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.

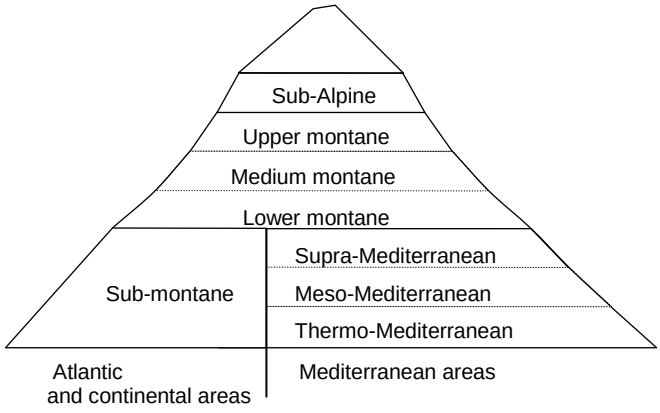
The maps showing distribution in France (IFN) were produced by the national forest inventory (IFN) based on vegetation data obtained prior to 2005 and the SOPHY database. Areas where a species is relatively common (percentage of vegetation surveys where the species is present = level of occurrence ≥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

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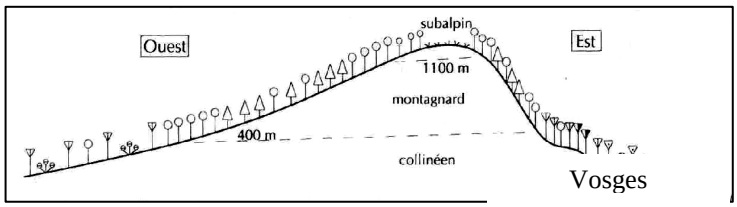
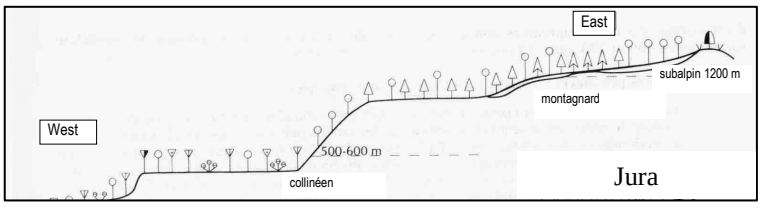
[1] Autecology: study of the site requirements for a species.
[2] Version of factsheets with bibliographic references available on the internet: www.foretpriveefrancaise.com and www.pirinoble.eu

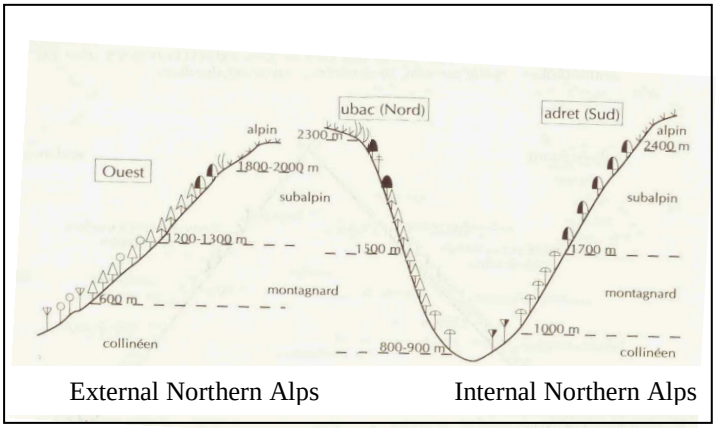
Limits of vegetation stages in French mountain areas and natural vegetation found
(According to Rameau *et al*., 1989: FFF, vol. 2 Mountains)



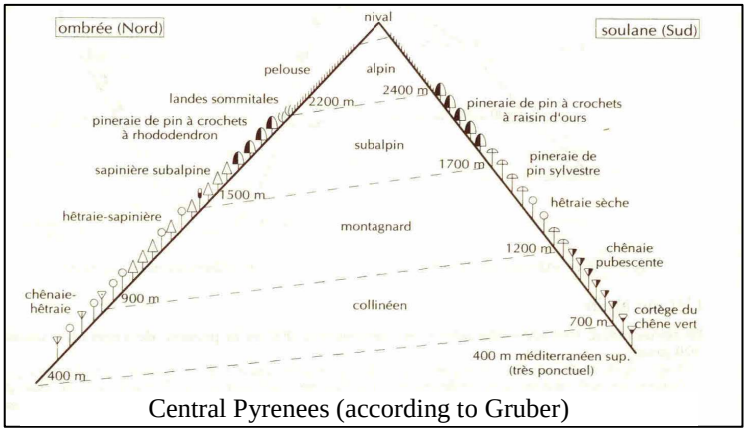
Vosges



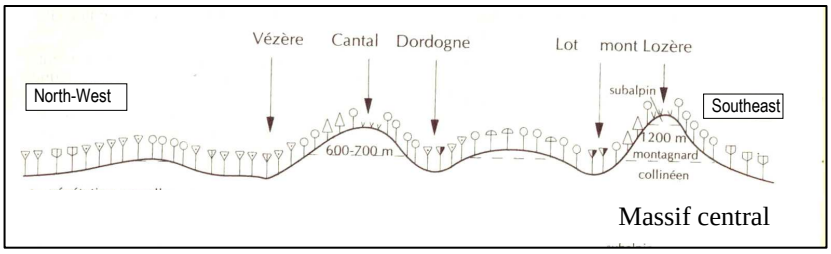
Jura



External Northern Alps — Internal Northern Alps



Central Pyrenees (according to Gruber)



Massif central

Meaning of key to the essences :

Holm oak, Downy oak, Sessile oak, Pedunculate oak, Hornbeam, Birch, Alder, Rowan/ Mountan ash, Sweet chestnut, Sycamore, Large-leaved lime, Scots pine, Beech, Fir, Spruce, Mountain pine, Arolla pine, Larch, sub-Alpine moorland, green alder

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

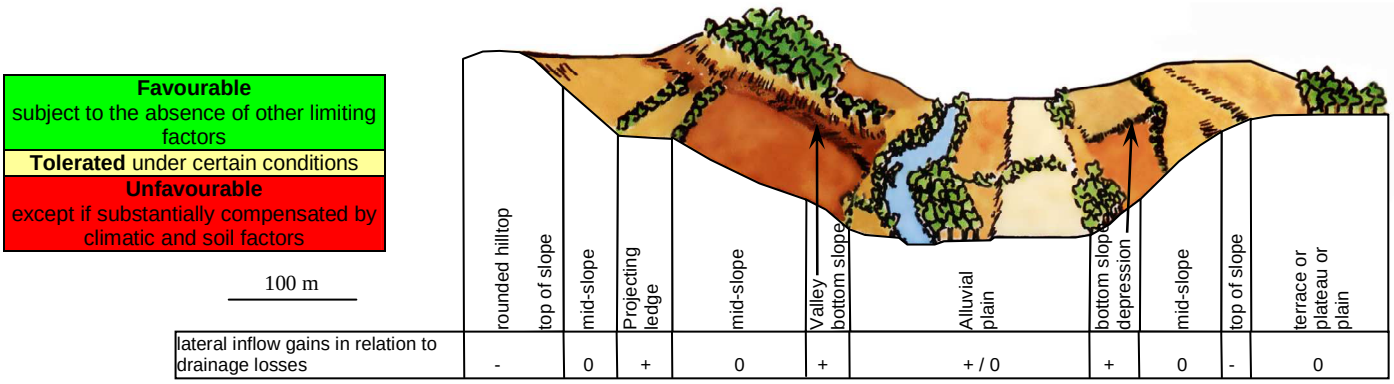
			a	b	c	d	h	i	e	f	g
definition		on loam - clay		not gleyed	slightly gleyed	moderately gleyed	heavily gleyed (temporary water table)	Very heavily gleyed (temporary water table)	heavily gleyed with reduced horizon (permanent water table)	very heavily gleyed with reduced horizon (permanent water table)	reduced (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.

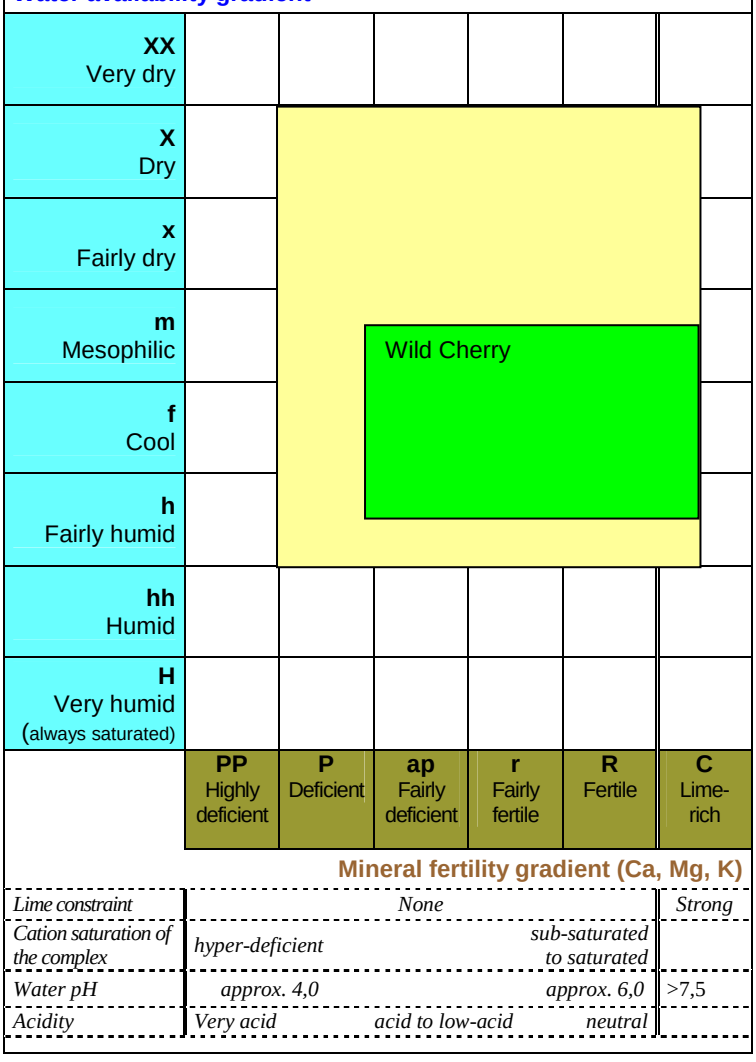
This type of representation is based on *Flore forestière française* (forest flora in France) (Rameau *et al*., 1989, 1993, 2008), with two changes made to the horizontal axis:

→ 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

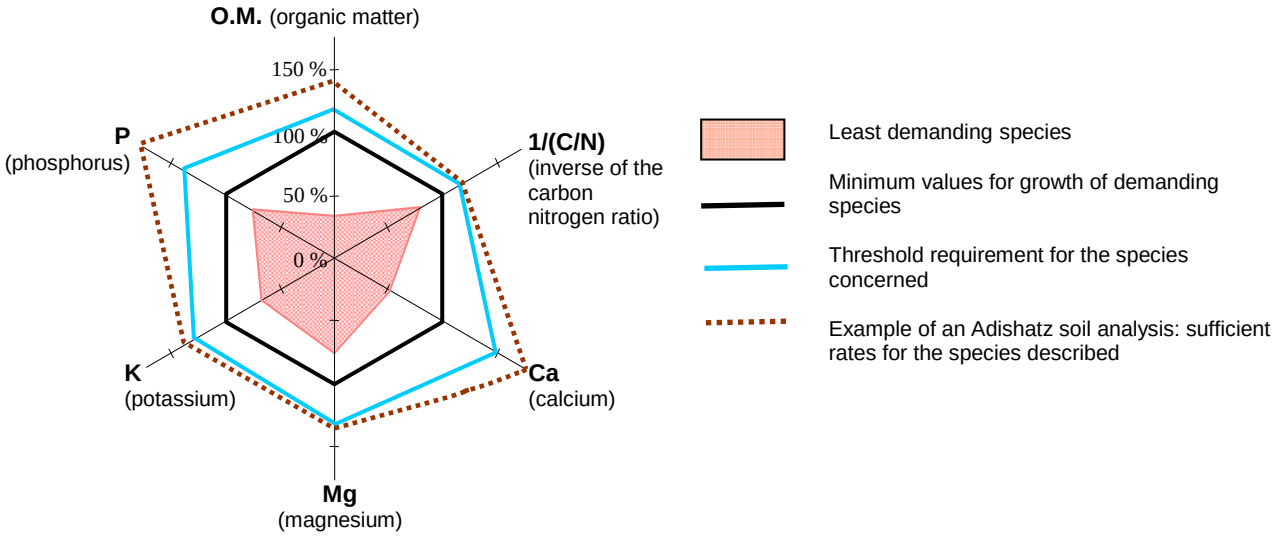
This diagram shows the nutrient levels from the soil horizon that ensures healthy growth of the species. It is based on the same model as the Adishatz "radar" graph, a computer tool developed by the Midi-Pyrénées CRPF (Regional Centre for Forest Owners) (Larrieu & Delarue, 2004) for interpreting soil 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





■ 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).

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■ 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.

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