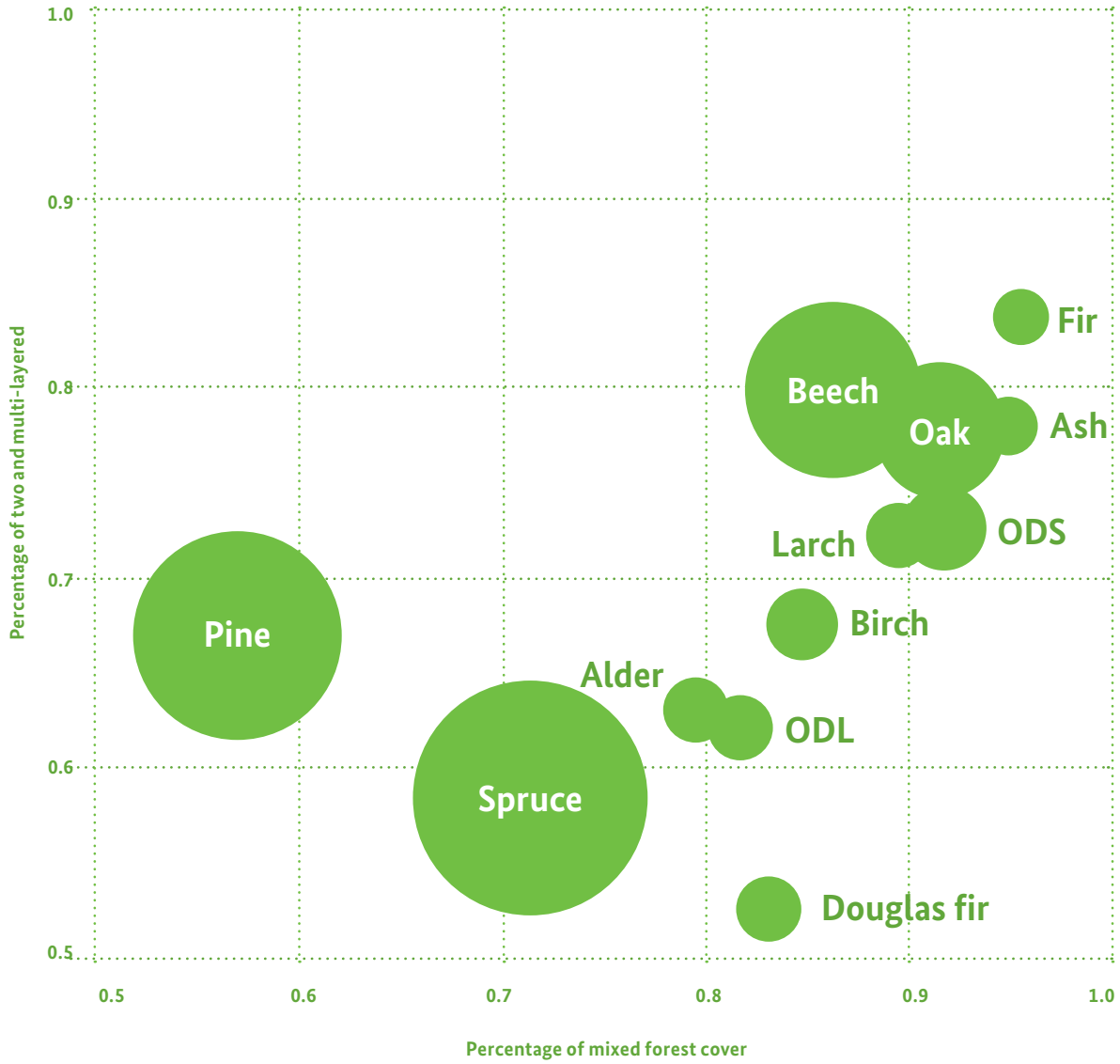
The vertical structure of a forest is described by its stratification. 68 % of our forests are two or multi-layered. That is 28 % more than in the year 2002. Young forest cover is found on approximately one fourth of all timberland. It is therefore an important element of the vertical structure of the forest.

In addition, there are approximately 30 million holdover trees. Holdover trees are particularly old trees that remain in the forest for a second rotation or cutting interval and therefore whose crowns frequently rise above the others. They are important elements for the forest structure and biological diversity. On average, we find three holdover trees per hectare.

The most frequent structures are two and multi-layered structures among fir (84 %), beech (80 %), oak (78 %) and ash forests (78 %). Two and multi-layered structures are less common among Douglas fir (53 %) and spruce forests (58 %).

Forests in which trees of various species and sizes occur together offer the greatest structural diversity. These are often beech forests or oak forests. Even the rare fir forests often exhibit structures with multiple tree species and layers in the canopy. Mixed and stratified structures are less common in spruce and pine forests.

Structural diversity of the forests



Basis: Stocked timberland
ODL = other deciduous trees with long life expectancy, ODS = other deciduous trees with short life expectancy

One-layered or multi-layered forest

The layers describe the vertical structure of the forest. One layer is formed by all trees that share a canopy and exhibit at least a 10 % degree of coverage. Hence, a two-layer forest is one that has two crown canopies above and not touching one another. For example, this can be young growth below the shelter of an old stand.

Plenter forests are particularly demanding for forestry and structurally diverse. They are always multi-layered, but they have special site requirements and tree species compositions and occur at only negligible area percentages in Germany.

Naturalness of the tree species composition is somewhat improved

The growth and vitality of a forest are determined by the competition among trees. The most vital trees are those on sites that optimally fulfil their species-specific demands for water, nutrients, light, warmth, etc. Other tree species can hardly compete on such sites without human assistance. Hence, natural selection gives rise to the typical tree species composition, also called the "present potential natural vegetation." This is the vegetation that would occur at the end of all development stages under the present site conditions without human interference.

If trees are planted on sites that are less suitable for them, their vitality suffers and they become susceptible to damages from pests, drought, storms and other stress factors. The ability of such forest stands to react to additional or new stress factors like air pollutants or climate change is reduced and their stability is impaired.

The parameter "naturalness of the tree species composition" describes the extent to which the tree species composition of our forests corresponds to the present potential natural vegetation. This is an indicator for forestry policy and ecologically compatible forest management.

The forest is an element of the cultural landscape influenced by humans. By nature, Germany is beech country and if left to nature, today's forest area would be made up of 75 % beech forests and 17 % oak forests. Where beech forests would naturally grow, today only 21 % beech forests stand; 34 % are spruce forests and 17 % are pine forests. On the area of natural oak forest communities, today only 14 % oak forests grow; 55 % are pine forests.

The naturalness of the tree species composition in the main forest cover changed only slightly compared with the last inventory. A bit less of it is conditioned by culture and thus somewhat more are semi-natural forests. 15 % of the forests have a very semi-natural composition and another 21 % a semi-natural composition of tree species. The share of these two stages of naturalness is particularly high among beech forests (84 %) and fir forests (6 %). It is especially low among pine forests at 15 %.

The investments made in the semi-natural transformation of forest stands are apparent, however, among the young forest cover (trees up to 4 metres in height) where the share of very semi-natural and semi-natural tree species composition is approximately 51 %. Only 5 % of young forest cover is accentuated by culture and 13 % is conditioned by culture.

Semi-natural and very semi-natural tree species compositions are very high in the state forests (43 %) and in the communal forests (41 %) where the transformation of forest stands has advanced the farthest.

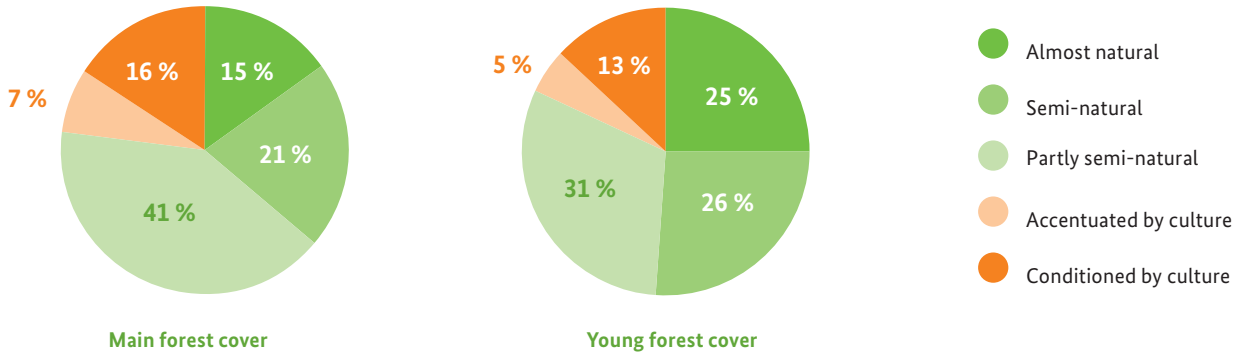
How do we record forest naturalness?

The interpretation of naturalness in the National Forest Inventory refers exclusively to the tree species of the forest. To assess naturalness, we compare the presently occurring tree species with those of the natural forest community (or the "present potential natural vegetation," which is the vegetation that would develop under the present site conditions without human intervention).

Naturalness categories

The National Forest Inventory uses a five-level scale to describe naturalness. The further removed the existing tree species composition is from that which would naturally occur, the lower the naturalness is categorized.

Naturalness of the main and young forest cover



Basis: Stocked timberland

More deadwood found than ten years ago

Deadwood is part of the natural life cycle of the forest. It occurs when trees die and their timber decomposes. Many, in particular rare species are specialized in this habitat. Fungi, lichen, insects and birds live off or in deadwood, where they find food, shelter and breeding places. Deadwood is therefore an important factor for biological diversity.

In the German forests there are on average 20.6 cubic metres of deadwood per hectare and a total of 224 million cubic metres. Thus, deadwood stock is now 6 % of the live timber stock. Almost half of it (49 %) is lying deadwood, 23 % is standing deadwood and 28 % is root stock. This is 18 % more dead timber than there was ten years ago. The increase is predominant among standing pieces of conifers.

Deadwood decomposes. A constant supply is needed to preserve deadwood for those species specialized in deadwood. In earlier times, most of the deadwood was removed from the forests and used to supply the population with fuel. Today, sustainable forest management practices actively strive to retain a suitable amount of deadwood to protect biological diversity.

Annually, about one cubic metre of timber is needed to lastingly preserve a deadwood stock of 20 cubic metres per hectare[2].

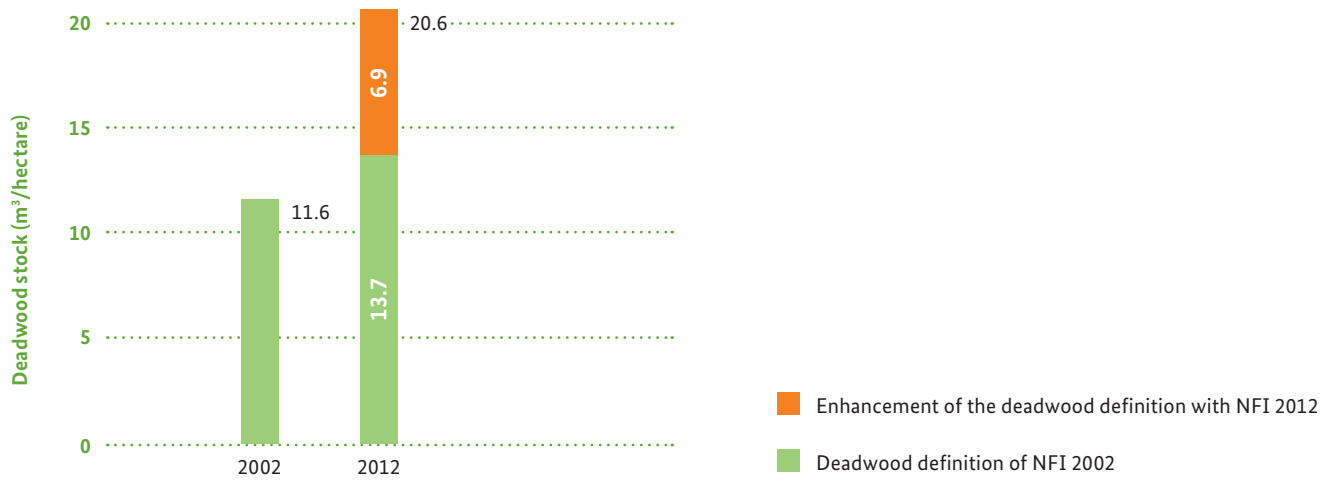
Many of the beetle species occurring in Germany depend on deadwood in various stages of decomposition.

This corresponds to non-use of roughly one tenth of the annual increment.

About half of the deadwood stock is in the stage of advanced decomposition or is heavily decomposed. Almost half (47 %) consists of large-girth deadwood pieces with a centre diameter of at least 30 centimetres.

2 Kroiher, Franz; Oehmichen, Katja (2010): Das Potenzial der Totholzakkumulation im deutschen Wald. Schweizerische Zeitschrift für Forstwesen = Journal forestier suisse, Volume 161, Issue 5, pages 171–180

Deadwood stock and how it has changed

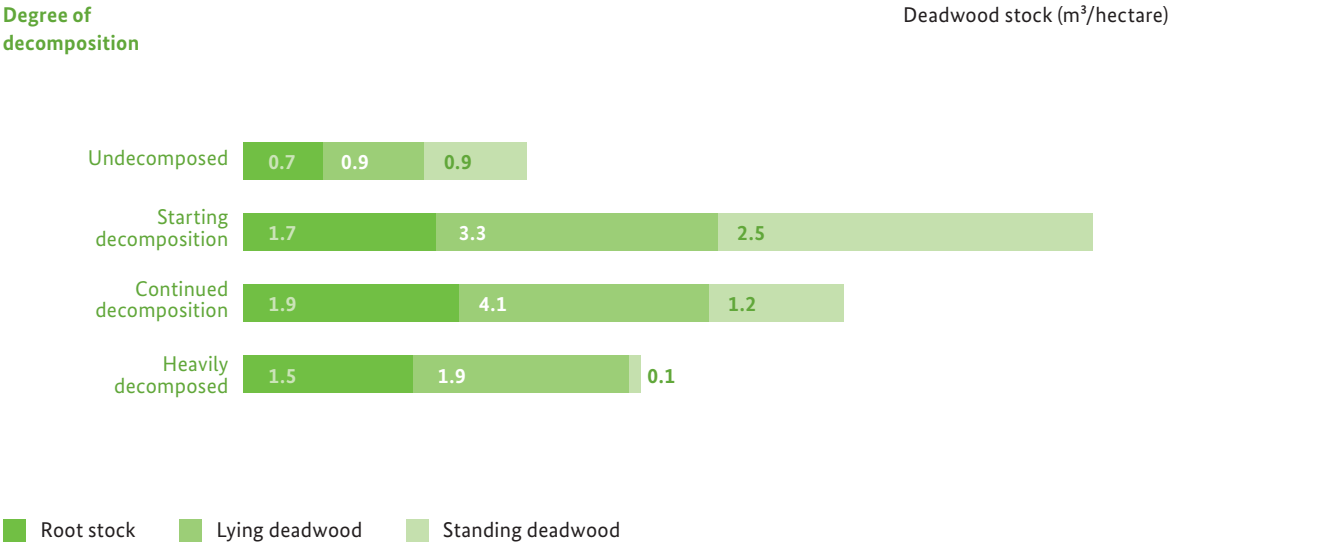


Basis: Timberland

Tawny owl in a dead beech tree.

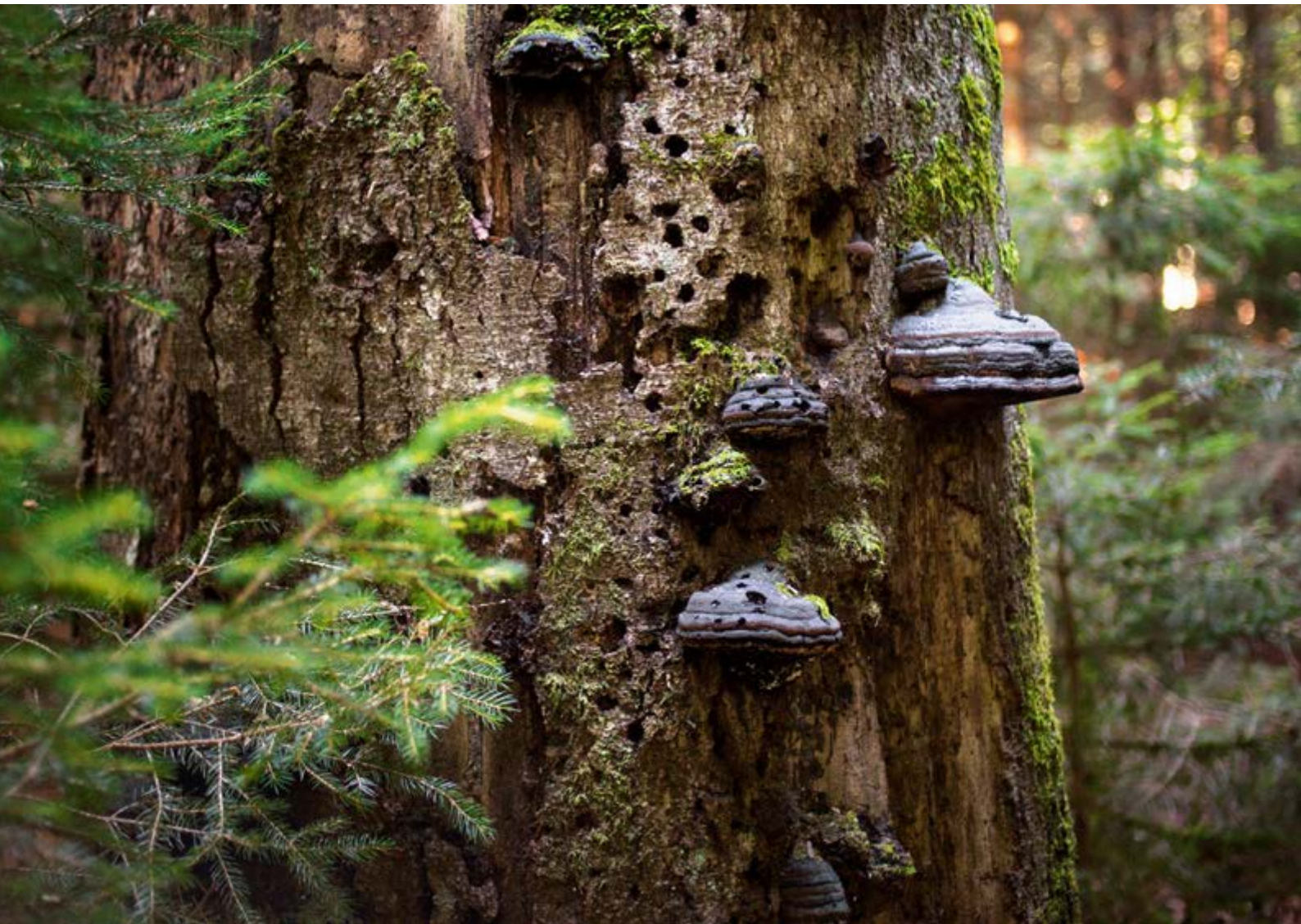
Deadwood is very important for biological diversity as it offers habitats to many animal and plant species. Foresters are increasingly ensuring that the ecological communities of deadwood find such habitats in the productive forests.

Deadwood stock by degree of decomposition



Basis: Timberland

Fungi need dead timber to colonize in or decompose in order to survive and propagate.



Specially protected biotopes on five percent of the forest area

In addition to the designated and usually signposted protected areas (such as nature protection zones), certain biotopes are protected by the Federal Nature Conservation Act, Land Nature Conservation Acts or Land Forest Acts wherever they occur. Due to their special significance as biotopes, actions that could lead to their destruction or other considerable impairments are prohibited (Article 30 of the Federal Nature Conservation Act).

As a rule, these biotopes can be managed, but in individual cases may be subject to special restrictions.

The specially protected biotopes are located on approximately 593,000 hectares or 5 % of the forest area. They are, in most cases (77 %), fen, swamp or lowland riparian forests as well as other wetland biotopes.

Invasive plants in the forest are currently of little significance

For the first time, the inventory included some adventive herbaceous plant species that could possibly be invasive. Only the small balsam or small-flowered touch-me-not *(Impatiens parviflora)* from eastern Siberia and Mongolia was found in amounts worth mentioning. It occurs on 3 % of the forest area with at least a 10 % degree of coverage. The species is most common in Mecklenburg-Vorpommern, where it occurs on a little less than 9 % of the forest area. Extensive incidences grow in the forests of Germany primarily on sites that do not offer good living conditions for other species, for example because they are too dark or their layers of leaf litter are too high.

The National Forest Inventory recorded the following other invasive species: giant hogweed *(Heracleum mantegazzianum)*, giant knotweed *(Fallopia japanica, F. sachalinensis)*, Policeman's Helmet *(Impatiens glandulifera)*, American pokeweed *(Phytolacca americana)*. They hardly occur in the forest, however.

While invasive herbaceous plant species are not significant area-wise in the forest, one invasive woody species is notable: the black cherry *(Prunus serotina)*. It takes up approximately 104,000 hectares of the young forest cover and can impede the regeneration of native forest tree species. Its vigour is, however, inferior to that of our forest trees and remains in the understorey, forming the main stand on less than 11,000 hectares or approx. 0.1 % of the total forest area.

Biotope trees – stepping stones for biological diversity

There are over 90 billion trees in our forests, every single one is a part of the forest ecosystem. Trees with special, ecologically significant tree characteristics are an important element of biological diversity in the forests. These include, for example, trees with woodpecker and breeding cavities, eyrie trees, marked biotope trees as well as trees with crown deadwood and other special habitat characteristics. Some of these characteristics may have been surveyed in the same tree at once.

The National Forest Inventory found an average of nine trees per hectare possessing ecologically significant characteristics. That is 93 million trees in the entire German forest. Deciduous trees are in the majority with a share of 60 %.

The National Forest Inventory recorded approximately 22 million woodpecker or hollow trees, 741,000 eyrie trees and 1 million marked biotope trees. 80 % of woodpecker and hollow trees are deciduous and, with an average of 1.9 cubic metres per tree, are above average in mass. The eyrie trees, with an average mass of 1.7 cubic metres are only slightly smaller, but 54 % of them are also found among conifers. Marked biotope trees exhibit a medium timber mass of 3.4 cubic metres per tree. They are genuinely thick and old trees with high value for biological diversity. Forestry integrates such trees in the productive forests. 31 million trees are recently dead. These are the many young and thin trees that do not survive the competition with their neighbour trees.

Young great spotted woodpecker in a tree cavity.

Conservation status of large-area forest habitat types protected under the Fauna-Flora-Habitats Directive

Forests as a rule are the least impaired natural environments within our cultural landscape.

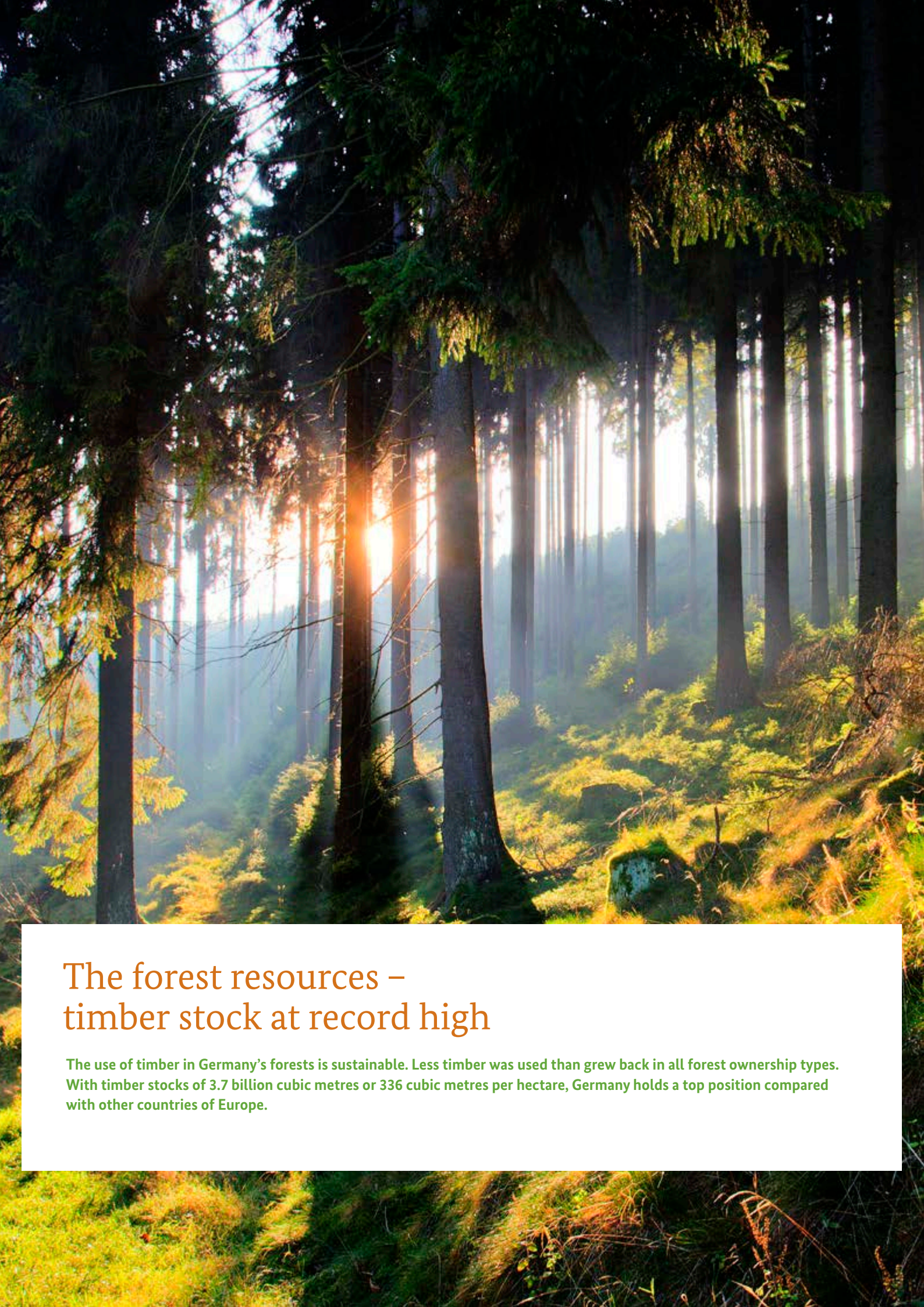
They are the homes of a considerable share of the native flora and fauna. Approximately 17 % of German forests are therefore protected areas under European Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) and therefore part of the Natura 2000 European protected site network. These habitat areas serve to protect specific animal and plant species and their habitats.

Article 11 of the Habitats Directive stipulates that Member States must regularly undertake surveillance of the conservation status of the habitat types. For this purpose, the National Forest Inventory in 2012 was the first to uniformly survey and assess parameters on the specific structures and functions of forest habitat types nationwide.

The National Forest Inventory lists 19 forest habitat types for Germany. The three large-area forest habitat types occurring in Germany – Luzulo-Fagetum beech forests (9110), Asperulo-Fagetum beech forests (9130) and Galio-Carpinetum oak-hornbeam forests (9170) – are surveyed representatively by the National Forest Inventory. They make up approximately 83 % of the total area of all forest habitat types in Germany.

The other 16 forest habitat types make up the remaining 17 % of the area. A representative survey of these forest habitat types is not possible in the scope of the National Forest Inventory due to the low sample sizes. The Länder have therefore surveyed the conservation status of these forest habitat types using other methods. The results are summarized in the national 2013 Habitat Report of the Federal Republic of Germany[3].

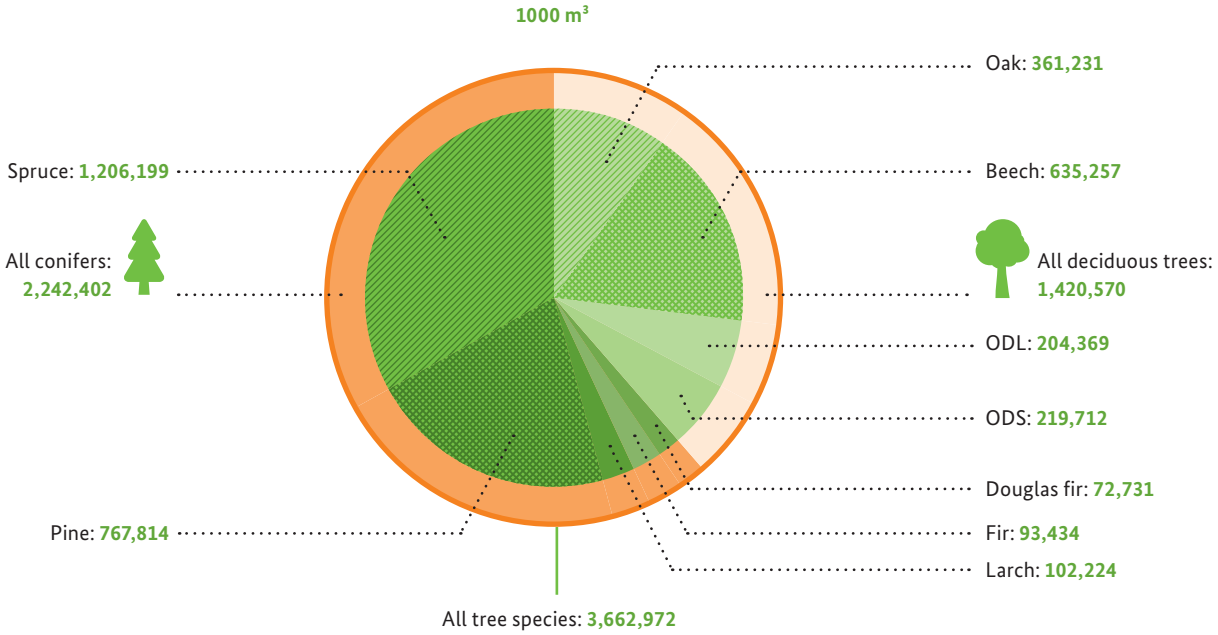
3 See: www.bfn.de/0316_nat-bericht_2013-komplett.html



The forest resources – timber stock at record high

The use of timber in Germany's forests is sustainable. Less timber was used than grew back in all forest ownership types. With timber stocks of 3.7 billion cubic metres or 336 cubic metres per hectare, Germany holds a top position compared with other countries of Europe.

Timber stock by tree species groups



Basis: Timberland, all canopy classes
ODL = Other deciduous trees with long life expectancy, ODS = Other deciduous trees with short life expectancy

The forests supply timber and create jobs. In Germany more than 1.1 million people are employed in the forestry and timber sector [4]. In addition, in the era of climate change and the rise in prices of fossil fuels, the importance of timber as a renewable resource is increasing.

Stock rose again

The timber stock has reached a size not seen in many centuries. Within ten years it grew by another 7 %. With a stock of 336 cubic metres per hectare, Germany, following Switzerland and Austria, is at the top of European countries. With a total stock of 3.7 billion cubic metres, more timber is standing in German forests than in any other country in the European Union.

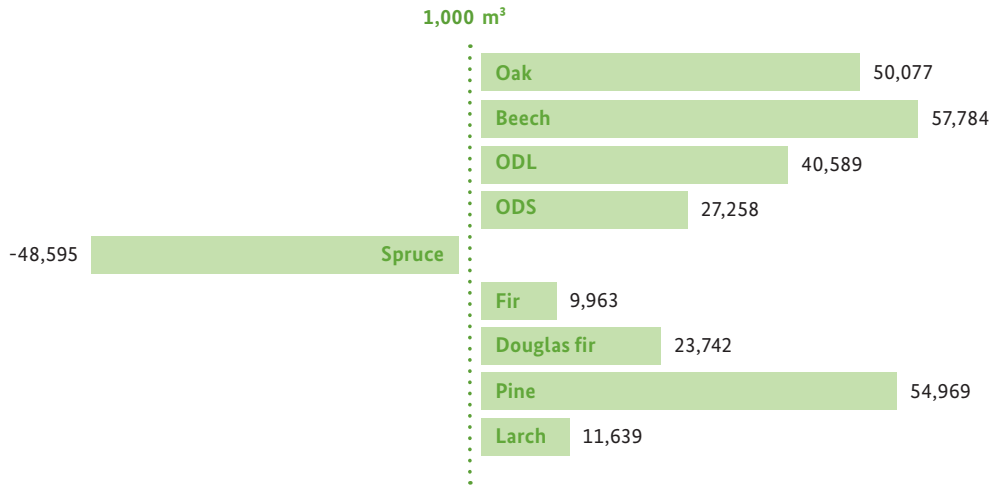
All types of ownership participate in this stock increase. The greatest per hectare stock – 352 cubic metres – is located in the private forests.

In the past decade, the utilization intensity in the private forests in the average of all size classes was just as high as in the state forests and exceeds it in some *Länder*. High stocks are a great potential. However, the amount of stocks goes hand in hand with the increase in the risk of abiotic and biotic damage and accompanying losses in value, for example through storm damages.

With the exception of the spruce, the stocks of individual tree species rose – the pine by 8 % (55 million m³), the beech by 10 % (58 million m³) and the oak by 16 % (50 million m³). The greatest relative stock increase was recorded in the Douglas fir at 47 %. The Douglas fir stock rose by 24 million cubic metres on a small area. The reasons behind this high stock increase are the productivity of this tree species and the high number of vigorous young forest stands that will take a few decades to reach their harvesting age.

4 Seintsch, B. (2013): Cluster Forst und Holz nach neuer Wirtschaftszweigklassifikation. Thünen Working Paper 5

Change in timber stock by tree species groups



Basis: Timberland, all canopy classes
ODL = other deciduous trees with long life expectancy, ODS = other deciduous trees with short life expectancy

Rise in stock primarily among large-girth trees

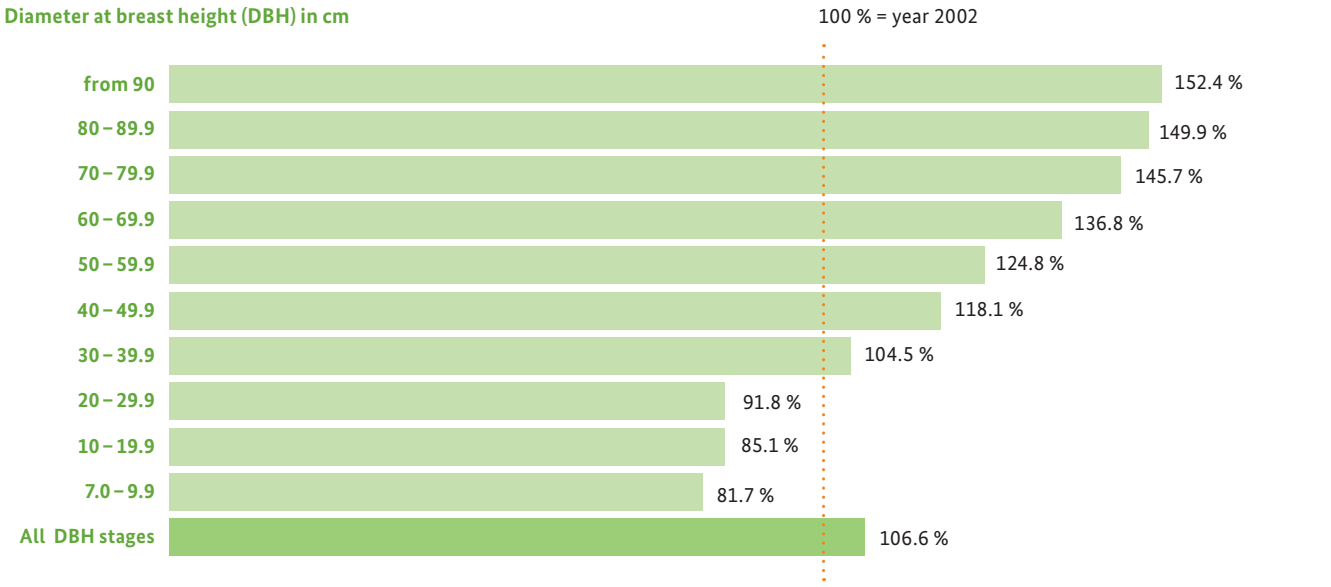
The timber stock has increased. Today, the forests contain more large-girth and less thin trees than ten years ago. Among trees under 30 centimetres DBH the timber stock dropped. Almost all of the stock increase is among large-girth trees from 50 centimetres DBH. In the meantime, 23 % of the total timber stock is trees with a DBH from 50 centimetres. This share is particularly high in heavy timber among fir (48 %), oak (42 %) and beech (38 %).

This indicates a continuation of a trend that was ascertained as early as the 2002 National Forest Inventory. If this trend continues, based on the age structure of the forests we can expect that the heavy timber will increase in coming years in above-proportional amounts. This development is a challenge because the processing capacities for heavy timber have diminished due to the specialization of the timber industry in small to medium sized trees. There are indications that the supply and demand of heavy timber from the timber industry are increasingly divergent. It is presently unknown whether these timber assortments may possibly be used more for energy production or, through new technologies, for the production of materials, or whether heavy timber will increase further in the forest.

However, the fact is that for the forestry holdings, a rise in the age of trees increases risks during harvesting (e.g. caused by crown deadwood), the risks of timber devaluation due to fungi and insects as well as the probability of species protection-related restrictions. A development leading to many of these large-girth trees remaining in the forest until they decompose can, on the one hand, promote the biological diversity of the forests, but on the other hand it reduces quantities of available raw wood and the potential of binding the greenhouse gas carbon dioxide for the long term in timber products.

A forestry policy aligned to the principle of utilization and conservation must weigh the balance between the services and demands of the forest in a constant dialogue with forest owners, nature conservationists, the timber industry and society. Findings from research and development supply important foundations for this.

Change in timber stock by diameter



Basis: Timberland, all canopy classes

Quo vadis, spruce?

Because of its good technical attributes, timber from the spruce is used widely, particularly by the construction sector. Due to the excellent environmental and carbon balances of the renewable construction material, timber is becoming more and more popular among architects and homebuilders. The carbon bound within the timber remains bound for decades. At the same time, timber can replace materials based on finite, fossil resources, thus making an important contribution towards protecting the climate. However the spruce itself is affected by climate change.

As a result of the major storm disasters of the early 1990s that laid waste to large areas of spruce forests, we began to transform non-site-appropriate pure spruce stands to more stable and natural mixed stands or deciduous forests with targeted funding from the Federal government and Länder. As a result, the spruce has distinctly been reduced in area in Germany, but also in timber stock. This trend may continue in varying degrees from region to region due to climate change since among the main tree species in Germany, the spruce is particularly vulnerable.

The consequences are a challenge: the spruce is still the main basis for added value in the forestry and timber industry. Making up only 25 % of the forest area and 33 % of the stock, in the last decade it contributed an above-average 52 % to the forest resources.

Should the spruce decline further, an important pillar for the added value of the forestry and timber industry and the downstream sectors is at risk of breaking away. The technological attributes of our deciduous tree species are not comparable to those of the spruce and mass-market products in the construction sector have so far been hardly competitive or available.

The risk to the existence of the spruce raises the question of alternative species. The grand fir or Douglas fir, which have done well in the native forests as imported tree species in some places for more than 100 years, have comparable technical attributes to the spruce. It is expected that they can better tolerate climate changes. In a suitable mixture with native tree species they can contribute to sustainably safeguarding the future of our forests.

The special case of spruce – stock decreased

The spruce is the only tree species of which the stock declined, and that was by 4 %. At the same time the area of spruce shrank. This corresponds to the silvicultural and forestry policy target objective of recent years. It was accelerated by storms and the mass propagation of beetles. The spruce stock declined particularly intensely in Nordrhein-Westfalen, where in January 2007, the windstorm Kyrill uprooted or fractured approximately 15.7 million solid metres of mainly pure spruce stands over an area of roughly 50,000 hectares [5].

Timber increment at a high level

The timber increment remains at a high level with 11.2 cubic metres per hectare and year or 121.6 million cubic metres per year. However, the acceleration of growth observed in the 1990s [6] has not continued. Of the widespread tree species, the spruce grows the fastest with 15.3 cubic metres per year and hectare, followed by the beech with 10.3 cubic metres per year and hectare.

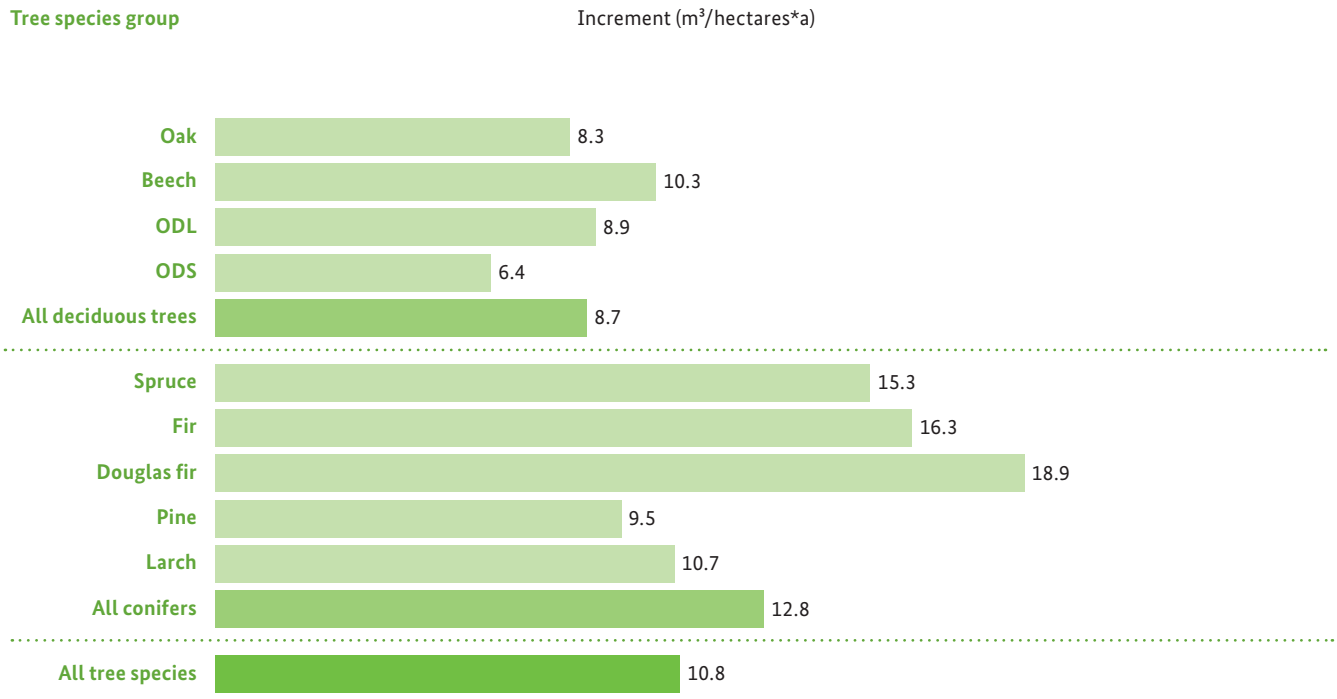
Although the Douglas firs with 18.9 cubic metres per year and hectare and firs with 16.3 cubic metres per year and hectare are the trees with the greatest increment, together they make up barely 4 % of the forest area.

The growth of a tree depends on the site conditions and the tree species-typical ageing process. Some tree species are fast growing and others are slow growing. For this reason, the age structure and the tree species composition of the forest determine the average timber increment. The presently high increment is therefore also a result of the many roughly 60-year-old post-war conifers planted in the 1950s. These forests are presently in their most productive stage.

The devastating storm Kyrill altered the structure of the forests in particular in the Sauerland and Siegerland areas. The damages to the forests of Nordrhein-Westfalen amounted to more than 1.5 billion euros [7].

5 Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen dated 13.01.2012
6 Spiecker, H., Mielikäinen, K., Köhl, M., Skovsgaard, J.P. (Eds.): Growth Trends in European Forests-Studies from 12 Countries. Springer, 1996
7 Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen www.umwelt.nrw.de/naturschutz/pdf/hintergrundinformationen_kyrill.pdf

Increment of stock by tree species groups



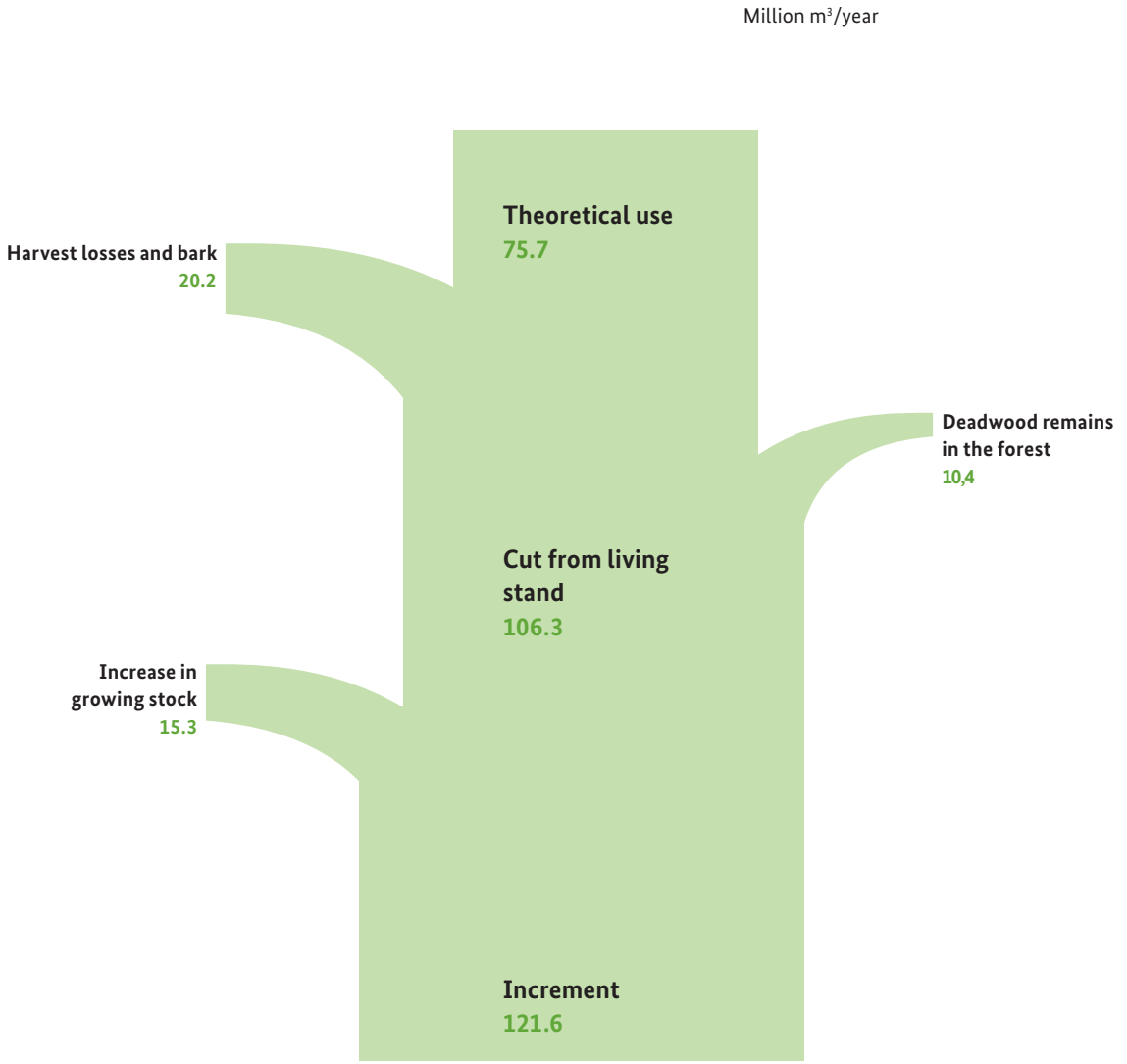
Basis: Timberland, main stand only incl. plenter forest, calculated pure stand
ODL = other deciduous trees with long life expectancy, ODS = other deciduous trees with short life expectancy

Timber use at a high level

Coppice shoot forests, at one time widespread, play an only minimal role in forests today.

Between 2002 and 2012, an average of 76 million cubic metres of raw wood (timber under bark) were utilized per year in Germany. The private forest owners in particular were able to increase their timber harvest and utilized the forest on average at the same intensity as the state forestry holdings in the state forests. In the state forests, the timber harvest remains unchanged at 98 % of the increment.

Increment and use



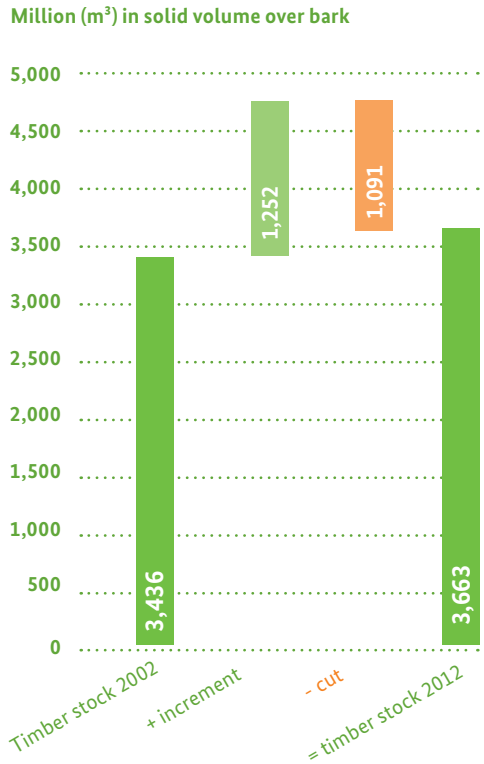
Basis: Timberland, corr. Dec. 2016

In particular the small private forests up to 20 hectares in size, or half of the private forest area of Germany, are used less intensively than the other size classes. The other private forests are more intensively utilized than the state forests.

The timber harvest was influenced by various events during the inventory period. In January 2007, the windstorm Kyrill downed 37 million cubic metres – almost half of an annual cut[8]. The financial and economic crises in 2008 and 2009 caused significant international markets to break away and timber demand declined perceptibly, in particular in the construction sector. At the same time, the use of timber for energy production experienced a renaissance. Until the year 2012 the timber prices rose continuously and the energy timber market remained at a high level. Increasing timber use and thereby increasing the use of the renewable resource of timber and saving fossil resources corresponds to the target objective of the "Charta für Holz" (Charter for Wood) in Germany initiated in 2004 by the Federal government.

8 Response by the Federal government to a minor interpellation, 9 July 2007, Printed Paper 16/6030

Stock balance



Basis: All canopy classes

Growth greater than use

The timber stock experienced renewed growth. More timber grew than was used. Timber use and the natural die-back of trees reach 87 % of the increment. The remaining 13 % go to the stock build-up. For most of the tree species this ratio is between 55 % and 80 %. In the case of the spruce, however, the timber use and natural dieback are 15 % above the increment, thus reducing its stock. This is partly a consequence of the forestry policy target objective and silvicultural demands (soil maintenance and climate change).

On principle, the utilization possibilities cannot be directly extrapolated from the increment, but result primarily from the present age and diameter structures and the planned target diameters or the scheduled harvest ages. It is therefore logical, considering the present age and diameter structure of the forest, not to utilize the total timber increment.

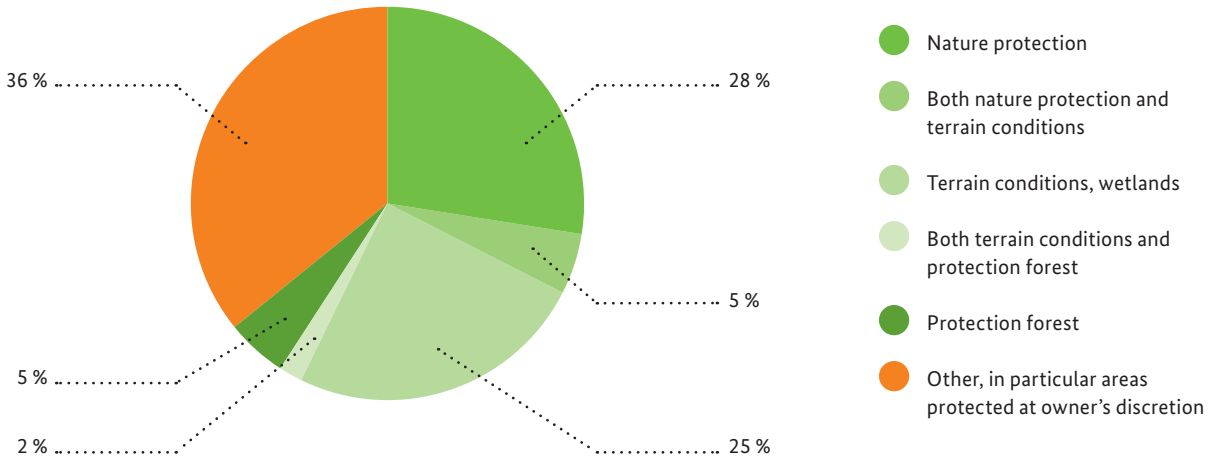
Future possible utilizations are determined based on the data from the National Forest Inventory with a Forest Development and Timber Harvesting Potential Model.

Use by ownership size classes in the private forest

Basis: Timberland, all canopy classes

The forests supply timber and create jobs. In Germany more than 1.1 million people are employed in the forestry and timber sector. In addition, in the era of climate change and the rise in prices of fossil fuels, the importance of timber as a renewable resource is increasing.

Causes of use restrictions



Basis: 450,000 hectares of timberland on which timber use is not permitted or not anticipated

Timber use increasingly restricted or suspended

The National Forest Inventory serves as the data basis for estimating future raw wood potentials and forest development, for which the increment and utilization for coming decades is modelled.

To achieve a realistic estimation, we differentiate by forest areas where timber use is possible without restrictions, partially restricted or completely suspended.

At present, timber use is basically possible without restrictions on 91 % of the forest area. Yet timber is not actually used everywhere. On 4 % of the stocked timberland (approx. 450,000 hectares) timber use is not permitted or not anticipated for a variety of reasons. On 7 % of the area of state forests owned by the Federal government and the Länder no timber use is anticipated, in the communal and the private forests this applies to almost 3 % of the area. Use is only anticipated in part on another 5 %. All in all, timber use is increasingly being suspended.

The reasons for use restrictions include unfavourable terrain conditions, wetlands or insufficient accessibility. Other causes for use restrictions are areas under nature conservation or legally specially protected biotopes, protected and recreational forests as well as natural forest reserves. Sometimes owners decide to suspend use by declaring their forests as protected forest or natural forest reserves. These forests are identified here as areas protected at owner's discretion. Sometimes the reasons for use restrictions also overlap.

The forests as climate protectors – still a carbon sink

The forests are exceedingly important for climate protection. As suppliers of timber, a renewable resource, they contribute to the transformation of Germany's energy system. In addition, they bind carbon dioxide and are thus a natural carbon sink. The atmosphere is released of approximately 52 million tonnes of carbon dioxide per year alone in the German forests.

Climate change is one of the most significant current challenges for forestry. The speed at which the climate is changing is problematic for the forests and forestry. Trees are long living and immobile, and forest stands are subjected to highly varying environmental and growth conditions during their lifespans. If forests are unable to adapt to changes in the environment, individual trees are weakened, but more-over, the entire forest ecosystem becomes impaired. Due to climate change, forest trees that are now still well adapted to the climate in their site may in future be faced with increasing problems with the increased frequency of weather extremes or with a gradual change on site.

Climate change has made forestry more risky. Foresters must take these future changes in growth conditions into account without knowing where and to what extent certain changes may take place. The tree species composition of forests is one important approach to stabilizing and vitalizing the stands and preserving the functions of the forest.

The diversity of mixed forests distributes the risk. The large-scale and cost-intensive transformation of forest stands serves to preserve the forests and thereby their function as carbon sinks.

Trees need the greenhouse gas carbon dioxide (CO_2) in order to grow, and therefore bind it within the timber. This makes forests a carbon sink when the increment exceeds use. They store carbon and can therefore contribute globally to lowering the CO_2 content of the atmosphere.

The National Forest Inventory serves as the data basis for estimating the carbon stock for living biomass above and in the soil and for deadwood during the observation period from 2002 until 2012.

At present, 1,169 million tonnes of carbon are bound in living trees and in deadwood. That is approximately ~~150~~ tonnes of carbon per hectare in of the aboveground and belowground biomass (not including the litter layer and mineral soil).

The soil survey in the forest indicates that the litter layer and the mineral soil contain another 850 million tonnes of carbon. The forests in Germany presently act as sinks and remove approximately 52 million tonnes of carbon dioxide from the atmosphere every year[9]. They lessen emissions by approx. 6 %.

9 Dunger, K. et al. (2014): Nationaler Inventarbericht Deutschland 2014, Kap. 7.2 Wälder. Umweltbundesamt, Nr. 24/2014

Forests bind CO_2

In addition to the carbon stocks in the living biomass and in the deadwood in the forests that are ascertained by the National Forest Inventory, the carbon balance account also includes the soil and dead plant material. The soil survey in the forest contributes to this. The total storage capacity of the forest is ultimately determined from these so-called carbon pools.

Timber products are also carbon sinks. They prolong the storage of carbon that was already bound in the trees beyond their use duration until it is finally used for energy or organically decomposes as timber waste. In addition to the storage function, timber products contribute to reducing greenhouse gas emissions amounting to about 105 million tonnes of CO_2 equivalent annually through substitution effects (substituting for more energy intensive fossil resources and fuels).

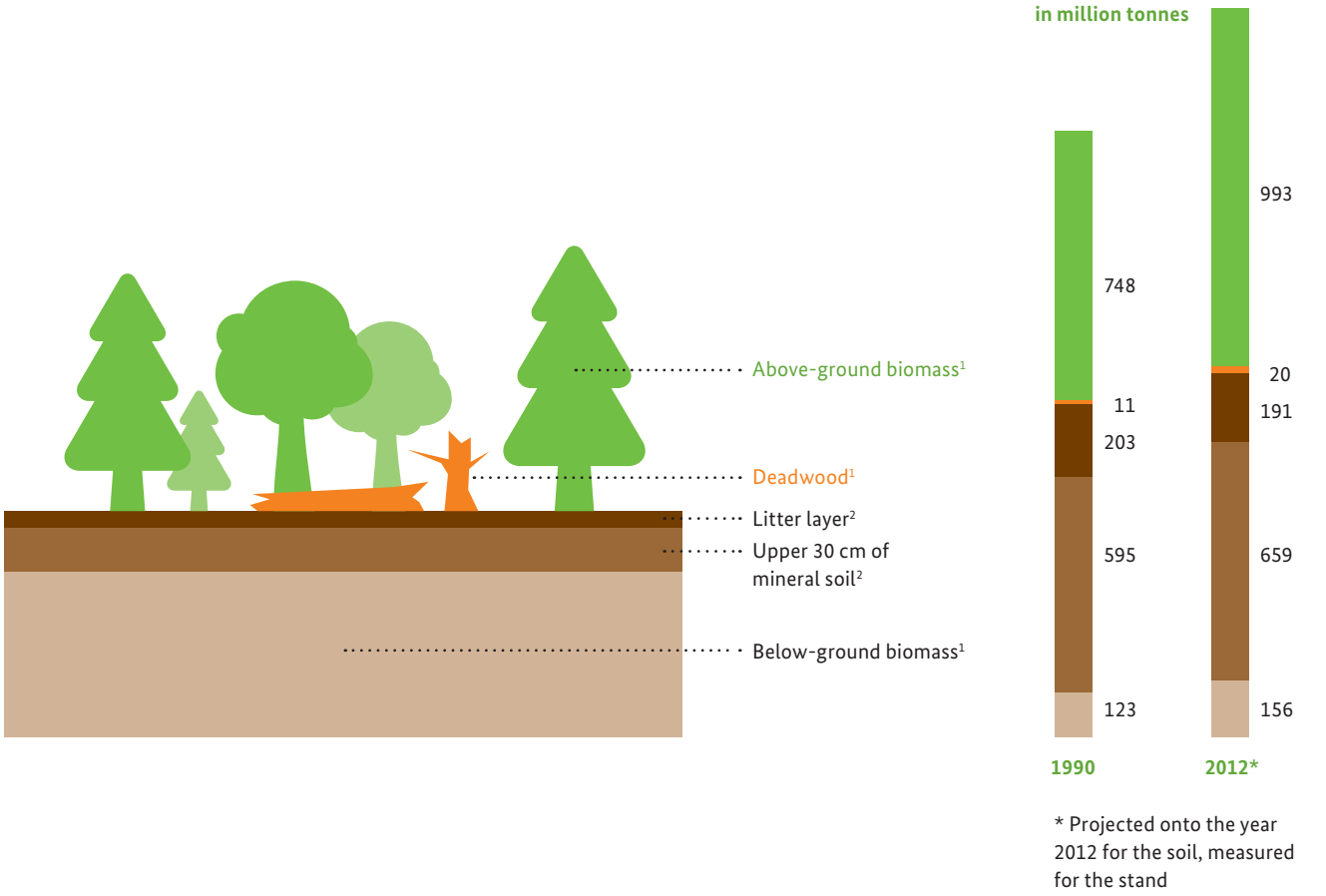
The effect of the forest as a carbon sink depends on its storage capacity. It is a carbon sink if it absorbs more carbon dioxide than it releases. The more CO_2 is lastingly stored in the form of carbon, the less it burdens the atmosphere. If, instead the forest loses more CO_2 than it absorbs, it is a carbon source.

Changes in the forest area, tree growth and the way a forest is managed influence its storage capacity. By signing the United Nations Framework Convention on Climate Change and the Kyoto Protocol, Germany has pledged to report annually on these changes.

With its resolution to establish the Forest Climate Fund, the Federal government underscores the significance of our forest ecosystems as well as the positive effects of sustainable forest management and timber use for protection of the climate. Funding from the Forest Climate Fund is intended to further optimize the CO_2, diminishing, energy and substitution potentials of the forests and timber as well as to support the measures needed to adapt the German forests to climate change.

For more information, see www.waldklimafonds.de

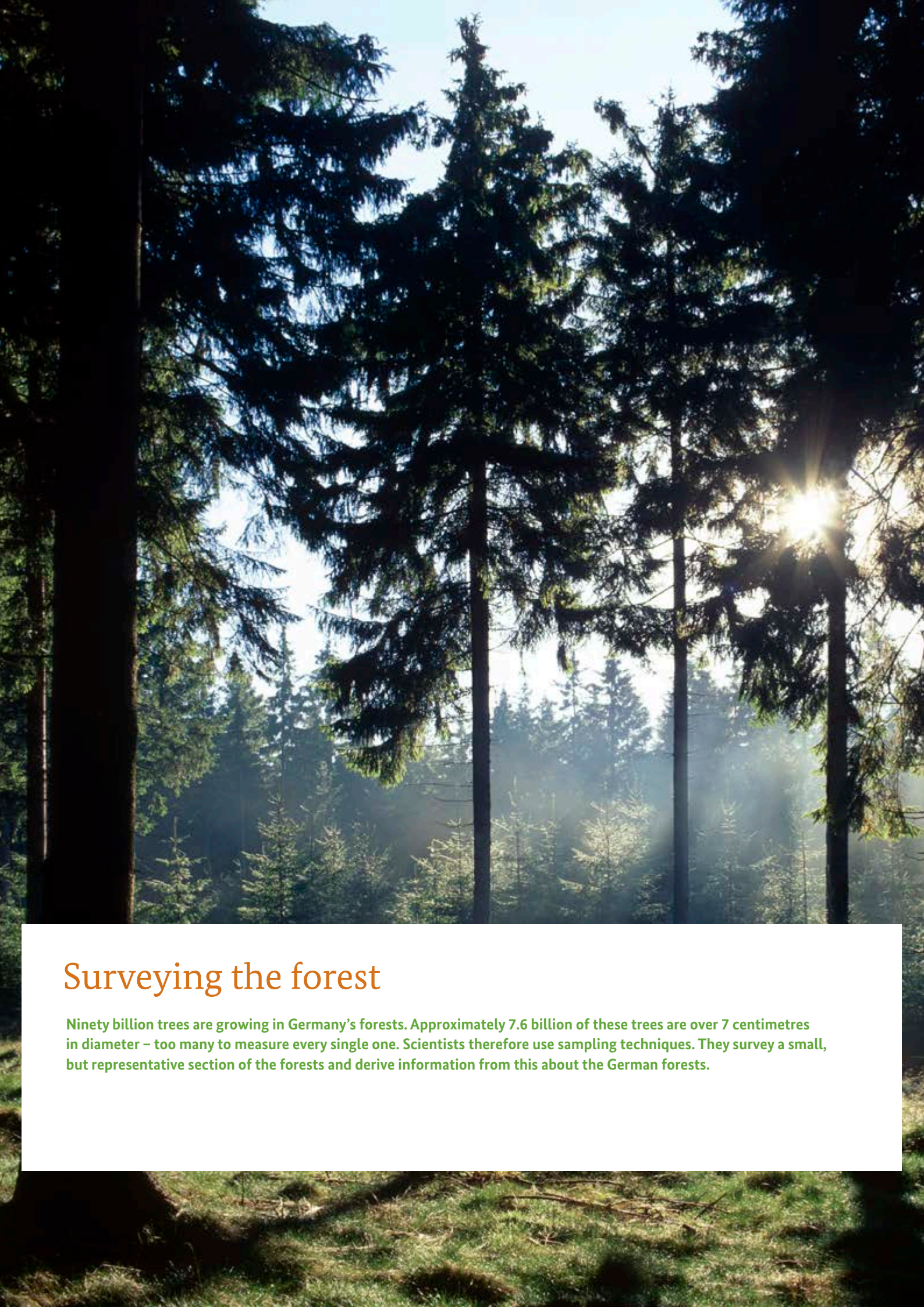
CO_2 Carbon sink in the forest



* Projected onto the year 2012 for the soil, measured for the stand

[1] Data from the National Forest Inventories 1987 (supplemented by the Forest Resource Database of the GDR for the new *Länder*), 2002 and 2012
[2] Soil survey in the forest

Source: Wellbrock, N. et al. (2014): Wälder in Deutschland speichern Kohlenstoff. AFZ – Der Wald, 18/2014 (revised)

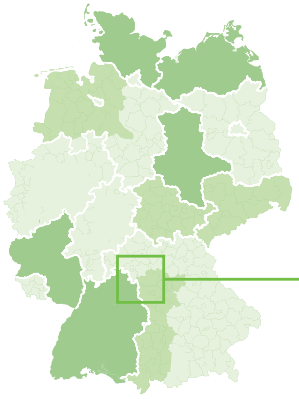


Surveying the forest

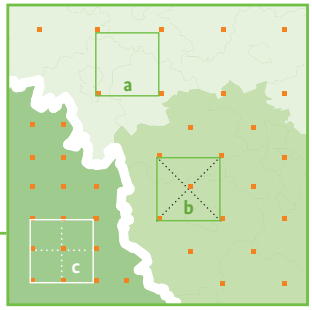
Ninety billion trees are growing in Germany's forests. Approximately 7.6 billion of these trees are over 7 centimetres in diameter – too many to measure every single one. Scientists therefore use sampling techniques. They survey a small, but representative section of the forests and derive information from this about the German forests.

Sampling grid in Germany

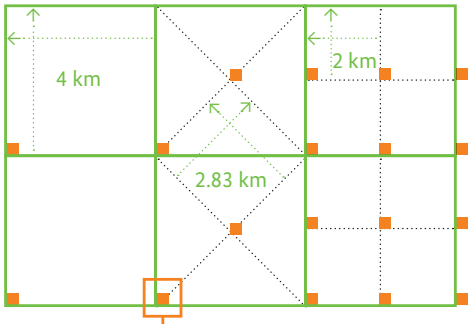
The densities of the *Länder's* sampling grids vary.

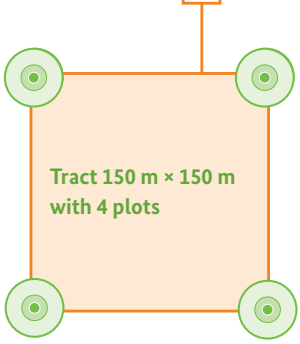


Arrangement of the samples on site with varying sampling densities



a. Base grid **b. Double density** **c. Quadruple density**





Sample (tract): The corners (plots) are the sample points where characteristics are recorded.

Base grid, 4 km × 4 km

Double density, 2.83 km × 2.83 km

Quadruple density, 2 km × 2 km

In the years 2011/2012, the National Forest Inventory was conducted for the third time. Earlier inventories were conducted in 1986–1988 and 2001/2002. The National Forest Inventory is an official mandate pursuant to Article 41a of the Federal Forest Act. It must be repeated every ten years.

Open during inventory – the inventory procedure

For the Third National Forest Inventory, 60 inventory teams all over Germany measured approximately 420,000 trees at roughly 60,000 sample points and recorded many more terrain, stand and tree characteristics. But before inventory teams survey data in the forest, scientists have to answer many methodological questions. How should the samples be distributed over the forest? What and how many tree characteristics should be surveyed on site? What methods are efficient and economical? How can the quality of the data be ensured? What estimation methods provide statistically substantiated results?

Scientists at the Thünen Institute of Forest Ecosystems and experts of the *Länder* are constantly further developing the inventory procedure. Specially trained staff conduct the data survey in the forest.

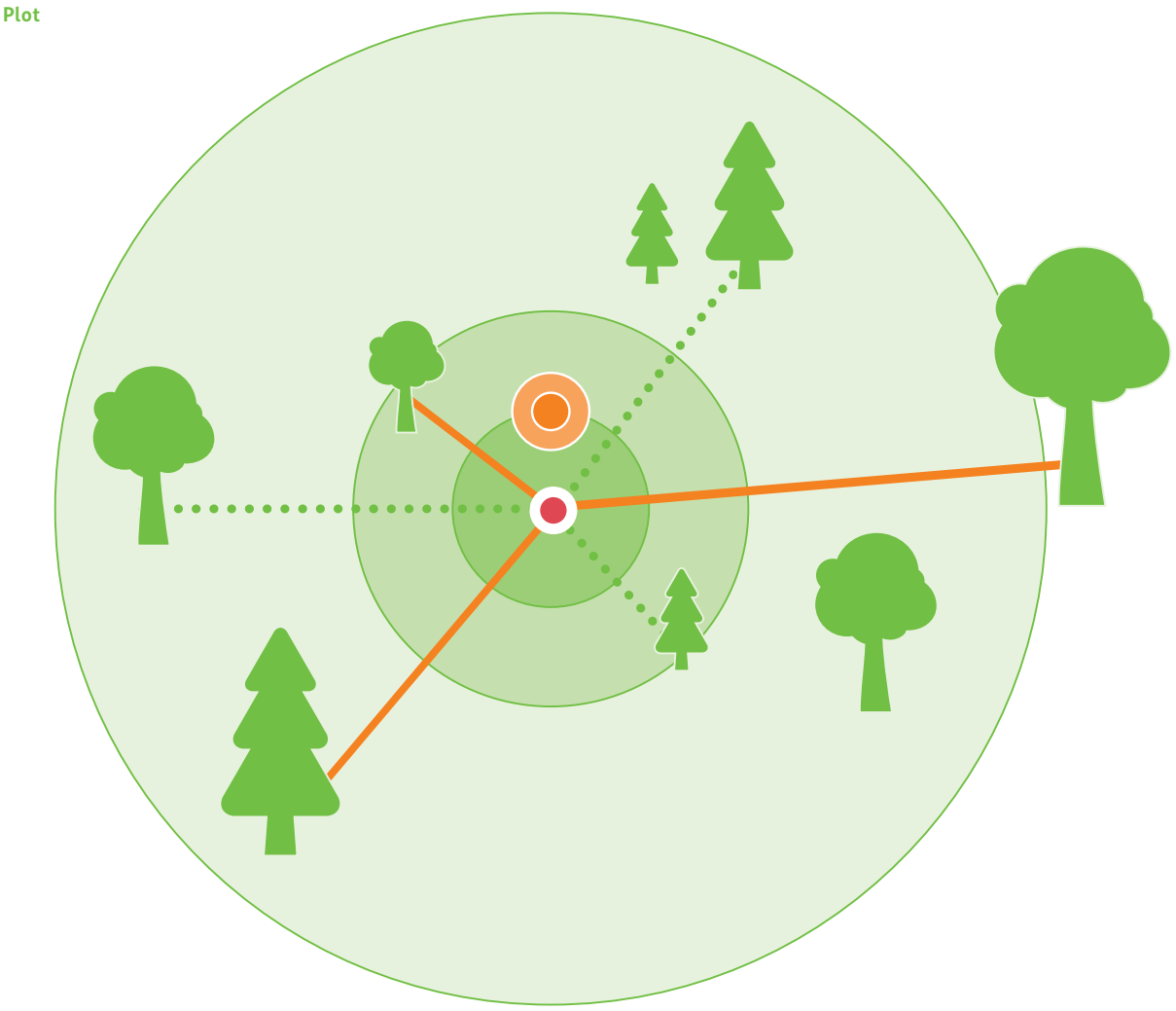
Systematic sampling method

The National Forest Inventory is a terrestrial sample with permanent sampling points. Inventory teams always record data in the forest at the same sampling points. This is done in all of the *Länder* and in forests of all types of ownership according to a uniform method every ten years.

In order to produce a representative portrayal of the German forests, back in the 1980s the founders of the National Forest Inventory laid a four-by-four-kilometre sampling grid over the entire country that is used for every inventory. The samples are located at the grid's junctions. Some of the Länder additionally densified the sampling grid.

Each sample, called a tract, is a square with 150 metre-long sides. The inventory teams survey the data at each of the corners, or plots, which are the sample points.

Surveys at the sample point



Angle-count sampling with basal area factor 1 or 2
for trees from 4 m height

Sample circle with radius r = 5 m for deadwood

Sample circle with radius r = 10 m for trees up to 4 m height, shrubs and ground vegetation

Sample circle with radius r = 25 m
for terrain characteristics and forest edges

Angle-count sampling with basal area factor 4
for trees from 7 cm diameter (DBH)

Sample circle with radius r = 1 m for trees from 20 cm to 50 cm height (for less than 4 trees: radius r = 2 m)

Sample circle with radius r = 2 m
for trees from 50 cm and with a DBH less than 7 cm

The sample trees for angle-count sampling are determined using a Bitterlich relascope and ultrasonic distance-measuring device.

Preparing for field surveys

For each sample point, the Länder compile information in advance that is not recognizable on site. Using forest distribution maps, aerial photographs, cadastral plans, information from the local forestry offices and other forestry information, they ascertain characteristics such as the type of ownership, the size of the communal and private forests, restrictions to timber use, for example due to nature protection zones, or incidences of hoofed game animals.

Roaming the forests with laptops and tree height measurement devices

The sample point is invisibly marked with a metal rod. Satellite navigation, a map, a compass, distance measurements and a metal detector help to relocate the sample points after ten years.

Equipped with field laptops and measuring devices, the inventory teams record over 150 characteristics at each sample point according to a uniform method. These characteristics include the tree species, tree height and diameter of selected sample trees as well as the type and amount of deadwood.

Ensuring the quality of the data

The validity of an inventory stands and falls with the quality of the data. The quality controls therefore already begin while the data is being recorded in the forest. It is based on a three-phase control system:

a) Controls during data entry: The inventory teams record the data with mobile field computers. Plausibility checks in the survey software are already run in the forest and indicate possible data errors. This means the inventory staff can correct the recorded data while still on site by re-measuring a value or survey and add overlooked values.

b) Controls of data collection: The Land inventory supervisors control on-site data collection at a minimum of 5 % of the sample points, by recording trees and characteristics on site independently of the team.

c) Plausibility checks: The data in the survey database are sent to the central database. Using check runs and error logs, the Federal and Land inventory supervisors control the quality of the data compiled. The Land inventory supervisors either correct errors themselves, if possible, or demand that the respective inventory teams make the corrections.

Field computers help to relocate the samples, to collect data and control the quality of the data.

Evaluating the data

Scientists at the Thünen Institute of Forest Ecosystems evaluate the individual data with the support of *Länder* experts.

Prior to analysis, they restructure the data for extrapolation and carry out a number of preparatory calculations. An example: The diameter of each sample tree is measured. Later, its volume is evaluated in order to calculate the timber stock.

Once the data basis has been created and checked, extrapolations are carried out for variables such as the forest area and for changes that the development of the forest exhibits since 2002. The complete evaluation of the data requires extensive analyses, interpretations, reconciliation and more checks.

Comparability of the results

Ten years passed between the Second and Third National Forest Inventory. The comparability of their results is one of the most important criteria for the inventory design. Still, the inventory procedure has to be adjusted again and again. Technical advancements, new scientific findings and new issues have to be taken into account. Differences to earlier published results can arise when new statistical estimation methods were applied. Therefore, the scientists re-evaluate the data from the 2002 inventory using the current methods so that the results can be compared with the 2012 National Forest Inventory and changes can be correctly estimated.

The sample size of the National Forest Inventory is representative and supplies reliable assertions for the entire German forest and most *Länder*.

If the region is too small or the question too detailed, the sample representativeness suffers so that assertions for small-area question cannot be reliably answered.

On some trees, the height is measured, as shown here, with an ultrasonic measuring device in order to precisely determine the tree shape and therefore the tree volume.

National Forest Inventory – established information basis

The results of the National Forest Inventory are significant at the international and national levels and the regional level of the *Länder*. However, they cannot convey assertions for smaller reference units well; the number of samples is often too small for statistically substantiated evaluations. Yet for the Federal and *Länder* governments, the inventory is a primary information source for their forest policies. The data is used to represent forestry interests in the European Union (e.g. in climate negotiations) and serves as a planning basis for industry, for example for the development and creation of processing capacities. In addition, the data are a fixed element of international reports such as those required by the Kyoto Protocol and the United Nations Framework Convention on Climate Change.

On 16 September 2014, Federal Minister Christian Schmidt familiarized himself with the inventory procedure of the National Forest Inventory, current questions in forestry policy and forest research at the Thünen Institute in Eberswalde during a forest tour in the Spechthausen forest district range of the Chorin state forestry field office.

Joint task of the Federal and *Länder* governments

The National Forest Inventory is a joint project of the Federal and *Länder* governments. The Federal Ministry of Food and Agriculture clarifies the need for information with the *Länder* and interest groups then aligns it to the existing resources of the Federal government and *Länder* for the inventory. It commissioned the Thünen Institute of Forest Ecosystems with national inventory supervision. The Thünen Institute draws up the survey method and data management, trains the inventory teams and evaluates the results.

The *Länder* compile the data. They deployed approximately 60 survey teams for the Third National Forest Inventory, which were specially trained in the survey methods and use of the survey software.

The Federal and *Länder* governments work together closely in the development of the inventory procedures. Their intensive cooperation and regular sharing ensure the uniform clarification of methodological questions as well as the quality of the data and results.

Terminology

Calculated pure stand
The main stand including plenter forest is calculated and divided up in areas of one age class and one tree species.

Communal forest
Forest owned by towns, local authorities or special purpose associations, other corporations, institutions and foundations under public law.

Compact wood
Above-ground woody mass having a diameter of over 7 centimetres including bark. Trees under 7 centimetres DBH are not compact wood.

DBH
"Diameter at breast height" or the diameter of a tree at a height of 1.3 metres

Forest [10]
The definition of forest according to the National Forest Inventory is based on that of the Federal Forest Act: within the meaning of the NFI, forest is any area of ground covered by forest vegetation, irrespective of the information in the cadastral survey or similar records. The term forest also refers to cutover or thinned areas, forest tracks, firebreaks, openings and clearings, forest glades, feeding grounds for game, landings, rides located in the forest, further areas linked to and serving the forest including areas with recreational facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures and rough pastures, as well as areas of dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50 % of the area is covered by forest. Areas with forest cover in open pastureland or in built-up areas of under 1,000 square metres, coppices under 10 metres wide and the cultivation of Christmas trees and ornamental brushwood as well as parkland attached to country houses are not forest within the meaning of the NFI. Watercourses up to 5 metres wide do not break the continuity of a forest area.

Forest cover
The forest cover describes the forest site irrespective of stand boundaries. It is divided into old forest cover, main forest cover and young forest cover.

Gap
Due to the sample method, no trees are recorded here although the sample is located on stocked timberland.

Hectares (ha)
Area measurement unit, 10,000 square metres

Main forest cover
That part of the forest cover with the main economic significance. If the coverage of trees over 4 metres in height amounts to at least 5/10, this is always the main forest cover.

Main stand
The canopy class with the main economic significance. If the degree of coverage of the highest canopy amounts to at least 5/10, this is always the main stand. Evaluations of the main stand include the plenter forest.

[10] Federal Ministry of Food, Agriculture and Consumer Protection: Survey instructions for the Third National Forest Inventory (2011–2012). 2nd revised version, May 2011

Criteria for the naturalness of tree species composition (AND operation)

Degrees of naturalness	Share of tree species of the natural forest community (main, secondary, pioneer tree species together)	Share of main tree species of the natural forest community	Completeness of main tree species of the natural forest community	Share of non-European tree species
Almost natural	≥ 0.9	≥ 0.5	= 1.0	≤ 0.1
Semi-natural	≥ 0.75 and < 0.9	≥ 0.1 and < 0.5	< 1.0	> 0.1 and ≤ 0.3
Partly semi-natural	≥ 0.5 and < 0.75	< 0.1		> 0.3
Accentuated by culture	≥ 0.25 and < 0.5			
Conditioned by culture	< 0.25			

Naturalness of the tree species composition
A comparison of the present forest cover with the natural forest community informs us of the naturalness of the tree species composition. “Non-European tree species” are tree species originally from outside of Europe recently introduced by humans, even if they have become elements of the natural forest community following their introduction (see illustration above for criteria).

Old forest cover
Trees over 4 metres in height recorded by means of angle-count sampling (basal area factor 1 or 2) irrespective of stand boundaries

Solid metres
One solid metre of timber equals 1 cubic metre of massive timber, i.e. with no gaps in the stratification.

Solid volume over bark
Unit of measurement for standing timber stock. Measured in cubic metres (compact wood)

Stand
Forest management unit; part of the forest contrasting with its surroundings as regards age and tree species. Over a longer period of time, it is the smallest silvicultural unit.

Stocked timberland
Timberland on which trees are growing

Layering, one or multi-layered forest
The layers describe the vertical structure of the forest. All trees that have a mutual canopy and exhibit at least a 10 % degree of coverage form one layer. Therefore, forests that have two crown canopies above one another that do not touch are considered two-layered. This can, for example, be young growth beneath the canopy of an old tree. Plenter forests are particularly demanding for silviculture and structurally dynamic. They are always multi-layered, but demand special site conditions and tree species compositions and occur only in negligible area percentages in Germany.

Temporarily unstocked area
Timberland on which no trees are standing temporarily

Timber under bark
Measurement in cubic metres. It corresponds to the solid volume over bark minus approx. 10 % bark losses and approx. 10 % harvesting losses.

Timberland
Area permanently serving the purposes of wood production. This also includes ditches, areas under power lines, areas unstocked for a time (temporarily unstocked areas) as well as roads and paths less than 5 metres wide, as well as areas within, for example, national parks.

Types of ownership
The types of ownership are differentiated as state forest (federal or *Land* property), communal forest and private forest (including *Treuhand* forest).

Unstocked forest land
Forest areas not considered timberland, such as forest tracks, rides and firebreaks over 5 metres wide, and landings.

Young forest cover
Trees from 0.2 to 4 metres in height in a 10-metre sample circle

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National Forest Inventory and Projection Modelling of Forest Development and Timber Harvesting Potential on the Internet

www.bundeswaldinventur.de
This is where you will find the report and selected results of the Third National Forest Inventory. The results database of the National Forest Inventory is linked there at the Internet address.

https://bwi.info
This is where you can access all of the results of the Third National Forest Inventory and draw up your own tables, diagrams and maps. The results of the Projection Modelling of Forest Development and Timber Harvesting Potential are expected to be available in 2015.