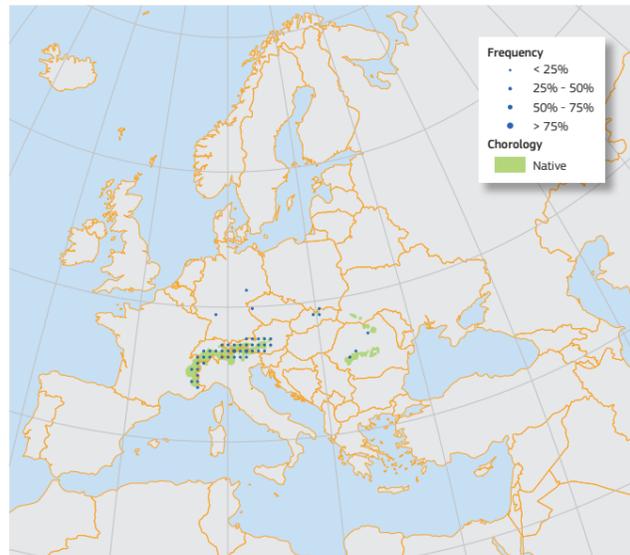


Pinus cembra in Europe: distribution, habitat, usage and threats

G. Caudullo, D. de Rigo

Arolla or Swiss stone pine (*Pinus cembra* L.) is a slow-growing, long lived conifer that grows at high altitudes (up to the treeline) with continental climate and is able to resist to very low winter temperature. It has large edible seeds which are dispersed principally by the European nutcracker. The timber is strong and of good quality but it is not a commercially important species because of its slow growth rate and frequent contorted shape. This pine is principally used to protect slopes and valleys against avalanches and soil erosion. In alpine habitats it is threatened principally by tourism development, even if the recent reduction of mountain pasture activities is allowing this pine to return in many areas.

Pinus cembra L., known as Arolla pine or Swiss stone pine, is a slow growing, small to medium-sized evergreen conifer (10-12m height, occasionally 20-25m), which can live up to 1000 years¹⁻⁵. The crown is densely conical when young, becoming cylindrical and finally very open⁶. It grows commonly in a curved or contorted shape, but in protected areas can grow straight and to considerable sizes. Needles are in fascicles of five, 5-9cm long^{1, 7}. Arolla pine is a **monoecious** species and the pollination is driven by wind³. Seed cones appear after 40-60 years, they are 4-8cm long and mature in 2 years^{3, 6}. The wingless seeds are large and edible (7x10mm)^{1, 7}. Genetically the Arolla pine is close to the Siberian stone pine (*Pinus sibirica*) and they can hybridise.



Plot distribution and chorology map for *Pinus cembra*.
Caption: Frequency of *Pinus cembra* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *P. cembra* is derived after EUFORGEN²⁸.

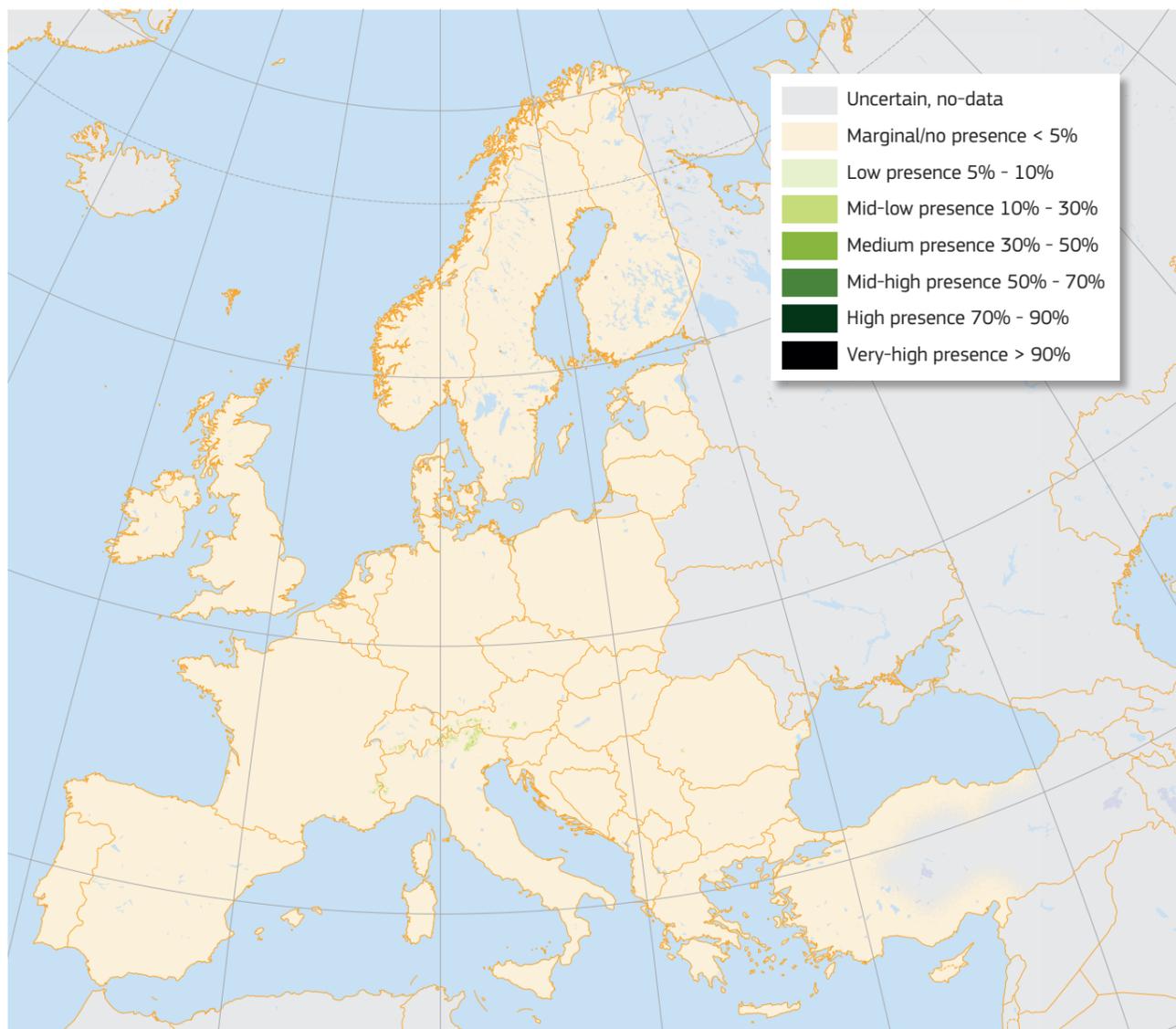
Some authors consider them as subspecies⁸. This Arolla pine is considered a glacial relict of the Siberian pine^{3, 6, 9, 10}.

Distribution

Arolla pine grows in the Alps chain, from the Maritime Alps in France to the Julian Alps in North Slovenia, and it is more abundant in the eastern sector. It occurs also in isolated groups in the Tetra Massif, the Carpathians and the Transylvanian Alps^{1, 10-13}. It had a wider range in Europe during the last glaciation, then with rising temperatures it suffered a sharp fragmentation as a consequence of its natural competition with Norway spruce (*Picea abies*), which isolated the Arolla pine in the highest elevations¹⁴.



Large seed cone takes 2 years to mature.
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Map 2: High resolution distribution map estimating the relative probability of presence.

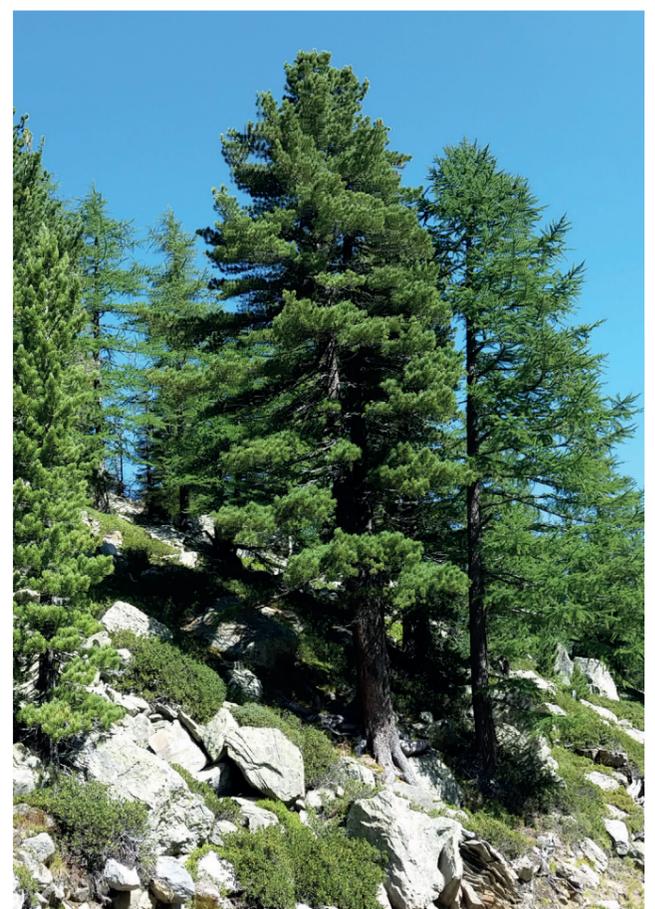


Seed cones are purplish in colour when maturing.
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Outside its natural range, it is planted in parks and arboreturns especially in northern Europe⁸.

Habitat and Ecology

This pine grows in the timberline of the alpine and subalpine zone with continental climate, from 1100m to 2500m and sometimes over 2700m in Italian Alps developing into a bush habit^{6, 8, 12, 15}. It is one of the most cold-hardy trees known, resistant to frost thanks to its evergreen foliage in which the water content can be reduced to a minimum during winter. It can reach temperatures in winter down to -43°C and in summer between -6°C and -10°C without damage (two to three year old needles)⁸. It is sensitive to 'late frosts' in spring and drought stress mainly in lower zones^{15, 16}. It grows better in fresh-humid, deep and well-drained soils. The substratum type is not particularly significant, growing both in calcareous or siliceous conditions^{1, 17}. Arolla pine rarely is found in pure stands, probably because the optimal habitats have been transformed into pastures¹⁸. In fact, it is more frequently found with other tree species forming open conifer forests and woodlands up to the tree line^{2, 7}. It is associated principally with larch (*Larix decidua*), with dwarf pine (*Pinus mugo*) where the soils is disturbed by landslides, with green alder (*Alnus viridis*) where avalanches are more frequent, or with Norway spruce (*Picea abies*) in lower elevations¹⁸. Seed dispersal is principally driven by the corvid Eurasian nutcracker (*Nucifraga caryocatactes*), which has a mutualistic relationship with the pine¹⁹. This bird, covering distances up to 15km, can collect more than 25000 seeds every year, storing them in many small deposits on the ground as a food winter reserve. Some of these reserves are abandoned and seeds can germinate^{1-3, 20}. Other animal species contribute to seed dispersion, such as woodpeckers (*Dryobates major*, *Picoides tridactylus*), Eurasian jay (*Garrulus glandarius*), red squirrel (*Sciurus vulgaris*) and dormouse (*Glis glis*)⁸.



Swiss stone pine mixed with larch (*Larix decidua*) in open subalpine woodland near Morgex (Valle d'Aosta, North-West Italy).
(Copyright Giovanni Caudullo: CC-BY)



Swiss stone pines at the limit of tree vegetation along the Aletsch Glacier (Valais, Switzerland). (Copyright Jo Simon, www.flickr.com: CC-BY)

Importance and Usage

Arolla pine is not an important timber tree economically, as it grows slowly and with irregular shapes, so forestry practices tend to favour other species in alpine habitats, such as the larch^{2, 15}. This pine has as a more ecological and protection function for slopes and valleys against avalanches and soil erosion¹⁻³. The wood has yellowish sapwood and reddish heartwood with a strong aromatic odour and it is very high quality, light, easy to work and durable, as it is resistant to woodworm⁸. It was overused for centuries in alpine areas as firewood, and for furniture and building construction. Now it is principally used for handicraft (turnery, carvings, toys, marquetry) and in a minor way it is still used in carpentry, traditional houses, and flooring. Pine nuts are tasty and rich in nutrients⁸. They were used more in the past: now Arolla pine is rarely cultivated for its seeds, as it is difficult to harvest due to the soft, resinous and closed cone scales^{1, 2}. Cones can be used to flavour alcoholic distillates¹. From cones, needles, buds and branches an essential oil can be extracted and used in natural medicine and as essence. Some cultivars with different habits and needle colours have been selected for ornamental purposes, used principally in Northern and Eastern Europe, where late frosts are less frequent¹⁵.

Threats and Diseases

Since Neolithic times human activities (alpine farming, intensive grazing with cattle, timber exploitation) have brought the treeline in the Alps down and turned much of the ancient alpine forests into pasture woodland. The recent abandonment of high alpine pasture is allowing the Arolla pine to make a comeback in many areas^{2, 21}. Nowadays the habitat fragmentation of this pine is principally caused by tourism development: in

particular ski runs, ski lifts, roads and parking lots². Damage to young seedlings by grazing animals can create gaps in the age distribution³. Deep snow layers lasting until late winter or spring causes browning needle diseases by the snow mold fungi *Phacidium infestans*, *Gremmeniella abietina* and *Herpotrichia juniperi*, which lead to mortality of young plants (seedlings)²²⁻²⁴. In the Alps, the larch bud moth *Zeiraphera diniana* has a species form genetically differentiated and specialised for defoliating the Arolla pine²⁵. However, the sporadic outbreaks do not influence the presence of the pine or its dominance in mixed forest with European larch^{26, 27}.



A Eurasian nutcracker. This corvid is the principal contributor of Swiss stone pine's seed dispersal. (Copyright Murray B. Henson, commons.wikimedia.org: PD)



Needles of this pine are in fascicles of five. (Copyright Michael Wunderli, www.flickr.com: CC-BY)



Grey-brown bark is fissured in mature pines with long plates. (Copyright Silvano Radivo, www.actaplantarum.org: AP)

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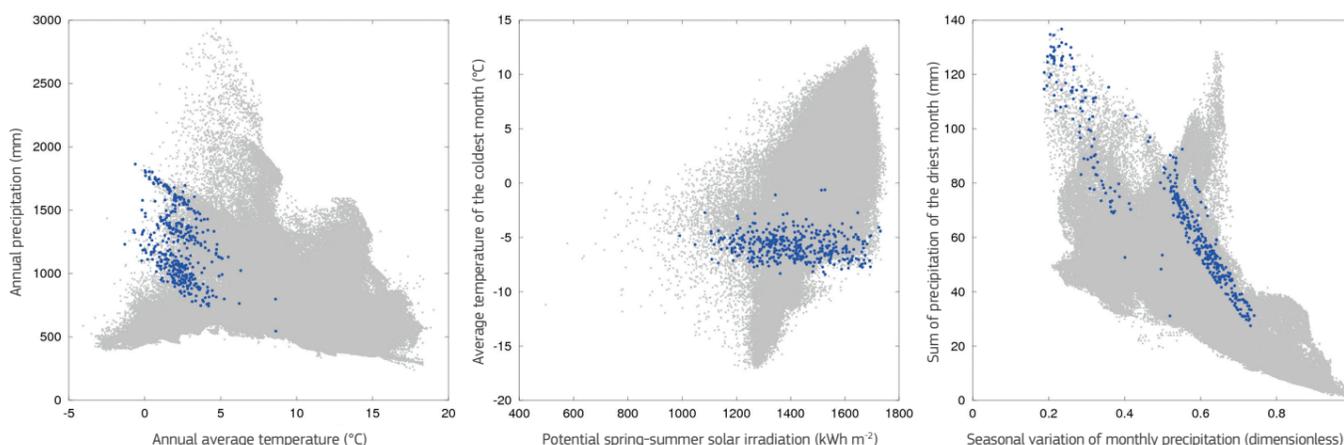
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Close-up of a purplish seed cone. (Copyright Silvano Radivo, www.actaplantarum.org: AP)

Field data in Europe (including absences) ● Observed presences in Europe ●

Autoecology diagrams based on harmonised field observations from forest plots.



This is an extended summary of the chapter. The full version of this chapter (revised and peer-reviewed) will be published online at <https://w3id.org/mtv/FISE-Comm/v01/e01bd9b>. The purpose of this summary is to provide an accessible dissemination of the related main topics.

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