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Autecology of broadleaved species

Pierre Gonin, Laurent Larrieu, Jaime Coello, Pauline Marty, Marine Lestrade, Jacques Becquey, Hugues Claessens

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Autecology of broadleaved species

Gonin P. (coordinador)
Larrieu L., Coello J., Marty P.,
Lestrade M., Becquey J., Claessens H.

CNPF
INSTITUT POUR LE DÉVELOPPEMENT FORESTIER

INSTITUT POUR LE DEVELOPPEMENT FORESTIER

Cover photo: A commercial hardwood plantation at Escatalens (SW France), © P. Gonin

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FOREWORD

Anyone involved in timber production needs some knowledge of autecology.
With the renewed interest in hardwoods in the last 20 years, they are increasingly being introduced by planting or encouraged in natural stands. The results in terms of growth have not always met foresters' expectations, due to technical problems and especially because the species are not always suited to the different sites. While the principle of establishing hardwoods is not in question, it is important to be aware of the conditions they need for their growth.

This is why the first component of the Pirinoble programme is about improving knowledge on the ecology and adaptation of valuable hardwood species. To support this, a wide-ranging bibliographic analysis was made of scientific publications in French, English, Spanish and Italian on the main hardwood species that can be established as plantations:

- Wild Cherry (*Prunus avium l.*),
- Common Ash (*Fraxinus* SSP.),
- Wild service tree (*Sorbus torminalis l.*), service tree (*Sorbus domestica* L.) and other sorbus species.
- Walnut (Juglans *SSP.*),
- Common pear tree (*Pyrus pyraster (l.)* Du ROI) and the European Wild Apple tree (*Malus sylvestris* Mill.).
- Lime (*Tilia* ssp.),
- Maple (*Acer SSP.*).

Favourable site conditions for hardwood trees are now better understood thanks to numerous observations carried out in stands and a number of scientific studies. Some species have been studied in more depth, including the wild cherry, wild service tree, common ash, maple and walnut.
This guide is based on the results of these studies, supplemented by the expertise of the authors. It includes a series of autecology factsheets that describe the **site conditions in which hardwoods will thrive and the minimum conditions required for rapid timber production**. The factsheets were published on a regular basis in *Forêt-entreprise* in 2012 and 2013 (see footnote at the end of each of factsheet), and are now published together in this guide along with the bibliographical references consulted.

PIRINOBLE: A BILATERAL COOPERATION PROGRAMME BETWEEN FRANCE AND SPAIN

PIRINOBLE is a transboundary scientific and technical cooperation programme. Its purpose is to encourage hardwood plantations producing high quality timber in abandoned agricultural lands in the Pyrenees. The aims are to test new afforestation techniques offering an alternative to conventional plantations, to compare their effectiveness in different situations and to disseminate the results widely among forest owners and managers.

The programme is organised into three complementary components:

- *furthering knowledge on the ecology and adaptability of valuable hardwood species, presenting the results in this guide;*
- *developing and assessing techniques for maintaining and protecting hardwood plantations;*
- *establishing and assessing mixed commercial hardwood plantations.*

Partners:

- *Forest Development Institute (IDF), a research and development organisation for private forests in France,*
- *The Catalan Forestry Technology Centre, a forestry research organisation in Catalonia*
- *The Centre de la Proprietat Forestal, the organisation in charge of forest development in Catalonia,*
- *The Regional Private Forestry Centre (CRPF) for the Midi-Pyrenees region in France, in charge of private forest development*

The PIRINOBLE programme is financed by the European Regional Development Fund (ERDF) under the Territorial Cooperation Operational Programme for Spain, France and Andorra, POCTEFA 2007-2013.

The results of the programme are available at www.pirinoble.eu

[1] Autecology: study of the site requirements for a species.

CONTENTS

FOREWORD 2

READER'S GUIDE 4

MAPLE 8
- Sycamore
- Norway maple
- Field maple
- Other maples

ASH 20
- Common ash
- Narrow-leaved ash

WILD CHERRY 26

WALNUT 32
- Common walnut
- Black walnut
- Hybrid walnut

APPLE AND PEAR 42
- Wild pear
- European wild apple

SERVICE TREE 49
- Wild service tree
- Service tree
- Whitebeam
- Mountain ash (Rowan)

LIME 58
- Small-leaved lime
- Large-leaved lime

Autecology of broadleaved species :
Reader's guide

As part of the European Pirinoble project (www.pirinoble.eu), a synopsis was produced of studies on the autecology of the main valuable hardwoods. The results are presented in the form of species factsheet published on a regular basis in Forêt-entreprise. This "Reader's guide" explains the definitions and terms used.

With the renewed interest in hardwoods in the last 20 years, they are increasingly being introduced by planting or encouraged in natural stands. The results in terms of growth have not always met foresters' expectations due to technical problems and especially because the species are not always suited to the different sites. While the principle of establishing hardwoods is not in question, it is important to be aware of the site conditions they need for their growth.

Anyone involved in timber production needs some knowledge of autecology[1].
Favourable site conditions for hardwood trees are now better understood thanks to numerous observations carried out in stands and a few scientific studies, especially on wild cherry, service trees, common ash, maples and walnuts. However, less data are available on other species such as mountain ash (rowan), common pear, wild apple and lime trees.
The autecology factsheets for the main hardwoods (wild cherry, sorbus sp., ash and maple) are based on the available literature[2] and the expertise of the authors. They describe the **site conditions in which hardwoods will thrive and the minimum conditions required for rapid timber production**.

Geographical distribution

The maps showing the natural distribution range in Europe (EUFORGEN 2009, www.euforgen.org) were produced from the existing literature and other sources of information by members of the Euforgen network and other experts. They may therefore differ slightly from the distribution maps derived from field surveys.

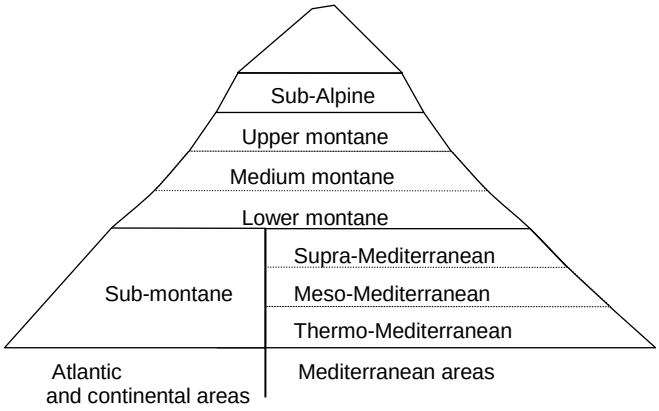
The maps showing distribution in France (IFN) were produced by the national forest inventory (IFN) based on vegetation data obtained prior to 2005 and the SOPHY database. Areas where a species is relatively common (percentage of vegetation surveys where the species is present = level of occurrence ≥ 5%) are shown in black and those where the species is present but less common (level of occurrence < 5%) are shown in blue.

The maps showing distribution in Spain were produced by the Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA) [Spanish National Institute for Agricultural and Food Research and Technology].

Climate and temperament

Bioclimatic conditions
Topoclimate: variation of the local climate resulting from a particular exposure or topographic position.

Vegetation stages
These are shown for each species using the following typology and colour code:

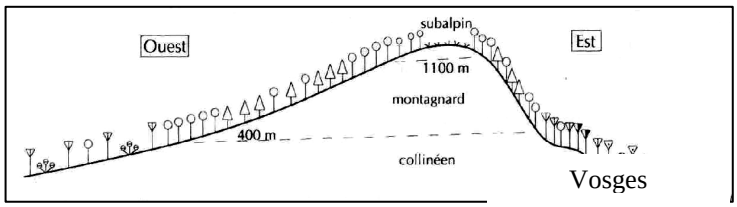


Favourable subject to the absence of other limiting factors
Tolerated under certain conditions
Unfavourable except if substantially compensated by other climatic and soil factors

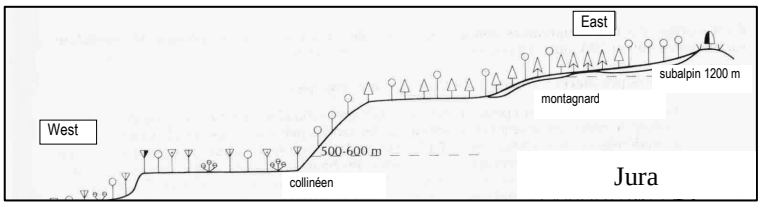
The **altitude limits** for each stage vary according to mountain areas (in connection with latitude) and exposure.

---
[1] Autecology: study of the site requirements for a species.
[2] Version of factsheets with bibliographic references available on the internet: www.foretpriveefrancaise.com and www.pirinoble.eu

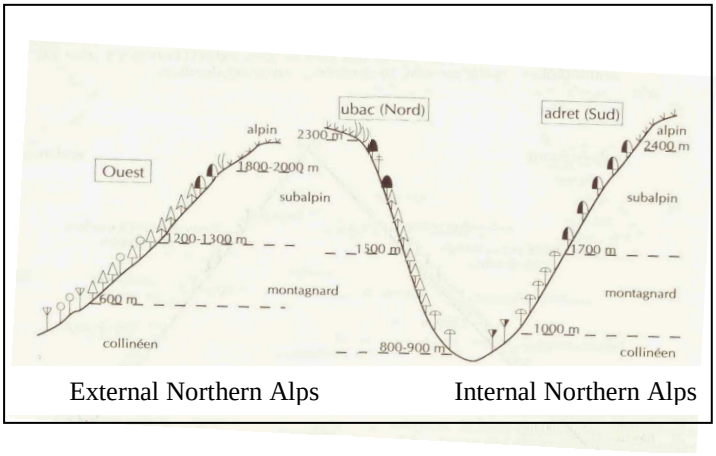
Limits of vegetation stages in French mountain areas and natural vegetation found
(According to Rameau *et al.*, 1989: FFF, vol. 2 Mountains)



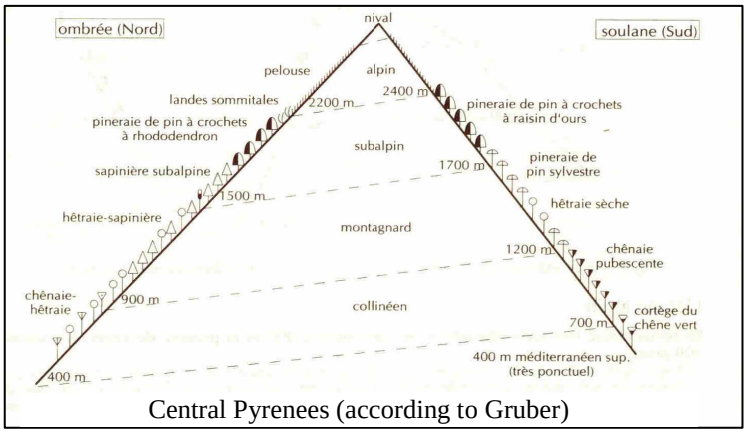
Vosges



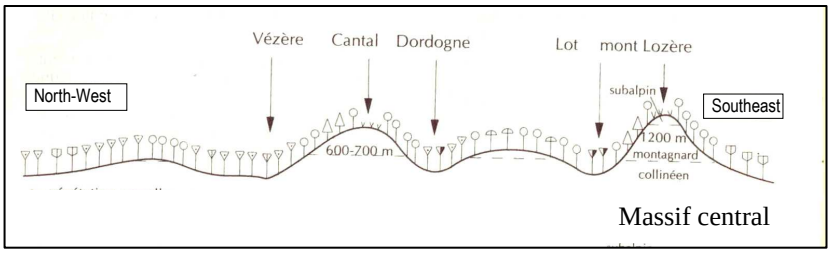
Jura



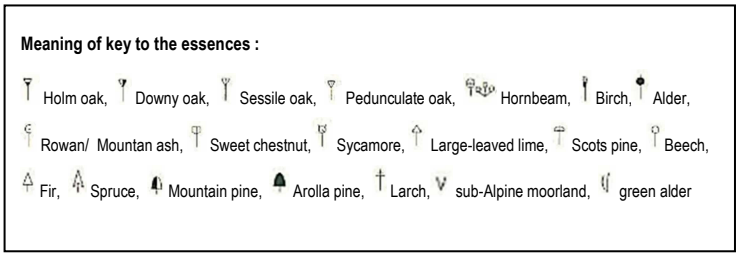
External Northern Alps Internal Northern Alps



Central Pyrenees (according to Gruber)



Massif central



Temperament

Legend:

shade tolerant species
tolerates very shady conditions
but will grow with a certain amount of light

Heliophilic species:
only grows in full sunlight

Phototropism: the organ

Climatic limits

P-ETP: the difference between rainfall and potential evapotranspiration, which determines the water demand according to climate. ETP (evapotranspiration) is usually calculated with the Penman formula, but this is difficult as a great deal of climate data is needed. The Penman –P-ETP during the growing season is calculated from 1 April to 30 October.
De Martonne aridity index: relationship between average annual rainfall and temperature according to the following formula: R / (T + 10) where R: annual rainfall in mm and T: average annual temperature in °C.
Dry month (as defined by Gaussen): a month in which the average rainfall in millimetres (R) is less than twice the average temperature (T) expressed in degrees Celsius: R < 2 T. A sub-arid month is defined as R < 3 T.

Soils

Water and drainage

Drainage and excess water

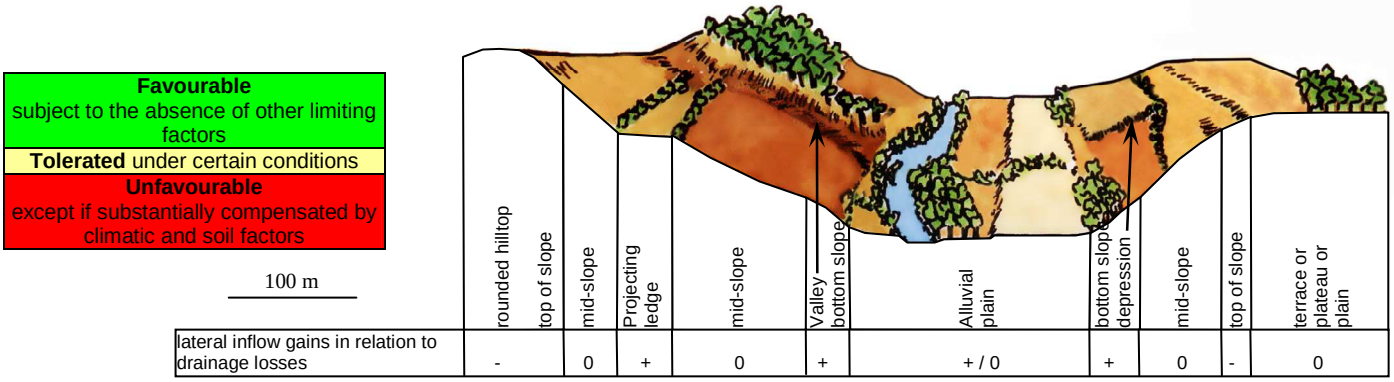
			a	b	c	d	h	i	e	f	g
definition		on loam - clay		not gleyed	slightly gleyed	moderately gleyed	heavily gleyed (temporary water table)	Very heavily gleyed (temporary water table)	heavily gleyed with reduced horizon (permanent water table)	very heavily gleyed with reduced horizon (permanent water table)	reduced (permanent water table)
		on sand	very dry	dry	moderately dry	moderately humid	humid	very humid	humid	very humid	extremely humid
Natural drainage			excessive	good	moderate	imperfect	bad	very bad	partial	virtually non-existent	non-existent
Water table	temporary	Redox horizon with rust spots	no water table	> 90cm	60-125cm	40-80cm	60-125cm	20-50cm	60-125cm	20-50cm	
	Permanent	Reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

favourable
tolerated
unfavourable

(from the Species Ecology file, Ministry of the Walloon Region, 1991, amended)

Topographical situations:

Topographical situations are specified for each species using the following typology, established for the scale of each site. The colour code differentiates the three situations according to the water supply.



Texture and materials

Key to table of textures:

Favourable, subject to the absence of other limiting factors	**Tolerated,** under certain conditions	**Unfavourable,** except if substantially compensated by other site factors

Ecogram

An ecogram (fig.1) summarises the environmental requirements of a species as regards the two main factors influencing the growth of plants:

→ **Water supply**, dependent on maximum useful soil reserves, rainfall and compensatory site factors (water containment and lateral circulation in the soil);

→ **Mineral nutrients,** related to the availability of minerals (calcium, magnesium, potassium) in fine soil and organic matter recycling.

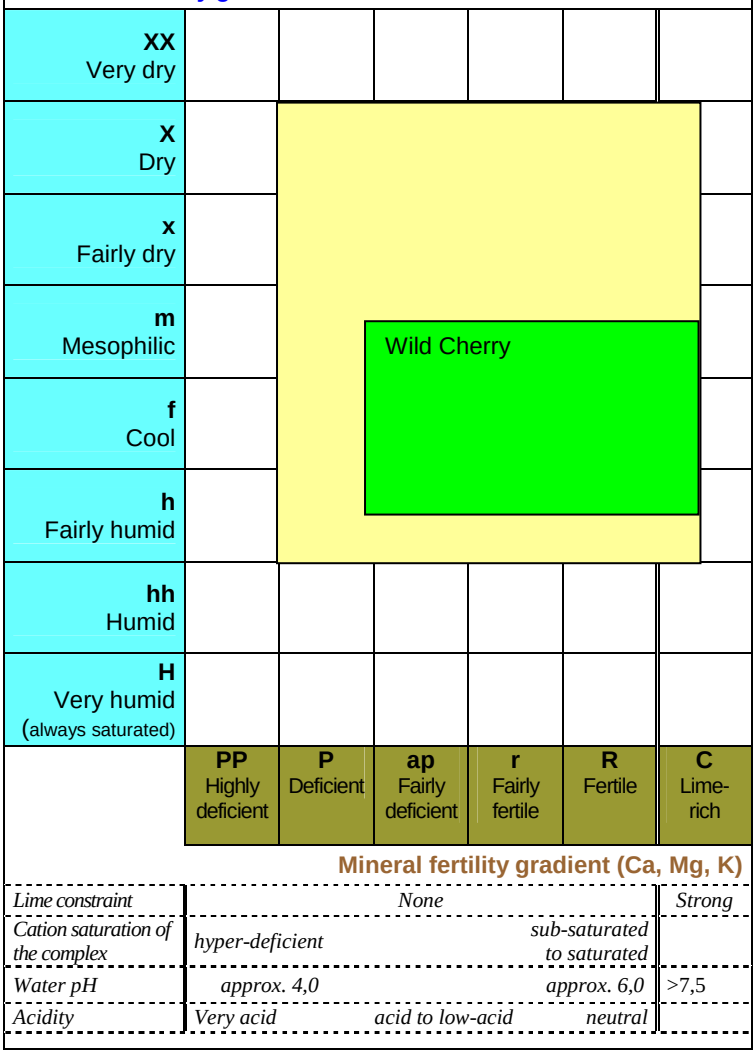
This type of representation is based on *Flore forestière française* (forest flora in France) (Rameau *et al*., 1989, 1993, 2008), with two changes made to the horizontal axis:

→ the trophic gradient no longer refers to acidity but to mineral fertility, as there is no strong correlation between acidity and nutrient availability between pH 4.5 and pH 6. We have nevertheless shown the correlation with a few significant pH values. We have also abandoned the strict relationship between forms of humus and the mineral fertility gradient because it varies with macroclimatic and pedoclimatic conditions.

→ the non-lime area is separated from the lime-rich area by a double vertical bar because a high proportion of calcium carbonate in fine soil can affect the mineral nutrition of certain tree species.

Two colour-coded zones are given for each species: green corresponds to **conditions that are sufficient to ensure fast timber production;** light yellow indicates the entire ecological range of the species and less favourable conditions for timber production, where more attention must be given to the limiting factors when planting and to the risks of failure. The ecological optimum of a species does not correspond to the centre of the green area: for example, the part on the lower right has a better water and nutrient supply. The ecological areas indicated in *Flore forestière française* have sometimes been slightly modified to take the bibliographic data into account and the species distribution compared to the trophic and water levels in national forest inventory surveys.

Figura 1 : Ecogram - the Wild cherry tree as an example



Mineral nutrition diagram

This diagram shows the nutrient levels from the soil horizon that ensures healthy growth of the species. It is based on the same model as the Adishatz "radar" graph, a computer tool developed by the Midi-Pyrénées CRPF (Regional Centre for Forest Owners) (Larrieu & Delarue, 2004) for interpreting soil analysis results and presenting them in a standardised manner. The figures (see Figure (2) are not derived from analytical results, but correspond to a graphic representation of the bibliographic data.

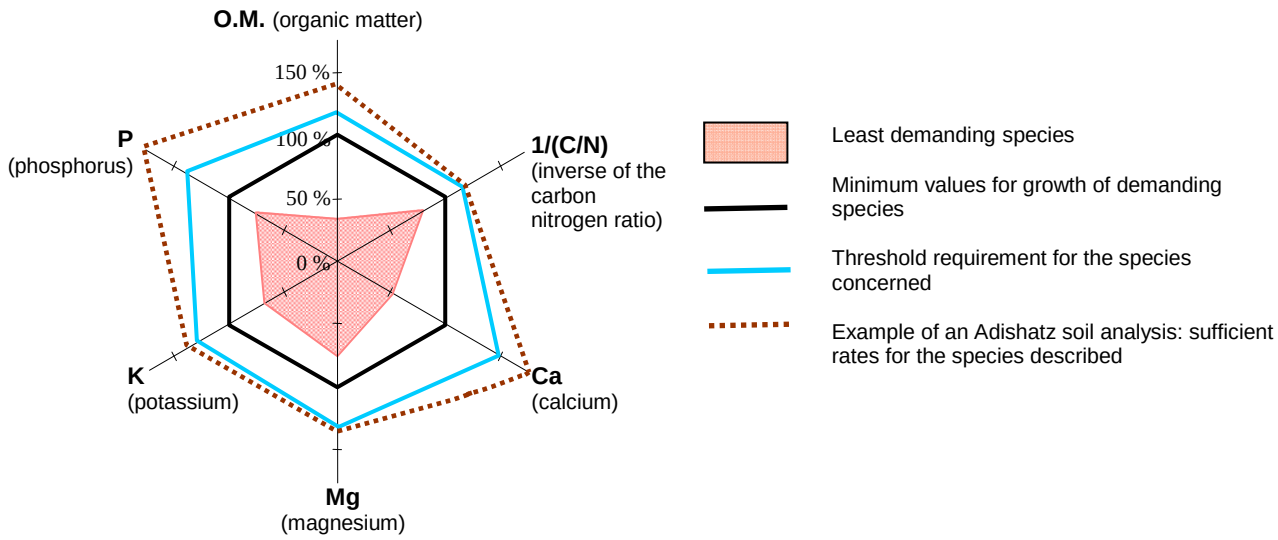
The diagram has 6 axes:

- 3 represent the fertility levels of calcium (Ca), magnesium (Mg) and potassium (K);
- 3 represent the nutrient cycle with: phosphorus intake (P), nitrogen intake represented by the functioning of the humus type (organic matter content, O.M.) and the rate of recycling and mineralisation of the litter represented by the carbon/nitrogen ratio (C/N, expressed in reverse in order to improve readability).

In figure 2, the black polygon shows the minimum nutrient levels needed to ensure healthy growth in most of the demanding species. The pink area shows the limits within which other species will grow, with the exception of the least demanding. The blue line shows the threshold requirements of the species concerned: the higher the value on a given axis, the more demanding the species for the nutrient under consideration (e.g. 140% for P indicates that the species needs 1.4 times more than the minimum for demanding species, although the threshold values should be taken as orders of magnitude because they are not derived from analytical data).

This diagram can be used to verify the suitability of the species to the site conditions by checking the Adishatz soil analysis values (brown dotted line in the example in fig.2), which must be higher than those given for the species to ensure optimum growth. The comparison must be done on a soil profile representative of the site being studied; the chemical analysis is performed for the A horizon containing organic matter and supplemented by an underlying horizon representative of the profile (analysis without organic matter). Samples should preferably be taken in a trench, at least for the upper horizons and possibly on several representative trench faces. Soil samples are taken from the entire height of the horizon, within limits – e.g. for a 30-90 cm horizon, take samples between 40 cm and 80 cm – and avoiding contamination of the sample from other horizons. Analysis may be performed for a group of several samples (from 4-5 places in the same horizon and the same type of soil) to obtain an average value over a homogeneous area. The samples should be sent to an approved soil analysis laboratory (for further details, see: Larrieu & Jabiol, *Rev. For. Fr.* LIII - 5-2001, p. 558-567).

Figure 2: Example of a mineral nutrition diagram



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■ This factsheet was produced under the European interreg 4a "Pirinoble" project (www.pirinoble.eu) involving four French and Spanish partners: CNPF - Institut pour le Développement Forestier (IDF), Centre Régional de la Propriété Forestière de Midi-Pyrénées (CRPF), Centre Tecnològic Forestal de Catalunya (CTFC), Centre de la Propietat Forestal (CPF).

■ Authors: **Laurent Larrieu (CRPF Midi-Pyrénées/INRA Dynafor), Pierre Gonin (IDF), Jaime Coello (CTFC).** Translators : **Ilona Bossanyi-Johnson** (ilona.bossanyi@wanadoo.fr), **Mark Bossanyi** (markbossanyi@gmail.com).

■ Thanks to Miriam Piqué, Teresa Baiges Zapater, Jacques Becquey, Hugues Claessens, Nicolas Drapier, Gérard Dumé, Christian Gauberville and Georg Josef Wilhelm for their French revising.

■ The reading guide is published in *Forêt-entreprise* n° 203 - 2012 and available online at www.foretpriveefrancaise.com and www.pirinoble.eu.

■ Reader's guide reference: **Larrieu L., Gonin P., Coello J.** - Autecology of broadleaved species: reader's guide. In : Gonin P. (coord.) *et al.* - *Autecology of broadleaved species*. Paris : IDF, 2013, 65 p.

Autecology of the

SYCAMORE

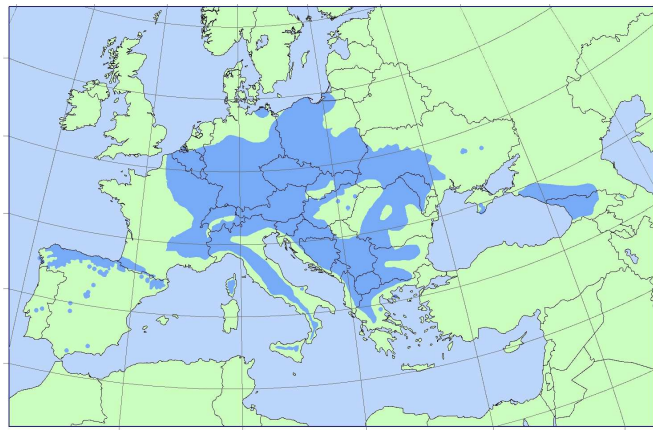
***Acer pseudoplatanus* L.**

Fr. : Érable sycomore
Sp. : Arce blanco; Cat.: Fals plàtan (Auró blanc)
Ger. : Bergahorn
It. : Acero montano

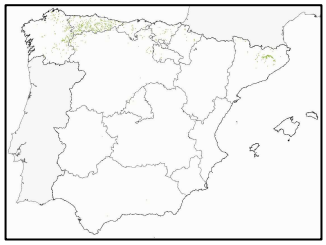
Geographical distribution

- Extensive distribution in Europe, but absent naturally in large part of western Europe and Mediterranean region [14, 9, 3].
- In France, occurs particularly in mountain areas, but can grow at sub-montane levels, especially in the north-east [14].
- In Spain, it is found in Galicia, in the Pyrenees and Cantabria [3].

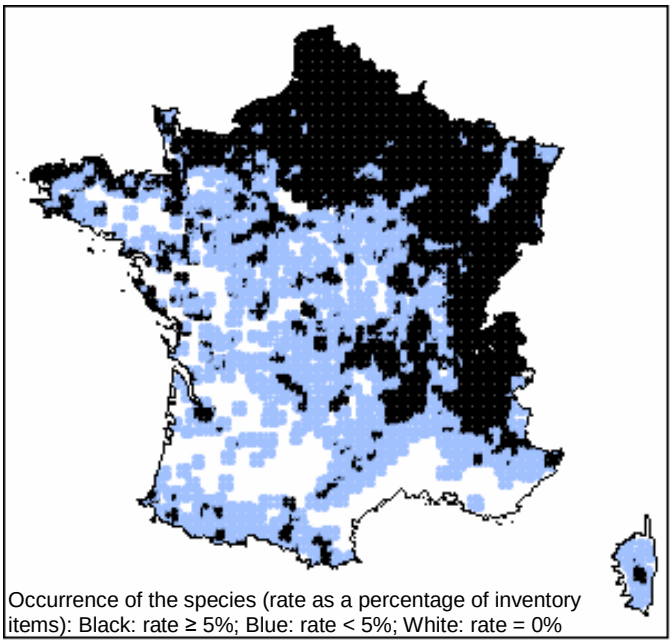
Natural distribution range of the Sycamore in Europe



Distribution of the Sycamore in Spain



Distribution of the Sycamore in France



Occurrence of the species (rate as a percentage of inventory items): Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

Climate and temperament

Bioclimatic conditions

- Resistant to cold weather [17]. Very sensitive to spring frost due to late budding (causing damage to flowers only) [9, 17, 11], and sensitive to early frost [17].
- Cool climate species [23] that can withstand hot summers [14, 26, 7] but not extreme heat [17].
- Drought sensitive [14, 3]: more so than the Norway maple but less than ash; avoid regions that have more than 2 to 3 months of drought per year [17].
- Requires abundant humidity, although a good water supply can partly compensate for dry weather [14, 23, 18, 26, 9]. Occurs where rainfall ranges from 600mm to 1600 mm/year, but requires at least 800-900 mm/year for proper growth [3, 17, 5].
- Good resistance to frost, heavy snow and wind due to the strong root system [9].

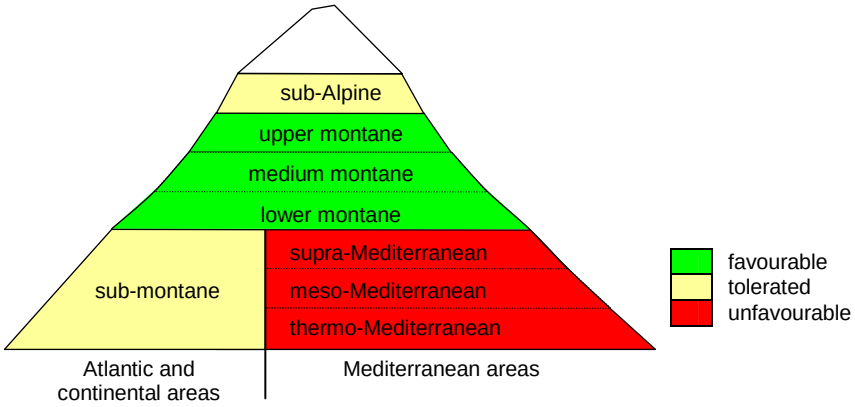
Summary of bioclimatic requirements and sensitivity of the Sycamore

Warmth requirements	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Low	Low	Low	Moderate	Low	Low	moderate to high

Vegetation stages

- Mainly a mountain species, but may be found at low altitude on cool sites and in the northern plains [14, 9] or at sub-Alpine level [23].
- Occurs in all French mountains up to 1,500–1,800 m [14, 23, 1, 9, 17].
- Occurs in Spain between 600 and 1000 m [3].

Distribution of the Sycamore by vegetation stages



Temperament

- Semi-shade species, tolerant of shade in its early stages (grows under a closed canopy for the first 5 to 7 years). Seedlings respond well to opening gaps in the canopy [14, 23, 18, 26, 9, 29, 17, 5, 11, 21].
- Adult trees are heliophilic [18, 12].
- Bark sensitive to sudden exposure to light, causing sun scald and epicormic shoots [14, 18, 26, 9, 4].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
Moderate	High

Soils

Water and drainage

Water supply:

- Prefers moderately humid to cool and humic soils [23, 28], growing best on soil with good water reserves; more demanding than the Norway maple, but less than beech or ash [18, 26, 17, 30].
- Excessively wet or dry soils are unfavourable to seedlings [9].

Waterlogging:

- Protect from excessive moisture [14, 26], especially in soils with a permanent water table close to the surface [9, 17, 15], but also avoid soils with a moderately deep temporary water table (less than 70 cm) [6].

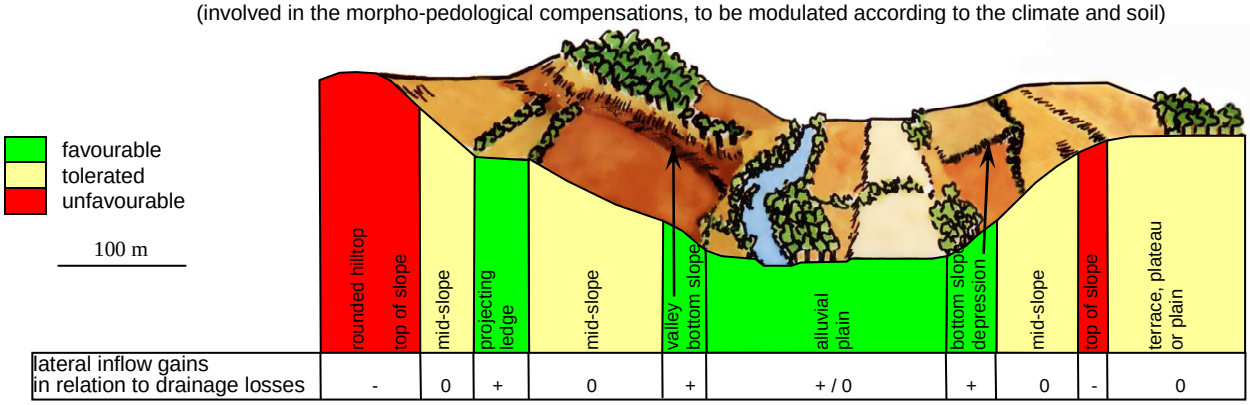
Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
Water table	permanent	reductive waterlogged horizon	no water table	-	-	-	-	-	> 80cm	40-80cm	<40cm

favourable
tolerated
unfavourable

From the Species Ecology file, Ministry of the Walloon Region, 1991, amended [18])

Favourable topographic locations for the Sycamore in terms of water supply
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)



- Cool, north-facing slopes are preferable [18, 26].
- In Spain, occurs mainly in humid valley bottoms, gorges and canyons and at the base of cliffs [5].

Texture and materials

- Sensitive to compact soils, prefers deep, friable, cool and aerated soils (> 120 cm deep) [23, 26, 9, 6, 17].
- Occurs on a variety of substrates: siliceous, lime, loam or silt [23, 9, 15], growing best on loamy, even pebbly colluvial or alluvial soils. [27] Can only grow on clay if there is proper drainage [15].

Textures favouring the growth of Sycamore

(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediary LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- Fairly demanding in terms of nutrients [14, 23, 26, 9, 12, 27, 22, 5], especially at a young age [30].
- Oligomull to carbonated eumull humus [14, 23, 9].
- Occurs on basic to slightly acidic soils (pH between 4.5 and 7.5, optimum = 5.5 to 7.5), excessively acidic soils are harmful to the growth of seedlings [18, 26, 9, 17].

Nitrogen and phosphorus:

- Requires abundant potassium and nitrogen, less calcium and magnesium [9, 15, 30].
- Tolerates a lack of phosphorus [26, 9].
- The C/N ratio does not affect growth significantly [15].

Lime in fine soil:

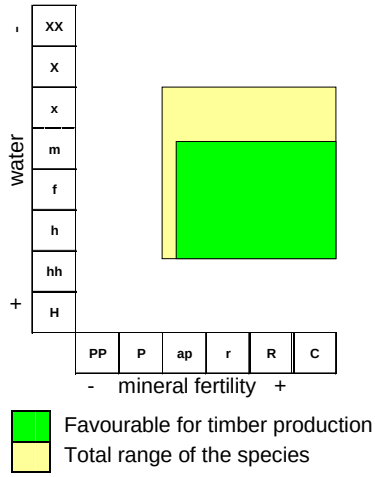
- Tolerates active lime [17], which is beneficial in the soil in small doses [26].
- Tolerates the presence of heavy metals [17].

Synthesis of water and nutrient requirements and sensitivity of the Sycamore

Water requirements	Moderate to high
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	Moderate to high
Sensitivity to lime in fine soil	Low

Ecogram for Sycamore

(according to Rameau *et al.*, 1989, amended)



Favourable for timber production
Total range of the species

DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Good growth of basal shoots [14, 13, 11].
- Vulnerable to herbaceous competition [17, 11].
- Occurs as single trees, never in pure stands, due to its vulnerability to competition [14, 9].
- Colonising species [23].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- Inconsistent water supply during the growing season
- Permanent surface waterlogging
- Slowly mineralising humus
- Atmospheric drought

Autecology of the

NORWAY MAPLE

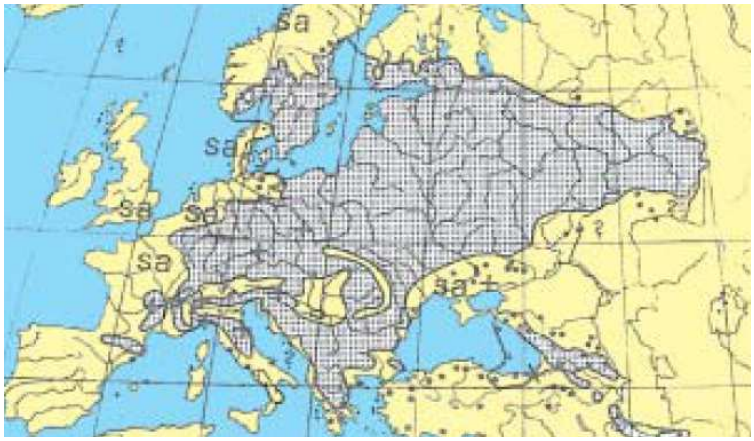
Acer platanoïdes L.

Fr. : Érable plane
Sp. : Arce real ; Cat.: Erable
Ger. : Spitzahorn
It. : Acero riccio

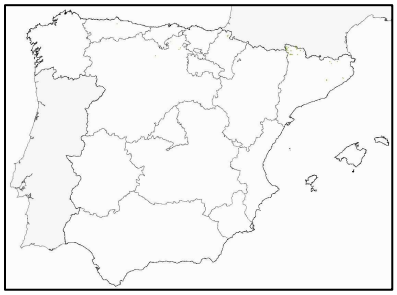
Geographical distribution

- European range, more northern, eastern and subcontinental [14, 9] than that of the Sycamore; rare in the Pyrenees [23].
- Less common than Sycamore [2].

Natural range of the Norway maple in Europe
(according to Meusel *et al.*, 1978, modified in Barengo *et al.*, 2001 [2])



Distribution of the Norway maple in Spain



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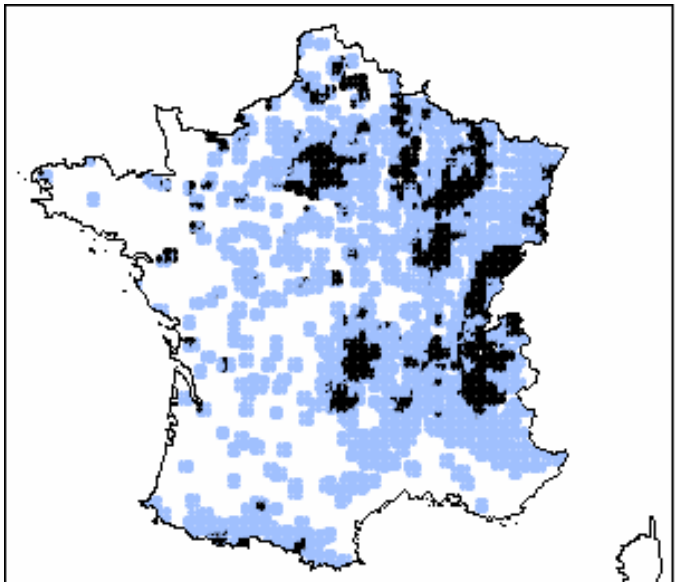
Distribution of the Norway maple in France



Occurrence of the species (rate as a percentage of inventory items): Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

© IFN

Climate and temperament

Bioclimatic conditions

- Withstands cold weather [25]. Sensitive to spring frost due to late budding (only causing damage to flowers) [9, 17]. Fairly sensitive to early frost. [17]
- Needs summer heat, but not in excess [14, 9, 2].
- Less sensitive to drought than the Sycamore [14, 12] with a broader distribution range on dry sites.
- Needs moist air [14, 26, 12].
- Good resistance to frost, heavy snow and wind thanks to strong fasciculate root system and tap roots [9, 12, 2].

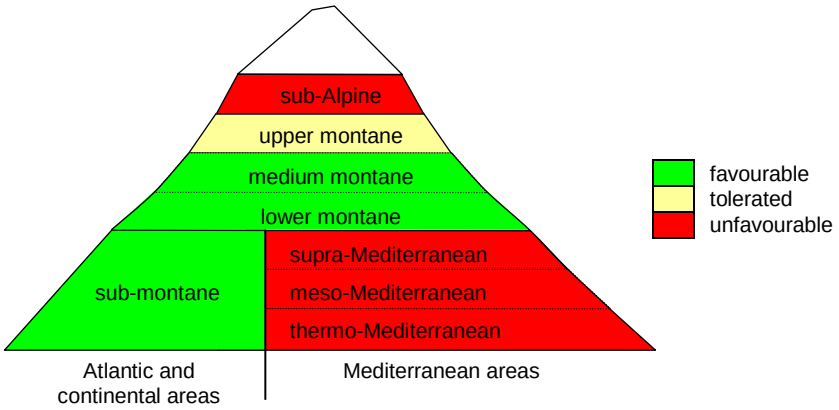
Summary of bioclimatic requirements and sensitivity of the Norway maple

Warmth requirements	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Low	Low	Moderate	Low	Low	Moderate

Vegetation stages

- Occurs in sub-montane and montane vegetation stages up to 1500 m, more abundant at the sub-montane level than Sycamore [14, 1, 9] and at lower altitudes [14, 26, 9].

Distribution of the Norway maple by vegetation stages



Temperament

- Semi-shade species, more tolerant to shade at a young age than Sycamore (seeds will germinate under a dense canopy) [14, 26, 9, 2].
- Requires light for optimum growth of mature trees [2].
- Bark sensitive to sudden exposure to light [14].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
Moderate	High

Soils

Water and drainage

- Grows in humid, cool or semi-humid [14, 28] and fairly dry conditions [23]; more tolerant than Sycamore in terms of water supply [26, 2].
- Excessively wet or dry soils are unfavourable to seedlings. [9]

Waterlogging:

- Protect from excessive moisture [14, 12], especially in soils with a permanent water table near the surface, although the Norway maple is less sensitive than the Sycamore [2]. Tolerates temporary waterlogging [12].
- Does not grow on dry filtering soils [23, 9].

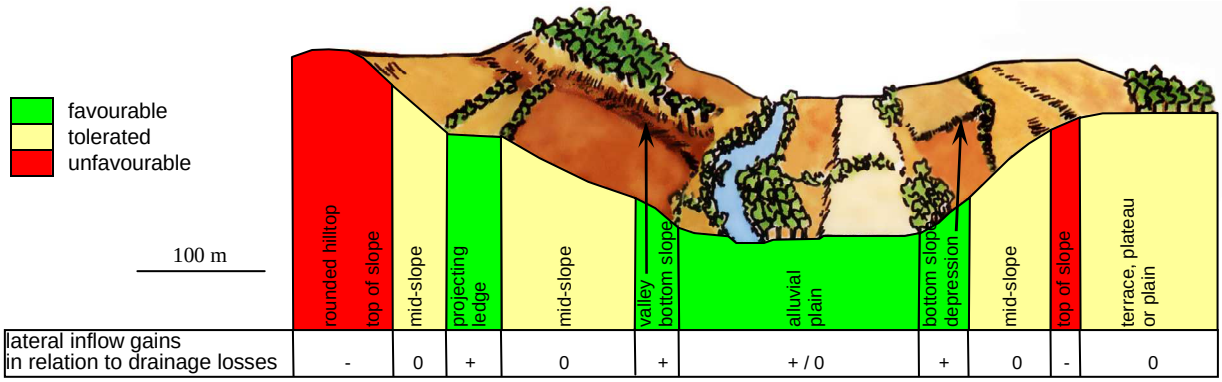
Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	<40cm

favourable
tolerated
unfavourable

From the Species Ecology file, Ministry of the Walloon Region, 1991, amended [18])

Favorable topographic locations for the Norway maple with regard to the water supply
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)



Texture and materials

- Occurs on a wide variety of substrates [2]: decarbonated clay, pebble colluvium and loam [23].

- Avoid very sandy or compact soils [26, 12].

Textures favourable to the development of the Norway maple
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediary LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

Fairly demanding in nutrients, growing less well on acidic soils, hence a smaller range than Sycamore [14, 23, 12, 2].
- Mesomull to eumull humus [14, 9].

Nitrogen and phosphorus:

- Grows best in potassium and nitrogen rich soils [23, 26].
- Tolerates phosphorus deficient soil [26].

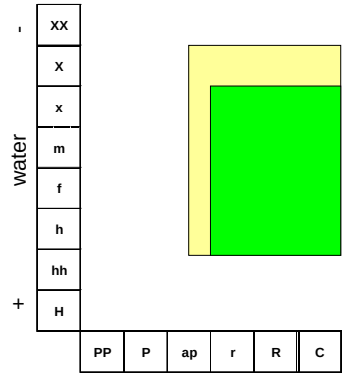
Lime in fine soil:

- Tolerates active lime, which is beneficial in the soil in low doses [26].

Synthesis of water and nutrient requirements and sensitivity of the Norway maple

Water requirements	Moderate
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	High
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soil:	Low

Ecogram for the Norway maple
(according to Rameau *et al.* 1989)



Favourable for timber production
Total range of the species

DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Good growth of basal shoots; bears fruit well [14].
- Occurs as single trees, never in pure stands [14].
- Pioneer species on humid sites or steep slopes [2].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- Inconsistent water supply during the growing season
- Permanent surface waterlogging
- Slowly mineralising humus
- Atmospheric drought

Autecology of the

FIELD MAPLE

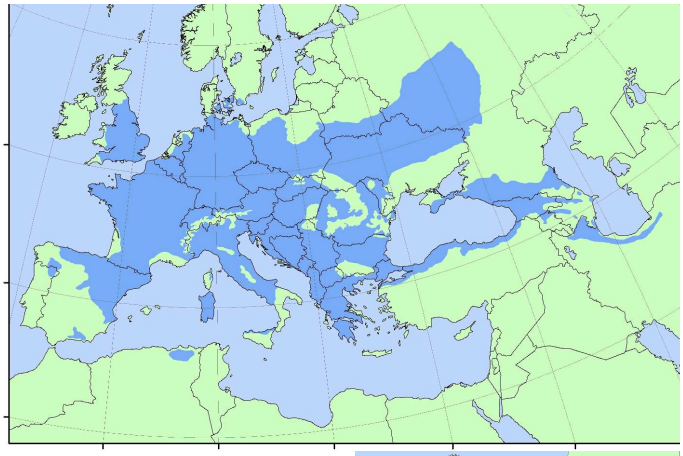
***Acer campestre* L.**

Fr. : Érable champêtre
Sp. : Arce moscón ; Cat.: Auró blanc
Ger. : Feldahorn
It. : Acero campestre

Geographical distribution

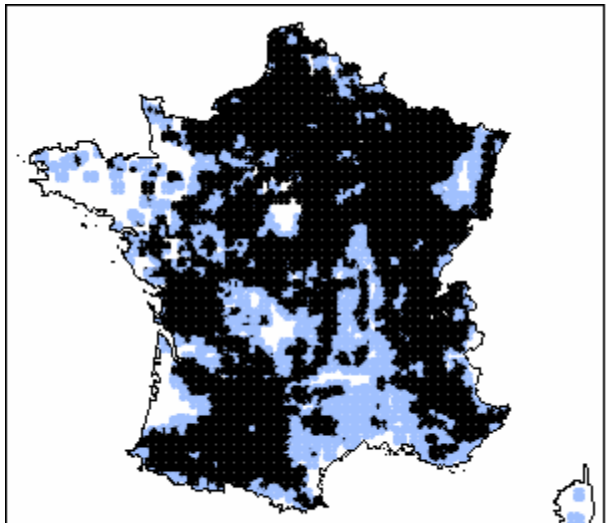
- Occurs on plains and sub-montane level in mid-Europe [14] and western Asia [9]; less common in the Mediterranean region [23] except in Mediterranean mountain areas [17].

Natural range of the Field maple in Europe



Distribution of the Field maple in Spain

Distribution of the Field maple in France



Occurrence of the species (rate as a percentage of inventory items): Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

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Climate and temperament

Bioclimatic conditions

- Very good resistance to cold [14, 17].
- Requires a sufficiently warm climate [12].
- Good tolerance to drought [14, 12], although more sensitive than the Montpellier Maple or Italian Maple [29].
- Resists wind [12].

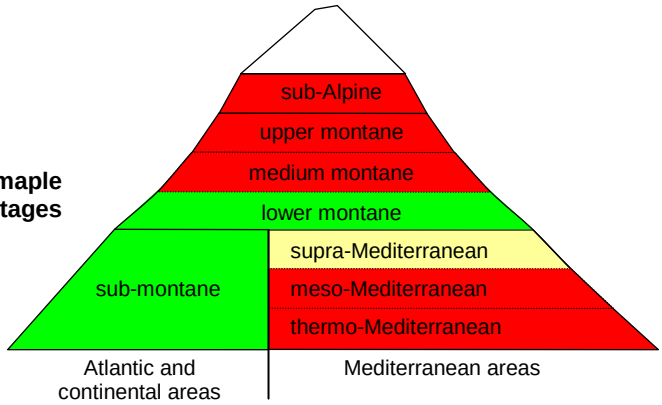
Summary of bioclimatic requirements and sensitivity of the Field maple

Warmth requirements	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Low	Low	Low	Low	Low	Low

Vegetation stages

- Occurs at low altitudes from sub-montane to lower montane [14, 12], where it is rarely found above 1,000 m [1].
- Replaced by the Montpellier Maple in the Mediterranean region [14].

Distribution of the Field maple according to vegetation stages



favourable
tolerated
unfavourable

Temperament

- Prefers full light, but tolerates shade [14, 23].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
Moderate	Moderate

Soils

Water and drainage

Water supply:

- Grows in moderately dry to temperate conditions [23].

Waterlogging: ***Drainage and excess water***

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	<40cm

favourable
tolerated
unfavourable

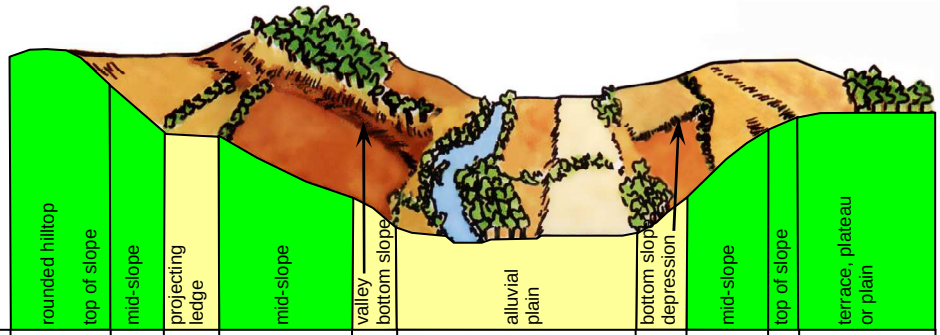
(From the Species Ecology file, Ministry of the Walloon Region, 1991, amended [18])

Favourable topographic locations for the Field maple in terms of water supply

(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

favourable
tolerated
unfavourable

100 m



	rounded hilltop / top of slope	mid-slope	projecting ledge	mid-slope	valley bottom slope	alluvial plain	bottom slope depression	mid-slope	top of slope	terrace, plateau or plain
lateral inflow gains in relation to drainage losses	-	0	+	0	+	+ / 0	+	0	-	0

Texture and materials

- On surface limestone or marl and marly limestone [14]; avoid stony soils [19].

Textures favourable to the development of the Field maple

(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediary LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- Carbonated eumull – mesomull humus [14, 23], on alkali-rich soils rich with a basic to neutral pH [23, 1].

Nitrogen and phosphorus:

- Nitrogen rich soils [23, 1].

Lime in fine soil:

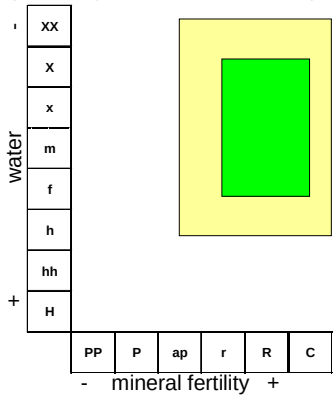
- Typically lime-loving species adapted to calcareous soils, but also occurs on soils decarbonated at the surface [14, 12].

Synthesis of water and nutrient requirements and sensitivity of the Field maple

Water requirements	Low
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soil	Zero

Ecogram for Field maple

(according to Rameau *et al.*, 2008)



Favourable for timber production
Total range of the species

DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Post-pioneer, nomadic species [14].
- Good growth of basal shoots [14].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- Permanent surface waterlogging
- Slowly mineralising humus

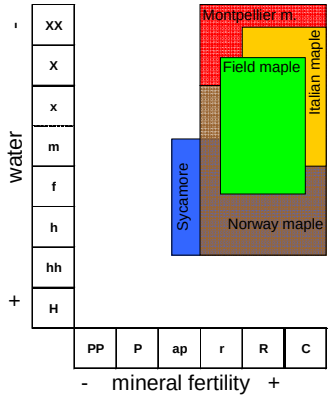
Autecology of the
ITALIAN MAPLE

***Acer opalus* Mill.**

Fr. : Érable à feuilles d´Obier
Sp. : Acirón; Cat.: Rotaboc

Ger. : Italienischer Ahorn
It. : Acero opalo

Ecogram for Maple species
Favourable for timber production
(according to Rameau *et al.*, 1989, 2008, modified)



Species centred in the western Mediterranean [14]. Occurs in the foothills and lower slopes of southern mountain ranges (Pyrenees, Cevennes, Alps), extending north up to the Jura Mountains and Burgundy, from supra-Mediterranean to montane stages [14, 23, 9, 12].
Key features:
- Resistant to heat and summer drought (thermophilic species);
- Fairly resistant to cold, but prefers mild climates; fairly sensitive to frost [12];
- Lime-loving species;
- Mesoxerophilic species occurring in soils that dry frequently and soils with a slight water balance deficit [28];
- Full light or semi-shade species.

Autecology of the
MONTPELLIER MAPLE

***Acer monspessulanum* L.**

Fr : Érable de Montpellier
Sp : Arce de Montpellier; Cat.: Auró de Montpellier

Ger : Französischer Ahorn
It. : Acero minore

Occurs in southern Europe, western Asia and northern Africa and around the Mediterranean [14, 9, 12]. Supra-Mediterranean species occurring on hills and lower mountain slopes around the Mediterranean [14, 23, 9, 12] and at the sub-montane level in suitable sites.
Key features:
- Heat and light demanding; withstands cold very well;
- Mesoxerophilic to xerophytic species, very resistant to drought, occurring in shallow, dry, aerated soils [28];
- Occurs on lime-rich alkaline soils;
- Avoid acidic, heavy and clay soils and cold, wet sites [12].

■ This factsheet was produced under the European POCTEFA 93/08 "Pirinoble" project (www.pirinoble.eu) involving four French and Spanish partners: CNPF - Institut pour le Développement Forestier (IDF), Centre Régional de la Propriété Forestière de Midi-Pyrénées (CRPF), Centre Tecnològic Forestal de Catalunya (CTFC), Centre de la Propietat Forestal (CPF).

■ Authors: **Marine Lestrade (CRPF Midi-Pyrénées), Pierre Gonin (IDF), Jaime Coello (CTFC),** with contributions from Eric Bruno (IGN) for the French distribution maps. Translators : **Ilona Bossanyi-Johnson** (ilona.bossanyi@wanadoo.fr), **Mark Bossanyi** (markbossanyi@gmail.com).

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■ Factsheet references: **Lestrade M., Gonin P., Coello J.** – Autecology of the Sycamore (*Acer pseudoplatanus* L.), Norway maple (*Acer platanoides* L.), Field maple (*Acer campestre* L.) and other Maple species. In : Gonin P. (coord.) *et al*. - *Autecology of broadleaved species*. Paris : IDF, 2013, 65 p.

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Autecology of the

COMMON ASH

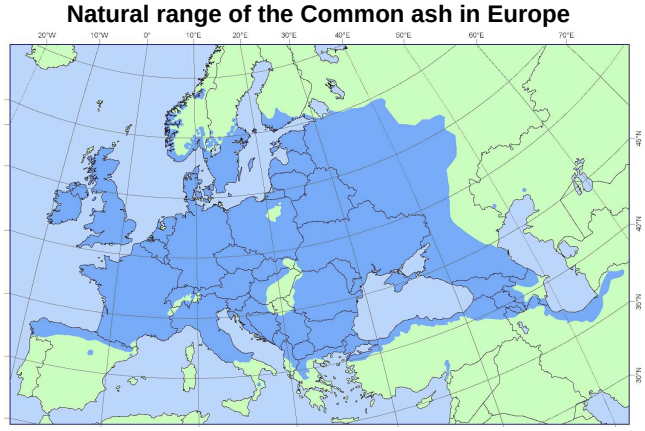
Fraxinus excelsior L.

Fr. : Frêne commun
Sp. : Fresno Común; Cat.: Freixe de fulla gran
Ger. : Esche
It. : Frassino maggiore

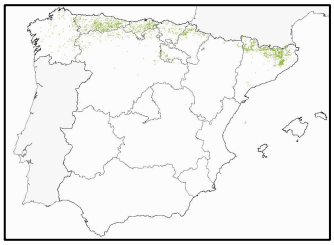
GEOGRAPHICAL DISTRIBUTION

- **European species extending into Sub-Atlantic areas** [28, 27].
- Occurs **throughout France, less common in the Mediterranean region** [27]; occurs in **Spain,** mainly in the **North** of the country.
- Area of stands in France = **583 000 ha** (NFI data, 2005-2009, main species Fraxinus, all species together, but mostly Common ash).

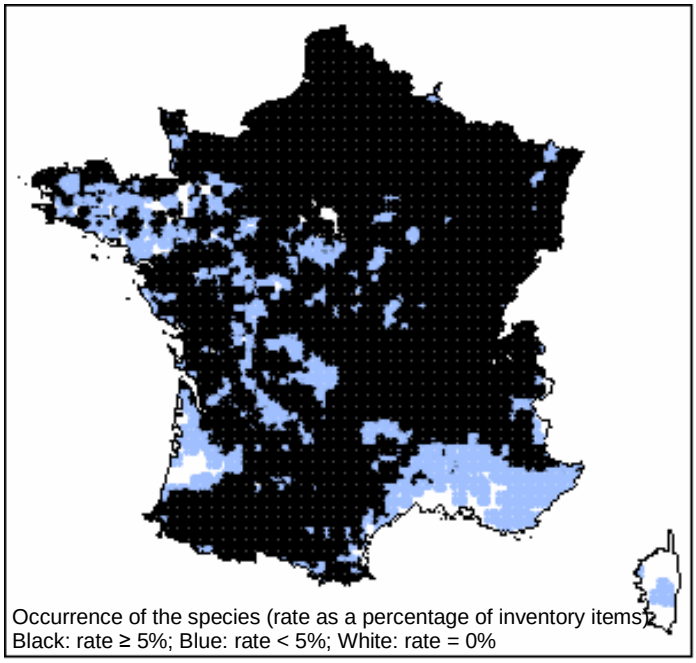
Natural range of the Common ash in Europe



Distribution of the Common ash in Spain



Distribution of the Common ash in France



CLIMATE AND TEMPERAMENT

Bioclimatic conditions

- Not sensitive to winter cold [31, 14, 1].
- In mountain areas, mild temperatures at the start of the growing season positively affect growth [15].
- **Sensitive to spring frosts** [31, 28, 22, 14, 1] causing forks [24, 2].
- Poor growth when average annual temperatures < 5.6 ° C [17].
- **Demands abundant water** [28, 19, 22, 2], particularly in May and June [31]; **sensitive to atmospheric drought** [28, 14].
- **Sensitive to the drying action of wind** [31, 14].
- **In Spain,** demands **annual average rainfall > 700 mm** [21, 2, 1].

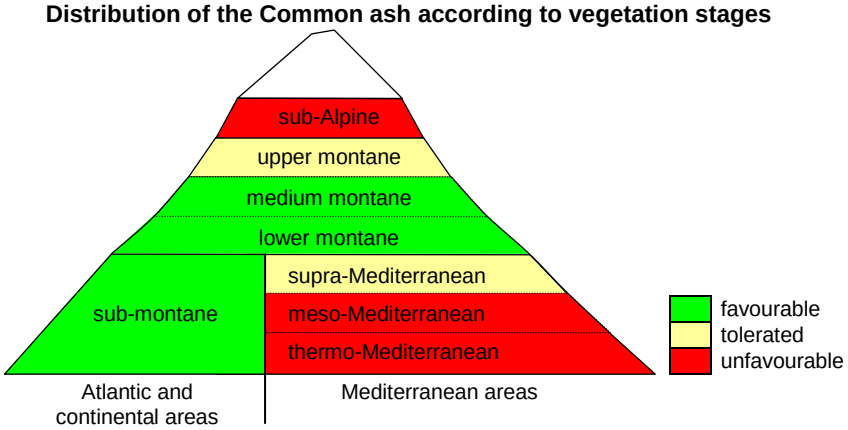
Summary of bioclimatic requirements and sensitivity of the Common ash

Warmth requirements	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Very low	Very high	Very low	Very high to high	High	Very high to high

Vegetation stages

- Occurs from the **sub-montane** to the **upper montane** stage (400 to 1800 m) [28, 27, 14, 2, 13, 1].

Distribution of the Common ash according to vegetation stages



Temperament

- **Heliophilic** [30, 31, 28, 27, 22, 14, 2, 13, 1].
- Shade-tolerant in the first years [30, 31, 28, 22, 14, 25, 2, 1].
- **Vulnerable to competition** when adult [14, 4].
- Reported **sensitivity to strong lateral light** that appears to cause bark necrosis [14].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
High	Moderate

SOILS

Water and drainage

Water supply:

- Essential growth factor [12, 19, 7, 5, 3, 9, 14, 2, 32].
- **Needs soil with a good water supply** for sustained growth (thick soil with a high maximum useful reserve) [28, 7, 9, 14, 8, 1]. Occurs on dry soil but smaller in size and less productive [31, 27, 10, 32].
- **Topographic** position ensuring a lateral water supply [12199, 14, 4, 10] or presence of a permanent **water table** [9, 8, 10] significantly increase growth.
- **Very vulnerable to interruptions in the water supply** [3, 14] which cause forking [24]; delays in regulating transpiration [3, 5].

Waterlogging:

- Prefers **well-drained soils** [31, 7, 22, 14, 2, 13, 1].
- Occurs on temporarily flooded ground or permanently flooded areas around springs [10], but **waterlogging very close to the surface reduces growth** [28, 12] and may even prevent growth [9, 10] in marshy conditions.
- Waterlogging promotes black heartwood [7, 9].

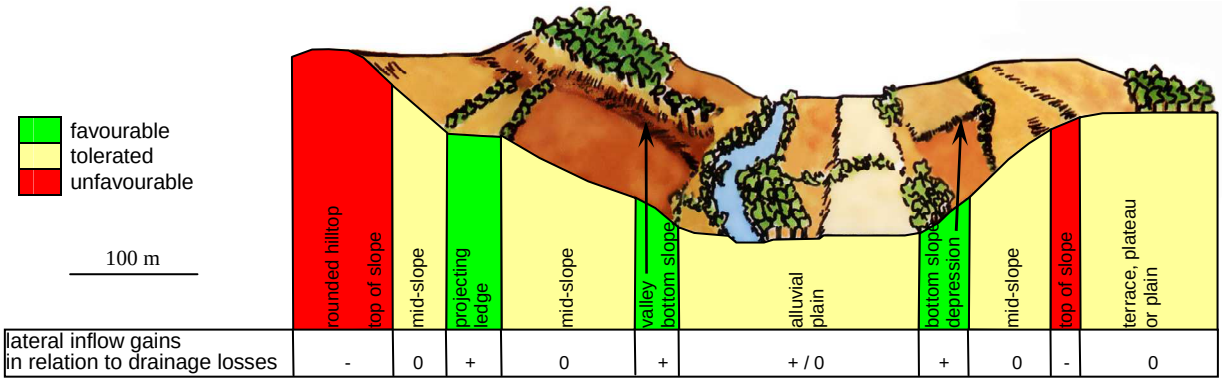
Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

favourable
tolerated
unfavourable

(from the *Species Ecology* file, Ministry of the Walloon Region, 1991, amended [20])

Favorable topographic situations for the Common ash with regard to water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- Materials favouring **good water retention** [28, 7, 2722, 14, 13, 1] and poor in coarse components.

Textures favourable for growth of the Common ash
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediate LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- This growth factor is less crucial than the water supply [121914, 21, 2, 1].
- Occurs over a **wide pH range** from 3.8 to 7.8 [16, 9]. However, **growth is very poor on very acid soils** [31, 28, 19, 8, 1] due to the sensitivity of the species to aluminium toxicity, which causes root necrosis [33].
- Adult tree growth limited by availability of K [15].
- Juvenile growth depends on availability of Ca and Mg [33].

Nitrogen and phosphorus:

- Humus in mull form. Ash tree litter has a low C/N ratio [16, 22, 14].
- Growth depends mainly on the availability of **nitrogen** [16, 28, 17] associated with phosphorus [18, 20].

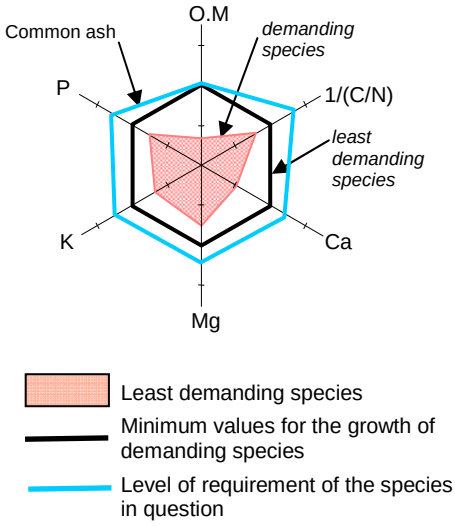
Lime in fine soils:

- **Appears unaffected** unless the concentration is very high [9].

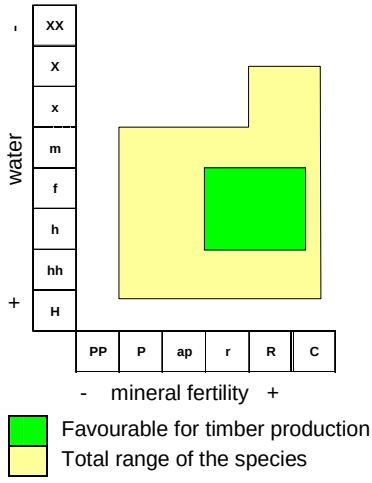
Summary of water and nutrient requirements and sensitivity of the Common ash

Water requirements	Very high
Sensitivity to temporary waterlogging	Moderate
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	High
Sensitivity to lime in fine soil	Low to zero

Mineral nutrition of the Common ash



Ecogram for the Common ash
(According to Rameau *et al*., 1989, amended)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- **Nomadic species with a pioneer temperament** [30, 31, 25].
- Good growth of basal shoots
- Life span about 150 to 200 years [27]. Timber harvesting recommended at **less than 60 years** to **minimise black heartwood** [9]. In areas favourable to production, ash trees can reach 180 cm in circumference in 60 years [99.
- Common ash is easily established because the seedlings can develop a dense and robust root system [17] even in poor light.
- In 2008, ash dieback appeared for the first time in north-east France, linked to the fungus *Chalara fraxinea*. This is an ash tree parasite in North-Eastern Europe, causing twig die-back followed by necrosis and leaf wilt on the branches, and even crown dieback [23]. Particular attention should be paid to the spread of this so far little-known disease.

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- Inconsistent water supply during the growing season
- Permanent waterlogging in surface horizons
- Slowly mineralizing humus
- Presence of exchangeable aluminium
- Nutrient-poor soils
- Heavy snow
- Late frost
- Atmospheric drought

Autecology of the
NARROW-LEAVED ASH

Fraxinus angustifolia Vahl

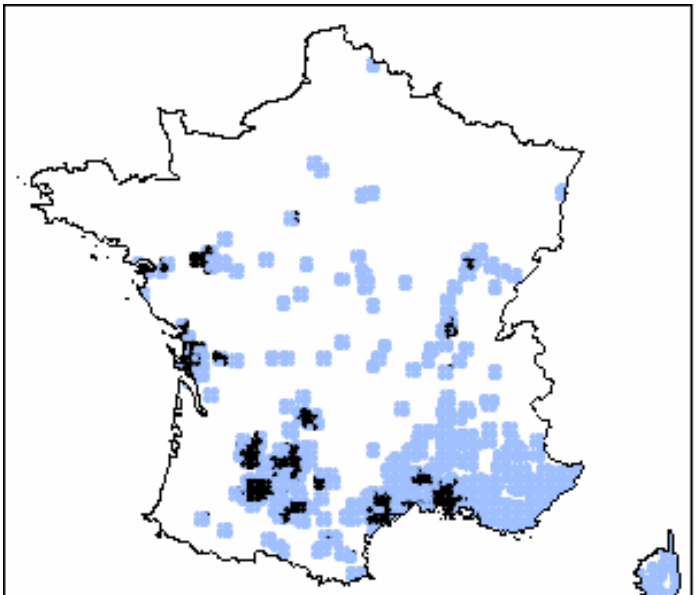
Fr. : Frêne oxyphylle
Spa. : Fresno de hoja estrecha
Cat. : Freixe de fulla petita
Ger. : Schmalblättrige Esche
It. : Frassino meridionale

- A **Supra-Mediterranean species** [27, 1].
- Occurs in **France at heights of up to 300 m** in the **Mediterranean** region and in **south-west France** at sub-montane, supra-Mediterranean and meso-Mediterranean stages, less common in the north of France [27]
- Occurs throughout **the Iberian Peninsula, except in the mountains** and along the upper reaches of rivers in the northern third of the country, where it is replaced by the Common ash.

- Thermophilic [27], occurs where average rainfall is >450 mm/year [21]; **not susceptible to summer drought** provided that there is a good **water supply** in the soil [21, 1]; **not susceptible to winter cold** [21].

- **Susceptible to waterlogging** [11; prefers soils with sandy textures [21, 1]; rarely occurs on highly acidic soils [27].
- Like Common ash, this species can be affected by ash dieback disease [23].

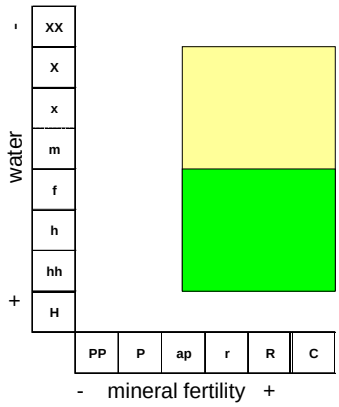
Distribution of the Narrow-leaved ash in France



Occurrence of the species (rate as a percentage of inventory items)
Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

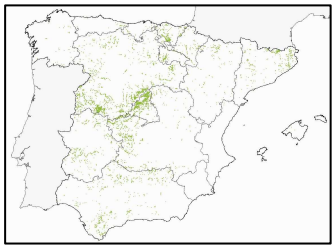
© IFN

Ecogram of the Narrow-leaved ash
(According to Rameau et al., 1989, amended)



Favourable for timber production
Total range of the species

Distribution of Narrow-leaved ash in Spain



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European Union
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Autecology of the

WILD CHERRY

***Prunus avium (L.)* L.**

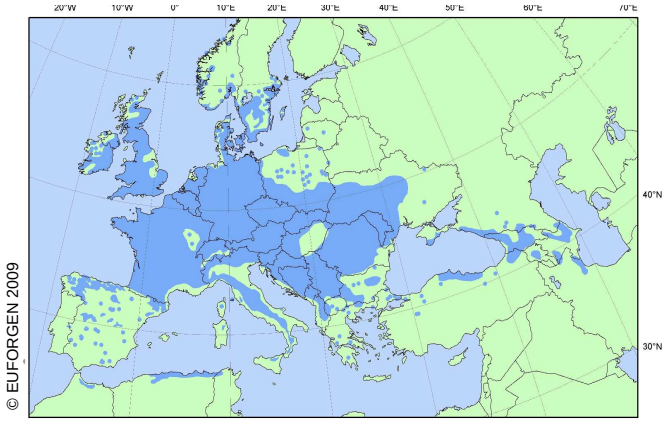
Fr: : Merisier
Sp. : Cerezo; Cat.: Cirerer

Ger. : Vogelkirsche
It. : Ciliegio

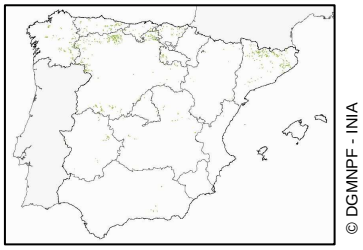
GEOGRAPHICAL DISTRIBUTION

- **Eurasian** species extending into **Sub-Atlantic** areas [23].
- Area of production stands in France = **51,000 ha** (IFN data, 2005-2009, Wild cherry, main species)

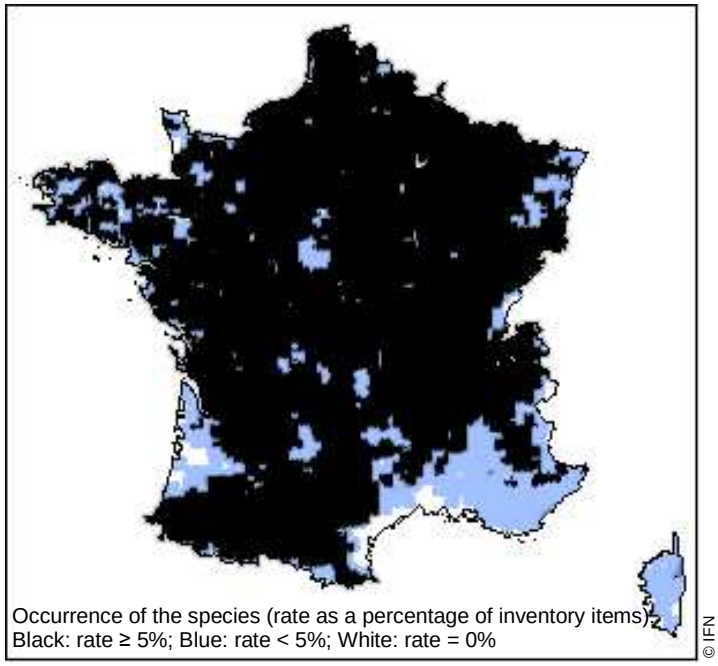
Natural range of the Wild cherry in Europe



Distribution of the Wild cherry in Spain



Distribution of the Wild cherry in France



Occurrence of the species (rate as a percentage of inventory items)
Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

Climate and temperament

Bioclimatic conditions

- Thrives in the **temperate and humid climates of oceanic and continental regions, less common in the Mediterranean region** where it is limited to cooler areas better supplied with water [20, 23, 7, 10].
- Moderately demanding in terms of total annual rainfall and atmospheric humidity, provided that the overall water balance of the soil remains favourable [11, 5, 32], at least in North and East France, but with a minimum of 600-700 mm of rainfall evenly distributed over the year [25, 17, 7]. **Sensitive to summer droughts** [17, 1] with a risk of premature leaf drop [27]; risk of cryptogamic (fungal) diseases (cylindrosporium, etc.) in humid atmospheric conditions [30].
- No geographical individualisation of cultivars in France [24].
- **Requires warmth** [6, 27, 30] and prefers warm topoclimates in harsh climates [18, 6, 5, 29].
- **Fairly resistant to cold** [19, 13, 31, 5, 27, 17, 20, 25, 7, 30]; frost crack and freezing of shoots infrequently [6, 30] but there is a risk of flowers freezing [5, 8, 30].
- **Sensitive to sticky snow** [13, 6, 11, 5] or **ice** [5] causing the tops to break.
- **Fairly sensitive to wind on thin soils** [28, 11, 32].

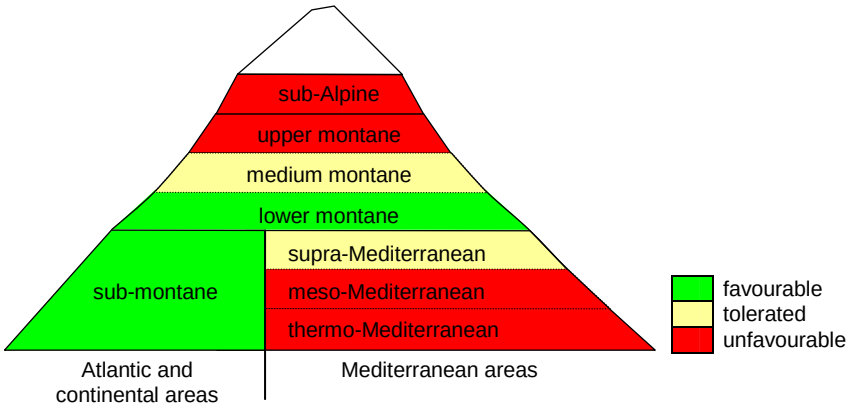
Summary of bioclimatic requirements and sensitivities of the Wild cherry

Warmth requirements	Sensitivity					
	cold	late frosts	early frosts	sticky snow	wind	drought
High	Very low	Low	Low	High	High to moderate	High

Vegetation stages

- Occurs mainly in sub-montane [10] and montane stages, where it can reach 1700 m [23, 20, 9]; optimum growth no higher than the lower montane stage [15, 5.29].

Distribution of the Wild cherry according to vegetation stages



Temperament

- This species is tolerant of shade at a young age, but needs more light in the adult phase [12, 27, 25, 17, 33, 7], hence occurring more frequently on forest edges (some, however, consider it as a partial shade species [23, 6, 11] favoured by lateral shade [13], whereas others consider it as a light-demanding species as from its earliest stages [15, 31, 21, 11, 22], which no doubt relates to the regional climate).
- **Scattered, non-social** species [11, 12].
- **Sensitive to competition,** which greatly reduces its growth rate and affects its straightness (slightly phototropic species) [11, 7].
- **Trunk sensitive to sun scald**, especially on the west side [11, 5].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
High	Moderate

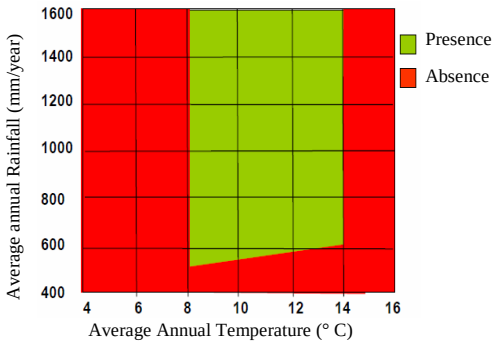
Climatic limits

(Lemaire J., comm. pers., 2011; calculated over the period 1960-90 from its natural European distribution as established by Euforgen)
Climatic limits on occurrence of the species in the absence of other limiting factors

Temperature: Average annual: 8 to 14 ° C
Absolute daily minimum: - 29 ° C
Absolute daily maximum: 41 ° C

P - FTE Penman during the growing season >- 400 mm
P - FTE Penman absolute minimum during the growing season: - 600 mm
Absolute minimum **de Martonne index**: 14
The Wild cherry is absent if there are at least 3 dry months (R < 2 T) or at least 4 sub-arid months (R < 3 T)

Climate limits of the Wild cherry
(Presence of the species if there are no other limiting factors)



Soils

Water and drainage

Water supply:

- Ground with **a significant water reserve** is needed [19, 4, 13, 18, 23, 21, 10, 6, 11, 29, 16, 9, 32]; **favourable topographic** position [5, 30]; a **demanding species** [15] optimally grown on cool sites with ample but not excessive water [3, 33, 30, 1].

Waterlogging:

- This species is **sensitive to poor root oxygenation**, even over short periods [23, 21, 11, 5, 29, 32, 33, 30, 1], especially in superficial horizons [13, 2], at less than 40 cm [26, 5, 8, 30], which can also hamper plant recovery [6] or result in windfall if waterlogged at a depth of less than 60-80 cm [30]. Waterlogged and highly compact soils and those with low water reserves are unfavourable conditions for the timber (butt rot) [19] and render the Wild cherry susceptible to cryptogramic diseases [11].

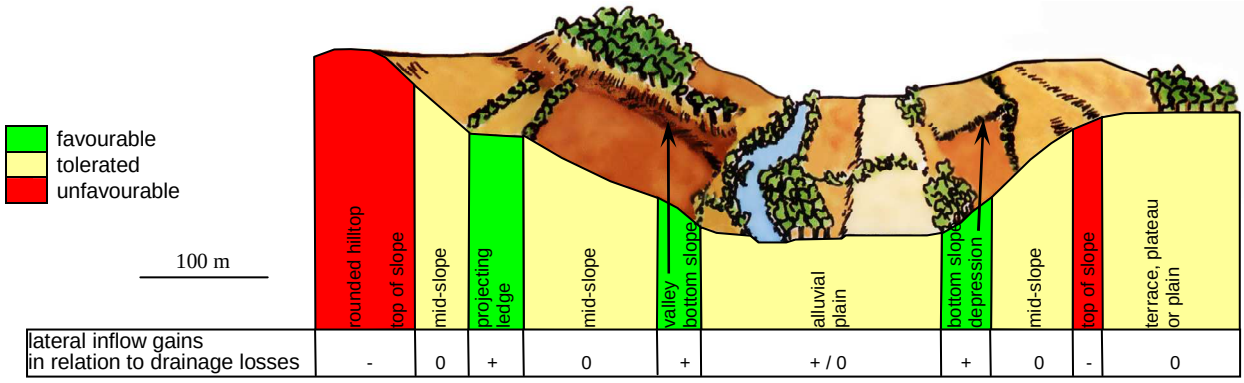
Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	<40cm

favourable
tolerated
unfavourable

(from the *Species Ecology* file, Ministry of the Walloon Region, 1991, amended [21])

Favorable topographic situations for the Wild cherry in terms of water supply
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)



Texture and materials

- Occurs on pure or stony silt or clay [23], optimum growth on **thick silt** [26, 14, 8, 9] at least 40 to 80 cm thick [17, 25, 32, 33]. Clay can be unfavourable if the porosity is low [30]; sensitive to significant variation of texture at less than 40-50 cm [6] or to the occurrence of a poorly structured argillaceous level with no transition [13]; risk of root breakage on swelling clays [14].
- **Very sensitive to compaction** [5] and **high soil compactness** [21, 10, 11, 30]; prefers **well-structured soils [28, 11].**

Textures favourable to the development of the Wild cherry
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)

very sandy S	coarse SA, LS, SL	silty LmS, Lm, Ll, LlS	intermediate LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- Species occurs over a **wide pH** range between 4.5 and 7.5 [28, 6, 26, 5, 32, 33], with **optimum** growth **on sites that are chemically rich enough** [3]. It is therefore considered as a demanding species for timber production [13, 23, 10, 29, 30]; not to be planted in poor soils [5, 24] where its occurrence is exceptional [30].
- French cloning tests show that the growth rate does not depend on soil pH, hence the adoption of a single region of origin in France [8: 24].

Nitrogen and phosphorus:

- Fairly demanding species, especially of **nitrogen** (mull humus) [15, 13, 31, 21, 10, 11, 29, 5, 9], with optimum growth on **eumull soils** characterised by complete decomposition of the litter over the year [3].

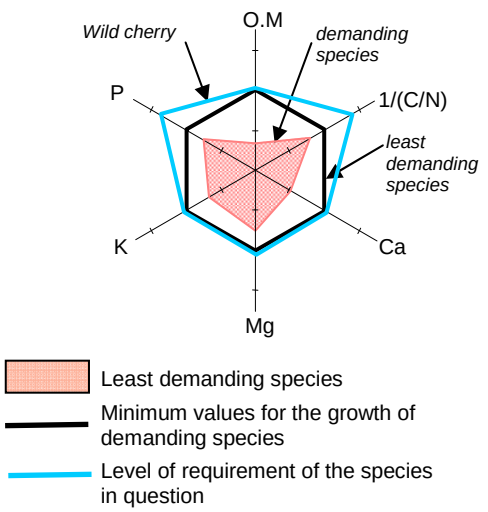
Lime in fine soil:

- The species is **not affected by low lime content** [31, 11, 16] and can be considered as totally independent in this respect [19, 28, 6, 2, 32].

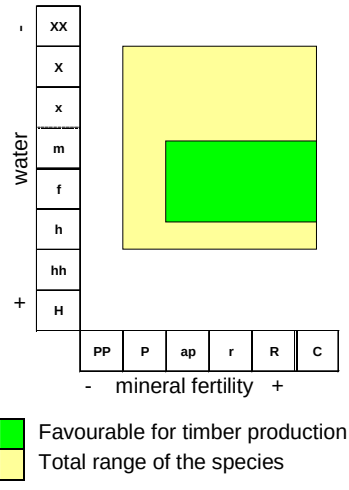
Summary of the water and nutrient requirements and sensitivity of the Wild cherry

Water requirements	High
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	Average
Nitrogen (and phosphorus) requirements	High
Sensitivity to lime in fine soil	Low to zero

Mineral nutrition of the Wild cherry



Ecogram for the Wild cherry
(according to Rameau *et al.*, 1989, modified)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- **Post-pioneer** species [23].
- Good ability to **create basal shoots** [24].
- Lifespan of about 150 to 200 years [23, 27]. Trees should be harvested **before they reach 80 years** to prevent timber deterioration [27, 30]. For sites favourable to production, the growth rate is enough to produce trees of 150-180 cm circumference in 50-65 years [3, 5], or even 80 years [27].
- Risk of **uprooting on thin soils [**11] or on soils waterlogged near the surface.
- One of the most limiting factors for the production of precious timber is **green vein**, typically localised in tension wood and linked to ecological and genetic factors [27] as well as temporary drought [comm. (J). Coello].

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MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- water supply disruption during the summer; this species is sometimes abundant in dry, fertile sites, but cannot produce high-quality timber in such locations.
- excessive water near the ground surface (less than 60 cm) during the growing season, even for short periods
- low porosity, poorly structured and clayey soils or with abrupt changes in texture
- slowly mineralizing form of humus (moder and mor)
- soil too poor in nutrients
- frost and heavy snow
- trunk sensitive to sun scald (especially in unprotected forest edges exposed to the west or south-west)

■ This factsheet was produced under the European POCTEFA 93/08 "Pirinoble" project (www.pirinoble.eu) involving four French and Spanish partners: CNPF - Institut pour le Développement Forestier (IDF), Centre Régional de la Propriété Forestière de Midi-Pyrénées (CRPF), Centre Tecnològic Forestal de Catalunya (CTFC), Centre de la Propietat Forestal (CPF).

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Autecology of the

COMMON WALNUT

***Juglans regia* L.**

Fr. : Noyer commun
Sp. : Nogal Común; Cat.: Noguer comu
Ger. : Echte Walnuss
It. : Noce bianco

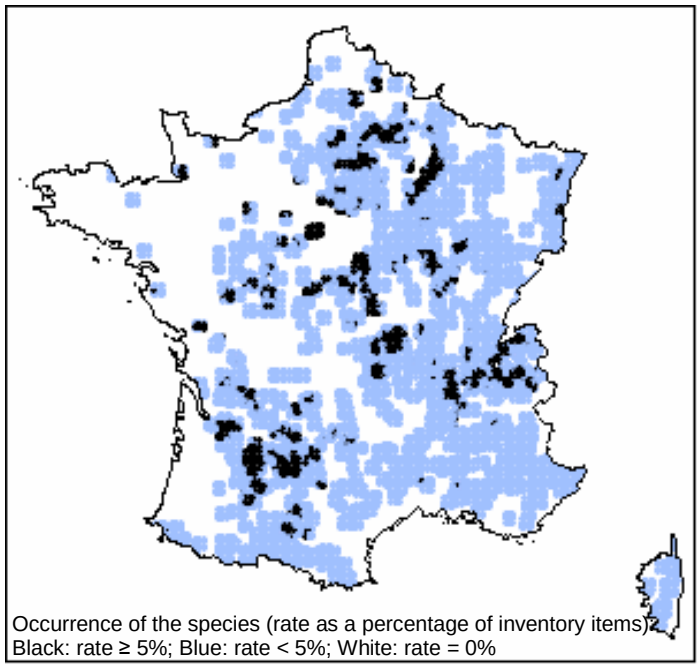
GEOGRAPHICAL DISTRIBUTION

- Species originated in the Balkans [30]; Asia Minor [2] and Persia [10].
- Occurs naturally south of the Caspian Sea and in the southern Caucasus, and extends to Turkey, Bulgaria, Greece, Yugoslavia [22] and as far as China [9, 24].
- **Introduced into Europe in classical times** [30].

Area of origin of the Common walnut in Europe
(Krussmann, 1979, as amended [5])

Distribution of the Common walnut in Spain

Distribution of the Common walnut in France



Statistics for France:
- Area planted with Common walnut = 20 117 ha (Agreste, 2007).
- Volume of Common walnut in production forests as surveyed in 1996 (NFI): 423,153 m^3 (2 021 300 trees). Together with trees surveyed in other woodlands, planted rows, hedges, etc., and single trees, and in the dual-purpose walnut groves in Isère (119,000 m^3), the total number of trees amounts to 4.5 - 5 million [7].
- Volume of marketed timber: 100,000 m^3/year at the beginning of the last century; 20,000 m^3/year in the early 1990s [7].

CLIMATE AND TEMPERAMENT

Bioclimatic conditions

Climate is the main growth factor [5] for this species although it tolerates varied climate conditions [17].
Common Walnut:
- **Prefers mild climates** [30] with dry continental air [17]. Cool and humid climates encourage fungal diseases [5].
- Requires **warmth during the growing season** (6 months with an average temperature ≥10 ° C) [12, 2, 7, 25, 10, 17, 20].
- **Withstands cold conditions** down to -30 ° C in winter if the temperature drops gradually [7, 25]. A sharp drop in temperature can damage or kill the trees [7].
- **Fairly vulnerable to late frost** (for varieties in which the buds break early) and **vulnerable to early frost** (below -7 ° C [7, 10] or even - 2 ° C), especially after a mild autumn and in particular during the first years of growth [12, 21].
- Requires a minimum of 180 days of growing season per annum [7].
- **Requires over 700 mm/year of rainfall, well distributed throughout the year** (optimally from 1000 to 1200 mm/year [25] unless there are sufficient water reserves in the ground, in which case 500 mm/year may be enough) [12, 28, 5, 7, 25, 10, 17].
- **Resistant to drought** thanks to its tap root: on soft ground, it can draw water from deep underground [7, 20], but the minimum rainfall during the growing period must remain above 100-150 mm [12, 18]; more drought resistant in the juvenile stage [31].

- Fairly sensitive to wind [77: stems may break in storms or growth may lean away from frequent winds in a constant direction (e.g. mistral, etc.). Plant the trees on sites sheltered from the wind [14, 5] or plant quick-growing hedge-type vegetation to protect them. [31, 13].

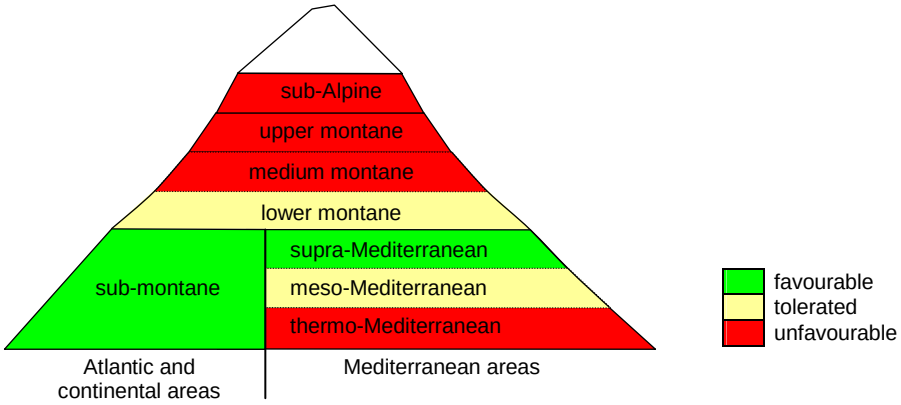
Summary of bioclimatic requirements and sensitivity of the Common walnut

Warmth Requirement	Sensitivity					
	cold	late frosts	early frosts	Sticky snow	wind	drought
High	Moderate	Moderate	High	Low	Moderate	Low

Vegetation stages

- Occurs essentially in the **sub-montane stage** up to 700-800 m [12, 16, 5, 7, 31].
- Although found on higher stages, it can be planted at up to 1000 m in the protected valleys of the Southern Alps [5, 7, 2]. Elsewhere, the timber is likely to incur frost crack above 800 m. (invisible from the outside) [5, 7].

Distribution of the Common walnut according to vegetation stages



Temperament

- An open-field species thriving in **full light** [5, 7, 30, 22, 10]: tolerates shade in its early years, but at the expense of growth. Light-demanding in its mature phase [5].
- **Very sensitive to competition** from other forest species [10, 20].
- Sensitive to sun scald at a young age [27, 7] (while the bark is smooth).
- **Phototropic** [5, 7].
- Exposure: favours south-west facing slopes in cool climate areas. Avoid south-facing slopes in hot climates [14, 2].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
High	High

Climatic limits

Temperature: Annual average: at least 7° C [5].
Absolute minimum: -30° C [5, 7], but varies with the origin of the tree.
Absolute maximum: probably high (the species has withstood heatwaves such as in 2003 in France, but this can depend on the origin of the tree [Becquey J., pers. comm., 2012]).

SOILS

Occurs on rock and a variety of geological formations [5].

Water and drainage

Water supply:

- **Water demanding** species, thrives in humid to moderately humid conditions [30], requiring soils with plentiful water reserves [19, 8, 14, 13] for good growth. Moderate potential on moderately humid sites [19].

Waterlogging:

- The species is **very sensitive to waterlogging,** even temporary, to at least 80 cm in depth [14, 5, 7, 17]. Soils to avoid are therefore wet soils and areas with a permanent water table close to the surface (ideally the water table should be deeper than 1.5 m [17]).

Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
water table e	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

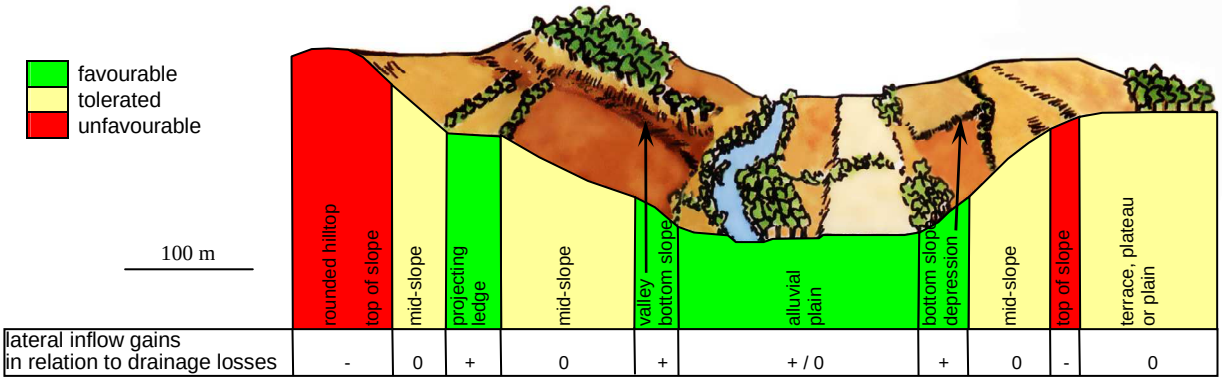
favourable
tolerated
unfavourable

(From the Species Ecology file, Ministry of the Walloon Region, 1991, amended [27])

Topographic situations:

- Favourable: alluvial plains (the most favourable areas when stagnant water is absent), small enclosed side valleys [17], slopes with a good water supply (deep soils, especially in concave areas [7]), depressions on plateaus.
- Unfavourable: frost pockets and valley bottoms with stagnant air (narrow valleys, basins) [14, 5, 7].

Favourable topographic situations for the Common walnut in terms of water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- The texture of the surface horizons should be balanced: clay-sand loam or sand-clay loam [11, 30]. Waterlogging may occur in a rainy climate on clayey soils, especially on the surface. The ideal soil composition is as follows: clay = 18-25%, loam = 30-50% and sand = 30-50% [28, 18, 25]. The proportion of clay may be greater at depth. A sandy texture is appropriate if there is a plentiful water supply (water table present) [11, 7].
- **Surface** horizons must be **friable, well structured and porous**, lumpy or sub-angular polyhedral [11].
- The soil must be at least 80 cm **thick** with **good water retention** [12, 16, 5, 11, 7, 10, 20].
- Grows on stony soils if rooting is possible at 80 cm. It can be even found on scree [20]. To ensure good productivity, particularly in dry climates, the coarse component of the surface horizons should be less than 10% [11].

Textures favouring growth of the Common walnut
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediate LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Favourable:

- Thick brown lime or calcium soils at the bottom of slopes (colluvium) [27, 19].
- Neutral or slightly acidic, deep, loamy or predominantly sandy valley or plain soils (alluvial) [11, 13].

Unfavourable:

- Compact or wet clay soils (pseudo gley) [12, 21, 5, 11, 7,32, 25, 10]; very loamy soil crusts [7]; thin or highly filtering soils [2].

Nutrients

Nutritive elements:

- Should be planted on **rich soils for optimum production** [14, 7, 2], but **adapts to moderately fertile soils if the water supply is sufficient** [9]. Optimum growth on rich soil with pH = 6.5 to 7.5 [12, 11, 7, 25, 30, 10], but tolerates a pH of 5.5 to 8.5 [2]; avoid poorer soils with pH < 5.5 [5, 7].
- Optimum humus: calcium to mesotrophic mull [30].
- The growth of the Common walnut is closely linked to the **C/N ratio** and to a lesser extent to the P_2O_5 content; for good growth, mineral nutrients must be readily available with sufficient organic matter and phosphoric anhydride: 1.5-2% organic matter [12, 11, 25].
- On poor soils where growth is slow, the timber is highly coloured and veined and thus suited to top-of-the-range veneer and high-quality cabinet making (unique furniture pieces); fast-growing trees on rich soils usually produce light-coloured timber suitable for cladding and industrial cabinet making (mass production) [7].
- Sensitive to soil salinity (electrical conductivity < 1.5 dS/m) [12, 21].

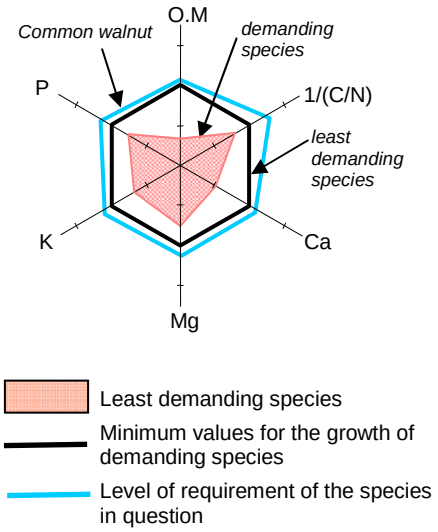
Lime in fine soil:

- **Grows on fertile alkaline soils** [30, 26], but avoid pH > 7.5-8.5 with excessive active lime that causes chlorosis [12, 5, 11, 7, 10], especially when present in surface horizons (over 40 cm) [14].

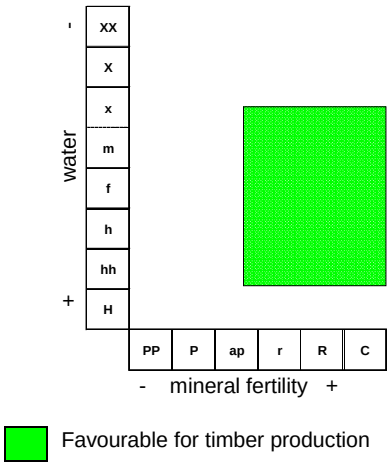
Summary of water and nutrient requirements and sensitivity of the Common walnut for

Water requirements	High
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	High
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soil	Low

Mineral nutrition of the Common walnut



Ecogram for the Common walnut
(according to Rameau *and al.*, 1989, amended)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- **Post-pioneer** species [30].
- **Adversely affected by herbaceous competition** [26].
- Sensitive to Armillaria root rot (Armillaria mellea) and Phytophthora (*Phytophtora cinnamomi*) [7, 9]. In Spain, *Zeuzera pyrina* is a serious parasite, especially near fruit plantations [1].

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MAIN FACTORS FOR THE PRODUCTION OF GOOD QUALITY TIMBER

Limiting factors

- poor water supply, hydromorphy
- excessive competition for light
- early frosts, sharp temperature drops in winter, strong winds

.

Favourable factors

- deep, aerated, non-acidic soils, cool but not wet, sunny exposure, sufficient rainfall or abundant water reserves in the soil

Autecology of the

BLACK WALNUT

***Juglans nigra* L.**

Fr. : Noyer noir
Sp. : Nogal negro Americano; Cat.: Noguer Negro
Ger: : Schwarznuss
It. : Noce nero

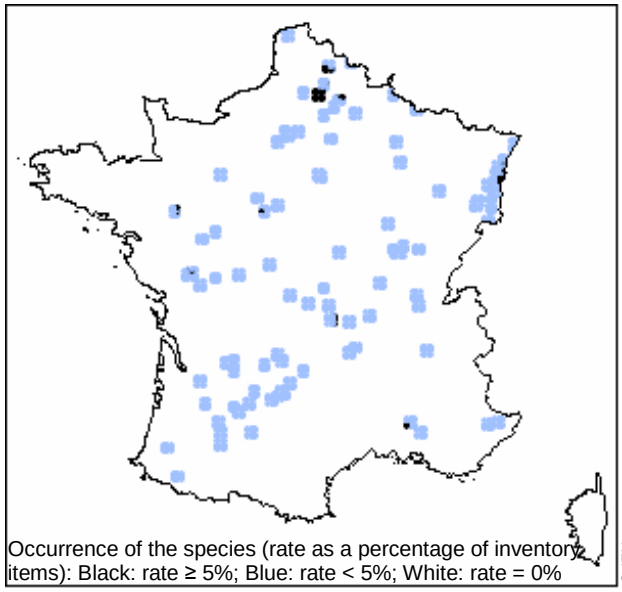
This description is limited to features distinguishing the Black walnut from the Common walnut.

GEOGRAPHICAL DISTRIBUTION

- **Natural range**: Temperate eastern United States (from Atlantic coast to Nebraska, Kansas and Oklahoma in the west and from the Canadian border to Texas, Missouri, Alabama and Georgia to the south) [9]. This broad range explains why the species behaves variably, depending on the [7] origins of the plants.
- **Introduced in France in 1629** [30, 22].

Distribution of Black walnut in North America
(Williams, 1990 [33

Distribution of Black walnut in France



CLIMATE AND TEMPERAMENT

Bioclimatic conditions

- **Sensitive to late frost** due to early budding (mid-April in the south-west, but variable according to the origin of the plants) [10, 9]; can be **very sensitive to early frost** [10].
- Root growth observed at ground temperature above 4 °C, with optimum root growth at 19 °C [23].
- Sensitive to gales during the growing period (gusts of wind, thunderstorms) causing breakage of branches or even trunks [7]. However, the stems grow vertically even in steady constant winds (mistral, etc.)

Summary of bioclimatic requirements and sensitivity of the Black walnut

Warmth Requirements	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Moderate	High	Moderate	Low	High (summer, thunderstorms)	High

Vegetation stages

- Identical to Common walnut, except at < 800 m altitude.

Temperament

- Light: less demanding than the Common walnut, **growing well, even thriving, in a forest environment** [22] [7].
- **Withstands competition better than the Common walnut** [7, 10].
- **Almost non-phototropic [**77.
- Lateral shelter during the first years is beneficial [10].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
Moderate	Low

Climatic limits

- **Resistant to cold** [9] down to -35 °C [26, 10].
- Rainfall: must be frequent and well-distributed (minimum 900 mm per year, [12]); **vulnerable to summer drought** (poor stomatal control and quick leaf fall) [10, 23], but withstands very hot weather if there are abundant water reserves.
- Atmospheric humidity favours the species.
- Requires a growing season of at least 140 days, ideally 170 days [6, 7].

SOILS

Water and drainage

Water supply:

- More demanding than the Common walnut.

- Growth is closely linked to the water supply (rain or ground water reserve) [15]. The species is severely affected by droughts [12].

Waterlogging:

- Withstands temporary waterlogging [12, 7, 29], but **excessive water at the beginning of the growing period is detrimental** [15].
- **Avoid waterlogged soils to less than 60 cm in depth** [10].

Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
water table e	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

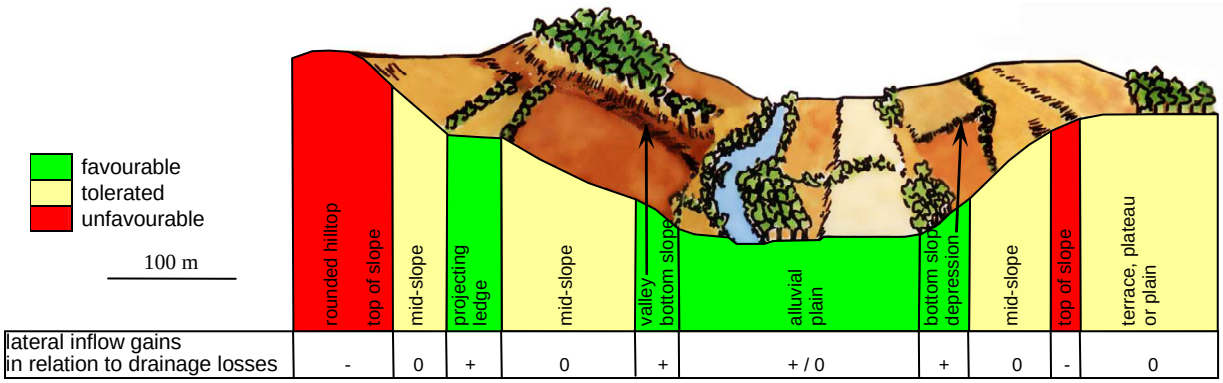
favourable
tolerated
unfavourable

(from Species Ecology file, Ministry of the Walloon Region, 1991, amended [27])

Topographic situations:

- Alluvial plains (valleys of the Rhine and its tributaries, Saone and Yonne valleys, etc.) [7] and alluvial terraces; slopes, but avoid dry exposure (south, west) [6, 29].
- Grows well on the rich and cool areas of slopes and alluvial plains, especially in the Aquitaine basin on alluvial soils traditionally planted with poplar [19].

Favourable topographic situations for the Black walnut in terms of water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- the nature of the soil is the main factor limiting the **Black walnut tree,** which is **more demanding than the Common walnut** [8, 6, 29].
- Prefers **relatively balanced and well aerated soils** [30, 10, 29]; beware of excessively filtering soils, which are too dry on coarse sand or alluvium.
- Requires soils at least 1 m thick; if less, e.g. 60-80 cm, the ground must be very well aerated and constantly supplied with water (water table at a maximum depth of 1.50-2 m) [7, 29].
- **Avoid: compact clay soils** and **pseudo gleys** (with an impermeable layer), **poorly structured loams and stony soils** [7, 10, 29].

Textures favouring growth of the Black walnut
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediate LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

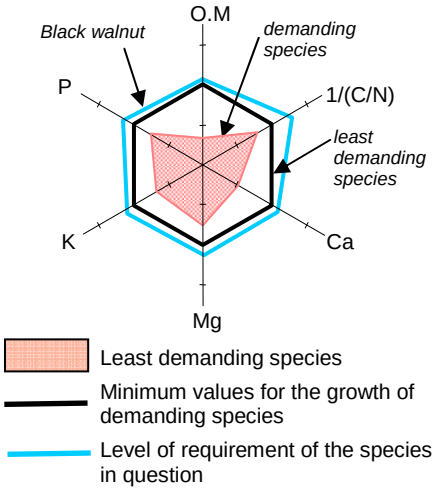
Nutrients

- Although not lime-intolerant, it **does not grow well on limestone** and is more tolerant of acidity, which corresponds to a range of pH from 5 to 7.5 [12, 7, 10, 25].
- Rather **demanding in terms of nutrient minerals**: gives the best results on rich sites [11, 19].
- Ideal: deep, well-drained loamy soils, rich in organic matter and minerals, such as alluvial soils (ash and elm stands) [29].

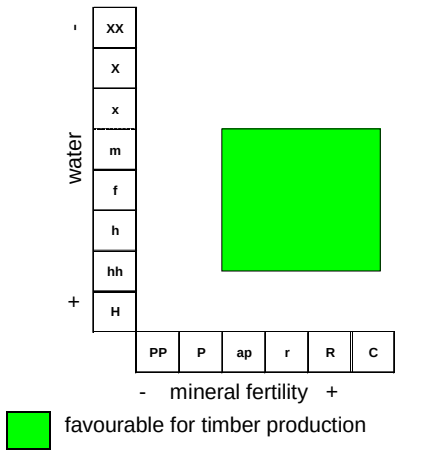
Summary of water and nutrient requirements and sensitivity of the Black walnut

Water requirements	High
Sensitivity to temporary waterlogging	Low
Nutrient requirements (Ca, Mg, K)	High
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soil	Moderate

Mineral nutrition of the Black walnut

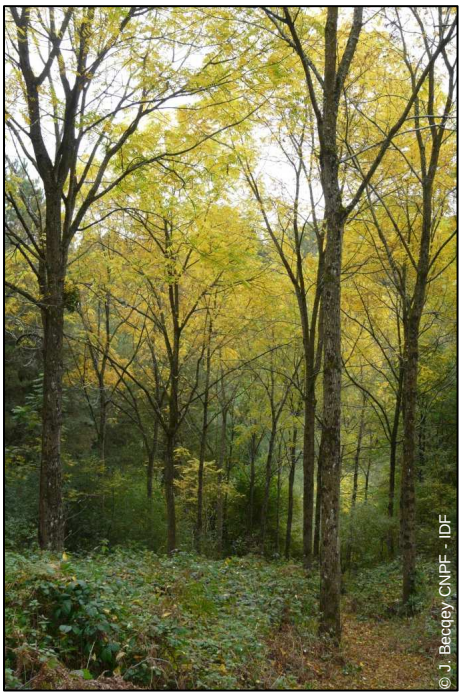


Ecogram for the Black walnut
(according to Rameau *et al*., 1989 amended)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- **Post-pioneer** species [30].
- Not sensitive to Armillaria root rot (Armillaria mellea) [7].
- Grows **better in forest conditions than the Common walnut**, in mixed, high-density stands.



MAIN FACTORS FOR THE PRODUCTION OF GOOD QUALITY TIMBER

Limiting factors

- In particular, insufficient or irregular water supply on compact or excessively filtering soils
- Dry air, strong winds when in leaf and late frost. However, these risks can be mitigated by planting black walnut in protected locations or in a forest environment with appropriate tree care (form pruning)

Favourable factors

- Aerated and deep soils, cool but not wet, preferably rich but not acid, sunny exposure with sufficient rainfall or abundant water reserves in the soil
- high atmospheric humidity

.

Autecology of the
HYBRID WALNUT

Juglans x intermedia

Commercially available in France under the names:

MJ209 x RA = *Juglans major* 209 x *Juglans regia* (most common)
NG23 x RA = *Juglans nigra* 23 x *Juglans regia*
NG38 x RA = *Juglans nigra* 38 x *Juglans regia*

Fr. : Noyer hybride
Sp. : Nogal hibrido. Cat. : Noguer hibrid
Ger. : Echte Walnuss
It. : Noce ibrido

The ecological requirements for this species are similar to those of the Common and Black walnut, with more or less marked characteristics of one or the other:

- Hybrid NG23 x RA is a little less sensitive to winter frost than the Common walnut and less sensitive to late frost than the Black walnut, due to later budding [12, 8, 5, 7].
- Hybrid MJ209 x RA appears more sensitive to cold (T. Avg. annual > 8 ° C) than the hybrid NG23 x RA [3].
- This species appears less phototropic and less sensitive to shade than the Common walnut [5].
- Tolerates slightly acidic soils, up to pH 5 [3, 7, 10]; the hybrid MJ209 x RA is not sensitive to active lime and alkaline soils, but appears more sensitive to acid soils [3, 12, 10].
- Takes over most distinctly from its parents (the Common and Black walnut) on sites with a moderate water supply. Resistance to droughts and heatwaves appears to be intermediate between those of its parents.
- Optimum: well-structured and aerated clay-loam soils.
- Avoid heavy, waterlogged soils with an insufficient rate of saturation of exchangeable bases and pH values below 4 (oligotrophic soils) [3, 1].
- Very sensitive to herbaceous competition [3].

Comparison of requirements and site susceptibilities for walnut trees
(According to Becquey, 1997, amended [8])

Criteria		Common walnut	Black walnut	Hybrid walnut
Soil	Water requirements	High	High	High
	Susceptibility to temporary waterlogging	High	Low	Moderate
	Nutrient requirements	High	High	High
	Susceptibility to active lime	Low	Moderate	Low
Climate	Warmth requirement	High	Moderate	Moderate
	Rainfall requirement (during the season)	Moderate	High	Moderate
	Susceptibility to cold	Moderate	Moderate	Moderate
	Susceptibility to late frost	Moderate	High	Moderate
	Susceptibility to early frost	High	Moderate	Moderate
	Susceptibility to wind	Moderate	High (summer, thunderstorms)	Moderate
	Susceptibility to drought	Low	High	Moderate
Light	Susceptibility to competition for light	High	Moderate	Moderate
	Phototropic tendency	High	Low	Moderate

■ This factsheet was produced under the European POCTEFA 93/08 "Pirinoble" project (www.pirinoble.eu) involving four French and Spanish partners: CNPF - Institut pour le Développement Forestier (IDF), Centre Régional de la Propriété Forestière de Midi-Pyrénées (CRPF), Centre Tecnològic Forestal de Catalunya (CTFC), Centre de la Propietat Forestal (CPF).

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■ Factsheet references: **Lestrade M., Becquey J. Coello, J. Gonin P., 2012** - Autecology of the Common walnut (*Juglans regia* L.), Black walnut (*Juglans nigra* L.) and Hybrid walnut (*Juglans x intermedia*). In : Gonin P. (coord.) *et al*. - *Autecology of broadleaved species*. Paris : IDF, 2013, 65 p.

European Union
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Autecology of the

WILD PEAR

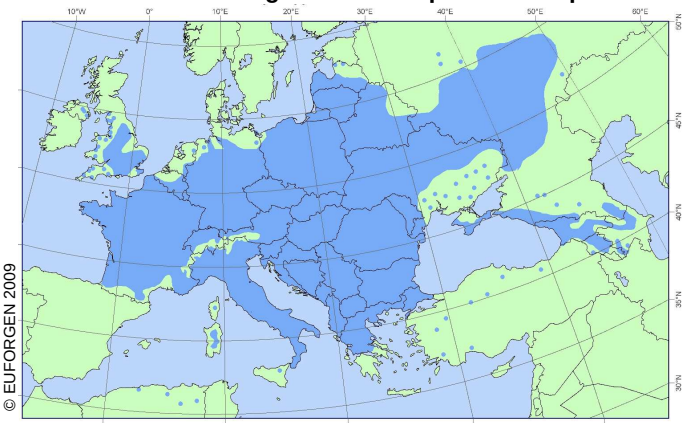
***Pyrus pyraster* (l.) Du Roi**

Fr. : Poirier Commun
Sp. : Peral silvestre (Peral, Piruetano, Perojo, Peral bravio, Peruyero)
Cat. : Perera (Perera borda)
It. : Pero selvatico (Pero pirastro, Perastro)
Ger. : Holzbirne (Wildbirne, Birnbaum, Birne)

GEOGRAPHICAL DISTRIBUTION

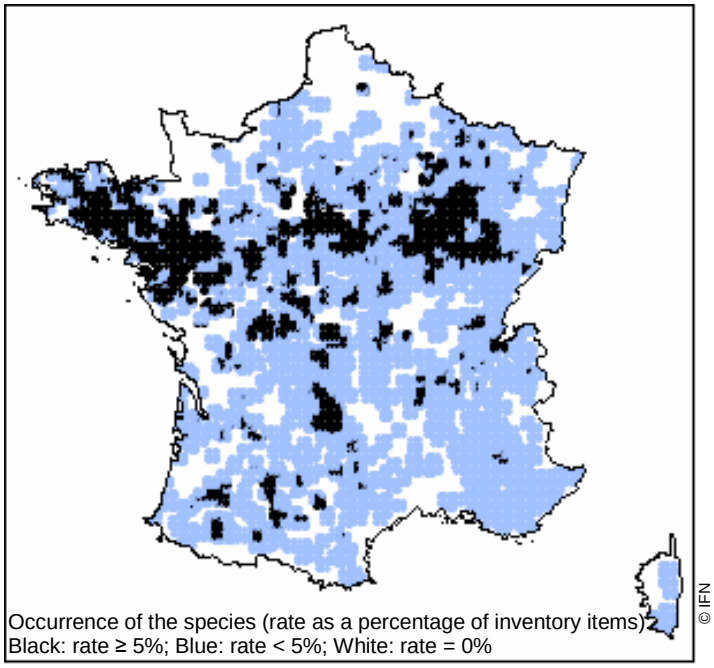
- Species with a large natural range: **Eurasian,** extending into **Sub-Atlantic** areas [10].
- Found everywhere in France, but less common in the Mediterranean region and in the North of France [10]; generally present in the mountainous region in the northern third of Spain, especially in hardwood forests [2].

Natural range of the Wild pear in Europe



Distribución del Peral silvestre en España

Distribution of the Wild pear in France



Occurrence of the species (rate as a percentage of inventory items)
Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

CLIMATE AND TEMPERAMENT

Bioclimatic conditions

- Thermophilic species, resistant to cold [4, 10, 8], but prefers warm topoclimates in areas with harsh climates[1] [10, 8]; considered sensitive to late frost [1].

Summary of bioclimatic requirements and sensitivities of the Wild pear tree

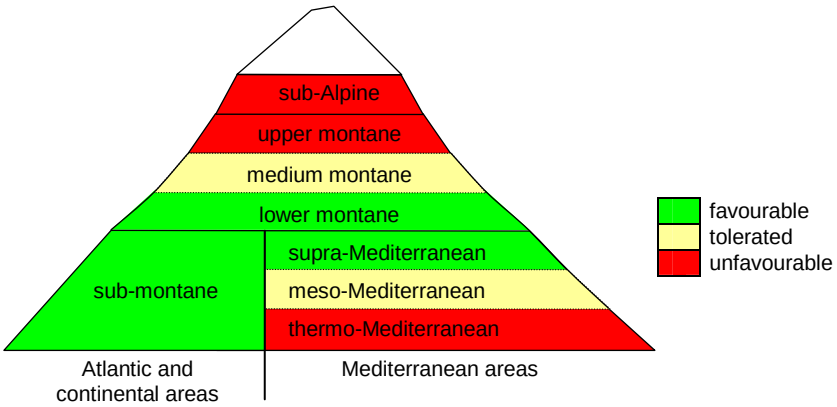
Warmth requirements	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Very low	Moderate	Low	-	Very low	Low

[1] topoclimate: variation of the local climate resulting from exposure or a particular topographic position.

Vegetation stages

- Low altitude species [4,12] occurring from sub-montane to lower montane stages up to 1200 m and at the supra-Mediterranean stage [10].

Distribution of the Wild pear according to vegetation stages



Temperament

- Fairly light-demanding [48,12, 2], especially at the adult stage [1]; can tolerate partial shade [10,5], but does not grow to a large size under cover [1].
- Sensitive to competition; tends to grow towards the light (phototropic) [1]; reacts well to canopy opening [1].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
High	Moderate

SOILS

Water and drainage

Water supply:

- Non-demanding species [10,8,12], able to grow with limited water resources [1] but fairly demanding for timber production[4]; optimum growth on fresh soils [5, 2].

Waterlogging:

- Sensitive to poor root oxygenation [8], but can colonise humid environments [1].

Drainage and excess water

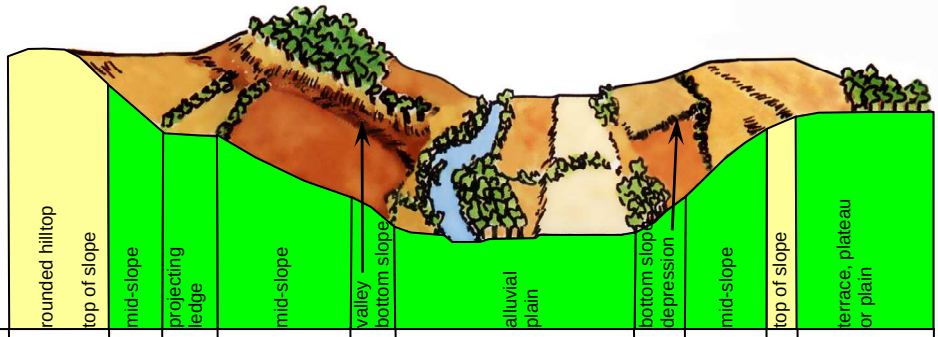
			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	Redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

favourable
tolerated
unfavourable

(from the *Species Ecology* file, Ministry of the Walloon Region, 1991, amended [8])

Favourable topographic situations for the Wild pear with regard to water supply
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

favourable
tolerated
unfavourable



	rounded hilltop	top of slope	mid-slope	projecting ledge	mid-slope	valley bottom slope	alluvial plain	bottom slope depression	mid-slope	top of slope	terrace, plateau or plain
lateral inflow gains in relation to drainage losses	-		0	+	0	+	+ / 0	+	0	-	0

Texture and materials

- Varied, equally clayey and loamy, with more or less coarse components [10]. Compact soils limit growth [8].

Soil textures favourable for growth of the Wild pear
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediate LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- Species with a wide range [13], but optimum growth on rich soils [4,8,91,5, 2].

Nitrogen and phosphorus:

- Demanding species (mull humus) [10,8].

Lime in fine soil:

- Not affected [10,1].

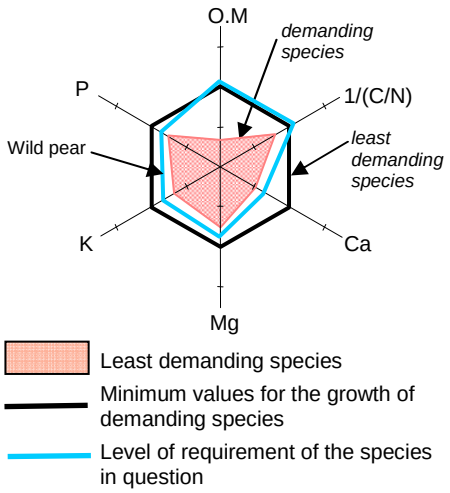
Note:

- As this species is susceptible to competition, it grows well in restrictive conditions, but thrives on all types of soils and deserves to be favoured on fertile sites [13].

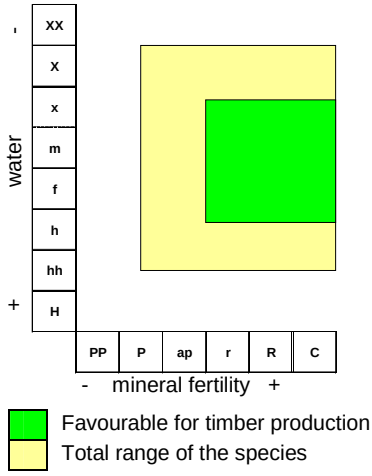
Summary of water and nutrient requirements and sensitivity of the Wild pear

Water requirements	Moderate
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	High
Sensitivity to lime in fine soil	Zero

Mineral nutrition of the Wild Pear



Ecogram for the Wild pear
(according to Rameau *and al.*, 1989,



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Often a small-sized tree, but it can reach 20 m in height in favourable conditions [10].
- Post-pioneer species [10].
- Probably reproduces mainly from basal shoots [1].
- Fairly long-lived [32]; 150-250 years [13].
- Risk of disease related to fire blight (*Erwinia amylovora*) or cedar-apple rust (a fungal disease caused by the pathogen *Gymnosporangium juniperi-virginianae*), usually affecting cultivated pear trees [1, 7, 6, 2] and other species of the Rosaceae family (Apple, Hawthorn, etc.).
- Scattered [10] and infrequent in forest conditions due to its sensitivity to competition, despite a wide distribution range [5, 6]. This species is hard to spot in stands, which may lead to its depletion if the forest is not managed appropriately for its growth [6].
- Possible hybridization with various *Pyrus* species, including with cultivated pear trees (*Pyrus communis* L.) [1]. This constitutes a threat to preserving the genetic resources of the species [6]. It is therefore essential to ascertain the origin of artificially introduced plants or to take the risk of hybridization into account in naturally regenerating stands [6].
- Two other, smaller pear species occur in their natural state in the forest: the Plymouth pear tree (*Pyrus cordata* Desv.), an Atlantic and sub-Atlantic species, and the almond-leaved pear tree (*P. spinosa* Forssk. = *P. amygdaliformis* Vill.), a Mediterranean species [5]. In shrubby thickets, the snow pear tree also occurs (*Pyrus nivalis* Jacq.) (very localized), as well as the Iberian Pear tree (*Pyrus bourgaeana* Decne.; Piruetano, Galapero, Guadapero) present in the centre and in the west of the Iberian Peninsula [11].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- competition for light
- strong soil compaction may cause waterlogging problems
- low water balance
- mineral poverty and slow recycling humus (moder)

Autecology of the

EUROPEAN WILD APPLE

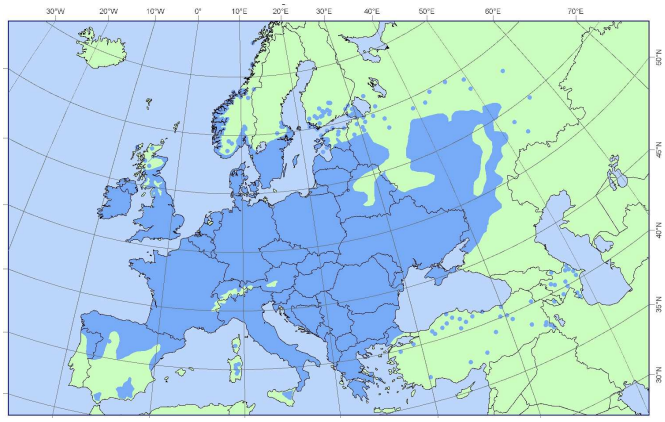
***Malus sylvestris* Mill.**

Fr. : Pommier Sauvage
Sp. : Manzano (Manzano Silvestre, machi); Cat. : Pomera borda
It. : Melo selvatico (Pomo selvatico)
Ger. : Holzapfel (Wilder Apfelbaum, Wildapfel)

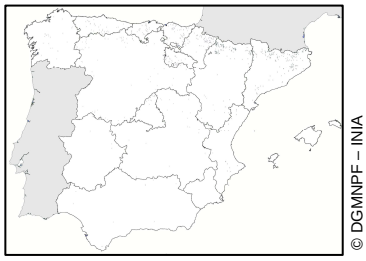
GEOGRAPHICAL DISTRIBUTION

- Species with a large natural range: Eurasian, with an affinity for the sub-Mediterranean stage [10].
- Found everywhere in France, but less common in the Mediterranean region [10]; present in Spain, mainly in the north half of the country. [11, 7]

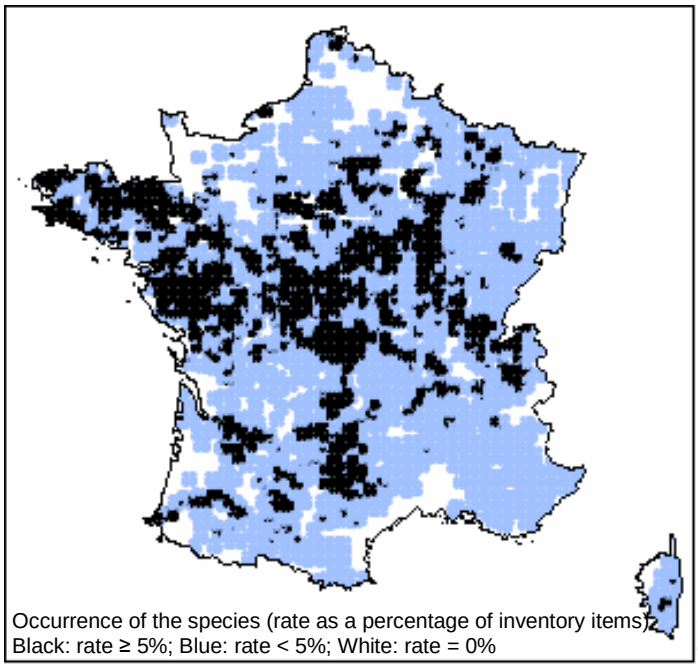
Natural range of the European wild apple in Europe



Distribución del Manzano silvestre en España



Distribution of the European wild apple in France



CLIMATE AND TEMPERAMENT

Bioclimatic conditions

- Withstands harsh climates [8,12] and [7] cold conditions; in Spain, favours temperate climates with some humidity and without hot summers [11, 7].

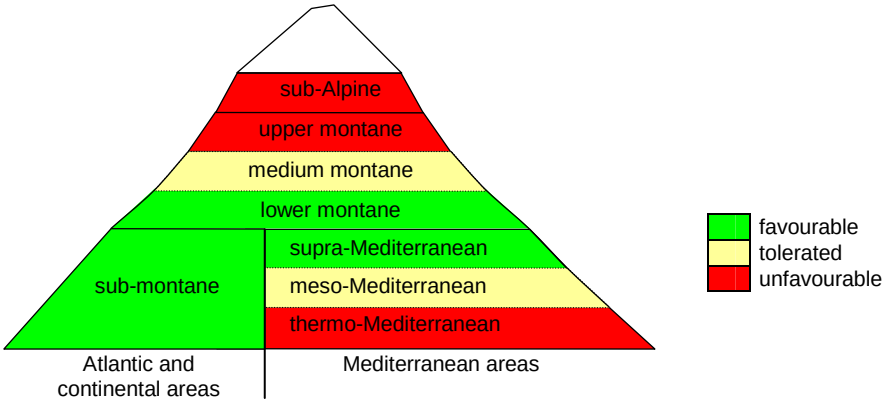
Summary of bioclimatic requirements and sensitivities of the European wild apple

Warmth requirement	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Very low	Low	Low	-	Low	Low

Vegetation stages

- From the sub-montane to the montane stage (up to 1300 m in France) [10].

Distribution of the European wild apple according to vegetation levels



Temperament

- Heliophilic, tolerates shade [10, 11], but this considerably slows its growth [5].
- Very sensitive to competition [4,8, 9].

Young adult adult

Sensitivity to competition for light	Phototropic tendency
High	Moderate

SOILS

Water and drainage

Water supply:

- Mesophilic [10], fairly undemanding [8], but grows best on thick, fresh soil with good water reserves [5, 11, 7].

Waterlogging:

- Sensitive [8,12].

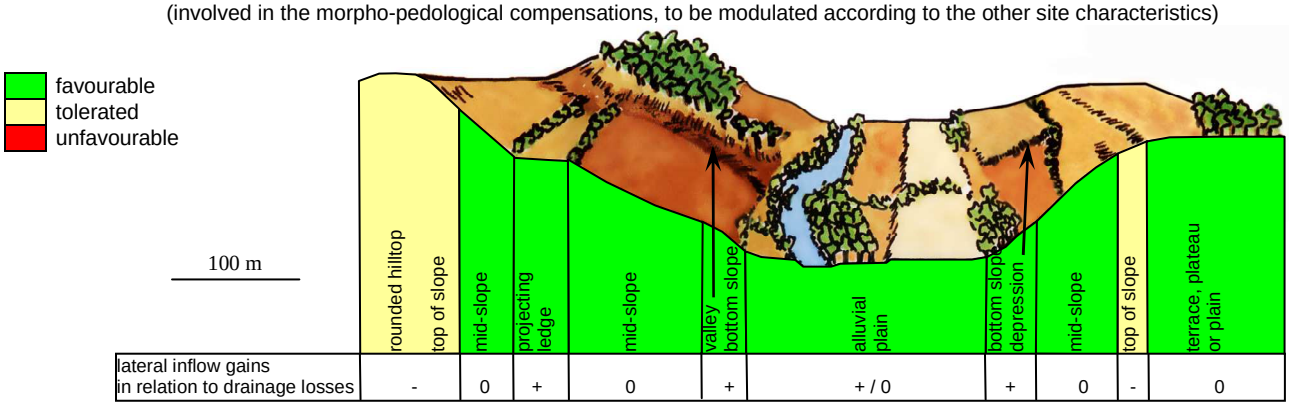
Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

favourable
tolerated
unfavourable

(from the *Species Ecology* file, Ministry of the Walloon Region, 1991, amended [8])

Favourable topographic situations for the European Wild Apple with regard to water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- Varied, equally clayey and loamy, with more or less coarse components [10]. Highly compacted soil limits growth [8].

Textures favouring growth of the European Wild Apple
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediary LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- Large amplitude species [7], greater than that of the [13] pear tree, but optimum growth is on rich soils [10,8,9,5]; uncommon on acid soils [5].

Nitrogen and phosphorus:

- Demanding species (mull humus) [10,8].

Lime in fine soil:

- Not affected by low content [10, 8].

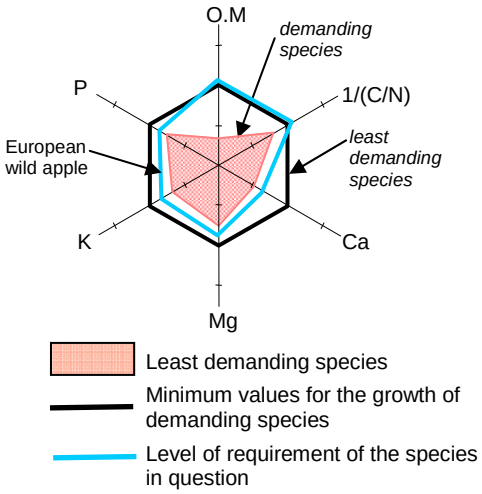
Note:

- Due to its sensitivity to competition, this species grows well on restrictive sites, but thrives on all types of soils and deserves to be favoured on fertile sites [13].

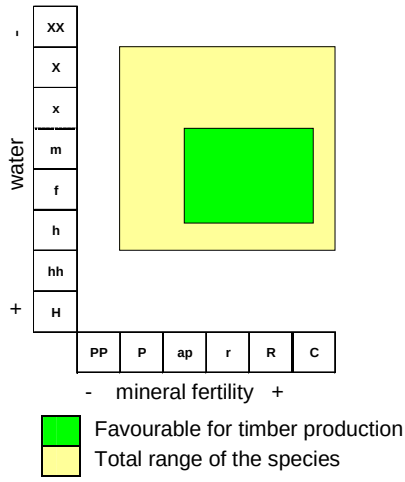
Summary of the water and nutrient requirements and sensitivity of the European wild apple

Water requirements	Moderate
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	High
Sensitivity to lime in fine soil	Very low

Mineral nutrition of the European wild apple



Ecogram for the European wild apple
(according to Rameau *and al*., 1989, amended)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Small tree reaching 10 m in height [10].
- Life span estimated at 70-100 years [10].
- Scattered [10] and infrequent occurrence in forest conditions due to its sensitivity to competition, despite a broad distribution range [65]. The species is hard to spot in stands, which may lead to its depletion if the forest is not managed appropriately for its growth [6].
- In forest conditions, the orchard apple tree (*Malus domestica* Borkh.) can occasionally occur naturally [10]. Many individuals identified as wild apple trees on the basis of morphological criteria are also hybrids of the orchard apple tree; the risk of hybridization, currently under study, should be taken into account when managing the genetic resources of the species [3]. In particular the origin of the plants should be ascertained if artificially introduced or the risk of hybridization in natural regeneration operations should be taken into account [6].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- competition for light
- low water balance or soil waterlogging
- soil compaction may cause waterlogging problems
- mineral poverty and slow recycling humus (moder)

■ This factsheet was produced under the European POCTEFA 93/08 "Pirinoble" project (www.pirinoble.eu) involving four French and Spanish partners: CNPF - Institut pour le Développement Forestier (IDF), Centre Régional de la Propriété Forestière de Midi-Pyrénées (CRPF), Centre Tecnològic Forestal de Catalunya (CTFC), Centre de la Propietat Forestal (CPF).

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■ Factsheet reference: **Larrieu L., Gonin P., Coello J.** - Autecology of the Wild pear (*Pyrus pyraster* (L.) Du Roi) and the European wild apple (*Malus sylvestris* Mill.). In : Gonin P. (coord.) *et al*. - *Autecology of broadleaved species*. Paris : IDF, 2013, 65 p.

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Autecology of the

WILD SERVICE TREE

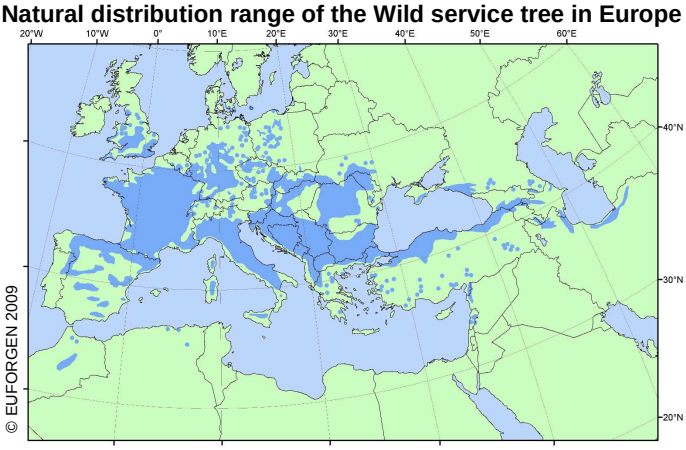
Sorbus torminalis (L.) Crantz

Fr. : Alisier torminal
Sp. : Serbal silvestre; Cat.: Moixera de pastor
Ger. : Elsbeere
It. : Sorbo ciavardello

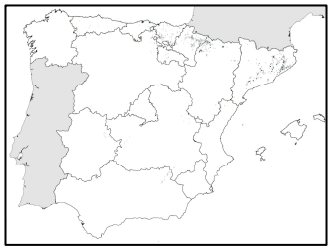
GEOGRAPHICAL DISTRIBUTION

- **Sub-Mediterranean** species [29].
- Occurs throughout the temperate parts of Europe, less common in the North.

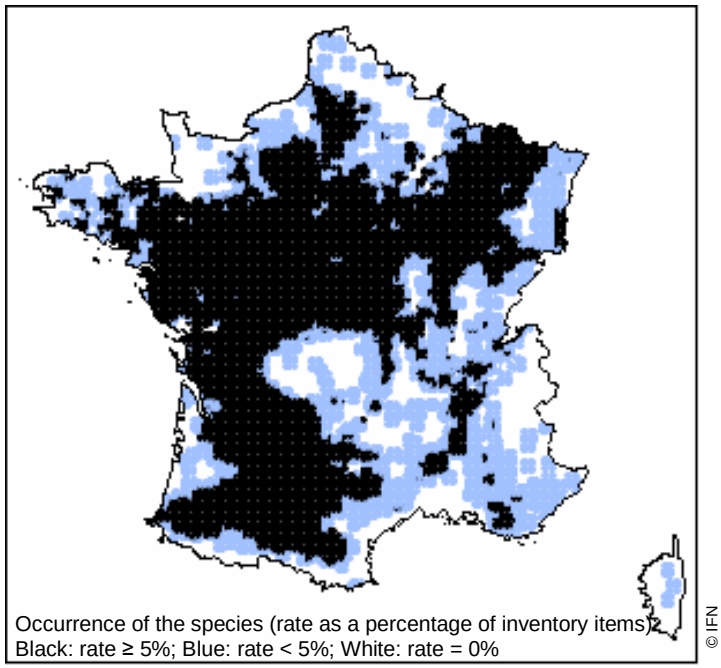
Natural distribution range of the Wild service tree in Europe



Distribution of the Wild service tree in Spain



Distribution of the Wild service tree in France



Occurrence of the species (rate as a percentage of inventory items)
Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

CLIMATE AND TEMPERAMENT

Bioclimatic conditions

- Withstands **harsh winter conditions** [15, 8, 38]; not sensitive to late frosts, withstands down to -5 ° C in April [Haralamb 1967 *in* 22, 8, 15, 19]. Occasional frost crack [15]. Needs **warmth** during the growing season [19], therefore scarce in mountain areas and the North of France [8], and uncommon in cool locations (north-facing slopes, cold valley bottoms), except around the Mediterranean [21,15].
- **Tolerates summer drought** [38, 22], even up to 2 months [Haralamb 1967 *in* 22, 19]; requires rainfall of **600 - 700 mm/yr.** [38, 19, 22].
- Wind resistant [15, 19, 22].

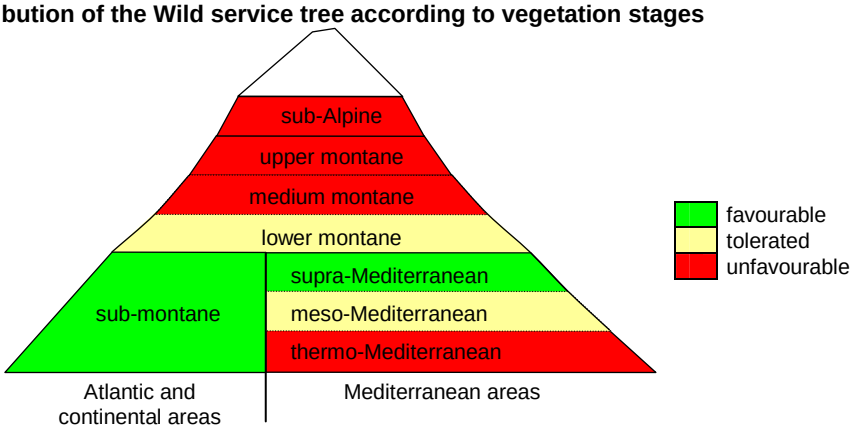
Summary of bioclimatic requirements and sensitivity of the Wild service tree

Warmth requirements	Sensitivity					
	cold	late frost	early frost	Sticky snow	wind	drought
Moderate	Very low	Moderate	Low	-	Low	Low

Vegetation stages

- Very wide bioclimatic distribution in France, from the sub-montane stage [17,14,29,15,40] to the montane stage, but not above 1000 m [29, 15, 43, 26, 19]; absent from the North Atlantic coast [26, 9]; less frequent in the Mediterranean region where it is found at the supra-Mediterranean stage [29,31].
- **In Spain**, occurs in the **montane stage** up to 1000 m [1919, or even 1300 m if exposed to warm conditions [23].

Distribution of the Wild service tree according to vegetation stages



Temperament

- Heliophilic species [8, 38, 5, 36], sensitive to competition [17, 8, 26, 11, 38, 19, 5]; can withstand some cover [40], hence its occasional classification as a partial shade species [15, 23]. However, shade results in very slow growth [14, 15, 25] and poor form [26].
- Does not produce epicormic shoots when exposed to light [26, 42, 25].
- Phototropic species [37].
- **Long-lived species** [26], up to 200 [37, 17, 33, 4] or 300 years [27].
- Growth in height and diameter often slow, less than those of the dominant species, but continues in the long term. Responds well to thinning [26,42].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
Moderate	Moderate

SOILS

Water and drainage

Water supply:

- **Undemanding** species, **tolerant to moderate drought** [35, 15, 8, 22]; makes use of sites with low water reserves (exposure to warmth, shallow soils or abundant coarse components) [17, 35, 15, 11] or soil with highly variable water conditions (alternately dry and waterlogged, depending on the season) [15, 8, 11, 22]. **Optimum growth** and form are obtained on soils with abundant water [24].

Waterlogging:

- Prefers well-drained soils [39], but tolerates temporary waterlogging [35, 15, 36, 25, 38, 13, 19], even close to the surface [11] or intense in nature [8]. This, however, slows growth [16]. Considered as a sensitive species by some authors [20].

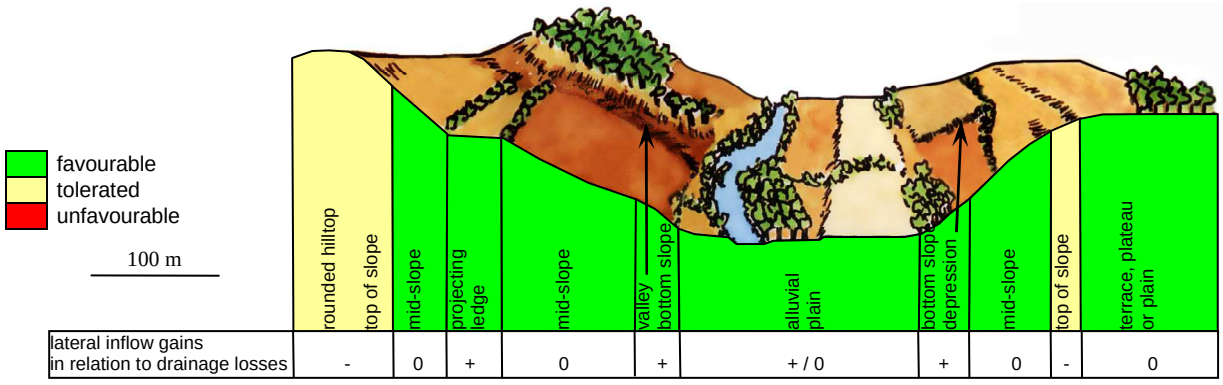
Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
Water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50 cm	0-30 cm	
	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80 cm	40-80cm	< 40cm

favourable
tolerated
unfavourable

(From the *Species ecology* file, Ministry of the Walloon Region, 1991, amended [20])

Favourable topographic situations for the Wild service tree with regard to water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- **Various**, equally clayey and loamy, with varying amounts of pebbles [29,15].
- **Soil compaction** and highly argillaceous horizons with a massive structure **restrict** [20] growth.

Favourable textures for the growth of the Wild service tree
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediate LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- **High** nutrient requirements [8, 20, 19, 22, 23], but very adaptable [14, 11] and observed over a wide pH range [39] from 3.5 to 8 [12, 15, 19, 22]; **restricted growth on infertile sites** [39].

Nitrogen and phosphorus:

- **Fairly adaptable** [29,15,20], occurring on dysmoder to carbonate mull humus [15, 39]. However, care should be taken to avoid forms of humus that recycle too slowly, releasing little nitrogen and phosphorus.

Lime in fine soil:

- **Not affected** [29, 15, 8, 11, 23, 19].

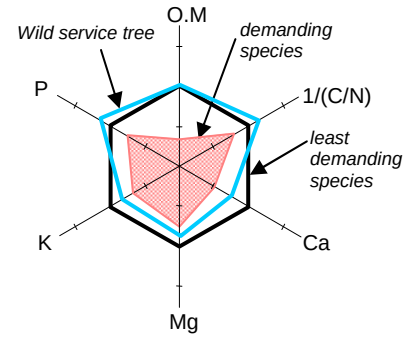
Note:

- With its very broad ecological range [14, 15, 26, 20] and its vulnerability to competition, this species grows well in restrictive conditions that they make good use of, but **deserves to be favoured in more fertile areas** [39,1].
- Occasionally considered as a bimodal[1] species [14] with varying geographical behaviour [29], but it is believed that this site distribution is linked to its susceptibility to competition, which excludes it from the most productive environments.
- No geographic structure in terms of neutral genetic diversity[2] [6].

Summary of water and nutrient requirements and sensitivity of the Wild service tree

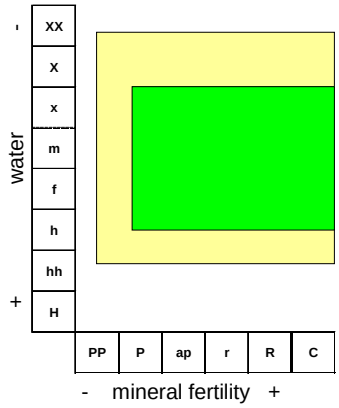
Water requirements	Moderate
Sensitivity to temporary waterlogging	Moderate
Nutrient requirements (Ca, Mg, K)	Low
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soil:	Zero to very low

Mineral nutrition of the Wild service tree



Least demanding species
Minimum values for the growth of demanding species
Level of requirement of the species in question

Ecogram for the Wild service tree
(according to Rameau *et al*., 1989, amended)



Favourable for timber production
Total range of the species

DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- **Post-pioneering nomadic species** [15,31], **asocial** [6].
- This species mainly regenerates through **basal shoots** [26,37] and over significant distances, up to 20-30 m [37]; stump shoots uncommon; seeds dispersed by birds [14], regeneration from seed infrequent [37].
- Possible hybridization with the white Wild service tree [28], giving vigorous but poorly-shaped trees [26] due to a tendency to grow epicormic shoots inherited from the white Wild service tree, but can produce good quality logs [Drapier, pers. comm. pers.].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- competition for light
- soil waterlogged near the surface over a long period
- very low water balance on the site

1: bimodal: refers to a species that will grow optimally under two distinct sets of ecological conditions that are separated by an area where the species is absent or infrequent (e.g. a species preferring alkaline conditions in some areas and acid conditions in others).
2: neutral genetic diversity: diversity resulting from the evolution of populations independently of environmental influence.

Autecology of the

SERVICE TREE

***Sorbus domestica* L.**

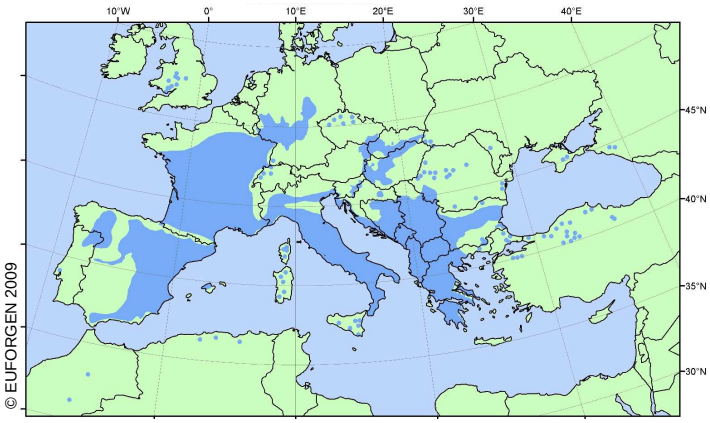
Fr. : Cormier
Sp. : Serbal Común; Cat.: Servera
Ger: : Speierling
It. : Sorbo doméstico

© P. Gonin CNPF - IDF

GEOGRAPHICAL DISTRIBUTION

- **Sub-Mediterranean** species [19,31].

Natural distribution range of the Service tree in Europe



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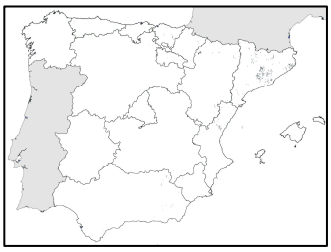
Distribution of the Service tree in Spain



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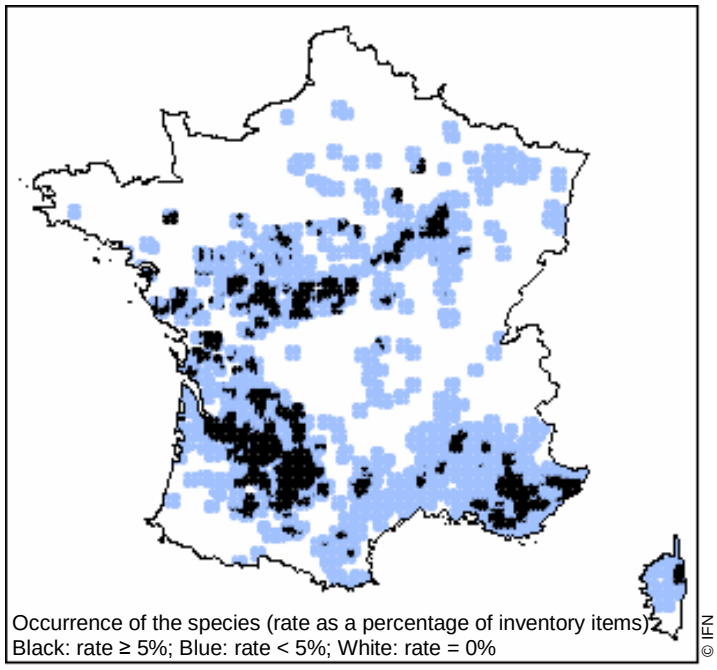
Distribution of the Service tree in France



Occurrence of the species (rate as a percentage of inventory items)
Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

© IFN

CLIMATE AND TEMPERAMENT

Bioclimatic conditions

- **Requires more warmth** [14, 29, 40, 25, 34] than the Wild service tree [21].
- **Withstands summer heat and drought** [23, 44, 3], especially on loamy and clay soils [7]. The minimum required rainfall is 500 mm per year [19, 23, 44, 3].
- **Resistant to cold** down to - 25ºC [23] and withstands **late frost** [34, 3].
- Wind resistant [21, 2].

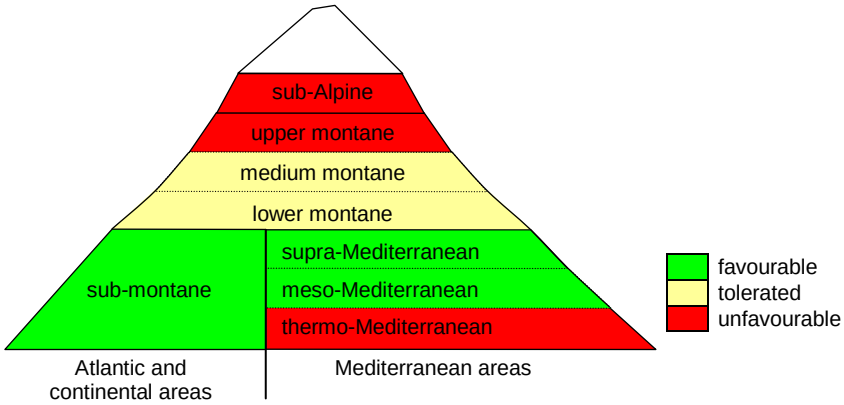
Summary of bioclimatic requirements and sensitivity of the Service tree

Warmth requirement	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
High	Very low	Low	Low	-	Low	Low

Vegetation stages

- **In France**, occurs at the **meso-Mediterranean, supra-Mediterranean, sub-montane and montane stages** up to 1400 m; fairly common in the south and rare in the north of France [29, 30, 31].
- **In Spain**, found mainly in the **eastern half** of the country, as well as in Castile and Leon, Rioja and Álava [3, 41] up to altitudes of 1300 m -1400 m, optimally not above **1000 m** [19, 23, 2, 3].

Distribution of the Service tree according to vegetation levels



Temperament

- **Heliophilic** [291923, 3] needing light from its earliest stages [40,25]; sometimes considered as a partial shade species [29], especially on cold sites [7], because while withstanding temporary light cover, young Service trees prefer even light shade to full sunlight [34].
- Non-phototropic [34].
- **Highly vulnerable to competition** [9,34, 3].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
High	**Zero to very low**

SOILS

Water and drainage

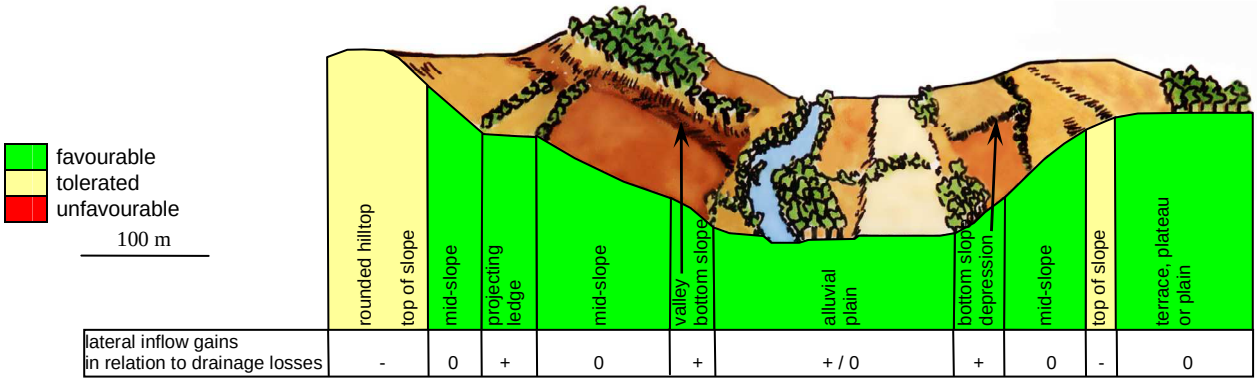
Water supply:

- **Undemanding** species [29, 34, 19, 23]: even less demanding than the Wild service tree [9]. Can be grown on sites with a low water balance [25] (e.g. exposure to warmth, shallow soil or abundant coarse components). Suitable for clay soils with variable water conditions [11].

Waterlogging:

- Considered tolerant **to soils with varying water conditions** [Drapier, comm. pers., 19, 44].

Favourable topographic situations for the Service tree with regard to water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- **Various** [29]; this species tolerates clay or loamy soils with a heavy texture [9, 34, 19, 44, 3].

Textures favourable to the growth of the Service tree
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediate LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- **Undemanding** species [29, 23], grows on various soils [34] and over a wide pH range [19, 23, 44, 2], but fairly demanding if aiming for timber production [40, 25].
- On dry sites in Spain, prefers rich soils with a basic pH [19, 7].

Nitrogen and phosphorus:

- Species occurs on a range of humus from **moder to carbonate mull** [2929. Forms of humus that recycle too slowly, releasing less nitrogen and phosphorus, should be avoided.

Lime in fine soil:

- **Not affected** [29, 44, 3, 41].

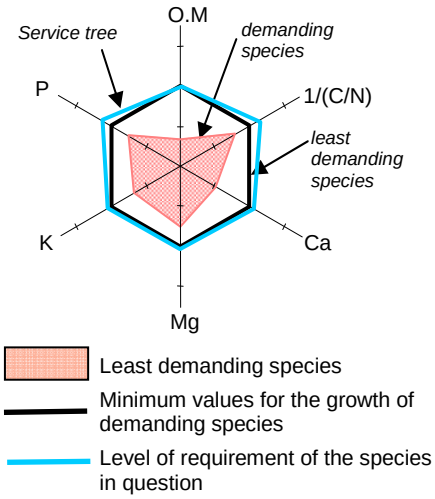
Note:

- This species has a very wide ecological range and grows more readily in restrictive conditions of which they make good use, but it deserves to be favoured in more fertile areas [9], as it is believed that its site distribution is mainly linked to its sensitivity to competition, which excludes it from the most productive environments.

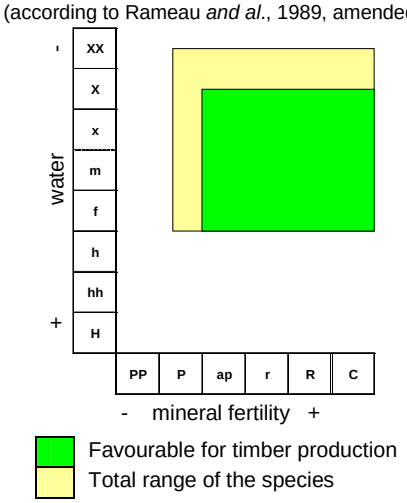
Summary of water and nutrient requirements and sensitivity of the Service tree

Water requirements	Low
Sensitivity to temporary waterlogging	Moderate
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soils:	Zero to very low

Mineral nutrition of the Service tree



Ecogram for the Service tree
(according to Rameau *and al.*, 1989, amended)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

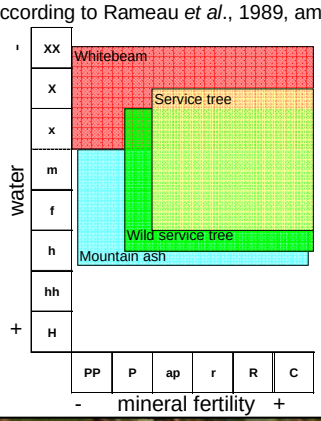
- **Post-pioneer nomadic** species [30].
- Strong growth in height at a young age [34].
- **Shoots from the stump** [9].
- **Long-lived:** 150 to 200 years, up to 400 years [34].
- Does not hybridise with other service trees [28].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- competition for light
- mineral deficiency and slow recycling humus (moder)
- cold topoclimate

Autecology of
OTHER SORBUS SPECIES

Ecogram for Sorbus species
Favourable situations for timber production
(according to Rameau *et al*., 1989, amended)



The Whitebeam (*Sorbus aria*) and **Mountain ash** or **rowan** (*Sorbus aucuparia*) are **very hardy species,** adapted to various soil and climate conditions. However, they **need light** as from their very first years and are very uncompetitive in the presence of other species. Their productive potential is lower than that of the service tree or the Wild service tree because they are conditioned by the harsh environments in which they occur. However, their use in high quality sites in mountain areas can increase their economic value, in addition to their value for restoration purposes.

WHITEBEAM

Sorbus aria (l.) Crantz

Fr. : Alisier blanc
Sp.: Mostajo; Cat. : Moixera vera

Ger. : Mehlbeerbaum
It. : Sorbo montano

© P. Gonin CNPF - IDF

This is a European species extending into **sub-Mediterranean** areas [32]. The Whitebeam occurs **in France** from the sub-montane to the **montane stage** between 100 and 1700 m, but is less common in the western half of the country due to its affinity for the continental climate [10, 32]. Occurs **in Spain, especially in mountain** areas between 600 and 1700 m [19, 23].
Among Sorbus species, the whitebeam is the hardiest. It **withstands the wide range of mountain temperatures** and will grow under **widely varied trophic conditions**: calcareous soils suit it better, but it also tolerates acidic soils and is unaffected by the presence of carbonates [9, 19, 23]. This leads to a distinction between two sets of populations, one on rich soils or carbonates and the other on poor soils [32]. It is a **xerophilic** species and can grow on dry soils [19, 32], but is not found in even temporarily **waterlogged site**s, especially with heavy soils [9, 19].
This is a **thermophilic and heliophilic species** [19, 32, 23] that is sensitive to **competition,** which often confines it to infertile areas although it could grow well in better conditions [9, 19]. The Whitebeam is wind resistant [19].

The quality of Whitebeam timber is slightly inferior to that of the service tree or the Wild service tree and its economic value as timber is limited by the usually small log sizes.

MOUNTAIN ASH

Sorbus aucuparia L.

Fr. : Sorbier des oiseleurs
Sp.: Serbal de cazadores ; Cat. : Moixera de guilla

Ger. : Eberesche Vogelbeerbaum
It. : Sorbo degli uccellatori

© P. Gonin CNPF - IDF

The Mountain ash (or rowan) is a Eurasian species **extending into sub-oceanic areas** [32] and is common throughout Europe into Scandinavia, except in the south where it is but limited to **mountains** areas [10]. In France, it is very common up to an altitude of 2000 m and only occurs in sub-montane stages in cool and humid sites, often with acid soils [32, 10]. Occurs in Spain, especially in mountain area, between 600 and 1700 m a.s.l. [19, 23, 44].
The Mountain ash needs **humidity** and an **even rainfall distribution** throughout the year [10, 19, 32], with at least 500 mm/yr. [19] to 700 mm/yr. [32]. It will grow in a wide range of trophic conditions in montane areas, but prefers acid soils in sub-montane zones [9, 32]. It does not tolerate waterlogging [19, 44].
The Mountain ash is a **heliophilic species** [10, 19, 32, 23, 18] and resistant to wind and cold [19].

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Autecology of the

SMALL-LEAVED LIME

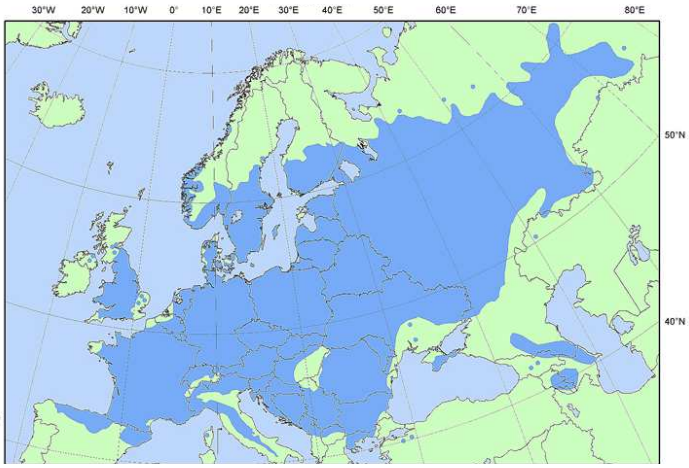
***Tilia cordata* Mill.**

Fr. : Tilleul à petites feuilles
Sp. : Tilo norteño; Cat.: Tiller de fulla petita
Ger. : Winterlinde
It. : Tiglio selvatico

Geographical distribution

- Eurasian and **mid-European** species [13].
- **Common in eastern France** and in the **Pyrenees; less common in the west**; rare **in the Mediterranean region** [13].
- Very often mixed with oak and beech in eastern France [14].

Natural range of the Small-leaved lime in Europe



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Distribution of the Small-leaved lime in Spain

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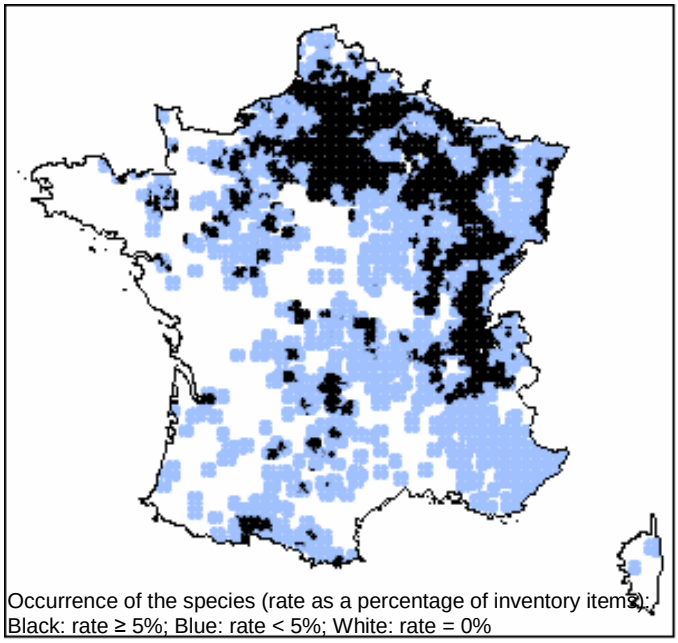
Distribution of the Small-leaved lime in France



Occurrence of the species (rate as a percentage of inventory items):
Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

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Climate and temperament

Bioclimatic conditions

- Continental or slightly oceanic temperament: **not sensitive to cold** [1, 6]. **Grows moderately well with atmospheric moisture** [6, 7].
- **Needs substantial rainfall** [1].
- **Requires warmth**, growing best in temperate climates. Grows well on sites that are warm in summer and sheltered from cold winds. **Less demanding of warmth and humidity than the Large-leaved lime** [1].
- **Tolerates drought** [8, 1].
- **Sensitive to late frost** [14], but less so **than the Large-leaved lime,** which buds earlier [1].

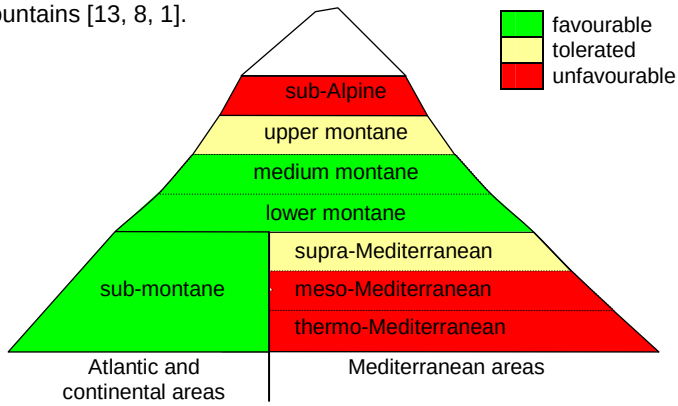
Summary of bioclimatic requirements and sensitivity of the Small-leaved lime

Warmth requirements	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Very low	Moderate	Low	Low	Low	Moderate

Vegetation stages

- This species occurs in the sub-montane and **montane stages** [13], rarely above 1000 m although it can grow up to 1,500 m in the Central Alps and 1,100 m in the Jura Mountains [13, 8, 1].

Distribution of the Small-leaved lime by vegetation stages



Temperament

- **Semi-shade species** [6, 13, 14], considered as tolerant to shade, but also **reacts very favourably to light** [12].
- Seedlings tolerate shade very well [1, 12] and must be protected from strong sunlight [14], even though a minimum of light is required for regeneration and to ensure good growth [12].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
Moderate to high	Moderate

Climatic limits

- In the north, the boundary coincides with the Northern European distribution range, with an annual average temperature of +2°C [12].
- In the south, limited by severe summer droughts in the Mediterranean region [12].

Soils

Water and drainage

Water supply:

- **Mesophilic species preferring thick soils** [13, 8, 1] with a **favourable water balance** [13], hence its occurrence on heavy, clay soils with a good supply of water [6]. **Moderately water-demanding** in **dry climatic conditions (Mediterranean)** [13, 12]. However, it can grow on drier sites where it competes with species such as beech with similar site requirements [1].

Waterlogging:

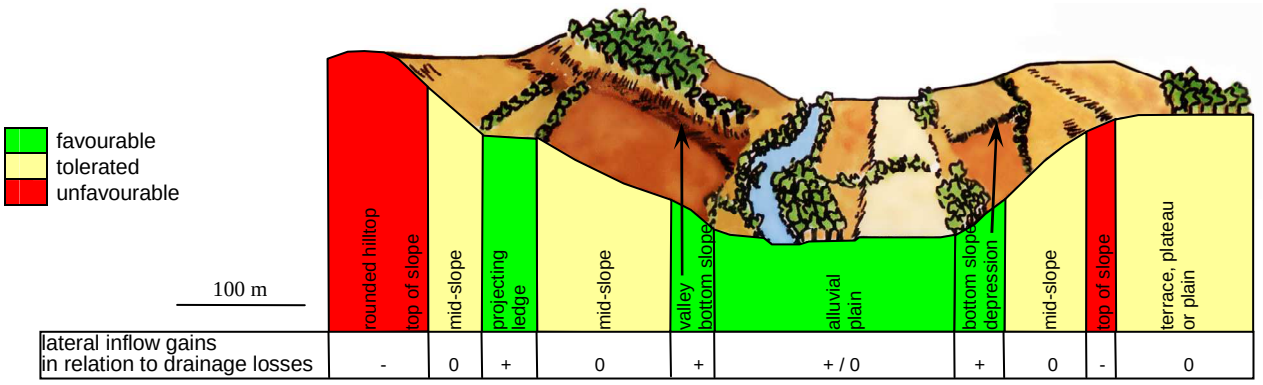
Drainage and excess water

			a	b	c	d	h	i	e	f	g
Natural drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	20-50cm	0-30cm	20-50cm	0-30cm	
water table	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

favourable
tolerated
unfavourable

(from the Species Ecology file, Ministry of the Walloon Region, 1991, amended)

Topographic situations favourable to the Small-leaved lime in terms of water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- Occurs most frequently on clay, loam and loess [6, 13], This species is **not very demanding** and is also found on compact clay soils, sand or limestone screes [11,14, 12].

Textures favouring growth of the Small-leaved lime

(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediary LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- Species present over a **wide pH range**, basic to acidic [13].
- **Prefers mineral-rich soils**, though it can be found on poor soils [1].

Nitrogen and phosphorus:

- **Moderately demanding** species, occurring on humus forms ranging from **eumull to moder,** but grows best **on mull** [13].

Lime in fine soil:

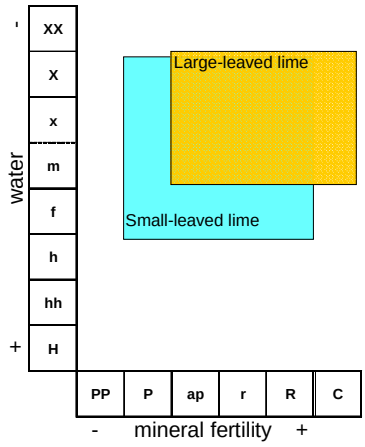
- Occurs on **lime** and prefers calcium-rich soils [12].

Summary of water and nutrient requirements and sensitivity of the Small-leaved lime

Water requirements	Moderate
Sensitivity to temporary waterlogging	Low to moderate
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soils	Low

Ecogram for Lime species

Favourable situations for timber production
(according to Rameau *and al*., 1989, amended)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Nomadic post-pioneer species [13], capable of **colonising screes** [1].
- Basal shoot growth and suckering [13].
- **Slow growth in height in the first years, then rapid growth** up to 70 years followed by very slow growth after 150-180 years. Small-leaved limes can grow to 30 m in height, less than Large-leaved limes [1].
- **Long-lived** (500 to 1000 years) [1, 13].
- Occurs scattered or in stands that are often small as the species is light-demanding; sensitive to competition, particularly from beech.
- Occurs in forest gullies (Lime-maple [1313community), but also in beech-oak woodlands and on river banks [13].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- Competition for light after the establishment phase.
- Waterlogged soils near the surface over a long period
- Broad ecological range, but chemically fertile sites with a good water supply are preferable.

Autecology of the

LARGE-LEAVED LIME

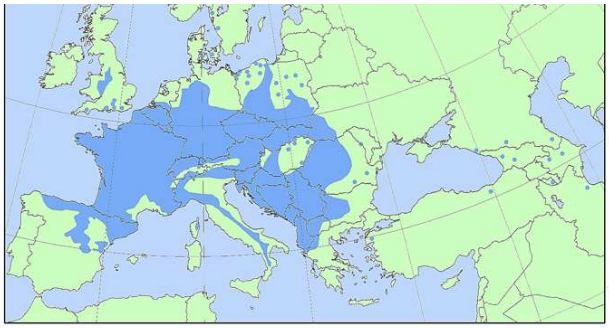
***Tilia platyphyllos* Scop.**

Fr. : Tilleul à grand feuilles
Sp. : Tilo hoja ancha; Cat.: Tell de fulla gran
Ger. : Sommerlinde
It. : Tiglio nostrano

Geographical distribution

- Eurasian, **sub-Atlantic and sub-Mediterranean species** [13].
- In France, fairly common in **the east, the Pyrenees and the southern foothills of the Alps**, **uncommon in the west and on the Mediterranean coast** [13].

Natural range of the Large-leaved lime in Europe



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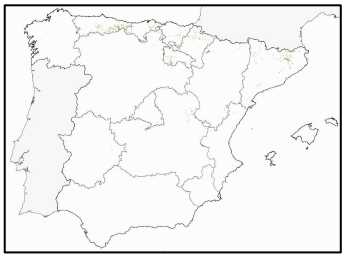
Distribution of the Large-leaved lime in Spain



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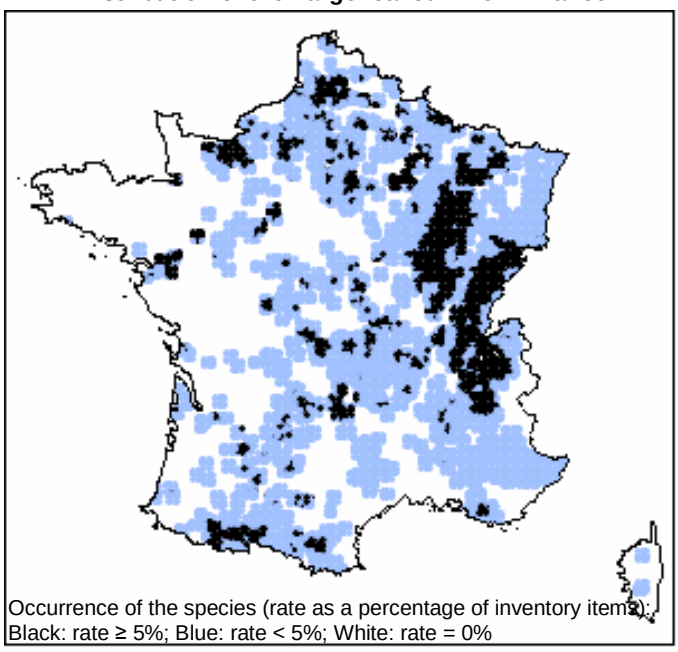
Distribution of the Large-leaved lime in France



Occurrence of the species (rate as a percentage of inventory items):
Black: rate ≥ 5%; Blue: rate < 5%; White: rate = 0%

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Climate and temperament

Bioclimatic conditions

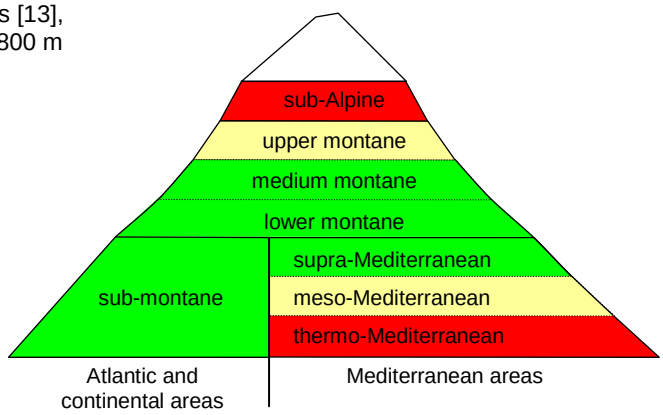
- Prefers **sub-Atlantic to sub-Mediterranean** climates, requires more **warmth than the Small-leaved lime** [1].
- **Withstands winter cold** [1, 6]. **More sensitive to late frost than the Small leaved lime,** which buds later [1].
- Needs more **air humidity than the Small-leaved lime**, hence its occurrence on northern slopes or in forest gullies [1].

Warmth requirement	Sensitivity					
	cold	late frost	early frost	sticky snow	wind	drought
Moderate	Very low	High	Low	Low	Low	Moderate

Vegetation stages

- Occurs at **supra-Mediterranean, sub-montane and montane** levels [13], where it may grow at altitudes above 1000m; will grow up to 1700-1800 m in the central Alps [13, 1, 12].

Distribution of the Large-leaved lime by vegetation stages



favourable
tolerated
unfavourable

Temperament

- **Shade or partial-shade** species [13], tolerant to shading in its early stages [1]. **Becomes more light-demanding than the Small-leaved lime as it grows**, including in unfavourable climatic or soil conditions [1].
- The Large-leaved lime therefore cannot compete with shade-tolerant species such as beech, although it occurs in beech-lime woodlands on shaded north-facing slopes or confined valley bottoms [1, 3].

Young adult Adult

Sensitivity to competition for light	Phototropic tendency
High	Moderate

Soils

Water and drainage

Water supply:

- **grows in dry to moderately humid conditions**, occurring on soils with a broad range of water supply conditions [13], including dry sites (top slopes to coarse screes and warm exposure) [3]. However, the Large-leaved lime is often found in **more humid conditions than** the Small-leaved Lime, with a good water balance, for example in shade and moisture-loving lime habitats [1, 3].

Water logging:

- **Does not occur on poorly aerated soil** [1].

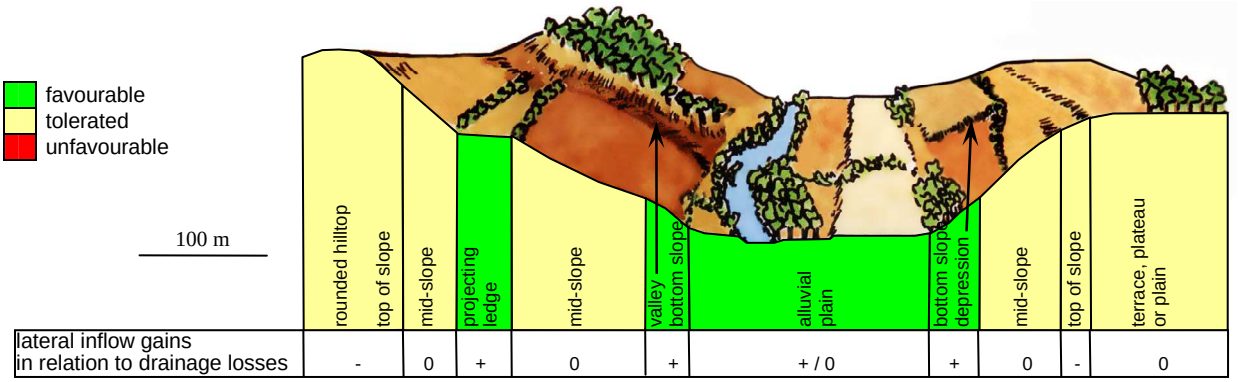
Drainage and excess water

			a	b	c	d	h	i	e	f	g
drainage			excessive	good	moderate	imperfect	poor	very poor	partial	virtually non-existent	non-existent
water table	temporary	redox horizon with rust patches	no water table	absent or > 90cm	60-125cm	40-80cm	60-125cm	0 - 30cm	60-125cm	0 - 30cm	
water table	permanent	reductive waterlogged horizon		-	-	-	-	-	> 80cm	40-80cm	< 40cm

favourable
tolerated
unfavourable

(from the Species Ecology file, Ministry of the Walloon Region, 1991, amended)

Topographic situations favouring growth of the Large-leaved lime in relation to the water supply
(involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)



Texture and materials

- Carbonates, coarse screes on gneiss or limestone, decarbonizing clays [13, 3].
- Due to its adaptability and nomadic behaviour, this species occurs on steep scree slopes and on filtering and aerated soils, often cool and humid [6], or on thin plateau soils [8].

Textures favouring growth of the Large-leaved lime
(involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

very sandy S	coarse SA, LS, SL	loamy LmS, Lm, Ll, LlS	intermediary LAS, LSA, LA, AL	clayey A, AS	very clayey Alo

favourable
tolerated
unfavourable

Nutrients

Nutritive elements:

- Occurs on base-rich, slightly acidic to basic soils. **More vulnerable to mineral deficiency than the Small-leaved lime** [13].

Nitrogen and phosphorus:

- Form of humus: **eumull**, even carbonated [13], but **can grow on soils poor in organic matter** such as screes with an adequate nitrogen supply [3].

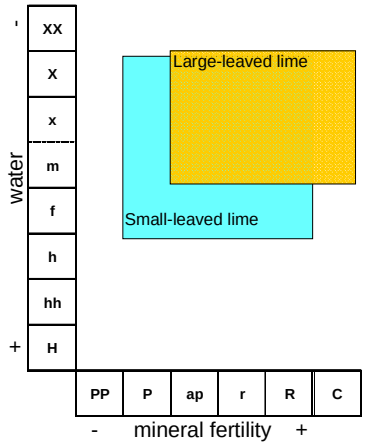
Lime in fine soil:

- Occurs on carbonate soils [2, 1].

Summary of water and nutrient requirements and sensitivity of the Large-leaved lime

Water requirements	Moderate
Sensitivity to temporary waterlogging	High
Nutrient requirements (Ca, Mg, K)	Moderate
Nitrogen (and phosphorus) requirements	Moderate
Sensitivity to lime in fine soil	Zero to very low

Ecogram for Lime species
Favourable situations for timber production
(according to Rameau *and al.*, 1989, amended)



DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Nomadic post-pioneer species [13], able to colonise screes, even on warm slopes [1].
- Growth of basal shoots from the stump [13].
- Slow growth in height in **the first years, followed by fast** growth up to 70 years and very slow growth after 150-180 years; Large-leaved lime can grow up to 40 m, higher than the maximum for Small-leaved lime [1].
- Very long-lived (1000 years), slightly more than the Small-leaved lime [1, 13].
- Mature species in forest gullies (maple woods on screes [6], ash woods on slopes [1], lime-maple communities [4]), also occurring in beech woods and dry beech-oak woods [13] or mixed with young oak woods in southern foothills and moderately high mountains [8].

MAIN FACTORS LIMITING THE PRODUCTION OF GOOD QUALITY TIMBER

- Competition for light, especially in the early years.
- Waterlogged soil near the surface for a long period
- Mineral deficiency and slow-recycling humus (moder)

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