

Important Woody crops for marginal lands facing natural constraints

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CENTRE FOR RENEWABLE
ENERGY SOURCES AND SAVING

Midas

MARGINAL LANDS, INDUSTRIAL CROPS
AND INNOVATIVE BIO-BASED VALUE CHAINS



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From 67 industrial crops to 4 woody species in MAGIC

Selection pathway used in the MAGIC project

67 industrial crops
screened in MAGIC



20 industrial crops
selected



Perennial herbaceous crops

e.g. switchgrass, miscanthus,
reed canary grass, cardoon



Fibre crops

e.g. industrial hemp,
fibre sorghum



Woody crops

e.g. willow, poplar,
Siberian elm, black locust



Selected from the broader MAGIC crop portfolio

4 woody species in focus



Willow

(*Salix spp.*)



Poplar

(*Populus spp.*)



Siberian elm

(*Ulmus pumila*)



Black locust

(*Robinia pseudoacacia*)



67 crops screened



20 crops selected



4 woody species highlighted

Willow (*Salix spp. L.*)

Contents

1



Crop
description

2



Origin and
cultivation area

3



Soil and climate
preferences



4



Cultivation
protocol

5



Harvesting

6



Uses

Willow (*Salix spp. L.*) – Crop description



Willow short-rotation coppice plantation



Willow catkins
(male and female)



Leaves and young shoots



Stool and coppice regrowth
after harvest



Botanical identity

Deciduous woody perennial genus in the Salicaceae family; includes many shrub and tree species grown for biomass and environmental uses.



Growth habit and size

Fast-growing, multi-stemmed habit in short-rotation coppice. Depending on species, site and rotation, shoots commonly reach about 3–8 m before harvest.



Root system

Extensive, fibrous and spreading root system; effective for water and nutrient uptake and for soil stabilisation.



Leaves and stems

Slender flexible stems; simple, narrow lanceolate leaves, usually finely serrated.



Flowers and reproduction

Dioecious plants with male and female catkins; commercial biomass willow is usually propagated vegetatively from dormant stem cuttings.



Adaptation and key traits

Strong coppicing ability, rapid juvenile growth, good suitability for moist temperate conditions and several marginal lands; valuable for biomass, shelterbelts and phytoremediation.



Key features

- Vigorous coppicing
- Easy propagation from cuttings
- Useful for biomass and environmental services.

Willow (*Salix spp. L.*) – Origin and cultivation area

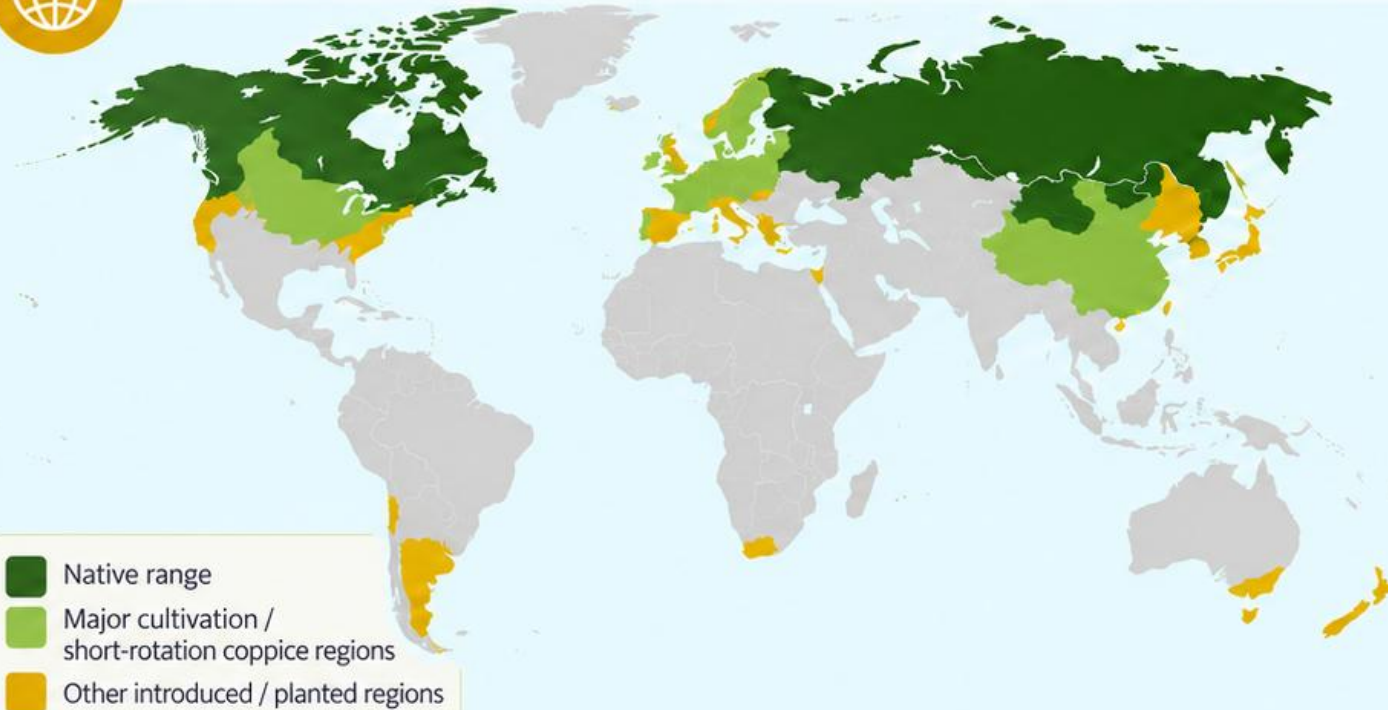


Origin

- Native mainly to **temperate, boreal and riparian regions** of the Northern Hemisphere.
- Diversity centres in **Europe, Asia and North America**.
- Many commercial biomass clones are derived from selected *Salix* species and hybrids.



Global distribution and cultivation area



Willow in a riparian habitat



Main cultivation regions (examples)

- **Northern and Central Europe:** Sweden, UK, Poland, Germany, Baltics and neighbouring regions.
- **North America:** USA and Canada.
- **Asia:** China and other temperate zones.
- Also planted for **riparian restoration, shelterbelts, wastewater treatment and phytoremediation**.



Key point

Willow is especially suited to **cool-to-temperate climates with adequate moisture**.

Willow (*Salix spp. L.*) – Soil and climate preferences and cultivation protocol



Willow short-rotation coppice plantation on a moist site

Soil and climate preferences



Best on deep, fertile, moisture-retentive loam or silt-loam soils.



Performs well where water supply is reliable; commonly suited to riparian or other moist sites.



Tolerates heavy soils and temporary waterlogging better than many crops, but shallow drought-prone soils reduce yield.



Prefers cool-to-temperate climates with good light and adequate rainfall or supplementary water during establishment.



Usually favours slightly acidic to neutral soils, though many clones also tolerate mildly alkaline and moderately saline conditions.

Cultivation protocol

1

Site selection & preparation: choose moist, accessible land; remove perennial weeds and prepare a firm seedbed.

2

Planting: establish with dormant stem cuttings or rods in early spring.

3

Planting density: typically about 10,000–15,000 cuttings ha⁻¹, often in twin-row systems.

4

Establishment year: maintain strict weed control; irrigate only if moisture is limiting.

5

Nutrition & management: fertilise according to soil tests and local needs; replace failures if needed.

6

Coppicing & harvest cycle: cut back after the first season to promote multi-stem stools, then harvest every 2–4 years over a long stand life.



Dormant willow cuttings for planting



Young plantation during establishment



Coppice regrowth after harvest



Key point

Willow is especially well adapted to cool-temperate climates and moist soils, making it a strong option for biomass, shelterbelts and phytoremediation.

Willow (*Salix spp. L.*) – Harvesting



Mechanised cut-and-chip harvesting of short-rotation coppice willow



Cut-and-chip harvesting with forage harvester and trailer



Coppice stool with multiple new shoots after harvest

1 Harvest timing

- Harvest in the dormant season (late autumn to winter) when leaves have fallen and soils are trafficable.

2 Establishment cutback

- After planting, the crop is usually cut back after the first growing season to stimulate multi-stem stool formation.

3 Rotation length

- Commercial short-rotation coppice harvest is typically every 2–4 years, commonly on a 3-year cycle.

4 Main harvest systems

- Single-pass cut-and-chip harvesting.
- Cut-and-store / whole-rod systems.
- Bale or billet systems.

5 Biomass use and handling

- Harvested biomass is usually chipped for heat, CHP or further processing.
- Stems may also be dried before chipping in some systems.

6 Productive lifespan

- Productive plantations can remain in rotation for around 20–25 years with repeated coppicing.

Key point

Willow is harvested as a coppice crop on repeated short rotations for woody biomass.

Willow (*Salix spp. L.*) – Uses



Bioenergy

- Wood chips for heat and combined heat-and-power (CHP).
- Feedstock for pellets and other solid biofuels.
- Fast-growing, high-yield biomass crop suitable for short-rotation coppice.



Willow wood chips and pellets for bioenergy



Biorefinery and biobased products

- Lignocellulosic feedstock for bio-based materials, fibres and chemicals.
- Used to produce bioproducts such as biochar, bioplastics, biochemicals and value-added materials.
- Supports a circular bioeconomy and replaces fossil-based products.



Willow fibres and biochar as biorefinery products



Phytoremediation

- Suitable for contaminated or marginal lands (e.g. former industrial and mining sites).
- Helps capture, accumulate or stabilise pollutants such as heavy metals and excess nutrients.
- Produces valuable biomass while improving soil quality.



Willow on a contaminated or marginal land site



Riparian buffers and erosion control

- Streamside planting, shelterbelts and windbreaks.
- Stabilises river and stream banks, reduces soil erosion.
- Helps filter runoff and improve water quality.



Willow riparian buffer along a watercourse



Wastewater and nutrient management

- Used in short-rotation coppice systems for wastewater treatment (e.g. constructed wetlands).
- Helps remove excess nutrients (N, P) and other pollutants.
- Recycles nutrients into biomass and supports a circular nutrient economy.



Willow used in a wastewater treatment system



Ecosystem services

- Sequesters carbon in biomass and soils.
- Provides habitat for wildlife and supports biodiversity.
- Contributes to landscape restoration, climate change mitigation and adaptation.



Willow habitat and biodiversity benefits

Key point

Willow combines productive biomass use with multiple environmental services, making it a versatile crop for a more sustainable and resilient landscape.

Poplar (*Populus* spp.) – Contents

Overview of the topics covered in the following slides



1



Crop description

2



Origin and cultivation area

3



Soil and climate preferences

4



Cultivation protocol

5



Harvesting

6



Uses

Poplar (*Populus spp.*) – Crop description



Poplar short-rotation coppice plantation



Catkins



Leaves and young shoots



Stool and coppice regrowth



Botanical identity

Deciduous woody perennial genus in the Salicaceae family; includes many *Populus* species and hybrids used for wood, biomass and environmental applications.



Growth habit and size

Fast-growing trees with strong juvenile growth; in short-rotation coppice, multi-stem shoots commonly reach about 3–8 m before harvest, while tree forms can become much taller.



Root system

Extensive and spreading root system, effective for water and nutrient uptake and useful for soil stabilization.



Leaves and stems

Simple alternate leaves, often triangular to ovate with serrated margins; straight stems and smooth young bark are typical features.



Flowers and reproduction

Dioecious plants bearing male and female catkins; seeds are tufted with cottony hairs, but commercial plantations are commonly established vegetatively from cuttings.



Adaptation and key traits

High productivity, strong coppicing ability and wide genetic diversity; well suited to temperate regions, especially on moist, fertile sites.

Key features

- Rapid growth and good coppice regrowth
- Suitable for wood, fibre and biomass production
- Useful for phytoremediation and environmental services.

Poplar (*Populus spp.*) – Origin and cultivation area



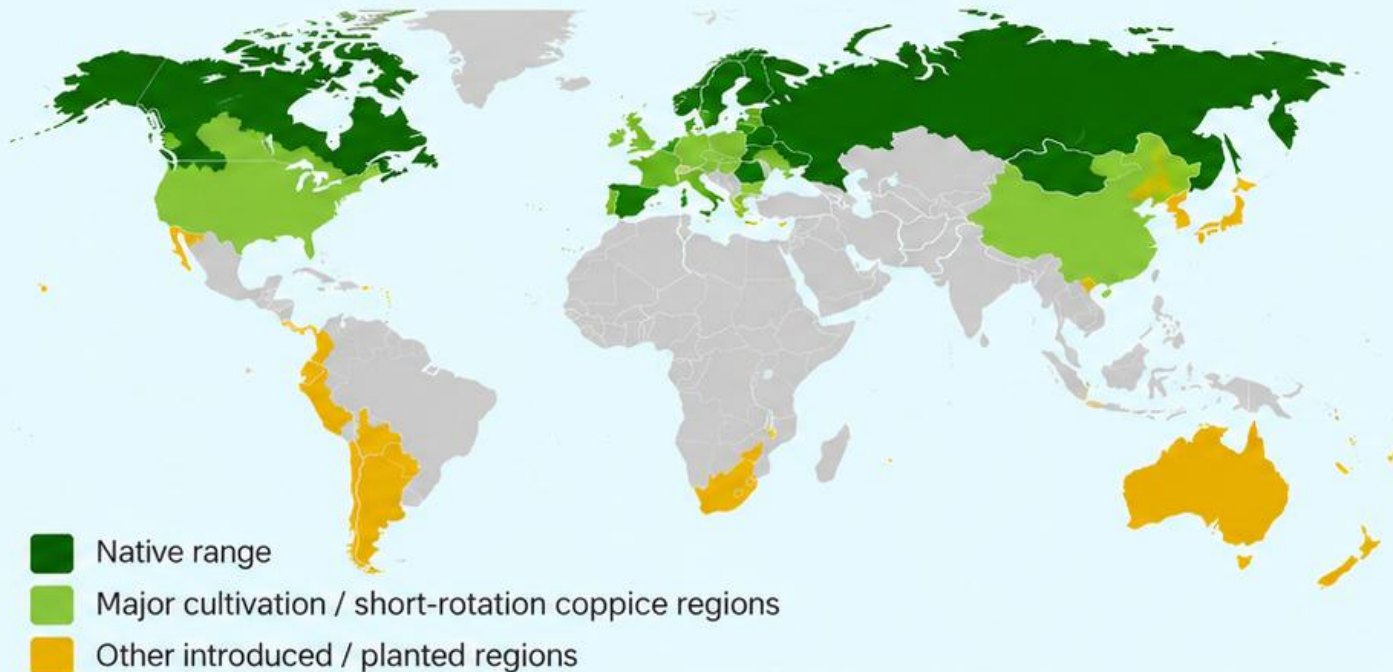
Origin

- Native mainly to temperate regions of the Northern Hemisphere.
- Diversity centres in Europe, Asia and North America.
- Naturally associated with riparian zones, floodplains and other moist alluvial habitats.



Poplar in a riparian habitat

Global distribution and cultivation area



Main cultivation regions (examples)

- Europe: Italy, France, Spain, Belgium, Sweden and other temperate regions.
- North America: USA and Canada.
- Asia: China and other temperate zones.
- Also planted elsewhere for wood, pulp, shelterbelts, bioenergy and phytoremediation.

Key point

Poplar performs best in temperate climates with good water availability and fertile soils.

Poplar (*Populus spp.*) – Soil and climate preferences



Soil preferences

- ▶ Deep, fertile, well-structured loam to silty/alluvial soils.
- ▶ Good water-holding capacity and adequate nutrient supply.
- ▶ Performs poorly on shallow, very stony or severely compacted soils.



Moisture and drainage

- ▶ Poplar is moisture-demanding and performs best where water is reliable.
- ▶ Many clones tolerate moist alluvial conditions, but prolonged drought strongly reduces growth.
- ▶ Avoid stagnant conditions that impair establishment.



pH / salinity

- ▶ Best on slightly acidic to neutral soils (approximately pH 6–7).
- ▶ Tolerance varies with clone.
- ▶ Generally not ideal for highly saline sites.



Climate preferences

- ▶ Best in temperate climates with full sun, a long growing season and adequate water availability.
- ▶ Many commercial systems perform well in cool-to-warm temperate zones.



Drought / irrigation

- ▶ In Mediterranean or water-limited areas, supplemental irrigation may be needed during establishment and dry periods.



Suitability and productivity

- ▶ Highly productive on fertile sites.
- ▶ Widely used in short-rotation coppice where site moisture is sufficient.



Key point

Poplar performs best on fertile, moist sites in temperate climates; water availability is a major driver of productivity.

Poplar (*Populus spp.*) – Cultivation protocol



Site selection and soil preparation

- ▶ Choose deep, fertile soils with reliable moisture supply.
- ▶ Remove perennial weeds and previous crop residues.
- ▶ Prepare a fine, even planting bed; subsoil or plough if compaction limits rooting depth.



Planting material and season

- ▶ Use dormant cuttings or rods of selected, high-performing clones.
- ▶ Plant in late winter to early spring, when soils are workable and moisture is available.



Planting layout

- ▶ Plant in rows designed for machinery access (e.g. 2.5–4 m between rows).
- ▶ Typical SRC densities are commonly around 5,000–10,000 plants per hectare, depending on clone, irrigation and harvest cycle.



Establishment management

- ▶ Weed control is critical in the first 1–2 years.
- ▶ Replace failed plants if needed.
- ▶ Irrigate in dry climates or during establishment to ensure good survival and early growth.



Nutrition and maintenance

- ▶ Fertilize according to soil tests and expected yield.
- ▶ Monitor and manage pests and diseases (e.g. rusts, leaf beetles, cankers).
- ▶ In some systems, cut back after the first season to stimulate multiple shoots.



Rotation and coppice management

- ▶ Manage as short-rotation coppice (SRC).
- ▶ Biomass harvest is often every 2–5 years, depending on target product (e.g. energy, fibre) and site conditions.
- ▶ Stools resprout and can be harvested for several rotations.



Key point

Successful poplar SRC depends on good site preparation, strong early weed control and adequate water during establishment.

Poplar (*Populus* spp.) – Harvesting



Harvest system

Poplar is commonly managed as short-rotation coppice (SRC) or short-rotation forestry for biomass.



Harvest timing

Harvest during dormancy, usually from late autumn to winter or before spring budburst.



Harvest interval

Biomass harvest is commonly every 2–5 years, depending on clone, site, density and target product.



Harvest method

Use whole-stem or cut-and-chip harvesting systems; specialized or adapted machinery improves efficiency.



After harvest

Stools resprout vigorously, allowing repeated coppice cycles over several rotations.



Quality note

Dormant-season harvest helps reduce leaf content and often improves storage and fuel quality.



Key point

Successful poplar harvesting combines the right rotation length, dormant-season cutting and efficient mechanized collection of biomass.

Poplar (*Populus* spp.) – Main uses



Bioenergy

- Wood chips, pellets and feedstock for heat, power and CHP.
- Short-rotation poplar is widely used as lignocellulosic biomass.



Pulp, paper and fibre

- Suitable for pulp, paper and some fibre-based products.
- Valued for good fibre properties and fast growth.



Wood products / biobased materials

- Can be used for panels, packaging, veneer or other biobased products depending on rotation and stem size.
- Lightweight, versatile wood for a range of applications.



Environmental uses

- Phytoremediation of contaminated soils and some wastewater/landfill sites.
- Useful in riparian buffers and ecological restoration.



Ecosystem services

- Carbon sequestration and climate change mitigation.
- Erosion control, shelterbelts / windbreaks.
- Habitat value in multifunctional landscapes.



Key point

Poplar combines high biomass production with important environmental services and multiple end uses, making it a versatile tree for a bio-based and sustainable future.



Siberian elm (*Ulmus pumila* L.)

A hardy, fast-growing tree for wood, biomass and ecosystem restoration



Leaves



Flowers and fruits
(samaras)



Bark

1



Description of the crop

Botanical characteristics, key traits and growth habit

2



Origin and cultivation area

Native range, global distribution and main areas of cultivation

3



Soil and climate preferences

Environmental requirements and site suitability

4



Cultivation protocol

Establishment, spacing, rotation length and management practices

5



Harvesting

Harvesting methods, timing and expected yields

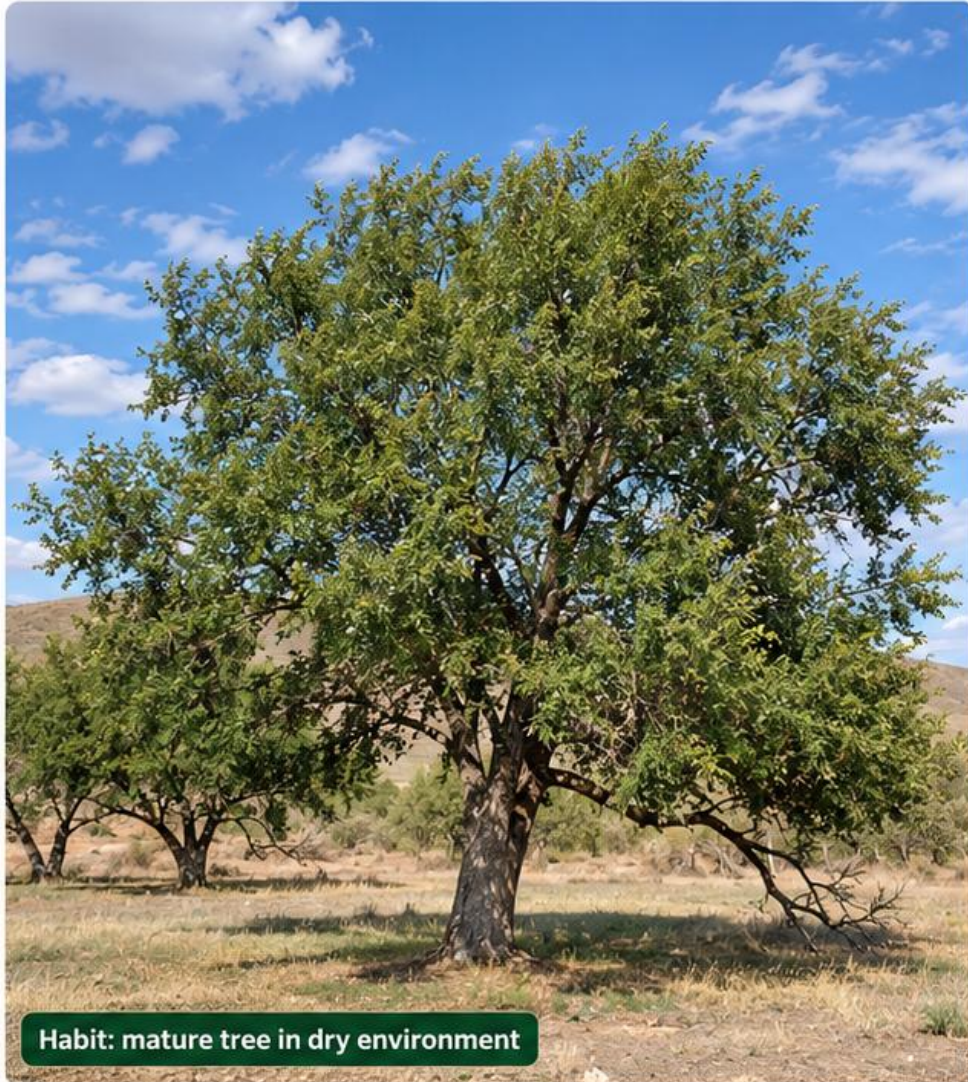
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Uses

Wood, biomass, environmental applications and other products

Siberian Elm (*Ulmus pumila* L.) – Crop description



Habit: mature tree in dry environment



Leaves



Fruits (samaras)



Twigs / young shoots



Botanical identity

Deciduous broadleaved woody perennial tree of the Ulmaceae family.



Growth habit and size

Fast-growing tree; usually about 10–20 m tall, sometimes smaller or shrubby under harsh dry conditions; rounded to open crown.



Root system

Deep and extensive root system contributing to drought tolerance and site stabilization.



Leaves and stems

Simple alternate leaves, small to medium, elliptic to ovate, sharply serrated, often 2–7 cm long; twigs slender.



Flowers and fruits

Flowers very early in spring before or with leaf emergence; fruits are round to oval samaras with a central seed, maturing quickly.



Adaptation and key traits

Strong tolerance to drought, wind and cold continental climates; good coppicing/resprouting ability; useful for shelterbelts, afforestation and biomass on marginal land.

Key features



**Fast-growing
woody species**

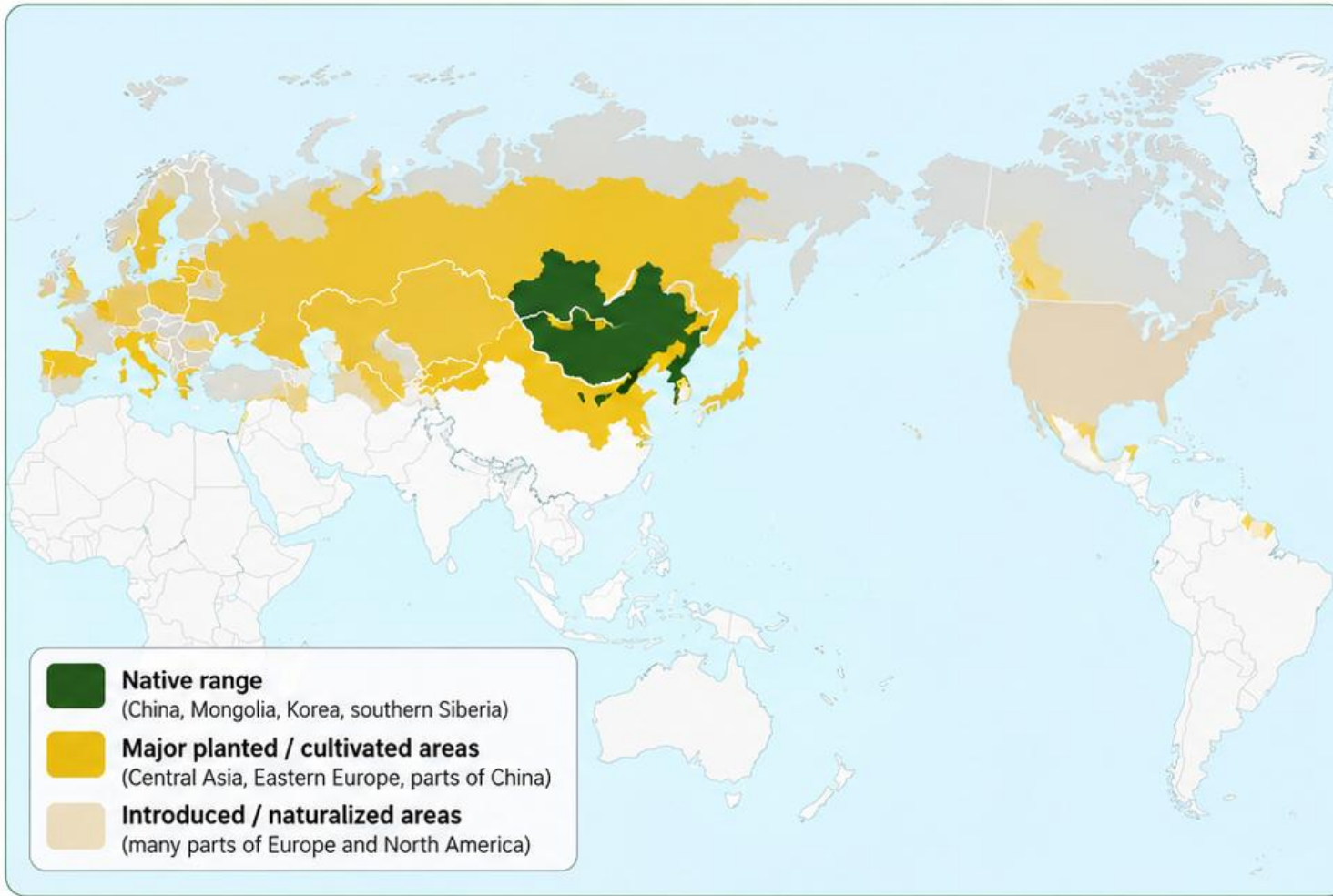


**Stress tolerant
and coppices well**



**Suitable for shelterbelts,
restoration and biomass**

Siberian Elm (*Ulmus pumila* L.) – Origin and cultivation area



Origin and native range

- Native to northern and eastern China, Mongolia, parts of Korea, and southern Siberia / the Russian Far East.
- Typical of continental steppe, forest-steppe and dry temperate regions.



Native habitat

- Plains, valleys, slopes and river terraces in semi-arid to temperate continental climates.



Main planting and cultivation uses

- Shelterbelts and windbreaks in northern China and Mongolia.
- Afforestation and restoration in semi-arid Eurasia.
- Urban and roadside plantings.
- Short-rotation biomass trials on marginal lands in Mediterranean environments such as Spain.
- Especially valued for drought tolerance, rapid establishment and adaptation to marginal dry sites.



Distribution and cultivation area

- Widely planted beyond its native range across Central Asia and Eastern Europe.
- Introduced and naturalized in many parts of Europe and North America.

Siberian Elm (*Ulmus pumila* L.) – Soil, climate preferences and cultivation protocol

Soil and climate preferences



Adapted to **temperate continental and semi-arid climates**; tolerates cold winters, wind and hot dry summers.



Best on **full-sun, open sites**.



Grows well on **well-drained sandy loam to loam soils**, but can also establish on marginal or degraded soils.



Performs on plains, valleys and slopes; relatively drought tolerant once established.



Avoid prolonged waterlogging; early establishment benefits from available soil moisture and, where needed, supplemental irrigation.



Suitable for dryland shelterbelts, restoration plantings and biomass trials on marginal land.



Young plantation on a dry site



Leaves



Mature Siberian elm stand



Samaras (fruits)

Cultivation protocol

1 Site selection and preparation



Choose a sunny, well-drained site; control perennial weeds and prepare planting rows.

2 Planting material



Use nursery seedlings or rooted planting stock; establish during dormancy or early spring.

3 Planting design



Use denser spacing for biomass plantings and wider spacing for shelterbelts or restoration.

4 Establishment care



Irrigate only if needed during the first season in very dry sites; keep rows weed-free in years 1–2.

5 Stand management



Monitor survival, replace failures, and use pruning or coppicing where multi-stem regrowth is desired.

6 End use



Suitable for shelterbelts, afforestation/restoration and short-rotation biomass on marginal land.



Key message

“Siberian elm is a hardy, fast-establishing woody species suited to dry continental environments and low-input planting on marginal land.”

Siberian Elm (*Ulmus pumila* L.) – Harvesting

Main harvesting points



Usually **harvested during dormancy, after leaf fall**, to ease cutting and reduce moisture content.



In biomass plantations, Siberian elm can be managed as a **short-rotation woody crop**, often with harvest cycles of about **2–4 years**, depending on site, density and objective.



Harvest can be **manual or mechanised**; stems are cut close to the stool and biomass is collected as whole stems or wood chips.



The species **coppices strongly** and can regrow after cutting, supporting repeated harvest cycles.



Avoid excessive soil compaction and protect stool health to maintain vigorous regrowth.



Mature Siberian elm biomass stand



Dormant stand ready for or after harvest



Coppiced stumps with basal regrowth after cutting

Harvest protocol

1

Harvest in **late autumn–winter** during dormancy.

2

Cut stems low and uniformly to encourage coppice regrowth.

3

Remove or chip biomass promptly for drying / handling.

4

Monitor regrowth and replace failed stools if needed.

Siberian Elm (*Ulmus pumila* L.) – Main uses

Main uses



Biomass and bioenergy

Woody biomass from short-rotation stands can be chipped or pelletised for heat and energy.



Restoration and afforestation

Suitable for dry, degraded or marginal land rehabilitation.



Shelterbelts and windbreaks

Useful in open agricultural landscapes because of rapid establishment and drought tolerance.



Wood and bioproducts

Lignocellulosic feedstock for wood-based products and emerging bio-based processing pathways.



Environmental plantings

Used in low-input plantings, erosion control and landscape improvement; management should be responsible where invasiveness is a concern.



Short-rotation biomass stand



Shelterbelt / windbreak in farmland



Restoration planting on marginal land



Woody biomass chips for bioenergy and bioproducts

Link with crop management

1

**Establish
plantation**

on suitable land.



2

**Manage low-input
stand / coppice**
with minimal inputs.



3

**Harvest
woody biomass**
on a short rotation.



4

**Direct to bioenergy,
restoration functions
or bio-based uses.**

Black locust (*Robinia pseudoacacia* L.)

A fast-growing, versatile tree for biomass, wood and ecosystem services



Flowers



Leaves



Pods and seeds

1



Déscription of the crop

Botanical characteristics, key traits and growth habit

2



Origin and cultivation area

Native range, global distribution and main areas of cultivation

3



Soil and climate preferences

Environmental requirements and site suitability

4



Cultivation protocol

Establishment, spacing, rotation length and management practices

5



Harvesting

Harvesting methods, timing and expected yields

6



Uses

Solid biofuels, timber, poles, biomaterials and ecosystem services

Black locust (*Robinia pseudoacacia* L.) – Crop description



A **fast-growing, deciduous broadleaf tree** in the Fabaceae (legume) family.



Native species with strong nitrogen-fixing capacity through symbiosis, helping it colonize poor soils.



Usually reaches about **10–25 m height**; can form single stems or multi-stemmed coppice stands.



Leaves are alternate and imparipinnate, usually with 7–19 oval leaflets; young shoots often bear paired spines.



Flowers are fragrant, white, pea-like, arranged in hanging racemes; fruits are flat brown pods with several seeds.



Strong root system; regenerates vigorously by root suckers and coppicing after cutting.



Key agronomic traits: rapid juvenile growth, drought tolerance, durable wood, value for biomass, timber, honey production, and land restoration.



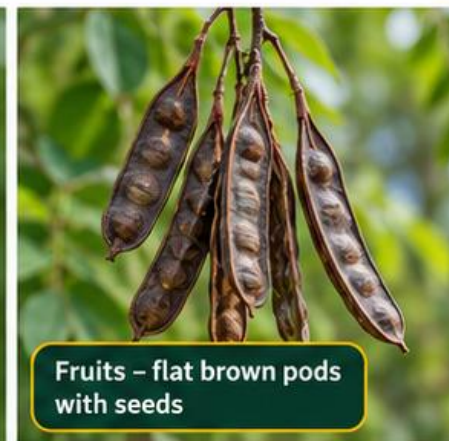
Caution: in some regions it behaves **invasively** and should be managed responsibly.



Flowering branch with leaves



Imparipinnate leaves (7–19 leaflets)



Fruits – flat brown pods with seeds



Young shoot with paired spines



Black locust plantation / stand

Cultivation snapshot

1



Plant on open sunny sites.

2



Use **seedlings** or root suckers / suitable planting stock.

3



Keep weed competition low during establishment.

4



Manage by coppicing, thinning or pruning depending on end use.

Black locust (*Robinia pseudoacacia* L.) – Origin, cultivation area and cultivation protocol

Origin

- Native to the **eastern USA**; original core areas include the **Appalachians** and **Ozarks**.



Cultivation area

- Introduced to Europe around the **beginning of the 17th century**, and later widely planted for wood, honey, erosion control and restoration.
- Today common in many temperate regions; in Europe especially important in countries such as **Hungary, Romania, Bulgaria, Serbia, France, Italy and neighbouring areas**.



Basic cultivation protocol

1

Site selection



Choose full sun. Tolerates poor and dry soils but performs best on deep, well-drained soils.

2

Planting material



Establish with seedlings, root suckers or other suitable propagation material, usually in spring.

3

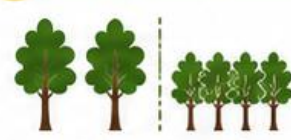
Establishment



Maintain weed control during the first years. Irrigation is mainly needed only where establishment conditions are very dry.

4

Stand management



Use wider spacing for timber or denser planting for biomass / short-rotation coppice. The species coppices and suckers readily.

5

Stewardship



Monitor spread, because the species can naturalise aggressively outside cultivation.

Typical uses of cultivation



Timber



Fuelwood / biomass



Apiculture (honey production)



Erosion control



Reclamation plantings

Black locust (*Robinia pseudoacacia* L.) – Soil and climate preferences and cultivation

Soil and climate preferences



Performs best on deep, fertile, well-drained soils, especially loams and sandy loams.



Tolerates poor, dry and calcareous soils, thanks to nitrogen-fixing ability, but growth is weaker on very compacted or shallow soils.



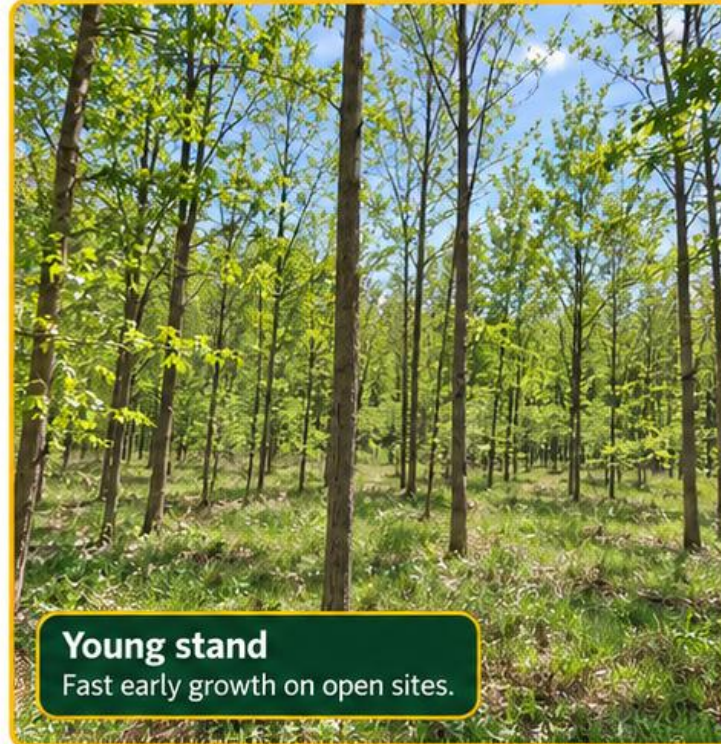
Prefers full sun and open sites; it is a warm-temperate / sub-Mediterranean species with rapid juvenile growth.



Drought tolerant once established; in Europe it can grow in areas with annual precipitation around 500–550 mm.

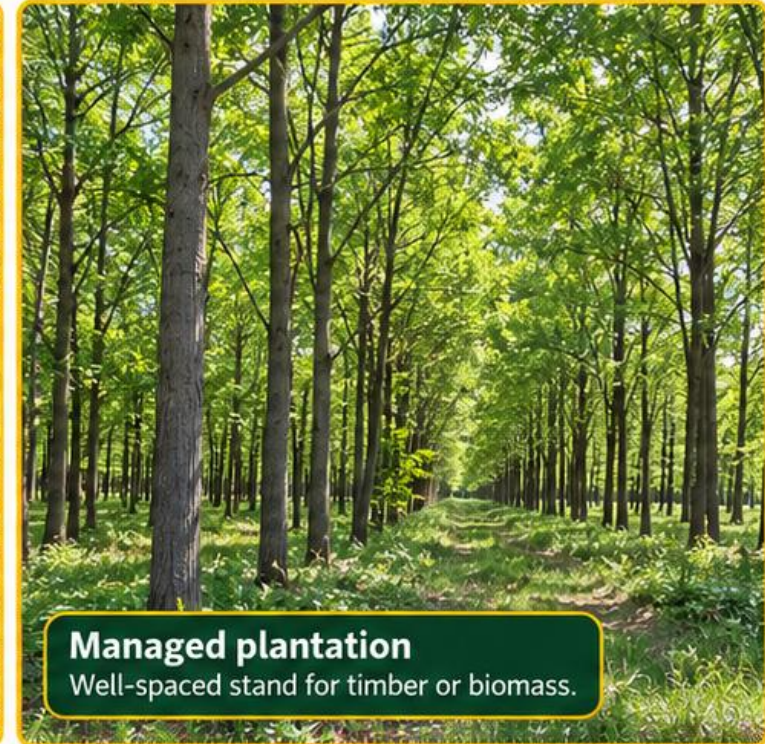


Avoid prolonged waterlogging, heavy poorly aerated clays, deep shade, and frost-prone situations for young plants.



Young stand

Fast early growth on open sites.



Managed plantation

Well-spaced stand for timber or biomass.

Basic cultivation protocol

1



Site selection

Choose sunny, open fields; prepare soil and reduce weed competition.

2



Planting material

Establish with seedlings, root suckers, or scarified seed; spring planting is common.

3



Spacing

Use wider spacing for timber and denser spacing for biomass / coppice systems.

4



Establishment care

Maintain weed control in the first 1–2 years; irrigate only if establishment conditions are very dry.

5



Stand management

Use pruning and thinning for timber quality, or coppicing for biomass; monitor and limit spread outside the plantation.



Management note: Black locust is valuable for biomass, timber and land restoration, but in some regions it can naturalise aggressively and should be managed responsibly.

Harvesting



- **Rotation age:** typically 15–25 years for timber (sawlogs, poles) and 3–7 years for short rotation biomass (coppice).



- **Method:** conventional felling with chainsaw or mechanised harvesters (cut-to-length or whole-tree).



- **Stump sprouting:** strong coppicing ability; after cutting, multiple shoots emerge from the stump, allowing repeated harvests.



- **Season:** harvesting preferably in late autumn–winter when foliage is reduced and wood is drier.



Mechanised harvesting
in a black locust plantation



Coppice regrowth after harvest
(stump sprouting)



Harvested stems for timber or biomass



Wood chips for bioenergy

Main uses



Timber and wood products

- Very durable, hard and rot-resistant wood (high natural durability to decay).
- Used for outdoor applications: posts, fencing, vineyard stakes, playgrounds, decking, sleepers.
- Also used for furniture, flooring and tool handles.



Posts, fencing and outdoor wood products



Bioenergy

- High calorific value ($\approx 18\text{--}20 \text{ MJ kg}^{-1}$, dry basis).
- Used as firewood, wood chips and pellets for heat and power.
- Suitable for short rotation coppice systems, providing regular biomass supplies.



Wood chips for bioenergy



Ecosystem services

- Nitrogen fixation (symbiosis with *Rhizobium* spp.), improving soil fertility.
- Erosion control, slope stabilisation and reclamation of degraded or marginal lands.
- Valuable for agroforestry, shelterbelts and urban green infrastructure.



Black locust plantation
for land rehabilitation and agroforestry



Other uses

- Nectar-rich flowers: important source for beekeeping (high-quality monofloral honey).
- Bark, leaves and flowers contain bioactive compounds (e.g., flavonoids such as robinin) with potential pharmaceutical uses.
- Biomass also considered for biorefinery applications (biochar, activated carbon, chemicals).



Flowers for beekeeping
(high nectar production)

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