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Ancient Woodlands and Trees: A Guide for Landscape Planners and Forest Managers

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Chapter 8
Ancient forests in Germany: distribution, importance for maintaining biodiversity, protection and threats

Monika Wulf

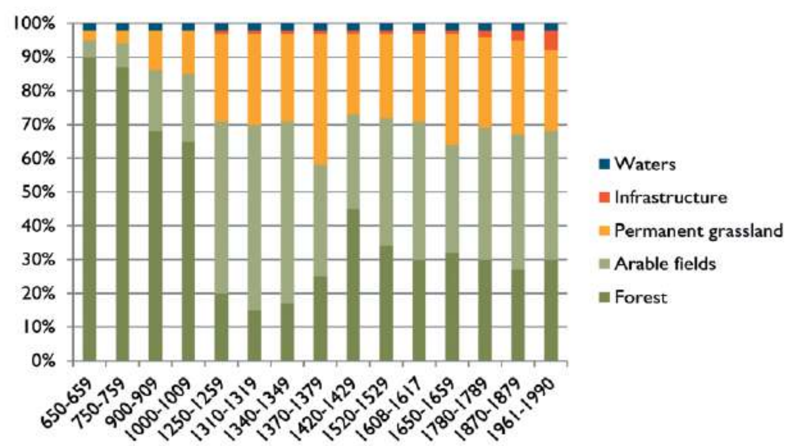
Introduction

Humans have tremendously altered the central European landscape for several centuries (Ellenberg and Leuschner, 2010). Thus, there is little virgin forest, and it is located on a few special sites that are not usable by humans, e.g., extremely steep slopes in mountainous areas. Despite early and extensive human impacts, central Europe was mainly covered with forests approximately 1,000 years ago, as shown on a small-scale map by Schlüter (1952, scale 1:500,000). The land-cover reconstruction by Schlüter (1952) was based on sources that vary greatly in quality and refer to the end of Antiquity until the beginning of the early Middle Ages, with a mean of approximately 900 A.D. At that time, clearing of the forests had already begun as well as the drainage of wet areas to acquire land for agricultural usage, but forests clearly prevailed. Forests were still semi-natural due to the marginal effects of humans (Walter and Straka, 1970; Ellenberg and Leuschner, 2010). According to Bork et al. (1998), forests in Germany covered slightly less than 70% of the land around 900 A.D.; but approximately 250 years before that time, they covered c. 90% (Figure 8.1).

Since 900 A.D., the human impact on the European landscape has led to extended clearing to acquire agricultural land for food production because of the growing human population. The peak of forest clearing in Germany is dated to the 12th and 13th centuries (late Middle Ages), in parallel with the increasing colonization of the landscape (Mantel, 1990). In the late Middle Ages, particularly in the 14th century, colonization was finished, clearing was stopped, and forest areas recovered (Figure 8.1). From the 16th to the 18th century, several episodes of clearing occurred again, particularly in Brandenburg (northeast Germany, Figure 8.2) and in the northernmost part of Germany (Schleswig-Holstein) because of the increasing number of inhabitants. At the beginning of the 19th century, a lot of clearing occurred again in all of Germany, mainly for receipts to fill the empty public treasury and war chest (Mantel, 1990). In the 19th and

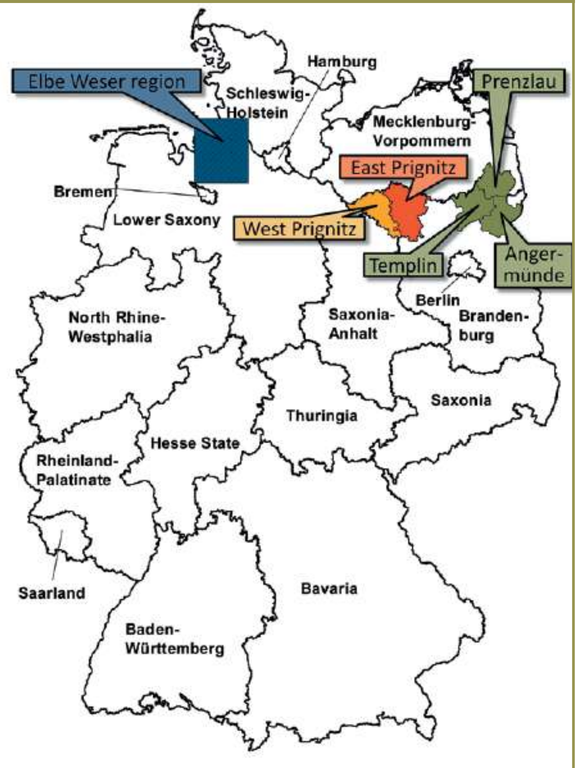
Development of land use in Germany

Figure 8.1



Development of land use in Germany (excluding the Alps) during the Middle Ages and in modern times according to Bork et al. (1998). Forests include shrubs outside forests. Arable fields include gardens and vineyards. Permanent grasslands include wasteland, grassland in urban areas and along roadsides. Infrastructure includes sealed areas near houses and roads.

Federal countries of Germany with some regions mentioned in the text **Figure 8.2**



twentieth centuries, there was a slight overall increase in forest area, and the pattern of forest-open land distribution changed little. These statements are consistent with Figure 8.1 in Bork et al. (1998). The final period of forest clearing is characterized by extensive conversions of semi-natural deciduous and mixed stands into coniferous dominated stands (Hesmer, 1938; Mantel, 1990)

Thus, it is clear why semi-natural forests with long habitat continuity, the so-called ancient forests (habitat continuity >200 years), came into focus during a symposium held at the Norddeutsche Naturschutzakademie (NNA) in 1993. The results from this symposium were published one year later (NNA, 1994). The main results were a definition of ancient forests, overviews of activities for an inventory of ancient forests and proving the importance of ancient forests for maintaining biodiversity. Ten years later, all of the ancient and recent forests in Germany were inventoried (Glaser and Hauke, 2004).

Most of the studies on ancient forests were published in the German language and are therefore inaccessible for international readership. The main intention of this book chapter is to report (i) the status of ancient forest and recent forest inventories, (ii) the importance of maintaining the plant species diversity of ancient forests, and (iii) the protection of and the threats to ancient forests in Germany. First, an overview of the entire situation in Germany is given, and second, some case studies are used to elucidate a more detailed situation in the northern lowland of Germany where semi-natural ancient forests are particularly rare.

Distribution of ancient and recent forests

At the NNA symposium, ancient forests were defined as, "Forests that have continuously existed for at least two centuries as forests, according to historical maps, historical site descriptions or other indications" (NNA, 1994). Thus, an ancient forest site is independent of the actual age of the tree species; however, continuous land cover as a forest is essential. The threshold of at least 200 years was set because for many central European countries, the most reliable historical maps have been produced from the mid-18th century on. Glaser and Hauke (2004) have used several maps of different scales and dates of production. For some regions in Germany, only maps at a scale of 1:100,000 are available, so the overview of ancient and recent forests was produced at this scale.

At the end of 1992, forest areas in Germany covered approximately 104,536 km², or c. 29.3%, of the entire area (Table 8.1). Of these nearly 30% forested areas, 77% are ancient forests, and 23% are recent forests (Table 8.2). Ancient forest areas are remarkably larger in the southern part of Germany, particularly in the highlands. In the northern part of Germany, recent forests prevail, which results from the tremendous clearing in the Middle Ages to the 14th century and from the 16th to the 18th century in some regions (Mantel, 1990; Küster, 2008).

The percentage of deciduous tree species is higher in ancient than in recent forest sites (Table 8.2). In contrast, coniferous tree species are dominant in the recent forest areas. The percentage of mixed forests is similar for both forest types. More than half of the ancient forest

Table 8.1 **Forest and non-forest area, deciduous, mixed and coniferous ancient and recent forests in Germany**

CORINE landcover 1998	km ²	%
Germany	**356,778**	**100**
Forests	104,536	29.3
Ancient forests	80,493	22.6
Coniferous ancient forests	41,815	11.7
Mixed ancient forests	17,771	5.0
Deciduous ancient forests	20,907	5.9
Recent forests	24,043	6.7
Coniferous recent forests	15,680	4.4
Mixed recent forests	5,227	1.4
Deciduous recent forests	3,136	0.9
Non-forests	252,242	70.7

Table 8.2

Ancient and recent forests according to three forest classes

Forest classes according to CORINE landcover 1998	Ancient forests = 100%	Recent forests = 100%
Deciduous forests	26	13
Mixed forests	22	22
Coniferous forests	52	65

area is covered by coniferous tree species, whereas both deciduous and mixed stands cover more than 20%. Recent forests that are dominated by coniferous and deciduous stands cover slightly more than 10% (Table 8.2).

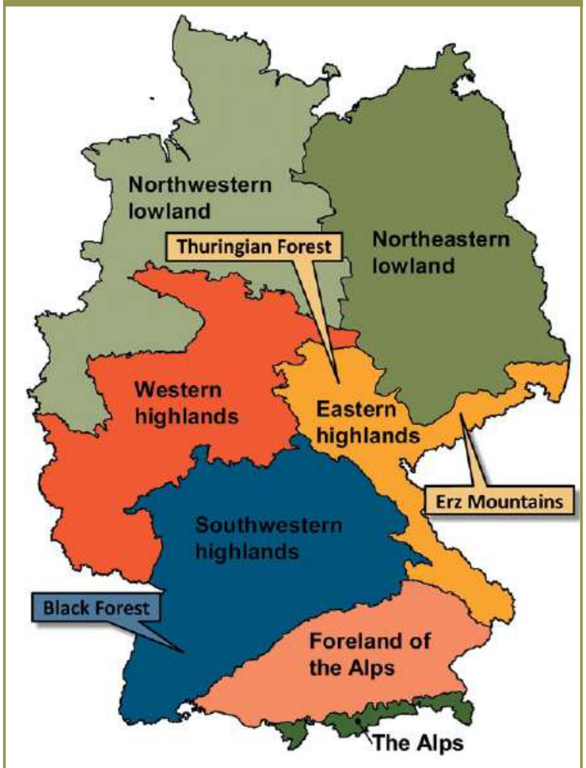
Deciduous ancient forests occur mainly in the highlands. The more or less continuous cover with forests and the dominance of specific tree species is strongly associated with ownership. The proportion of manorial and ecclesiastical forests was and is relatively high, and these are most often semi-natural deciduous stands. Such forests were mainly used for timber production and less for wood pasture. This is in contrast to the northern German lowlands, where forests have been intensively used for wood pasture and otherwise, e.g., pine stumps for tar production, litter raking and gaining of grass.

The recent forests that are stocked with coniferous tree species have faced intensive usage. They were exploited by timber production and litter raking, thus leading to the severe degradation of the soil sites. Those sites could be reforested only with coniferous tree species, mainly pine and spruce. This can be observed for example in the Thuringian Forest, Erz Mountains and the Black Forest (Figure 8.3).

At first, a large part of the recent forest areas was created by the systematic and extended afforestation of former agricultural land. Extended afforestations in the 19th century concentrated on the older and younger moraine landscape in northern Germany. In the late 19th and 20th centuries, new forest areas were established by afforestation or were developed by the small-scale, secondary succession of abandoned land on exceptional sites, e.g., military training areas and post-mining landscapes. The high percentage of coniferous tree species in recent forests indicates the extended afforestations with those species on potential deciduous or mixed forest sites within the last 200 years.

Figure 8.3

Biogeographic regions in Germany
(according to Riecken et al., 1994)



Distribution with respect to biogeographic regions

Following the suggestion by Riecken et al. (1994), the landscape of Germany can be divided into seven large biogeographic regions (Figure 8.3). The biogeographic regions were pooled to conform to those of Meynen and Schmithüsen (1953-1962), and climatic factors, geomorphology, topography, soil types and hydrology were considered (Riecken et al., 1994).

These biogeographic regions vary in the proportion of ancient and recent forests, and there are also large differences in the proportions of deciduous and coniferous forests (Table 8.3). These differences occur because of the variation of environmental conditions and because of ownership structures in the regions.

Northwestern lowland

This landscape is characterized by having the smallest portion of forest area. In the southern area and the Westphalian lowland, this small area occurs because of dense human populations (e.g., Ruhr District) and large areas that are intensively used for agriculture. In the past, the northern area was covered by huge heathland areas. They were afforested to a large extent, which explains the very high proportion of recent forests.

Northeastern lowland

The portion of forest area in the northeastern lowland is very small, but ancient coniferous forests prevail. Relatively extensive beech stands in ancient forest sites are specific to the northern part of Brandenburg and some areas of Mecklenburg-Vorpommern. The proportion of

Table 8.3

Proportion of deciduous, mixed and coniferous ancient and recent forests in the seven biogeographic regions in Germany

	% forest area	Ancient forest total	Deciduous ancient forest	Mixed ancient forest	Coniferous ancient forest	Recent forest total	Deciduous recent forest	Mixed recent forest	Coniferous recent forest
NW lowland	10.8	28.8	18.0	3.0	7.8	71.2	14.1	8.6	48.4
NE lowland	23.8	62.0	17.1	7.3	37.6	38.0	10.8	4.5	22.8
W high-lands	41.3	81.9	43.4	20.5	18.0	18.1	4.4	9.5	4.2
E high-lands	38.5	92.5	8.9	9.9	73.6	7.5	0.7	1.5	5.4
SW high-lands	41.6	85.9	25.5	28.3	32.0	14.1	1.9	7.0	5.2
Foreland of the Alps	24.3	85.0	5.0	13.0	67.1	15.0	1.0	4.3	9.7
The Alps	58.6	89.3	3.0	29.4	56.9	10.8	0.4	5.0	5.4
Mean	34.1	75.0	17.3	15.9	41.9	25.0	4.7	5.8	14.4

recent forests is high for two reasons. First, from the 18th until the 20th century, large areas of fen were cultivated with enormous effort. In particular, moist meadows were extensively used, and pastures were developed in Alnus-dominated stands by secondary succession. Second, either former military training areas or post-mining landscapes were afforested, or spontaneous reforestation took place. Altogether, secondary succession and spontaneous reforestation had led to an increase in the forest area, whereas the extension of rural areas has accounted for open land.

Western highlands

In this landscape, the forest area has remained more or less stable for the past 200 years, reflected by a very high proportion of ancient forests. A huge area of this landscape is characterized by relatively large differences in the relief, thus preventing profitable agricultural usage. Moreover, most of the forest areas are publicly or manorial owned and have been for a very long time, and these are the largest and most contiguous ancient forest sites.

Eastern highlands

In the eastern highlands, ancient forests is greatest, but the forests are dominated by coniferous tree species. Particularly, the Erz and Fichtel Gebirge, the Vogtland and parts of the Bavarian, Böhmer and Thuringia Forest are dominated by coniferous stands. The central part of the Thuringia Becken has been extremely poor in forests for several centuries.

Southwestern highlands

The proportion of ancient forests here is very high, and these are mainly coniferous stands. This is particularly true for the Black Forest and the Odenwald, the Spessart and parts of the Franconian Jura. There are also extended ancient forests on sandy soils around Nuremberg. Outstanding recent forests can be found in the Franconian and Swabian Jura.

Foreland of the Alps

This landscape is characterized by a large proportion of coniferous ancient forest, whereas deciduous forests on ancient forest sites are nearly restricted to the flood-plains of the larger streams.

The Alps

Because the proportion of forest area is the highest here among all of the biogeographic regions, this small mountain area has an exceptional position. The proportion of ancient forests is very high, and the high percentage of coniferous stands is because of site conditions prevailing at higher altitudes.

Distribution of ancient and recent forests, with particular focus on the northern lowland

From the facts shown above, it is obvious that semi-natural ancient forests are mainly threatened in the northern lowlands of Germany. Only small areas have remained as ancient forests, most of which have been converted into coniferous stands. Therefore, two case studies of the northeastern lowlands should give some detailed insights into the development of the forest-open field distribution at a scale of 1:50,000. Both regions, the Prignitz and the Uckermark, are located in the Federal state Brandenburg (Figure 8.2). The forest area in Brandenburg covers ca. 35%, and approximately 65% of the total forest area includes ancient forests (Wulf and Schmidt, 1996). Approximately 22% and 35% of the Prignitz and Uckermark regions, respectively, is covered by forests. According to Wulf (2004), not only ancient forests but also old forests (habitat continuity <100 years) have been identified in both regions using historical maps. The oldest is the Schmettau map from the 18th century (1767-1787, scale 1:50,000, Figure 8.4); for the 19th century, we used the Survey of the Prussian government (approximately 1880, scale 1:25,000, Figure 8.5). Various topographical maps (scale 1:50,000 and 1:25,000) were used as actual references.

According to Hesmer (1938), the Prignitz region comprises the two old rural districts West and East Prignitz, and the Uckermark region comprises the three old rural districts Angermünde, Prenzlau and Templin. In all but one district, coniferous forests, mainly Scots Pine, already prevailed ca. 150 years ago (Table 8.4). Even in the deciduous forest rich district, Prenzlau coniferous forests increased to ca. 20% within 50 years. Nevertheless, in that district, the proportion of deciduous stands remains the highest because of large areas with high relief that are impossible to use for profitable agriculture. The higher percentage of coniferous stands in East compared to West Prignitz is related to the higher proportion of sandy soils in the eastern part (Müller, 1941).

The Prignitz region

Nearly 10% of all forests are ancient forest sites, and nearly 7% are old forests with a habitat continuity of at least 100 years (Table 8.5). Within the last five decades, several new forests have been established. The afforestation has mainly occurred on moist grasslands that have failed to be drained well enough for profitable use as grassland or meadow.

The historical maps do not provide much information on the tree species in the forest areas, except for tree species names from relatively few locations. However, on the maps from the 1780s, ± closed or open forests and forests on moist or wet lowlands can be distinguished. On the maps from the 1880s, pure deciduous or coniferous and mixed stands were clearly indicated by boundaries of small dotted lines. A study by Wulf and Rujner (2011) indicates that the historical forest vegetation in ca. 1780 was dominated by deciduous stands. Taking this into account, the data in Table 8.6 show that mainly ± closed forests have been converted to coniferous forests only within one century. Large areas of forest on moist or

Section of the Schmettau map
(1767-1787, original scale 1:50,000; sheet no. 36 Oranienburg)

Figure 8.4

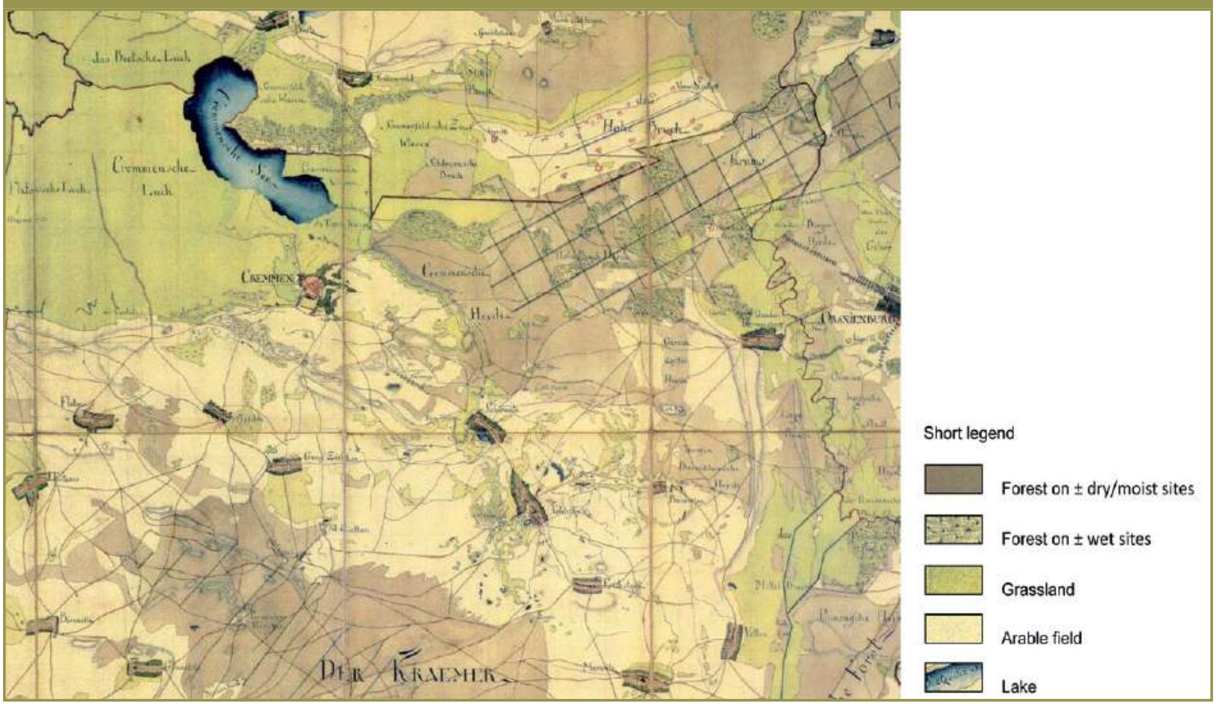


Figure 8.5

Section of the maps of the Prussian government
(c. 1880, original scale: 1:25,000; sheet no. 3143 Wustrau, 3144 Loewenberg, 3145 Nassenheide, 3243 Linum, 3244 Kremmen, 3245 Oranienburg, 3343 Nauen, 3344 Boetzow and 3345 Hennigsdorf)

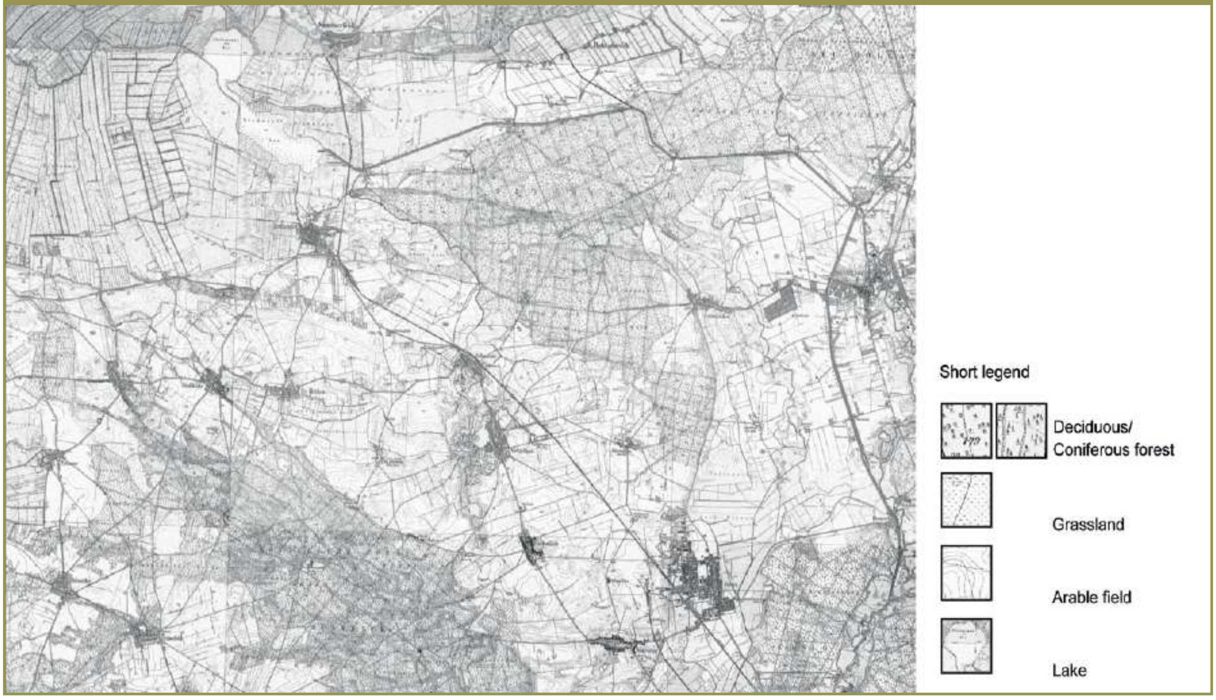


Table 8.4

Forest area, proportion of coniferous stands and proportion of dominant tree species in the Prignitz and Uckermark region in the year 1927 according to Hesmer (1938)

	Prignitz region		Uckermark region		
[%]	West Prignitz	East Prignitz	Prenzlau	Templin	Angermünde
Forest area	20 – 30	20 – 30	5.0 – 10	30 – 40	15 – 20
Of the total forest area					
Coniferous forests	80 – 90	90 – 95	50 – 60	80 – 90	70 – 80
Pine forests	80 – 90	90 – 95	40 – 50	80 – 90	70 – 80
Spruce forests	1.0 – 2.5	<1.0	2.5 – 5.0	1.0 – 2.5	<1.0
Beech forests	<0.1	2.5 – 5.0	20 – 25	5.0 – 10	10 – 15
Oak forests	2.5 - 5.0	1.0 – 2.5	10 – 15	2.5 – 5.0	10 – 15
Birch and elder	5.0 – 7.5	2.5 – 5.0	7.5 -10	2.5 – 5.0	2.5 – 5.0

Table 8.5

Overview of ancient, old and recent forest area in the Prignitz region

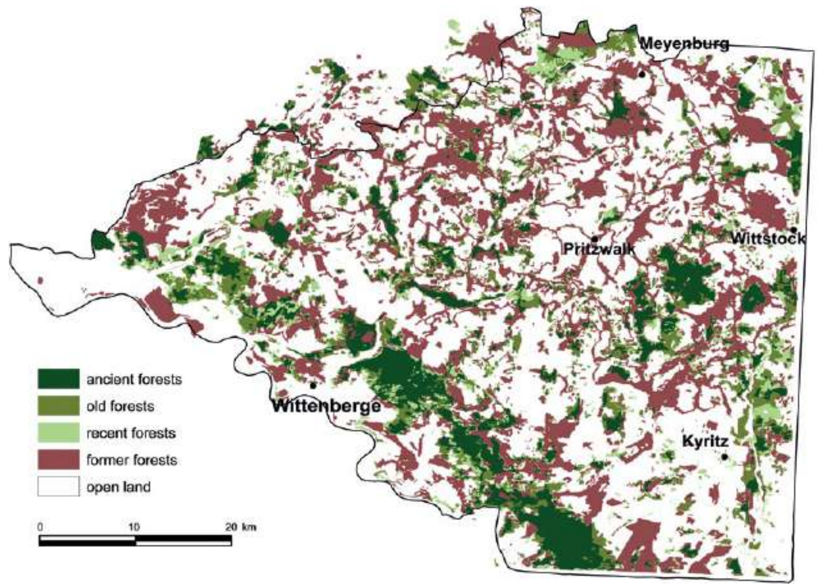
Forest type with regard to habitat continuity	Explanations	Area [ha]	% of the total area [ha]
Ancient forest	Continuously forest area since at least ca. 1780	30.659	9.7
„Old“ forest	Continuously forest area since at least ca. 1880	21.839	6.9
Recent forest 1	Forest area on the 1780 map, but arable field or grassland on the 1880 map, and again forest area on the 1980 map	6.572	2.1
Recent forest 2	Forest area only on the 1980 map	10.602	3.4
Sum		69.672	22.1

The total area of the region is 314,823 ha.

wet lowlands were cleared between 1780 and 1880. The proportion of ± open forests was not high, but most of them were also converted to coniferous stands.

The actual distribution of forest and open land in the Prignitz region has remained nearly stable for a century (Figure 8.6). There has been no severe decrease in oak and beech stands during this time, whereas many alder stands have been converted to grasslands (Hilf, 1928). Although nearly all of the deciduous and mixed stands have remained from 1880 until today, stands with old trees are rare, and larger areas of pure deciduous stands are rare. The Gadower Forest is a 3,000 ha forest near the Elbe River: of this forest, 65% is covered by deciduous stands, whereas the rest is predominantly covered by Scots Pine (Müller, 1941).

Forest-open land distribution in the Prignitz region Figure 8.6



Reconstructed with the Schmettau map (ca. 1780), the maps of the Prussian government (ca. 1880), and actual topographical maps (ca. 1980).

Proportion of combined forest types from the historical maps in the Prignitz region Table 8.6

Forest type on the 1780 map	Forest type on the 1880 map	Total area [ha]	% of the total area	% of the forest area [69,672 ha]
± closed forest	Deciduous forest	1.691	0.5	2.4
± closed forest	Mixed forest	2.087	0.7	3.0
± closed forest	Coniferous forest	22.440	7.1	32.2
± closed forest	No forest	4.325	1.4	6.2
Forest on moist/wet lowlands	Deciduous forest	739	0.2	1.1
Forest on moist/wet lowlands	Mixed forest	936	0.3	1.3
Forest on moist/wet lowlands	Coniferous forest	1.702	0.5	2.4
Forest on moist/wet lowlands	No forest	2.005	0.6	2.9
± open forests	Deciduous forest	43	0	0.1
± open forests	Mixed forest	52	0	0.1
± open forests	Coniferous forest	969	0.3	1.4
± open forest	No forest	242	0.1	0.3
No forest	Deciduous forest	1.167	0.4	1.7
No forest	Mixed forest	1.656	0.5	2.4
No forest	Coniferous forest	19.016	6.0	27.3
No forest	No forest	10.602	3.4	15.2
Other areas		245.151	77.8	
Sum		314.823	100	100

The Uckermark region

As in the Prignitz region, ancient and old forests cover 20% and ca. 8% of the Uckermark region, respectively, the highest proportion of the total area (Table 8.7). Approximately 18,000 ha have been afforested within the last ca. 50 years.

Also comparable to the Prignitz region, mainly ± closed forests have been converted to coniferous stands, but 5% of the ± closed forests have been converted to mixed stands. Other forest types are negligible in the Uckermark region (Table 8.8).

The Uckermark region is characterized by extended arable fields in the northeastern part where only a few small forests are embedded in the non-forest matrix (Figure 8.7). Here, the nutrient level of the soils is relatively high, and agricultural use is thus a very old tradition, dating back more than 200 years (Wulf and Schmidt, 1996). In contrast, in the southern and southwestern part, large forest areas have survived because they have been manorial or publicly owned for a long time. Most of the ancient forests were coniferous stands, but there are also extended areas of deciduous forest, mainly beech stands. One of them is the famous "Grumsiner Forest" (UNESCO world heritage site since June 2011).

Overview of ancient, old and recent forest area in the Uckermark region — Table 8.7

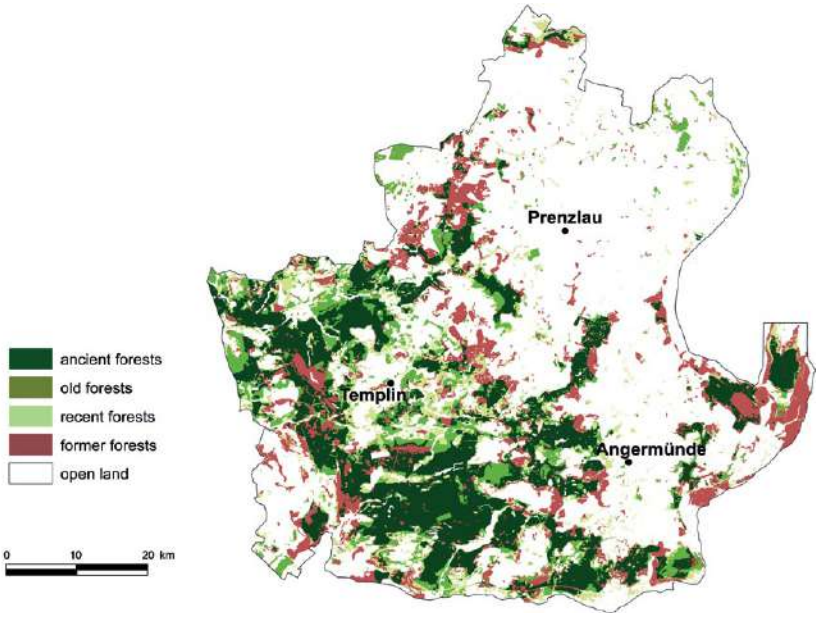
Forest type with regard to habitat continuity	Explanations	Area [ha]	% of the total area [ha]
Ancient forest	Continuously forest area since at least ca. 1780	79.520	20.0
„Old" forest	Continuously forest area since at least ca. 1880	33.040	8.3
Recent forest 1	Forest area on the 1780 map, but arable field or grassland on the 1880 map, and again forest area on the 1980 map	8.713	2.2
Recent forest 2	Forest area only on the 1980 map	17.770	4.5
Sum		139.043	35.0

The total area of the region is 398.405 ha.

Proportion of combined forest types of the historical maps in the Uckermark region — Table 8.8

Forest type on the 1780 map	Forest type on the 1880 map	Total area [ha]	% of the total area	% of the forest area [69,672 ha]
± closed forest	Deciduous forest	12,933	3.2	9.3
± closed forest	Mixed forest	18,658	4.7	13.4
± closed forest	Coniferous forest	44,930	11.3	32.4
± closed forest	No forest	7,275	1.8	5.4
Forest on moist/wet lowlands	Deciduous forest	852	0.2	0.6
Forest on moist/wet lowlands	Mixed forest	263	0.1	0.2
Forest on moist/wet lowlands	Coniferous forest	643	0.2	0.5
Forest on moist/wet lowlands	No forest	767	0.2	0.6
Pastured forests	Deciduous forest	45	0	0
Pastured forests	Mixed forest	43	0	0
Pastured forests	Coniferous forest	1,153	0.3	0.9
Pastured forest	No forest	241	0.1	0.2
No forest	Deciduous forest	4,164	1.0	3.0
No forest	Mixed forest	5,167	1.3	3.7
No forest	Coniferous forest	23,709	6.0	17.1
No forest	No forest	17,770	4.5	12.8
Other areas		259,791	65.1	
Sum		398,405	100	100

Forest-open land distribution in the Uckermark region — Figure 8.7



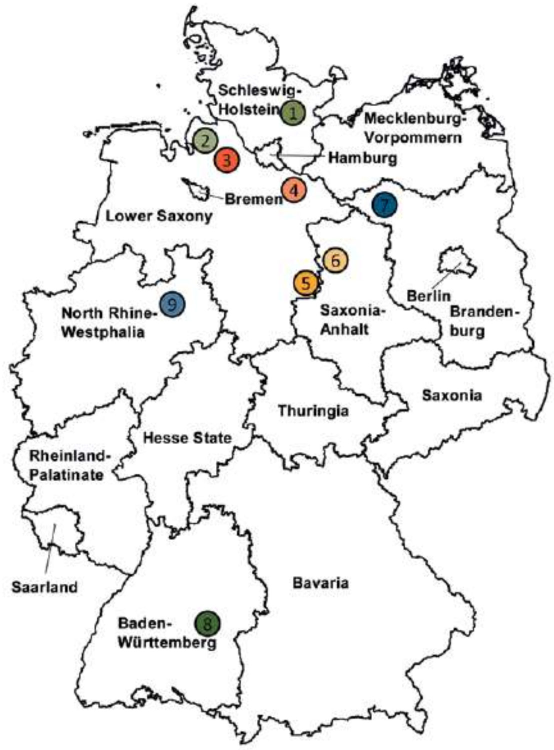
Reconstructed with the Schmettau map (ca. 1780), the maps of the Prussian government (ca. 1880), and actual topographical maps (ca. 1980).

Importance for maintaining biodiversity

Several publications on ancient forests indicate their particular importance for maintaining animal and plant species diversity in the temperate forests of Europe (e.g., Peterken, 1981, 1993; Peterken and Game, 1984; Hermy et al.,1999, Sroka and Finch, 2006) and of North America (e.g., Matlack, 1994). No review is likely to give a complete overview of all of the studies conducted in Germany, although it has been attempted, focusing on vascular plant species and considering only published studies. From Figure 8.8, it is obvious that most of the research has been performed in northern Germany. These studies were used to extract a list of 20 selected indicator plant species for ancient forests (Table 8.9). It must be noted that the list is not valid for all of Germany because it is well known that the associations of plant species with ancient forests vary among regions (Wulf and Kelm, 1994). Nevertheless, many of the species in Table 8.9 were mentioned as central European ancient forest plant species by Hermy et al. (1999).

Unfortunately, there is no standardized definition of ancient forest indicators, and the identification of indicators has only rarely involved statistical tests (Wulf, 1997). However, the large number of studies on plant species that are associated with ancient forests from several European countries (cf. Hermy et al., 1999) is convincing, and there are even several plant species that are restricted to ancient forests (e.g., Wulf, 2004). Among the plant species in Table 8.9, there are several on the Red List of the Federal State Lower Saxony (Wulf and Kelm, 1994) and Brandenburg (Wulf, 2004). This is mainly because of the restricted area of deciduous ancient forests, which are the usual habitats of these plant species.

Published studies of ancient forest indicator plant species in Germany — Figure 8.8



1: Härdtle & Westphal (1998); 2: Wulf & Kelm (1994); 3: Wulf (1997); 4: Heinken (1998); 5: Zacharias (1994); 6: Otte (1996); 7: Wulf (2003b); 8: Schneider & Poschlod (1999); 9: Kühn (2000).

Table 8.9

Twenty selected indicator plant species for ancient forests in Germany

Author number	1	2	3	4	5	6	7	8	9
Adoxa moschatellina			×		×	×			
Anemone nemorosa					×	×	×	×	×
Carex sylvatica		×	×		×	×	×		
Equisetum sylvaticum		×	×		×		×		
Galium odoratum		×	×		×	×	×		
Hepatica nobilis	×		×		×	×			
Lamium galeobdolon		×	×		×		×	×	
Listera ovata		×			×		×		
Lysimachia nemorum		×	×						
Luzula pilosa				×			×		×
Melica uniflora		×	×		×	×	×		
Mercurialis perennis		×	×		×		×		
Milium effusum				×	×		×		
Oxalis acetosella		×	×		×		×		×
Paris quadrifolia		×	×		×	×	×	×	
Phyteuma nigrum/spicatum			×		×		×		
Primula elatior		×	×		×				×
Pulmonaria obscura/officinalis		×			×				×
Sanicula europaea		×	×		×	×	×		
Viola reichenbachiana/riviniana		×	×		×	×	×	×	

For author numbers see Figure 8.8

Protection of ancient forests

From Heiss (1987), one may get the impression that ancient forests have been an international focus since the 1980s and that this may have had an effect on the German policy of forest protection. Additionally, the Nature Protection Academy of Lower Saxony published the results of a symposium on ancient forests in 1994, suggesting that ancient forests are at least a national focus. However, even the Federal inventory of ancient forests in Germany initiated by the Federal Agency for Nature Conservation (Glaser and Hauke, 2004) did not lead to obligatory laws or regulations protecting ancient forests. Nevertheless, it can be stated that there are several instruments in place to protect forest areas, and they should be mentioned here because they are potential bases for the protection of ancient forests in the future. There are also some different approaches to consider.

The Federal policy of forest protection in Germany is integrated in two main global processes based on the UNCED (United Nations Conference on Environment and Development) 1992;

- the global forest policy that is based on the "forest declaration" of UNCED 1992 and
- the global biodiversity policy that is based on the convention on biodiversity (CBD) 1992.

The "forest declaration" is a "declaration on principles" and is not related to the law of nations. However, all efforts to set the global forest policy on a foundation related to the law of nations with an international convention have failed. The CBD is an obligatory agreement (Winkel, 2006; Mann, 2012).

In the context of the global forest policy, the "Helsinki"-process at the Pan-European level was important. A definition of "sustainable forest management (SFM)" that was based on six criteria and 27 indicators was acquired, and the resolution L2 "Pan-European Criteria, Indicators and Guidelines for Sustainable Forest Management on Operational Level" was adopted (MCPFE, 2000). The Pan-European Criterion no. 4, with seven indicators, concerns the maintenance, conservation and enhancement of biological diversity in forest ecosystems. The first indicator refers to the changes in the natural and ancient semi-natural forest types (Puumalainen et al., 2003; Wulf, 2003a). According to the title of a publication by Heiss (1987), these forests have been inventoried for the European council memberstates and Finland. Unfortunately, a figure in Heiss (1987) shows in very rough 100,000 ha steps the estimated area of designated and potential woodland reserves. From that figure, it appears that approximately 100,000 ha of woodland were already designated as reserves with and without management and that the largest part of these areas are

Table 8.10

Forest area and protected forest area of the EU member state Germany
(according to Parviainen et al., 2000a and Bücking, 2007)

EU member state	Germany (FRG)
Area of forest	10,700,000 ha = 107,000 km²
Forest cover as % of total forest area	30
Total area of protected forests (ha)	400,000
Total area of protected forest area as % of forest cover	4.0
Area of strict forest reserves (ha)	24,976
Area of strict forest reserves as % of forest cover	0.23

potential woodland reserves.

Unfortunately, Heiss (1987) did not provide a definition of ancient woodland, but his introduction indicates that this term was synonymous with "virgin" forests. Thus, ancient forests in the sense of forests with a habitat continuity of at least 200 years were not inventoried at that time. However, several impulses for the Federal policy were revealed by the European Union (EU). Most important are the bird protection guidelines (from 1979) and the guideline for Flora-Fauna-Habitat (FFH) (from 1992), which both aspire to realize a European net of protected areas (Natura 2000). Despite the recommendations of the EU superior counselor (EU Ministerrat) from 1988, ancient forests have not been included in appendix I of the FFH guidelines from 1992 (Stegink-Hinrichs, 1994). Thus, it is not clear how many of the strict forest reserves mentioned by Parviainen et al. (2000a,b) occur on ancient forest sites (Table 8.10, see also Wulf, 2003a)

In the framework of the FFH, Germany has claimed to have a very high proportion of forest areas (Winkel, 2006). Though 17% of the total forest area includes FFH areas (unpublished data), it is not clear how many of the FFH areas are ancient forests. The same is true for the strict forest reserves (SFR), which have been designated within the last 100 years (Table 8.11). In the new "recommendations for the establishment and care of strict forest reserves" (Projektgruppe Naturwaldreservate 1993), the consideration of "ancient forest sites" is recommended for the selection of suitable areas. Meyer et al. (2007) mentioned that 716 SFRs existed in 2007, covering 31,176 ha in total (0.29% of the total forest area), but no information is given about whether ancient forests have been considered starting in 1993. Because particularly semi-natural stands were selected to be designated as SFRs, it can be assumed that these are ancient forests because those stands have usually survived on ancient forest sites. The data in Table 8.11 show some inconsistencies because of the different sources used. For completeness, the table is presented here as it was originally published by Meyer et al. (2007).

Recently, Germany took international responsibility to protect beech forests in an interlinked network (BfN, 2008). In the report commissioned by Greenpeace in April 2011, it mentioned that besides other sources, the Federal inventory of "ancient forests" by Glaser and Hauke (2004) has been considered the expert opinion (Panek 2011). In this context, the "Grumsiner Forest" (Brandenburg, NE Germany) attains world heritage status as part of the "Ancient Beech Forests of Germany" by UNESCO in 2011 (Geisel et al., 2012). The Grumsiner Forest is 1,291 km² and was shown to have been a beech-dominated forest for c. 400 years (Luthardt et al., 2004).

Table 8.11

Development of the designation of SFRs
(according to Meyer et al., 2007)

Year	Number of SFR	Area [ha]	Source(s)
1968*	150	2.100	Bauer (1968); Trautmann (1969)
1976**	472	10,880	Trautmann (1976)
1980**	472	10,315	Anonymous (1980)
1989	570	12,827	Bohn & Wolf (1989)
1991	564	16,443	Wolf & Bohn (1991)
1993	no data	44,650	BML (1994)
1994	637	19,380	Anonymous (1994)
1995	635	20,503	Bundesamt für Naturschutz (1997)
1997	651	21,795	Bücking (1997)
1998	678	25,016	Bundesamt für Naturschutz (1999)
2000	679	24,976	Bücking (2000); Parviainen et al. (2000a)
2001	629	23,718	Bundesamt für Naturschutz (2002)
2001	781	28,205	Bücking (2003)
2004	824	30,587	Bundesamt für Naturschutz (2004)
2007	716	31,176	Query by Meyer

*Only data for the former GDR (East Germany), no data for the former FRG (West Germany).
**Data for the former FRG, data from 1968 of the former GDR are added.

The inventory of German ancient forests was conducted in the framework of the research project "Analysis of the distribution of endangered biotopes in Germany with a European wide importance" from 1999 to 2001 (Verbreitungsanalyse gefährdeter Biotoptypen von europäischer Bedeutung in Deutschland (FKZ-Nr. 8988515)). In the foreword of the study by Glaser and Hauke (2004), the president of the Federal Agency for Nature Protection (Bundesamt für Naturschutz = BfN) mentioned that the results can be used as a basis for political decisions and plannings on the federal and state level. Nevertheless, on the national level, neither the Federal Forest Act (Bundeswaldgesetz) nor the Federal Law on Nature Conservation (Bundesnaturschutzgesetz) considered the protection of ancient forests (Stegink-Hinrichs, 1994). All German states have enacted their own State Forest Laws. They reflect the basic structure and the main provisions of the Federal Forest Act but differ "in terms of, e.g., (i) the legal definition of sustainable forest management (SFM) and minimum requirements for forest operations, (ii) safeguards for protective and social forest functions and environmental impact assessment (EIA) requirements, (iii) provisions regarding protected forest areas, (iv) structural set-up, mandates, and responsibilities of forest sector administrations and state forest enterprises, (v) public support to the forest sector, and (vi) penal provisions." (Mann, 2012, p. 22). Among these 16 State Forest Laws, no one considered "ancient forests" to be particularly in need of protection.

At least Lower Saxony considered ancient forests in the long-term ecological forestry planning of 1994, the so-called LÖWEN (Langfristige, ökologische Waldbauplanung für die Niedersächsischen Landesforsten, ML, 1994). In the LÖWEN, it is assured that, "On sites where soils were not degraded or severely disturbed by human impacts, disturbing or altering the naturally developed structure of the organic and mineral layer is not allowed" (LÖWEN, p. 11). Furthermore, "a sufficient representativeness of semi-natural forest communities should be achieved. This is particularly true for forest communities occurring on old, not otherwise used sites and on forest soils sites" (LÖWEN, p. 24). Lower Saxony has therefore put some efforts into creating maps of the historical land use derived from old maps (Ostmann, 1994). However, these maps are available for only 25% of Lower Saxony.

Despite these activities, Germany still lacks laws or guidelines that specifically address the protection of ancient forests.

Threats to ancient forests

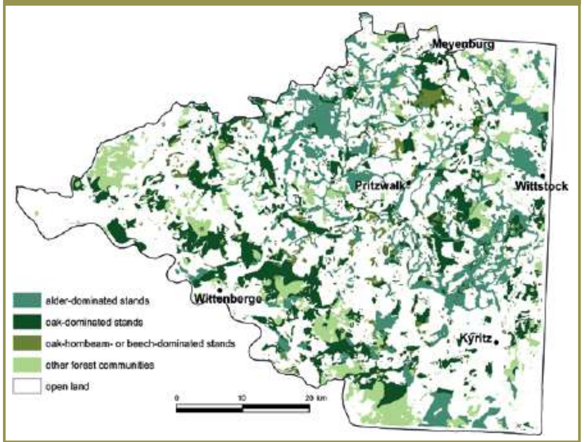
In general, there is no threat that solely affects ancient forests. Direct and indirect human impacts, e.g., forest management, atmospheric depositions and climate change, potentially affect all forests. For European forests, this is comprehensively demonstrated by Ellenberg and Leuschner (2010). One example is enhanced N deposition for more than 100 years (Ulrich and Meyer, 1987) that has resulted in an increase of the N content in forest soils and changes in the humus quality (Ellenberg and Leuschner 2010). As a result, changes in the vegetation toward an increase of nitrogen indicator plant species are observed (Zerbe, 1992).

However, one threat may particularly affect the plant species diversity of ancient forests: "extinction debt" (Tilmann et al., 1994), in which evidence of the process takes decades or even longer to appear. It is well known that forest herbs can live in a habitat for several decades or longer (Inghe and Tamm, 1985; Gilliam, 2007), even if the habitat conditions have become unfavorable. This delayed response to habitat alterations has been termed extinction debt (Paltto et al., 2006; Vellend et al., 2006; Lindborg et al., 2011). For instance, Paltto et al. (2006) found a delayed response of vascular forest plants to habitat loss and fragmentation during the past 120 years. Because recent forests may not exist for as long as is required for evidence of extinction debt to become apparent, it is likely that this effect is more relevant for plant populations in ancient forests.

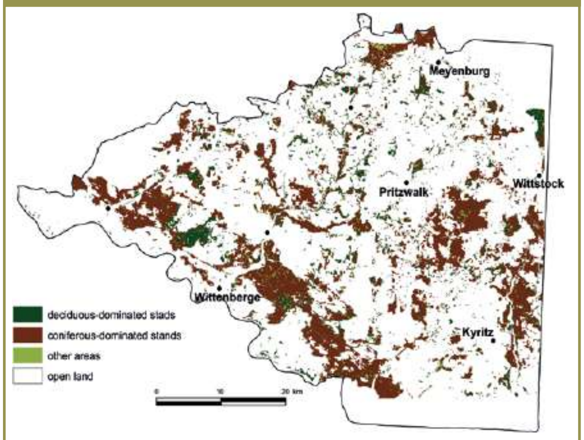
As mentioned above, 77% of all forests in Germany are ancient forests. Most of these forests have become fragmented in the past. Fragmentation is defined as the conversion of a former extended habitat into smaller, isolated habitats embedded in a matrix that is usually uninhabitable for species of the original habitats (Valladares et al., 2006). The process of fragmentation comprises two facts: loss of habitats and dissection of habitats (Köhler and Eggers, 2012). Around 1800, the proportion of deciduous and mixed stands was still relatively high, but this proportion has changed dramatically within decades. Mainly for economic reasons, these stands were converted to coniferous-dominated stands (Mantel 1990), and these have remained until today (Glaser and Hauke, 2004). It is likely that the animal and plant species that are adapted to semi-natural ancient forests are threatened simply because large parts of those stands have been converted to pure or prevailing coniferous stands in the past.

For example, Figures 8.9 and 8.10 demonstrate the dramatic changes in the dominant tree species from c. 1800 until today for the Prignitz region (northeast Germany) (Wulf and Rujner, 2011). Two hundred years ago, oak and alder forests covered 44% and 37% of the total forest area, respectively. Approximately 6% was covered by oak-hornbeam forests. Only 100 years later, most of the deciduous stands were converted to Scots Pine stands (Hesmer, 1938). An actual map of forest vegetation illustrated that pine stands still prevail, whereas oak and beech dominated stands cover only 7.6% and 3.4%, respectively (Wulf and Rujner, 2011).

Historical forest vegetation in the Prignitz region around 1800 **Figure 8.9**
(according to Wulf & Rujner, 2011)



Actual forest vegetation in the Prignitz region around 2000 **Figure 8.10**
(according to Wulf & Rujner, 2011)



A case study from northwest Germany

A study on semi-permanent plots in a northwestern German region (Naaf 2011) showed that environmental changes may have effects on the vegetation of ancient forests within only two decades. In the Elbe-Weser-Region (Figure 8.2), 415 vegetation plots in ash- and oak-dominated stands on moist and base rich sites were surveyed from 1986 to 1989 (Wulf, 1992). Of the 415 total plots, 175 relocated plots were selected (excluding the effects of spatial autocorrelation) and resurveyed in 2008 and 2009 by Naaf (2011). Several plant species show a significant negative or positive average change in their abundance, i.e., the so-called 'loser' or 'winner' species. Among the losers are many forest specialists (species closely tied to forests), including several ancient forest indicators, e.g., *Hepatica nobilis, Paris quadrifolia* and *Sanicula europaea* (Wulf, 1997; Naaf and Wulf, 2011).

Two decades ago, not all environmental factors that could be potential drivers of these changes had been measured or were available. Therefore, plant species' traits have been used that attempt to detect the drivers behind these changes in forest vegetation. Of 115 species tested, 31 were winner species and 30 were loser species (Naaf and Wulf, 2011). Among six traits, oceanic distribution is one of the important traits in discriminating between winner and loser species. The proportion of plant species with an oceanic distribution is 40% for the winner species compared to 3.3% for the loser species. Higher performance of species with an oceanic distribution (e.g., *Hedera helix* and *Ilex aquifolium*) can be interpreted as a response to the increasingly warmer winters (Naaf, 2011). This assumption is supported by a few empirical studies that "have observed shifts in local abundance of temperate forest plants in response to climate change. In a resurvey of 103 British woods after 30 years, Kirby et al. (2005) observed changes in mean cover that were related to an increase in the duration of the growing season for 17 species. However, decreases or increases in cover were not associated with a northern, southern, continental or oceanic distribution of the species (Kirby et al., 2005). Our study suggests that species with certain distributions may already show responses to climate warming over a short time period of two decades" (Naaf, 2011, p. 73).

Summary and concluding remarks

- A map at scale 1:100,000 provide an overview on the distribution of deciduous, mixed and coniferous ancient and recent forests in Germany (Glaser and Hauke, 2004).
- Several publications have shown that semi-natural ancient forests are important for the maintenance of plant species' diversity and that several plant species can be designated as ancient forest indicator species (e.g., Wulf, 2003b).
- Despite several political instruments to protect forests in the European Union (e.g., the forest declaration of the UNCED 1992) and at the Federal and State level in Germany (e.g., guidelines for Flora-Fauna-Habitat (FFH)), there are no laws or regulations to protect ancient forests (cf. Stegink-Hinrichs, 1994).
- Several strict forest reserves have been established since 1968. Today, these reserves comprise an area of c. 31,200 ha, which is only 0.3% of the entire forest area in Germany.
- Recently, Germany took international responsibility to protect beech forests in an interlinked network. Some "Ancient Beech Forests of Germany" were designated as world heritage sites by UNESCO in 2011 (e.g., Geisel et al., 2012).
- An example from northwest Germany revealed that forest plant species of ancient forest sites have been obviously affected by climatic changes within the last two decades. The average abundance of plant species with an oceanic distribution (e.g., *Hedera helix* and

Ilex aquifolium) has increased from 1988 to 2008 and can be interpreted as a response to increasingly warmer winters (Naaf, 2011).

- From the study in northwest Germany, it is obvious that there are several ancient forest indicator species among the 'loser', defined as plant species with a significant negative average change in their abundance (Naaf and Wulf, 2011).

Despite the growing interest in ancient forests and their doubtless importance for maintaining biodiversity, there is no published overview on protected ancient forest areas in Germany. This is in clear contrast to the attention given to them by many scientific studies, whose results show that the forests are potential "hot spots" of biodiversity in central Europe (e.g., Ray et al., 2004). As in other European countries, there is a lack of digital large-scale maps (scale at least 1:50,000) in Germany (but see Wulf and Schmidt, 1996; Wulf, 2004). This may be because of the time-consuming work to produce such a map and the restricted funding possibilities. Nevertheless, these maps are necessary for further scientific studies to be conducted at a small scale, e.g., estimation of the carbon sequestration potential of forest stands on ancient and recent forest sites (Ellenberg and Leuschner, 2010). This is one argument to follow the recommendation of Rackham (2008), who stated that "There is a need to maintain archives of the present or recent state of woodland as a basis against which to measure future changes" (Rackham, 2008, p. 583).

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