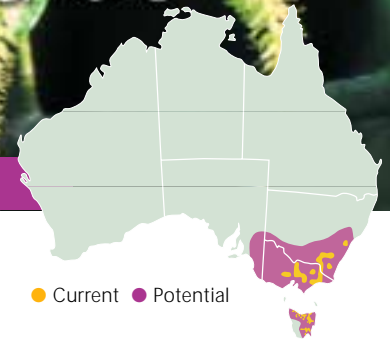


# Weed Management Guide

Willow – *Salix* spp.



## Willow (*Salix* spp.)

### The problem

Most species of willow are *Weeds of National Significance*. They are among the worst weeds in Australia because of their invasiveness, potential for spread, and economic and environmental impacts. They have invaded riverbanks and wetlands in temperate Australia, occupying thousands of kilometres of streams and numerous wetland areas.

Unlike most other vegetation, willows spread their roots into the bed of a watercourse, slowing the flow of water and reducing aeration. They form thickets which divert water outside the main watercourse or channel, causing flooding and erosion where the creek banks are vulnerable. Willow leaves create a flush of organic matter when they drop in autumn, reducing water quality and available oxygen, and directly threatening aquatic plants and animals. This, together with the amount of water willows use, damages stream health.

The replacement of native vegetation (eg river red gums) by willows reduces habitat (eg nesting hollows, snags) for both land and aquatic animals.

Millions of dollars are spent each year on willow control in southeastern Australia using chemical and/or mechanical techniques. In Victoria alone, the cost of willow management is about \$2 million annually.

Weeping willow *S. babylonica*, and two hybrid species of pussy willow *S. x calodendron* and *S. x reichardtii*, are not *Weeds of National Significance*. Nevertheless, these species are of



Willows shade out and displace native vegetation, potentially leading to erosion and poor water quality. Photo: Kate Blood

concern because they can hybridise with other species that would otherwise not produce seeds, so they should not be planted near other willows.

### The weed

Willows are deciduous trees or shrubs. They have small seeds with long, silky hairs attached to one end like a parachute, which help them spread. The seeds are usually short-lived, from days to a few weeks.

With the exception of the pussy willows, the leaves of all species are long and narrow, with finely toothed edges and usually a paler underside. Upright catkins (flower stalks) carry numerous tiny flowers.

The trees form large, dense root-mats on the surface of the soil or in shallow water and slow-moving streams.

### Key points

- Early detection and control are essential to prevent the spread of new infestations.
- Most willows are easily spread by stems and twigs breaking off and taking root.
- Some varieties of willow can also spread by seed, which can be carried up to 100 km by wind or water.
- Control techniques need to be carefully chosen to minimise unintended impacts. Stem injection of registered herbicide is recommended.
- Follow-up monitoring and control of regrowth (from stumps, pieces of stems or seeds) may be required for 3–5 years after initial control.

## Growth calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flowering												
Seed formation												
Seed drop												
Germination												

■ General growth pattern

Willows are either male or female and most groups in Australia are single-sex clones. However, they readily hybridise when opposite sexes come together. They flower in spring, the flowers only lasting for 2–3 weeks. The tiny seeds ripen about 3–4 weeks later in late spring or early summer. Germination is very fast, occurring within 24 hours, and seedlings grow rapidly under favourable conditions. The hybrid species are vigorous and can breed just two or three years after germination.

## How it spreads

Most willows spread by fragments of stems or twigs breaking off and growing new roots in water. Pieces can travel many kilometres before establishing at a new site. Fishermen often break off twigs and stick them in the riverbank to hold their lines, and these pieces will also grow.

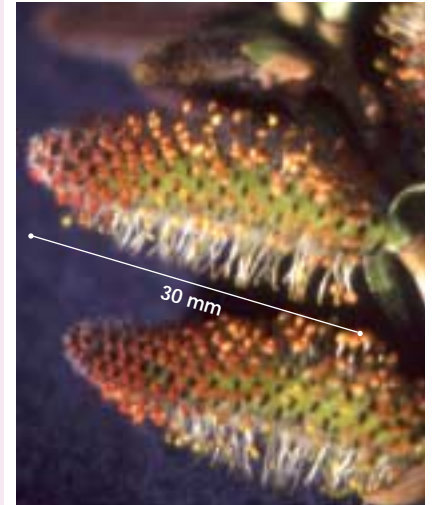
Seed is the main method of spread for several species, especially grey sallow and black willow. These species can invade off-stream wetlands from sea level to alpine locations. Seed carried by wind or water easily travels more than 1 km, with small amounts potentially spreading up to 100 km.

Seed production is becoming more common as more willows are introduced into Australia. However, the conditions required for germination (ie continuously wet, bare sediment) do not commonly occur and the seed only remains viable for between two and six weeks, depending on the species.

There are 32 different groups (species, varieties, subspecies and hybrids) of willows in Australia. Nearly all the different species have become naturalised here and can cross-breed with other willow species that flower at the same time. Most naturalised willow populations are hybrids and can be practically impossible to identify precisely.



Willow leaves brown off and drop during autumn and winter, causing an input of nutrients which can reduce water quality: Tambo River at Bruthen, Vic, in May. Photo: Kate Blood



The catkins of a male hybrid shrub willow, *S. x reichardtii*. Shrub willows have black flower scales, whereas tree willows have pale scales. Photo: Kurt Cremer

The introduction of New Zealand willows (*Salix matsudana* hybrids) throughout the Murray–Darling Basin in the 1980s and their widespread sale since then has only just begun to cause problems. These are about to escalate seriously, because the females produce abundant seed and the males fertilise the weeping willow (*Salix babylonica*), a widespread species that in the past usually did not seed because it had no male partner flowering at the same time.

## Where it grows

Willows occur naturally in permanently or seasonally wet, inundated or waterlogged sites. The largest infestations in Australia are in Victoria, Tasmania, New South Wales and the Australian Capital Territory. Several species (weeping, basket and crack willows) have been widely planted along the rural waterways of southeastern Australia for erosion control.

## Potential distribution

Willows have only invaded about 5% of their potential geographic range in temperate Australia. The most seriously invasive willow, grey sallow (*Salix cinerea*), is expanding its range rapidly in Victoria and New South Wales, and possibly in Tasmania.

## Key willow species and hybrids

### Grey willow or pussy willow (*Salix cinerea*)

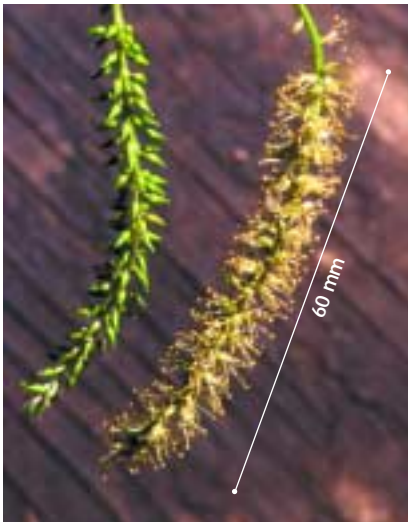
This is the most seriously invasive willow in Australia. It is a large spreading shrub or small tree with twigs or branches that are hard to break. It reproduces mainly by seed. Pussy willow is highly invasive in swamps, drainage lines and other moist sites including lowland and mountain streams. Large and rapidly expanding populations occur in Victoria, and this species will probably become a major wetland and riverside weed (as it is in New Zealand). It forms hybrids with other shrub willows.

### Crack willow (*Salix fragilis* var. *fragilis*) and basket willow (*Salix x rubens*)

These single- or multi-stemmed trees are by far the most widespread and abundant willows in Australia, and are the most serious problem willow in Tasmania. They are found along thousands of kilometres of streams in southeastern Australia where they were widely planted for stream stabilisation. Crack willow spreads almost exclusively by plant parts so it is only associated with streams.

### Black willow (*Salix nigra*)

This tree willow has been widely planted in northeastern Victoria and at several sites in New South Wales. It is now very abundant in some streams. Black willow has the potential to behave in the same invasive manner as grey willow in wetlands.



Black willow, *Salix nigra*. Female (left) and male (right) catkins.  
Photo: Kurt Cremer

## What to do about it

### Prevention of spread

Early detection and control are essential to prevent the spread of new infestations. The deliberate planting of willows along waterways has virtually ceased and extensive removal operations are common. It is fairly easy, given

enough resources, to prevent the spread of willows that propagate by plant parts, as they are confined to streams and are spread downstream. For seeding willows, prevention of spread is difficult because seed can be dispersed over large areas.

Willows are still widely planted, eg for windbreaks on farms, and many groups (including weedy ones) are sold by the nursery trade in Australia. There is potential for additional willow taxa to become naturalised if importation is not closely regulated.

### A strategic approach involves surveys and staged removal

A long-term plan should be devised before any attempt is made to eliminate problem willows. Removal of trees can actually increase erosion problems, so a plan to replace willows with more desirable species is needed.

Start by carrying out an extensive survey to identify potential seed sources. The willow species that set seed flower between September and November, so this is the best time to search for catkins on or under trees.



Grey willow or pussy willow, *Salix cinerea*. Left to right: female catkin elongated after flowering, female catkin at flowering, male catkin at start of flowering and peeled stem showing characteristic ridges.  
Photo: Kurt Cremer

CSIRO recommends identifying seed trees by attaching conspicuous plastic ribbons to them which will endure floods and grazing animals and last for 2–3 years. Trees growing more than 2 km away from a river may still be a significant seed source.

Staged removal should be undertaken over a number of years, starting in the upper reaches of each catchment and working downstream. Where willows have been planted to stabilise soils or banks, alternative vegetation should be established before the willows are removed.

Remove trees first which will not destabilise banks (eg on the inside of bends). Anticipate stream flow changes and be aware that removal of constrictions will allow greater pressure at restricted points further downstream. In these cases it may be advisable to start working on the lower end of the section, progressing upstream.

### Control options

Willows are relatively easy to kill and mechanical and chemical control techniques are well understood. However, it should be noted that indiscriminate removal of willows is not recommended as it may lead to stream instability. Control should be conducted in consultation with state or territory authorities (see weed control contacts p. 4).

## Weed control contacts

State/Territory	Department	Phone	Email	Website
ACT	Environment ACT	(02) 6207 9777	EnvironmentACT@act.gov.au	www.environment.act.gov.au
NSW	NSW Agriculture	1800 680 244	weeds@agric.nsw.gov.au	www.agric.nsw.gov.au
SA	Dept of Water, Land and Biodiversity Conservation	(08) 8303 9500	apc@saugov.sa.gov.au	www.dwlbc.sa.gov.au
Tas	Dept of Primary Industries, Water and Environment	1300 368 550	Weeds.Enquiries@dpiwe.tas.gov.au	www.dpiwe.tas.gov.au
Vic	Dept of Primary Industries/Dept of Sustainability and Environment	136 186	customer.service@dpi.vic.gov.au	www.dpi.vic.gov.au www.dse.vic.gov.au
Australia wide	Australian Pesticides and Veterinary Medicines Authority	(02) 6272 5852	contact@apvma.gov.au	www.apvma.gov.au

For up-to-date information on which herbicides are registered to control willows and the best application methods and dosages, contact your state or territory weed management agency or local council. This information varies from state to state and from time to time. Contact details are listed above, including contacts for the Australian Pesticides and Veterinary Medicines Authority, which hosts the PUBCRIS database. This database contains information on all herbicides that are registered for use on weeds in each Australian state and territory.

When using herbicides always read the label and follow instructions carefully. Particular care should be taken when using herbicides near waterways because rainfall running off the land into waterways can carry herbicides with it. Permits from state or territory Environment Protection Authorities may be required if herbicides are to be sprayed on riverbanks.



Stem injection into cuts. Make cuts to a depth of 20–30 mm into the sapwood with a small axe or chisel and immediately inject herbicides. Photo: Lisa Menke, NSW NPWS



Stem injection with the 'drill and fill method'. Drill holes at 50–100 mm intervals around the circumference of the stem and immediately inject herbicides. Photo: Trish Chadwick, NSW DIPNR

### Stem injection is the best suited of all herbicide applications

Herbicides available for woody weeds are effective in controlling willow. Trees can be killed by stem injection, application to leaves and stems, bark (chemical girdling) and cut and paint methods (check with state/territory agencies for current recommendations). In dry conditions herbicide can also be applied by basal bark spraying and treatment of seedlings. Although stem injection may be a slower, more laborious method, it is an important option for avoiding chemical runoff and protecting native vegetation. In general, herbicide should be applied from summer to early

autumn, although stem injection or cut and paint application is effective year round.

Stem injection is suited to large trees. Make cuts or drill holes below the branches, around the trunk, 20–30 mm into sapwood. The injection points should be single cuts spaced at less than 130 mm intervals, or holes drilled at 50–100 mm intervals, around the circumference. Angle holes and cuts downwards to minimise herbicide leakage. Herbicide should be immediately injected into each cut or hole at the recommended rate. Leave the tree undisturbed for at least 12 months after herbicide application to ensure a successful kill.

The cut-stump method should only be used to kill willows that can be easily and

safely disposed of (ie smaller specimens). Cut the aerial trunk off completely at a level below the first branches and immediately apply a recommended herbicide to the cut stump. Remove all material to prevent regeneration from pieces. The cut surface of the removed stem should also be painted with herbicide for safe disposal. Minimal transport of broken branches and stems will help avoid broken fragments being spread. Willow wood chips can take root and grow so trees for chipping should be killed prior to removal.

New infestations can occur when trees are cut and moved away from waterways with heavy equipment. Small pieces of branch embedded in the attached soil may take root or enter the water to float away to new sites.



The fluff attached to seeds allows dispersal by wind or water. Photo: Kate Blood

Foliar spraying (spraying the entire plant) should only be used to kill willows less than 2 m tall before the start of leaf fall and where herbicides will not affect native plants or make contact with water bodies.

### Mechanical removal of seedlings, or of larger trees in dry areas

Elimination of young seedlings is a cost-effective way of keeping waterways free of potential blockages, erosion and streambed change. Hand pulling of seedlings less than 0.5 m tall is the most practical and environmentally safe way of removing young plants. Leaving small roots in the ground does not lead to suckering or regrowth.

Using large machinery such as excavators or bulldozers to remove larger trees and root systems is not recommended except in dry areas. In wet areas bulldozers push broken branches into the ground and thus generate numerous new plants.

### Disposal recommendations

Trees killed while they are standing (ie by stem injection) should be left for 12 months before they are removed. They can then be cut at a suitable height and stacked away from watercourses. If it is

necessary to remove live trunks and limbs from the site, stack them to dry above flood level, taking care to minimise the spread of small pieces. Smaller twigs should be bagged and disposed of at tip facilities so that they do not sprout and cause further problems.

### Follow-up

Regrowth from stumps, pieces of stems or seeds will need to be followed up with monitoring and further control for 3–5 years after the initial effort. Check that treated trees have died, and remove trees that could cause problems if they become snared elsewhere by floods. Look for the spread of any new willows and follow up with substantial re-assessments at least every five years.

### Legislation

Relatively few species of willow are classified as noxious weeds across Australia, and the status of different species varies in the different states and territories. Similarly, the sale and trade of willow species is banned in some states but not others. However, the legislative status of willows is changing, so check with your local council or state/territory

government agency for the most up-to-date information.

### Acknowledgments

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Maps: Australian Weeds Committee.



Although planted for bank stability, changes to stream flow caused by willow roots can undermine banks.  
Photo: Trish Chadwick, NSW DIPNR

## ...case study

### Keeping willows out of Wollemi National Park, northwest of Sydney

The Wollemi National Park is the scene of a vigorous campaign involving the New South Wales National Parks and Wildlife Service (NPWS) and community volunteers against invading willows.

Black willows were imported from the USA and planted along the lower reaches of the Colo River in the 1930s. Although they were later removed, their offspring had already spread into the Wollemi National Park.

The problem was first brought to the attention of the NPWS in 1998 by bushwalkers and canoeists who were alarmed at the number of willows

along the river. A subsequent survey listed the willow population along a 60–70 km section running down to the edge of Wollemi National Park at about 5000 trees.

A control program 'Willows Out of Wollemi' began, and the community group Friends of the Colo was formed to help tackle the problem.

Groups of volunteers travel down the Colo River in canoes and rafts, stopping to apply herbicide to willows by stem injection. They use a dye to mark the trees that have been treated and to show if any herbicide has been

spilt. They also map the position of the willows and other weeds to help monitor progress.

Many follow-up inspections down the river have confirmed that the willows have been killed without harming other species. Once the willows are gone, native species quickly take their place.

The volunteers will continue their trips along the upper Colo to treat trees they may have missed, but gradually their focus will shift to other weeds within the park as well as willows and other weeds along the lower Colo River outside the national park boundary.

# How to control willow

## Quick reference guide



Willows damage stream health by using water rapidly, altering stream flow and reducing habitat availability for plants and animals. Photo: Kate Blood

### Pull seedlings by hand

The simplest strategy is to pull all seedlings (and rooted branches) while they are still small. This works best if it is done regularly, especially if there are limited sources of seed and few suitable regrowth sites.

### Mature trees should be injected with herbicide

Kill trees where they stand unless this is not possible for safety, practical or aesthetic reasons. Use stem injection of a registered herbicide to avoid chemical runoff. Best results will be achieved from summer to early autumn. Leave trees undisturbed for 12 months after herbicide application to ensure a successful kill.

### Start control in the uppermost part of the catchment...

A long-term planned approach to control is needed. Staged removal should start in the upper reaches of the catchment. In the case of seeding species (eg pussy willow and black willow) which can recolonise treated areas, a coordinated catchment-scale intensive attack is the best option.

### ...preferably on the inside of bends...

First remove trees on the inside of bends because these banks are more stable. Where willows have been planted to stabilise soil or creek banks, alternative vegetation should be established before all willows are removed.

### ...but be aware of stream flow dynamics

The flow of the river will change once the willows are removed, and this may place greater pressure on restricted points downstream. In these cases it may be advisable to start working on the lower end of the section, progressing upstream.

### Follow-up will be required

Monitor treated areas and use follow-up control on any regrowth for 3–5 years after the initial control.

## Control options

Type of infestation	Chemical	Physical	Mechanical
National parks and sites with a low risk to downstream infrastructure	Treat using stem injected registered herbicide. Leave stems standing to break down over time.	Hand pull young seedlings.	Not suitable.
Waterways through cleared areas, eg farmland	Cut and paint with concentrated herbicide. Fell trees and immediately treat stump and cut trunk with herbicide.		Only use large machinery such as excavators or bulldozers to remove larger trees and root systems in dry areas. In wet areas large machinery can push broken branches into the ground and thus generate numerous new plants.
Local government reserves / other crown land	Treat and leave where possible; eg on paths, roads or limited public access areas. Cut and paint and remove from creek banks or where treated plants have the potential to fall and destabilise the creek bank.		

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