Salix caprea in Europe: distribution, habitat, usage and threats

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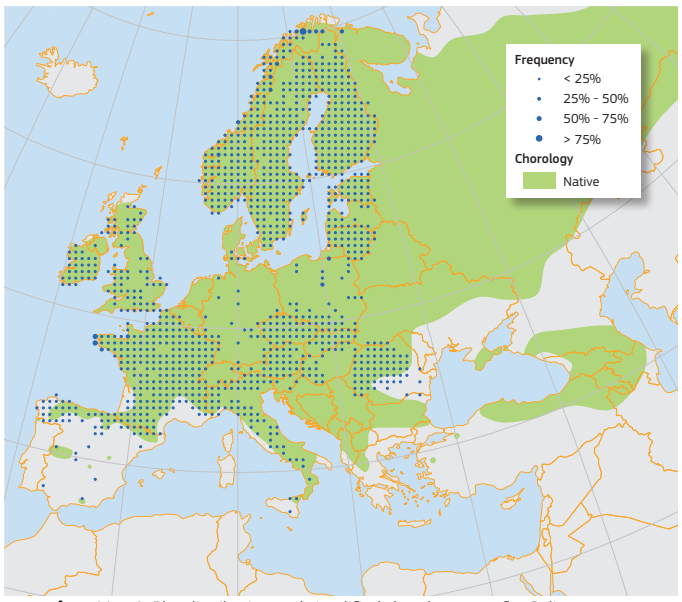
***Salix caprea* L., commonly known as goat willow, is a pioneer and a fast-growing plant, which has a wide distributional area across Europe and Asia in the boreal and temperate zones. The scientific name *caprea* means goat, which probably derives from the fact that its leaves were used as goat fodder. Due to its wide distribution range and its high ecological amplitude, goat willow represents a very valuable multi-purpose species, used principally for biomass plantation and for gardening and hedges.**

The goat willow (*Salix caprea* L.) is a deciduous small to medium-size tree or shrub with heights up to 10 m[1, 2], reaching only exceptionally 15 m[3]. It has a far-reaching and especially well-developed fibrous root system[1]. The trunks are small, occasionally reaching a diameter of 40 cm[4]. The bark is smooth at the beginning, forming a thin **rhytidome**, irregularly cracked[2]. The twigs are greenish, thick and with grey hairs. The leaves are alternate, broadly elliptic and up to 5-12 cm long. The upper side of the leaf is green and glossy, while the underside is covered by densely and softy white-downy hairs[1, 5]. The goat willow is a **dioecious** species and catkins appear in early spring (usually in March or April, depending on the site conditions). Male catkins have spreading yellow stamens, while female catkins are greenish and insect-pollinated. The catkins are erect, with approximately 100-200 flowers in each female catkin and 200-300 flowers in each male catkin, respectively. Catkins are produced abundantly and they appear before the leaves[3]. This willow naturally hybridises with a number of other *Salix* species, producing fertile descendants with intermediate characteristics. Hence, this makes it difficult to determinate taxonomical limits and to assign individuals to a particular species within the *Salix* genus[6, 7].



Map 1: Plot distribution and simplified chorology map for *Salix caprea*.
Frequency of *Salix caprea* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *S. caprea* is derived after several sources[9, 52-56].

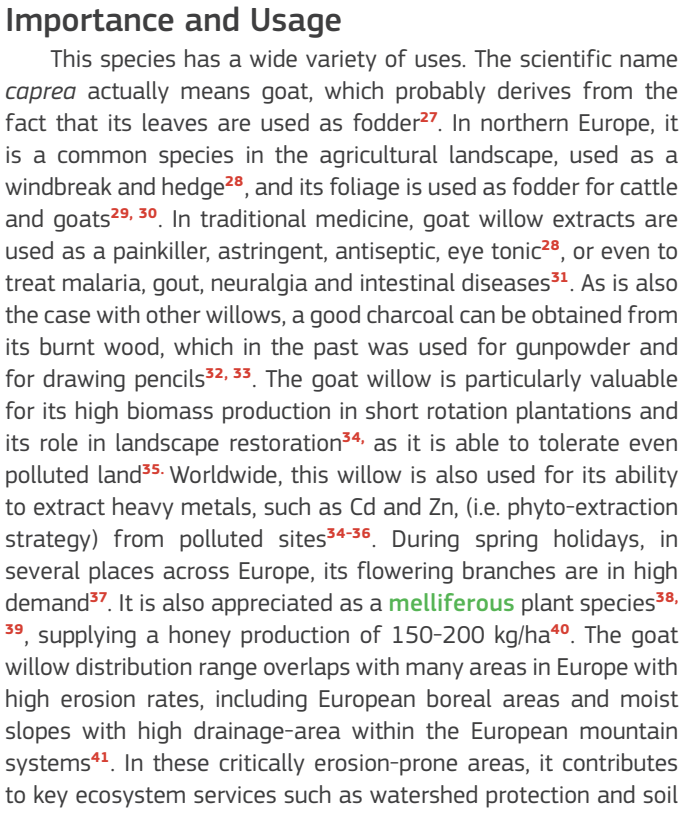
Distribution

This species is native to cool temperate and boreal regions of Europe and Asia, occurring in a large range of habitats across Europe and Asia[8]. Its wide distribution spreads from Spain to China, from Turkey and northern Iran to **Fennoscandia** and Siberia reaching up to 70° north latitude[1, 9-11]. It has been also introduced in eastern North America and is now naturalised[12].

Habitat and Ecology

The goat willow is a pioneer[13] and a fast-growing plant[14], tolerating a wide variety of **edaphic** and climatic conditions[1]. It shows a high adaptability to different habitat conditions[15], such as dry or wet sites[16], usually growing in **mesic** to moist stands[4]. It prefers the calcareous sites, but it grows on almost all soil types[17]. Compared with other willow species, the goat willow is more sensitive to continuous flooding[18], avoiding the saturated soils of wetlands[19]. Regarding its demand for light, it is a very shade intolerant species, occurring in open areas with full sun[1], but it is one of the few willow species able to grow in forest understories[8]. Unlike almost all other willows, the goat willow can only occasionally be propagated vegetatively by cuttings[8, 20].

In boreal forests, it is found in the dominant Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and birch (*Betula* spp.) forests, in admixture with other deciduous species such as aspen (*Populus tremula*) and rowan (*Sorbus aucuparia*)[21, 22], favoured by disturbances which create open areas[23]. In temperate forests dominated by oaks (*Quercus* spp.), European beech (*Fagus sylvatica*) and Norway spruce, it is present with other understorey species such as hazel (*Corylus avellana*), elder (*Sambucus nigra*) and bramble shrubs of the genus *Rubus*, occurring principally in forest clearings and open areas[24-26].



Goat Willow in Hesse, Germany.
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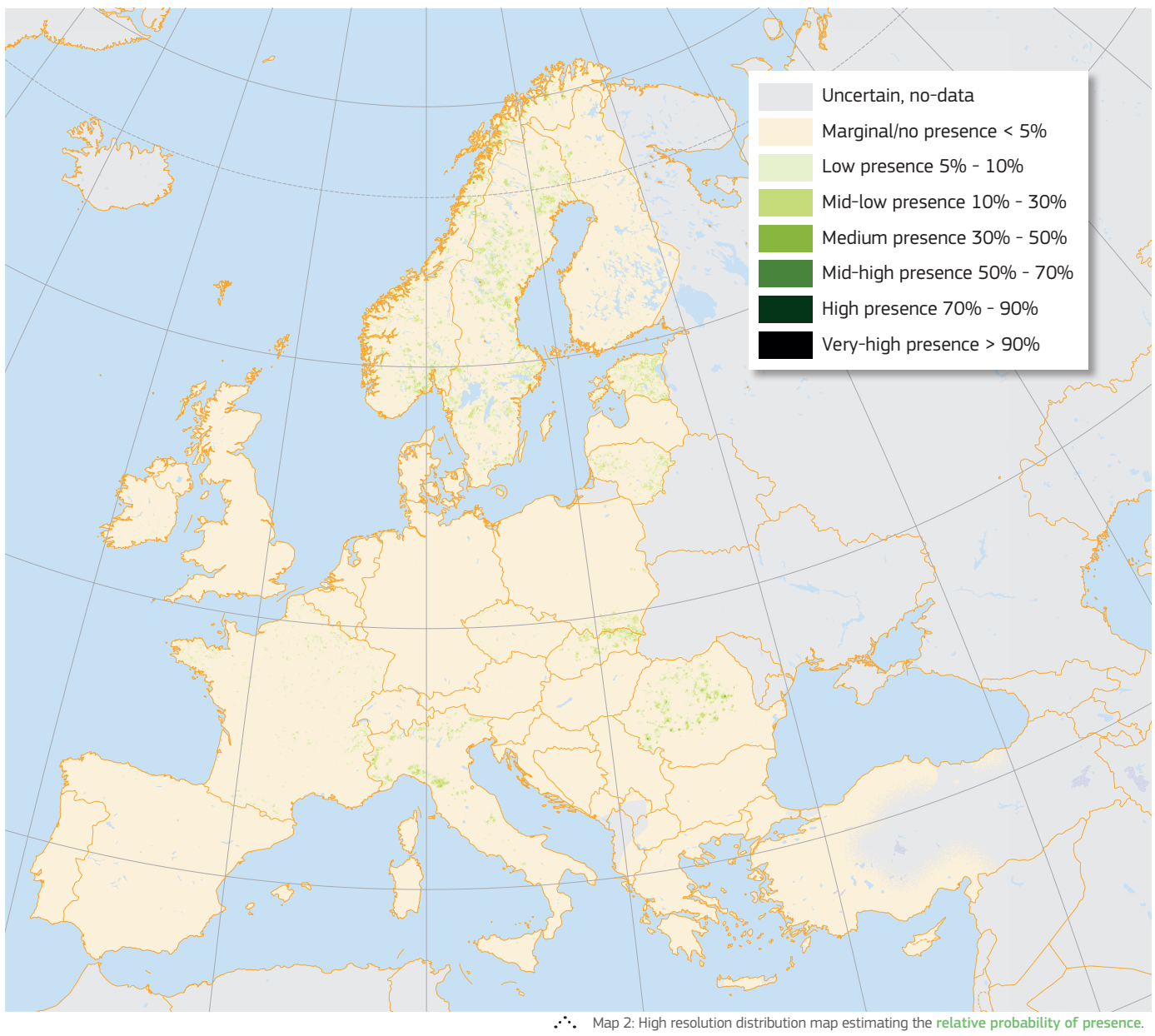
Importance and Usage

This species has a wide variety of uses. The scientific name *caprea* actually means goat, which probably derives from the fact that its leaves are used as fodder[27]. In northern Europe, it is a common species in the agricultural landscape, used as a windbreak and hedge[28], and its foliage is used as fodder for cattle and goats[29, 30]. In traditional medicine, goat willow extracts are used as a painkiller, astringent, antiseptic, eye tonic[28], or even to treat malaria, gout, neuralgia and intestinal diseases[31]. As is also the case with other willows, a good charcoal can be obtained from its burnt wood, which in the past was used for gunpowder and for drawing pencils[32, 33]. The goat willow is particularly valuable for its high biomass production in short rotation plantations and its role in landscape restoration[34,] as it is able to tolerate even polluted land[35.] Worldwide, this willow is also used for its ability to extract heavy metals, such as Cd and Zn, (i.e. phyto-extraction strategy) from polluted sites[34-36]. During spring holidays, in several places across Europe, its flowering branches are in high demand[37]. It is also appreciated as a **melliferous** plant species[38, 39], supplying a honey production of 150-200 kg/ha[40]. The goat willow distribution range overlaps with many areas in Europe with high erosion rates, including European boreal areas and moist slopes with high drainage-area within the European mountain systems[41]. In these critically erosion-prone areas, it contributes to key ecosystem services such as watershed protection and soil stabilisation[42]. As for other willows and poplars, it is also useful for ecosystem restoration and **phytoremediation**[43,44].

Finally, the goat willow plays an important role in maintaining species diversity, by being the host of several lichen species[4, 37].



Map 2: High resolution distribution map estimating the **relative probability of presence**.

Male catkins turn yellow when the pollen is ready for release.
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This willow is among the first flowering plants in the spring, the catkins providing a high quantity of pollen and nectar as a food source, to bees, insects or birds, such as Eurasian blue tits (*Cyanistes caeruleus*)[3].

Female catkins are insect pollinated.
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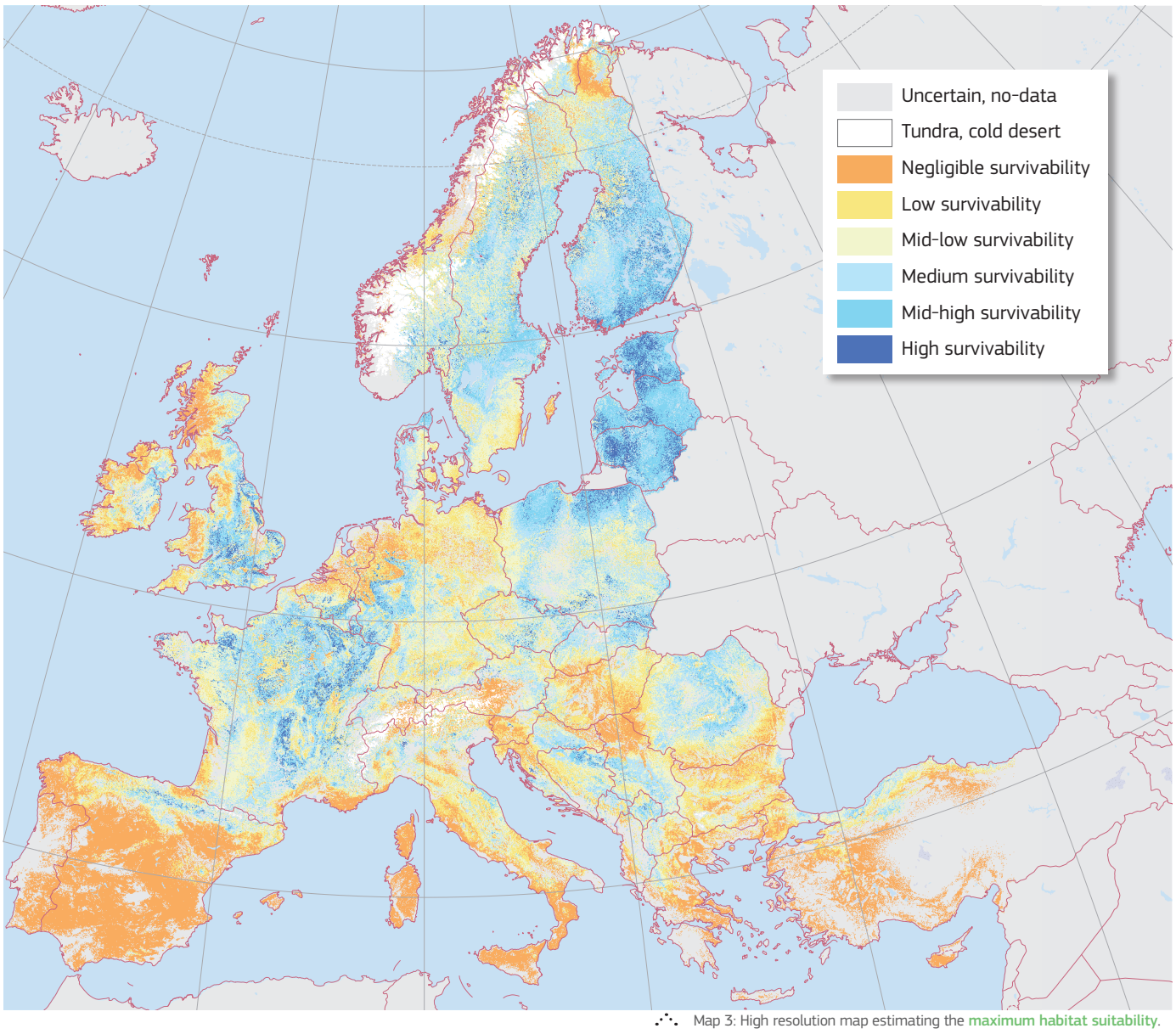

Map 3: High resolution map estimating the **maximum habitat suitability**.

Threats and Diseases

The goat willow is a short-living plant and has no severe threatening diseases in its natural habitats. Pests are reported to result in economic loss only in biomass coppice plantations. The fungus *Rhytisma salicinum*, the leaf-galler sawfly *Pontania pedunculi* and the leaf-folder sawfly of genus *Phyllocolpa* may cause damage to individuals, by affecting the leaves[45]. The rust fungus *Melampsora capaearum* may infect the goat willow and its hybrids, raising dusty orange spots or pustules on the leaves, resulting in lower photosynthetic performance and eventually defoliating the trees. Breeding programmes have been promoted for selecting rust resistant willows in biomass plantations and gardening plants[46, 47]. The goat willow is susceptible to attacks from the Asian longhorned beetle (*Anoplophora glabripennis*), despite showing noticeable resistance and thus potentially acting as overwintering reservoir of the beetle[48, 49]. It is also vulnerable to the gypsy moth (*Lymantria dispar*)[48, 50, 51]. *Nematus miliaris* can completely defoliate the goat willow, which in Poland has been reported to be preferentially attacked (along with *Salix*

The leaves are broader than those of many other willow species.
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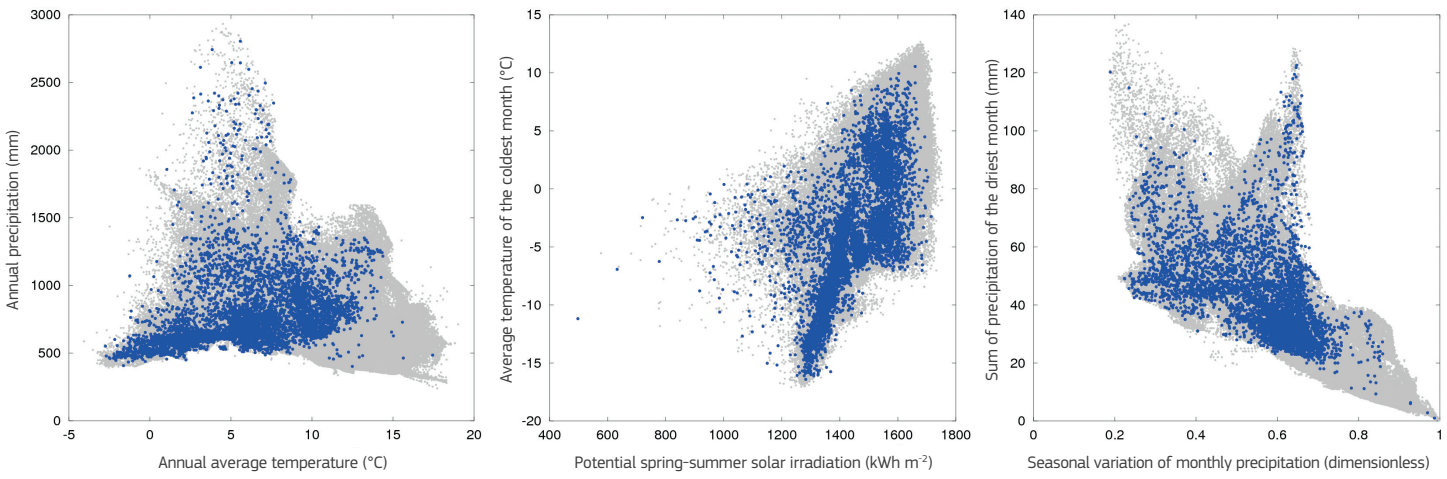
Field data in Europe (including absences) ● Observed presences in Europe ●

Autoecology diagrams based on harmonised **field observations** from **forest plots**.



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