G1.6b Fagus woodland on acid soils

Summary

This habitat includes those *Fagus sylvatica* woodlands occurring on impoverished, free-draining, base-poor soils developed from silicate bedrocks and sandy or gravelly superficial deposits through the Atlantic and Continental zones and, in northern Italy and the Balkans, into the Alpine region. Typically *Fagus* is overwhelmingly dominant, an understorey is often absent or sparse and the field layer species-poor, comprising scattered shade-tolerant grasses and herbs and a few bryophytes. Significant pressures are from forestry, urbanization and infrastructure development, regionally also eutrophication, pollution, invasive species and, in Mediterranean countries, grazing. Conservation depends on sensible sylviculture.

Synthesis

The habitat suffered a moderate qualitative decrease over more than one third of its area and a slight decrease over large area (>70%) with continuing pressures and threats being present. This leads to the category Near Threatened under criterion C/D1. Because of the large EOO and AOO, and a slight quantitative decrease all other criteria are Least Concern as well. Assessment of historic trends were not possible due to data deficiencies.

Overall Category & Criteria			
EU 28		EU 28+	
Red List Category	Red List Criteria	Red List Category	Red List Criteria
Near Threatened	C/D1	Near Threatened	C/D1

Sub-habitat types that may require further examination

While at least some good examples of acid mountain beech forests still persist, the situation in acid lowland beech forest on sandy plains and sanddunes is much more fragmented. Several of its subtypes (e.g. Annex I types) have been affected by a moderate to severe decline over large areas of their natural distribution with poor quality (Strutures and functions in U1 or U2). The very oligotrophic subtyes all suffer severely from atmospheric nitrogen input with slow changes in characteristic species composition and the humid subtypes are more endangered due to drainage and changes in the hydrological system, where a negative trend can last over many decades with slow deterioration in quality.

Habitat Type

Code and name

G1.6b Fagus woodland on acid soils

Fagus woodland on acid soils on a steep slope in Vitosha, Bulgaria (Photo: Axel Ssymank).

Fagus forest on acidic glacial soils in Montferland region, the Netherlands (Photo: Bas van Gennip).

Habitat description

Within the climatic zone where *Fagus sylvatica* is able to maintain dominance over other broadleaved trees, this habitat includes those beech woodlands which occur on impoverished, free-draining, base-poor rankers, acid brown earths and podzols developed from silicate bedrocks and sandy or gravelly superficial deposits. They extend from the Atlantic zone in Great Britain, France and Northern Spain, through Central Europe into the Continental zone and, in northern Italy and the Balkans into the Alpine region. Typically, *Fagus sylvatica* is overwhelmingly dominant (often ssp. *moesiaca* in the mid and eastern Balkans), when growing well forming a tall, cathedral-like canopy in which associates are few: *Quercus petraea* and less commonly *Q. robur* throughout the range, with *Q. pyrenaica* in the south-west and *Castanea sativa* in the west and south. In the Atlantic zone, *Ilex aquifolium* is a common understorey tree. *Pinus sylvestris* can be present at low altitudes, especially on shallow soils on siliceous rocks. At higher altitudes, *Acer pseudoplatanus* can occur, *A. heldreichii* in the Balkans and, towards the altitudinal limits of this woodland type, *Abies alba* and *Picea abies* in transitions to G3.1b and G3.1c mountain fir woodlands. The field layer is typically species-poor and often sparse, comprising shade-tolerant grasses and herbs and a few bryophytes. Commonest among these are *Deschampsia flexuosa*, *Agrostis capillaris*, *Carex pilulifera*, *Oxalis acetosella*, *Maianthemum bifolium*, *Luzula pilosa*, *Vaccinium myrtillus*, *Pteridium aquilinum*, *Polytrichum formosum*, *Dicranella heteromalla*, *Dicranum scoparium*, *Mnium hornum* and *Hypnum cupressiforme*. Generally, across the lowlands, *Melampyrum pratense* is characteristic with, towards the north-western Atlantic, *Ruscus aculeatus*, *Lonicera periclymenum*, *Teucrium scorodonia*, *Hypericum pulchrum*, *Blechnum spicant*, towards the south-west in the Massif Central, Pyrenees and Cantabrian Mountains, *Euphorbia angulata*, *E. hyberna*, *Saxifraga hirsuta*, *S. spathularis* and *Luzula sylvatica* spp. *henriquesii*. *L. nivea* and *L. pedemontana* occur in Insubria and Piedmont and *Festuca drymeja* in Illyria and the Carpathians. In the European lowlands, mixed Fagus-Quercus robur forests with this field layer should also be included under these *Fagus* woodlands. At higher altitudes, *Dryopteris dilatata*, *Festuca altissima*, *Prenanthes purpurea*, *Luzula luzuloides*, *L. sylvatica*, *Senecio ovatus* and *S. nemorensis* occur with, in

mountain stands, *Polygonatum verticillatum*, *Calamagrostis villosa* and *Homogyne alpina*. Apart from the altitudinal variation from lowlands to higher altitudes, there is a broad range of different ecological situations in climatic and soil moisture conditions, ranging from relatively dry conditions with *Carex pilulifera*, *Hieracium glaucinum* or complete moss layers of *Leucrobryum glaucum* s.l. to humid conditions with ferns like *Dryopteris filix-mas* and *Athyrium filix-femina*. In relatively wet conditions species such as *Frangula alnus*, *Lysimachia vulgaris* occur, sometimes *Molinia caerulea* agg. can be dominant or if temporarily wet conditions prevail also *Carex brizoides*. Especially in subatlantic and atlantic conditions dominant species in the herb layer can be *Pteridium aquilinum*.

Indicators of quality:

Through the lowlands, this habitat has been widely converted to dwarf-shrub heaths for stock rearing and, later, partially re-afforestation with pine and spruce. At higher altitudes, there has been widespread replacement by conifer plantations (*Picea* spp., *Pseudotsuga menziesii* etc). High quality stands should show:

• Natural composition of canopy with dominant beech trees

• Structural diversity/ complexity with (semi)natural age structure or completeness of layers

• Typical flora and fauna composition of the region

• Presence of old trees and a variety of dead wood (lying or standing) and the associated flora, fauna and fungi

• Presence of natural disturbance such as treefall openings with natural regeneration

• Long historical continuity (ancient woodland) with high species diversity

• Survival of larger stands of forest without anthropogenic fragmentation and isolation (to support fauna which need large undisturbed forests) • Absence of non-native species in all layers (flora & fauna)

• No signs of eutrophication (e.g. with the spread of shade-tolerant nitrophiles) or pollution

• No signs of acidification

• No man-induced very high population levels of ungulates

Characteristic species:

Tree canopy: *Fagus moesiaca*, *Fagus sylvatica*, *Quercus petraea*, *Q. robur*, *Pinus sylvestris.*

Field layer: *Deschampsia flexuosa*, *Agrostis capillaris*, *Calamagrostis epigejos*, *Carex pilulifera*, *Convallaria majalis*, *Oxalis acetosella*, *Ilex aquilifolium*, *Maianthemum bifolium*, *Luzula pilosa*, *L. luzuloides*, *Vaccinium myrtillus*, *Melampyrum pratense*, *Hieracium murorum* agg., *Pteridium aquilinum*.

Moss layer: *Polytrichum formosum*, *Leucobryum glaucum*, and other mosses like *Dicranella heteromalla*, *Dicranum scoparium*, *Mnium hornum*, *Atrichum undulatum*, and *Hypnum cupressiforme*.

Classification

This habitat may be equivalent to, or broader than, or narrower than the habitats or ecosystems in the following typologies.

EUNIS:

G1.6 Beech woodland

Includes forests dominated by beech *Fagus sylvatica* in western and central Europe, and F. orientalis and other *Fagus* species in southeastern Europe and the Pontic region. This Red List habitat includes all the

more calcifuge forest types dominated by beech. Those on non-acidic soils are included in G1.6a. Many montane mixed beech-fir or beech-fir-spruce forests are included under G4.6.

EuroVegChecklist:

Luzulo-Fagion sylvaticae Lohmeyer et Tx. in Tx. 1954

Ilici-Fagion sylvaticae Br.-Bl. 1967

Vaccinio-Fagion orientalis Passarge 1981 [in Caucasus]

Annex 1:

9110 Luzulo-Fagetum beech forests

9120 Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion)

91W0 Moesian beech forests

Emerald:

G1.6 Fagus woodland

MAES-2:

Woodland and forest

IUCN:

1.4 Temperate Forest

EFT:

6.1 Lowland beech forest of southern Scandinavia and north central Europe

6.2 Atlantic and subatlantic lowland beech forest

6.3 Subatlantic to Atlanto-Mediterranean submountainous beech forest

6.4 Central European submountainous beech forest

6.5 Carpathian submountainous beech forest

6.6 Illyrian submountainous beech forest

6.7 Moesian submountainous beech forest

7.1 South-western European mountainous beech forest

7.2 Central European mountainous beech forest

7.3 Apennine-Corsican mountainous beech forest

7.4 Illyrian mountainous beech forest

7.5 Carpathian mountainous beech forest

7.6 Moesian mountainous beech forest

7.7 Crimean beech forest

7.8 Oriental beech and hornbeam-oriental beech forest

VME

F5.1 Species-poor oligotrophic - mesotrophic beech and mixed beech forests

Does the habitat type present an outstanding example of typical characteristics of one or more biogeographic regions?
Yes

Regions
Atlantic
Continental

Justification
Fagus sylvatica dominated beech forest both on acid and on non acid soils have their worldwide centre of distribution in central Europe and some of the most outstanding examples have been chosen as part of the World Heritage site "Primeval Beech Forests of the Carpathians ID-Nr. 1133".

Geographic occurrence and trends

EU 28	Present or Presence Uncertain	Current area of habitat	Recent trend in quantity (last 50 yrs)	Recent trend in quality (last 50 yrs)
Austria	Present	1400 Km^2	Decreasing	Unknown
Belgium	Present	680 Km^2	Unknown	Decreasing
Bulgaria	Present	85 Km^2	Decreasing	Decreasing
Croatia	Present	44 Km^2	Stable	Stable
Czech Republic	Present	1511 Km^2	Decreasing	Decreasing
Denmark	Present	164 Km^2	Unknown	Decreasing
France	France mainland: Present	4500 Km^2	Increasing	Decreasing
Germany	Present	6100 Km^2	Increasing	Decreasing
Greece	Greece (mainland and other islands): Present	1342 Km^2	Unknown	Stable
Hungary	Present	25 Km^2	Stable	Stable
Ireland	Present	2 Km^2	Stable	Stable
Italy	Italy mainland: Present	2878 Km^2	Increasing	Decreasing
Luxembourg	Present	unknown Km^2	Unknown	Unknown
Netherlands	Present	1080 Km^2	Decreasing	Stable
Poland	Present	205 Km^2	Decreasing	Decreasing
Romania	Present	12730 Km^2	Decreasing	Decreasing
Slovakia	Present	420 Km^2	Decreasing	Unknown
Slovenia	Present	1534 Km^2	Stable	Decreasing
Spain	Spain mainland: Present	2544 Km^2	Increasing	Decreasing
Sweden	Present	unknown Km^2	Unknown	Unknown
UK	Northern Island: Present United Kingdom: Present	680 Km^2	Unknown	Decreasing

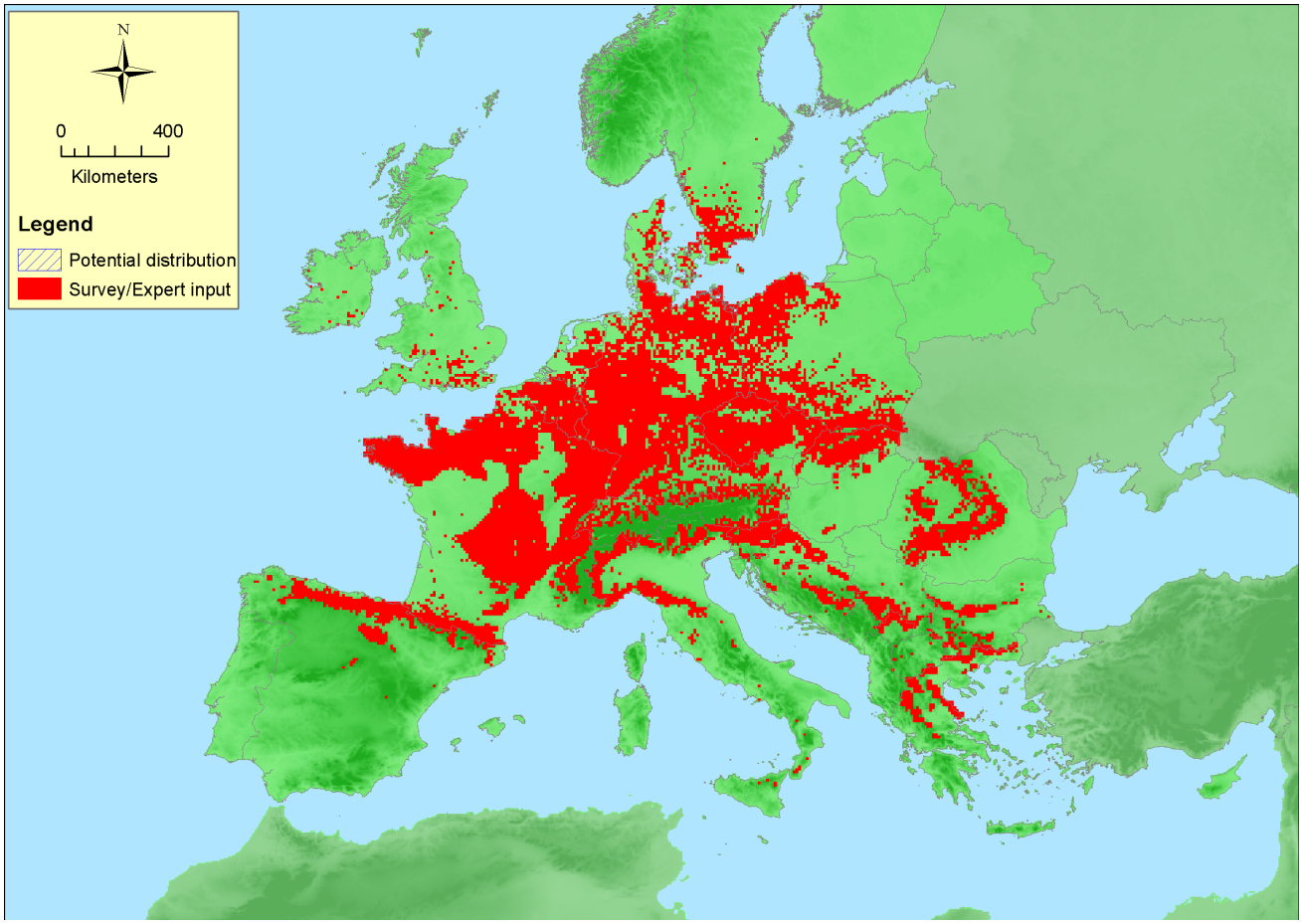
EU 28 +	Present or Presence Uncertain	Current area of habitat	Recent trend in quantity (last 50 yrs)	Recent trend in quality (last 50 yrs)

EU 28 +	Present or Presence Uncertain	Current area of habitat	Recent trend in quantity (last 50 yrs)	Recent trend in quality (last 50 yrs)
Albania	Present	unknown Km^2	Unknown	Unknown
Andorra	Uncertain	Km^2	-	-
Bosnia and Herzegovina	Present	1900 Km^2	Increasing	Decreasing
Former Yugoslavian Republic of Macedonia (FYROM)	Present	1798 Km^2	Increasing	Decreasing
Kaliningrad	Uncertain	unknown Km^2	Unknown	Unknown
Kosovo	Present	44 Km^2	Decreasing	Decreasing
Montenegro	Present	1490 Km^2	Stable	Unknown
Norway	Norway Mainland: Present	53 Km^2	Increasing	Unknown
Serbia	Present	unknown Km^2	Unknown	Unknown
Switzerland	Present	570 Km^2	Stable	Decreasing

Extent of Occurrence, Area of Occupancy and habitat area

	Extent of Occurrence (EOO)	Area of Occupancy (AOO)	Current estimated Total Area	Comment
EU 28	4979750 Km^2	11507	37719 Km^2	minimum, smaller data gaps
EU 28+	4979750 Km^2	12037	44000 Km^2	minimum, some data gaps

Distribution map



The map is rather complete, but lacks occurrences on Corsica. Data sources: Art17, EVA, Bohn.

How much of the current distribution of the habitat type lies within the EU 28?

Probably more than 90 %; outside the EU 28 are beech forests mainly in Switzerland and in Balkan countries, where part of the subpannonian-illyrian and moesian subtypes are not covered (see map 11, unit F5.1 of Bohn et al. 2003).

Trends in quantity

Average recent trend over the past 50 years is -15 % (for EU28) and -12% for EU28+ (but with less reliability because of bigger data gaps). Differences within Europe are substantial with stable to slightly positive trends in central Europe, however distinct decrease in Romania and a slight decrease in several other countries. Future quantitative trends are assessed as stable to slightly positive, possibly with the exception of Romania and some Balkan countries (data missing). Data on historic trends are largely missing, calculating an EU28 value is not possible; where present they indicate a clear decrease in some countries. In situations where the forest was largely reduced very early (depleted) an increase happened, like in Denmark.

- Average current trend in quantity (extent)
  EU 28: Stable
  EU 28+: Stable
- Does the habitat type have a small natural range following regression?
  No
  Justification
  The habitat has a very large range.
- Does the habitat have a small natural range by reason of its intrinsically restricted area?
  No

Justification
The habitat occurs in very large stands.

Trends in quality

The calculated extent of degradation from territorial data is 36% (EU28, 34% for EU28) with a severety of degradation 46% (EU28), resp. 45% (EU28+), in total moderate. The trends have been calculated from about 85% of the acid beech forest area. However a slight decline of quality (severity of 30%) is present over large areas (>70% extent) with a reduction in old trees (> 120 years) in the past 50 years (Vilén et al. 2012) ongoing losses in primary and ancient forests especially in SE-Europe (Knapp & Fichtner 2012, Griffiths et. al. 2012) and EU red-listed saproxylic beetles linked to beech forests (Nieto & Alexander 2010, Lachat et al. 2012). For acidic beech forest a slow decrease in quality with changes in typical species combination is present on 70-80% of the European area due to critical load exeedance for nitrogen (EEA 2010). With regard to the highest standard of the indicators of quality, completely untouched (pristine) or oldgrowth ancient forests with suffiecient dead and dying trees are only present on less than 1 % of the remaining European area. Current trends in quality are on average still decreasing, with a number of countries where it is stable or slightly increasing.

- Average current trend in quality
  EU 28: Decreasing
  EU 28+: Decreasing

Pressures and threats

Both in EU28 and EU28+ the most significant threats are forestry use (especially removal of dead and dying trees, planting of non-native or conifer trees, felling or logging, partially also removal of undergrowth), loss of area, fragmentation and impacts due to urbanization and infrastructure. Climate change pressures (both change of abiotic conditions and biotic effects) are still low, but tend to be more important or regionally important in future (drought risks, storm events etc.). Air pollution and eutrophication are regionally important. Especially in the Mediterranean countries grazing can be a major pressure and threat, in other regions high game densities can be an additional threat. In some countries deforestation without replanting, and/or invasive species are an important issue.

List of pressures and threats

Sylviculture, forestry

Forest and Plantation management & use
Forest replanting (non native trees)
Removal of forest undergrowth
Removal of dead and dying trees
Forest exploitation without replanting or natural regrowth
Forestry activities not referred to above

Transportation and service corridors

Roads, paths and railroads

Urbanisation, residential and commercial development

Urbanised areas, human habitation

Invasive, other problematic species and genes

Invasive non-native species

Natural System modifications

Other ecosystem modifications
Anthropogenic reduction of habitat connectivity

Natural biotic and abiotic processes (without catastrophes)

Damage by herbivores (including game species)

Climate change

Changes in abiotic conditions
Changes in biotic conditions

Conservation and management

The majority of beech forests in the EU are under regular forestry management, which reduces the development phases to about a third of the natural tree life with deficits in dead wood and all microhabitats associated with old trees. Apart from guaranteeing a regrowth (natural or by planting) of the beech forest after harvesting (no losses in area), a certain minimum of wilderness core zones combined with some allowance for dead or dying trees within used forests is a good way of combining nature conservation needs with forestry use. Forest fragmentation by urbanization and infrastructure needs adapted spatial planning. In regions with already a low forest cover, additional forest planting may be needed to reduce fragmentation in future. As full regeneration is very difficult; ancient woodland and the small remnants of pristine woodland are of highest conservation interest, but establishing protected areas on small areas is not sufficient alone. Regionally management of invasive species might be necessary, or in the case of high pressure of grazing, areas with exclusion of grazing should be established, or game populations should be reduced and managed.

List of conservation and management needs

Measures related to forests and wooded habitats

Other forestry-related measures
Restoring/Improving forest habitats
Adapt forest management

Measures related to spatial planning

Establish protected areas/sites
Establishing wilderness areas/allowing succession
Legal protection of habitats and species

Measures related to hunting, taking and fishing and species management

Regulation/Management of hunting and taking

Measures related to urban areas, industry, energy and transport

Specific management of traffic and energy transport systems

Conservation status

Annex I:

9110: ALP U1, ATL U1, BOR U2, CON U1, MED FV, PAN U1

9120: ALP U1, ATL U1, CON FV, MED U2

91W0: ALP FV, COn FV

When severely damaged, does the habitat retain the capacity to recover its typical character and functionality?

Both naturally and through interventation full recovery of the habitat usually needs time-spans over 200 years. While the tree species can be planted, the characteristic species of the herb layer include many myrmecochore species (seeds dispersed very slowly over small distances by ants). The full set of characteristic species includes many saproxylic invertebrates and fungi which need a historic habitat continuity. All of these require old and dead trees in a late development stage of forests, some of them are even after 2-3 tree generations unable to recolonise new forest stands. Furthermore, in situations where forests are isolated (especially in European densely populated lowlands) or where characteristic species are (on the verge of) extinction or extinct a full restoration is impossible even with active intervention. Pristine remnants and any ancient woodland therefore needs highest conservation priorities and connectivity needs to be developed especially in fragmented sites.

Effort required

200+ years
Naturally and through intervention

Red List Assessment

Criterion A: Reduction in quantity

Criterion A	A1	A2a	A2b	A3
EU 28	-15 %	unknown %	unknown %	unknown %
EU 28+	-12 %	unknown %	unknown %	unknown %

During the past 40-60 years there was an average decrease of -15% (EU28) rep. -12% (EU28+) with a large variation within Europe. Information on historical losses is very limited and therefore not useful for assessments. Major historical losses occurred to a large part already before 1750 and therefore an application of citerium A3 would not sufficiently reflect the situation.

Criterion B: Restricted geographic distribution

Criterion B	B1				B2				B3
	EOO	a	b	c	AOO	a	b	c	
EU 28	>50000 Km^2	Yes	Yes	No	>50	Yes	Yes	No	No
EU 28+	>50000 Km^2	Yes	Yes	No	>50	Yes	Yes	No	No

Both EOO and AOO are very large and do not meet the criteria B1 or B2. The habitat exists at numerous locations.

Criterion C and D: Reduction in abiotic and/or biotic quality

Criteria C/D	C/D1		C/D2		C/D3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	>70 %	46 %	unknown %	unknown %	unknown %	unknown %
EU 28+	>70 %	45 %	unknown %	unknown %	unknown %	unknown %

Criterion C	C1		C2		C3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	unknown %	unknown %	unknown %	unknown %	unknown %	unknown %
EU 28+	unknown %	unknown %	unknown %	unknown %	unknown %	unknown %

Criterion D	D1		D2		D3	
	Extent affected	Relative severity	Extent affected	Relative severity	Extent affected	Relative severity
EU 28	unknown %	unknown%	unknown %	unknown%	unknown %	unknown%
EU 28+	unknown %	unknown%	unknown %	unknown%	unknown %	unknown%

The overall extent and severity are based on weighted averages calculated from over 80% of the area, where all necessary data were present in territorial data sheets. The calculated extent affected seems to take into account mainly moderate severity and has been applied differently by territorial experts. A slight reduction in quality is present over >70% of the area, with a reduction in old trees (> 120 years) in the past 50 years (Vilén et al. 2012) ongoing losses in primary and ancient forests especially in SE-Europe (Knapp & Fichtner 2012, Griffiths et. al. 2012) and EU red-listed saproxylic beetles linked to beech forests (Nieto & Alexander 2010, Lachat et al. 2012). Additionally, for acidic beech forest a slow decrease in quality with changes in typical species combinations is present on 70-80% of the European area due to critical load exeedance for nitrogen (EEA 2010). Information on long historical or future trends is incomplete and could not be used for criteria CD2, CD3. Reduction in quality usually affected both abiotic and biotic changes and therefore criteria C and D were not split.

Criterion E: Quantitative analysis to evaluate risk of habitat collapse

Criterion E	Probability of collapse
EU 28	unknown
EU 28+	unknown

There is no quantitative analysis available that estimates the probability of collapse of this habitat type. Different climate change scenarios exist, but results are varying and usually only predict shifts in the distribution in some parts of the whole range. Predictions on changes of the whole habitat type with its species composition are not existing.

Overall assessment "Balance sheet" for EU 28 and EU 28+

	A1	A2a	A2b	A3	B1	B2	B3	C/D1	C/D2	C/D3	C1	C2	C3	D1	D2	D3	E
EU28	LC	DD	DD	DD	LC	LC	LC	NT	DD	DD	DD	DD	DD	DD	DD	DD	DD
EU28+	LC	DD	DD	DD	LC	LC	LC	NT	DD	DD	DD	DD	DD	DD	DD	DD	DD

Overall Category & Criteria			
EU 28		EU 28+	
Red List Category	Red List Criteria	Red List Category	Red List Criteria
Near Threatened	C/D1	Near Threatened	C/D1

Confidence in the assessment

Medium (evenly split between quantitative data/literature and uncertain data sources and assured expert knowledge)

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Date of assessment
28/10/2015

Date of review
20/05/2016

References

Bohn, U., Gollub, G. Hettwer, C., Neuhauslova, Z., Raus, T., Schlüter, H. & Weber, H. (2004): *Map of the Natural Vegetation of Europe*. Bonn: Bundesamt für Naturschutz.

Council of Europe (2010), *Interpretation Manual of the Emerald Habitats*. Strasbourg: Council of Europe.

Davies, C.E., Moss, D. & Hill, M.O. (2004), *EUNIS Habitat Classification, revised.* Report to the European Topic Centre, European Environment Agency.

European Commission DG Environment (2007), *Interpretation Manual of European Union Habitats.* Strasbourg: European Commission DG Environment.

European Environment Agency (2006), *European Forest Types*, EEA Technical report No 9/2006, Copenhagen: European Environment Agency.

European Environment Agency (2010). Critical load exceedance for nitrogen. - Indicator Assessment | Data and maps. 14 pp., Copenhagen.
http://www.eea.europa.eu/data-and-maps/indicators/critical-loadexceedance-for-nitrogen/critical-load-exceedance-for-nitrogen.

Griffiths, P.; Kuemmerle, T.; Kennedy, R. E.; Abrudan, I. V.; Knorn, J. & Hostert, P. 2012. Using annual time-series of Landsat images to assess the effects of forest restitution in post-socialist Romania. Remote Sensing of Environment 118 (2012) 199–214.

Knapp, H.D. & Fichtner, A. (Eds.) 2012. Beech Forests – Joint Nautral Heritage of Europe (2). BfN-Skripten 327: 1-222, Federal Agency for Nature Conservation, Bonn.
Lachata,T.; Wermelingera, B.; Gossnerb, B. M.; Bussler, H.; Isacssond, G. & Müller, J. 2012. Saproxylic beetles as indicator species for dead-wood amount and temperature in European beech forests. Ecological Indicators 23: 323–331.

Larsson, T.-B. (coord., 2001): Biodiversity Evaluation Tools for European Forests. Ecological Bulletin 50: 237 pp.

Lenkungsgruppe der Länder Brandenburg, Hessen, Mecklenburg-Vorpommern und Thüringen mit dem Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit und dem Bundesamt für Naturschutz (2009): Anmeldung „Alte Buchenwälder Deutschlands“ als Erweiterung des Weltnaturerbes Buchenurwälder der Karpaten (Primeval Beech Forests of the Carpathians ID-Nr. 1133). – Nationale Naturlandschaften, 186 S. (Download: https://www.bfn.de/0304_buchenwaelder-unesco-pdm.html). See also http://whc.unesco.org/en/list/1133)

Nieto, A. & Alexander, K.N.A. 2010. European Red List of Saproxylic Beetles. Luxembourg: Publications Office of the European Union, 46 pp. (http://ec.europa.eu/environment/conservation/species/downloads/European_saproxylic_beetles.pdf)

Suck, R.; Bushart, M. unter Mitarbeit von Hofmann, G.; Schröder, L.; Bohn, U. (2010): Karte der Potentiellen Natürlichen Vegetation Deutschlands : Maßstab 1 : 500.000 ; Münster : BfN-Schriftenvertrieb im Landwirtschaftsverlag, 2010. - Kartenteil: 7 Karten; Legende: 24 S.

Suck, R.; Bushart, M., Hofmann, G.; Schröder, L. (2013): Karte der Potentiellen Natürlichen Vegetation Deutschlands: 2. Band: Kartierungseinheiten; unter Verwendung von Ergebnissen aus dem F + E-Vorhaben FKZ 3508 82 0400. - BfN-Skripten 349: 1-305.

Suck, R.; Bushart, M., Hofmann, G.; Schröder, L. unter Mitarbeit von Bohn, U.; Jenssen, M.; Bushart, M. (2014): Karte der potentiellen natürlichen Vegetation Deutschlands : 3. Band: Erläuterungen, Auswertungen, Anwendungsmöglichkeiten, Vegetationstabellen ; unter Verwendung von Ergebnissen aus dem F+E-Vorhaben FKZ 3508 82 0400.– BfN-Skripten 377: 1-317.

Suck, R.; Bushart, M., Hofmann, G.; Schröder, L. (2014): Karte der Potentiellen Natürlichen Vegetation Deutschlands : 1. Band: Grundeinheiten ; unter Verwendung von Ergebnissen aus dem F+E-Vorhaben FKZ 3508 82 0400. – BfN-Skripten 348: 1-449.

Schamineé, J.H.J., Chytrý, M., Hennekens, S., Jiménez-Alfaro, B., Mucina, L. & Rodwell, J.S. (2013), *Review of EUNIS forest habitat classification, Report EEA/NSV/13/005*. Copenhagen: European Environment Agency.

Vilén, T.; Gunia, K.; Verkerk, P.J.; Seidl, R.; Schelhaas, M.-J.; Lindner, M. & Bellassen, V. 2012.. Reconstructed forest age structure in Europe 1950–2010. Forest Ecology and Management, 2012: 286: 203 DOI: 10.1016/j.foreco.2012.08.048 (see also note on science daily: https://www.sciencedaily.com/releases/2012/12/121213084931.htm)