

Controlling willows along Australian rivers

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Summary

- ~ Willows (*Salix* spp. and hybrids) are a serious weed threat to rivers, riparian areas and wetlands throughout south-eastern Australia, and are continuing to spread.
- ~ Willows can cause a range of deleterious morphological and ecological changes to rivers and aquatic ecosystems.
- ~ Effective methods are available for control and removal of willows, but using these methods requires careful planning and implementation, as well as follow-up maintenance .
- ~ This guideline summarises some of the existing information about willows and their management, and provides links to other more detailed sources of knowledge.





Some willow species can spread when branches and twigs fall into the water and are carried downstream.

Background

Willow management guides have been produced for several regions in southern Australia, and by different agencies (see examples in the references section). There is a lot of information available, but not all of the guides have all of the information required to set priorities and plan an effective control program. Some of the early information appeared contradictory, and further experience in willow management means that it can now be updated. In general, there is plenty of information about why willows are a problem, and how to control them, but there is much less on how to identify the main species or varieties, how they are spreading, and how to prioritise actions and engage communities in a long-term and effective program for their removal or management. This guideline provides an introduction to the information that is available about willows and their control, and outlines some of the key issues to be considered.

Willows in Australia

Willows (*Salix* species) are an introduced, deciduous riparian and wetland tree or shrub; there are no native species of willow in Australia. About 400 species and varieties (mostly hybrids) of willows occur in the northern hemisphere, and are found in Europe, Canada, the USA and Japan. About 100 of these have been introduced into Australia since European settlement, of which 32 have become naturalised (spread from their original planting sites). The first willows were planted more than 150 years ago for fodder, erosion protection, ornament and shelter. There was a surge of planting along streams and rivers in the period 1950 to 1980 as part of 'river improvement' works, often in an attempt to stop bank erosion. By the 1990s, the seriousness of the weed threat posed by willows had been recognised, and planting by government agencies largely ceased.



Willows growing into the stream channel, which they may eventually block.



Willows may occur as dense infestations or as single trees. Even the latter can be a source of new weed infestations from seed, or from twigs washed downstream.

At about that time it was also recognised that there are Australian native plant species that can be used to revegetate riparian areas and reduce bank erosion, for example, through water-jetting of long-stem rootstocks.

Willows are able to spread by vegetative means, that is, a new tree will grow from any broken twigs or branches swept downstream. Many varieties can also sucker from roots. Willows can also produce seeds, millions of them. Initially, seeding was not a major spreading mechanism in Australia, perhaps because of the distance between plantings or because the early plantings were all of the same few species or sex and hence, self-sterile (willows have male and female plants, i.e. they are dioecious, although some species can carry both male and female flowers on the same plant at different times of year). Once new species and the alternate sex were introduced and planted in close proximity, seed production and dispersal became another mechanism by which willows could spread widely, and they became a major pest plant. For at least 25 years, many species have been spreading by seed in Australia.

The ability of willows to spread by seed highlights their national significance as a major weed. Whereas vegetatively reproducing willows are generally confined to streams and are dispersed downstream, the great mobility of some seeding willows requires that effective control be coordinated across regions and states. For example, Cremer (2003) observed that the seed of *Salix nigra* (black willow) had spread up to 50–100 kilometres in every direction from a site near Tumut in New South Wales — it had been originally planted there 30 years earlier. In addition, Cremer (2003) observed that *Salix cinerea* (grey sallow or wild pussy willow) seed can travel by air or water for tens of kilometres. Such mobility provides these two seeding willows with the ability to move into streams and wetlands, rural and urban environments.



Above: A piece of willow wood may look dead, but this piece is resprouting near the water surface and well above it.

Below: Resprouting.



Further information about willows as Weeds of National Significance (WoNS) can be found at the website www.weeds.org.au/WoNS/willows



Left: Willow roots invading the channel and capturing deposited sediment; new sprouts or seedlings can stabilise this sediment leading to blocking of the channel. Right: The typical dense root mat of willows growing into the stream.

The relative importance of vegetative versus seed-based reproduction and spread of willows varies in different areas; both can lead to large, invasive populations. The seeds germinate on bare, wet sediments, while branches, attached or detached, root mainly on wet ground or in shallow water. This combination of reproductive mechanisms has resulted in naturalised willow populations that are now widespread throughout southern Australia. They occur through the Mt Lofty Ranges of South Australia, across all of Victoria and much of Tasmania, along the eastern half of NSW and into the southern part of Queensland. They form dense stands along many rivers, out-competing native plants and causing a range of problems. Many rivers and streams with extensive sand banks or bars are now choked by willows.

In recognition of their weed threat, all willow species (except *S. babylonica*, *S. x calodendron* and *S. x reichardtii*) were recognised in 1999 as Weeds of National Significance (WoNS) (ARMCANZ 2000). The recognition of willows as WoNS does not impose any direct regulation, control or enforcement to be undertaken. However, willows have been declared as noxious weeds under legislation in each state and territory of Australia. In some states this may mean regulation of the trade and distribution of willows, while in other states there may be requirements for control by land managers, with willow removal an important catchment management activity. Removing willows has been a popular stream management activity in south-eastern Australia over the last 15 years. In fact, clearing heavy concentrations of willows has been going on for over 50 years. One of the specific reasons for establishing the first River Improvement Trusts in Victoria was to deal with the flooding caused by dense infestations of willows in the King and Ovens Rivers in north-east Victoria.

State/territory legislation relating to willows can be found at www.weeds.org.au/WoNS/willows and a summary is provided in Appendix A.

What's the problem with willows?

Although willows can be effective at stabilising stream banks, in some cases the disadvantages outweigh their benefits. Their invasive nature results in thickets that grow into the channel and block its flow and capacity, diverting water around and out of the main watercourse causing flooding and additional erosion. In addition, willows use a large volume of water. Recent research by CSIRO suggests that 1 kilometre of willows along both sides of a stream will use up to 8 megalitres (eight olympic swimming pools) of water per year. All of this water use occurs in summer, when water is most scarce for both farmers and animals. Willow roots spread into the channel bed and trap sediment, this leads to a reduction in flow capacity. Willows do not provide the year-round supply of riparian inputs (leaves, flowers, fruits and twigs) that native plants do, and the annual drop of soft-tissued leaves can reduce dissolved oxygen within the stream water to very low levels as they decompose. The dense shade of willows prevents the in-stream primary production that supports aquatic food-webs. Scientific studies have shown that they do not provide the same ecological values as native riparian vegetation (see Figure 1) (Greenwood et al., 2004; Serena et al., 2001; Janssen & Walker, 1999; Read &

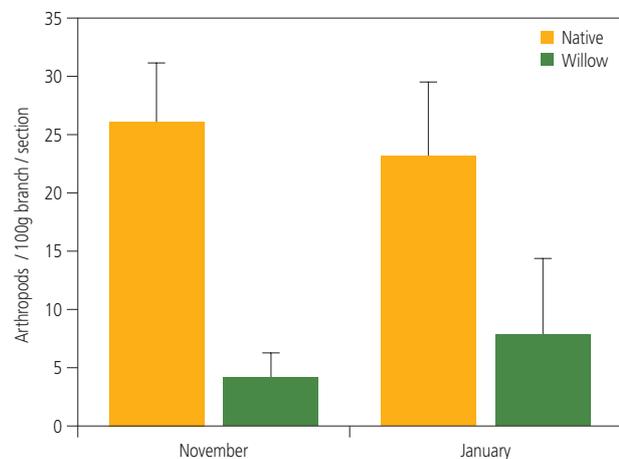
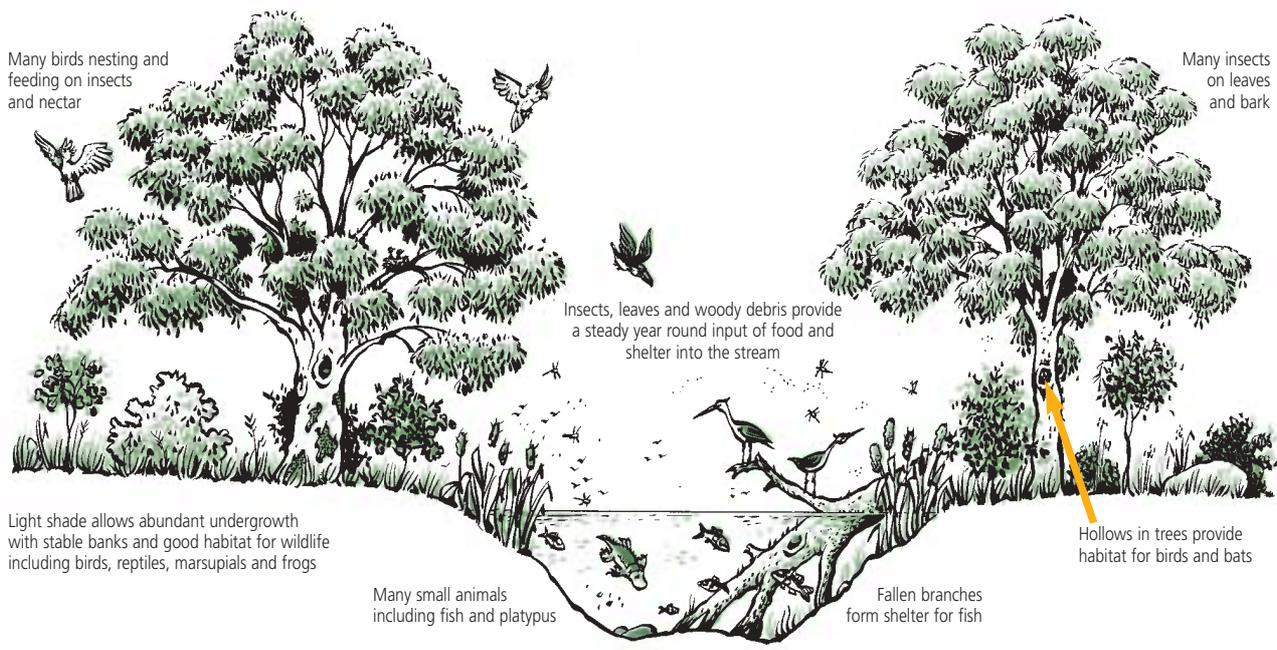
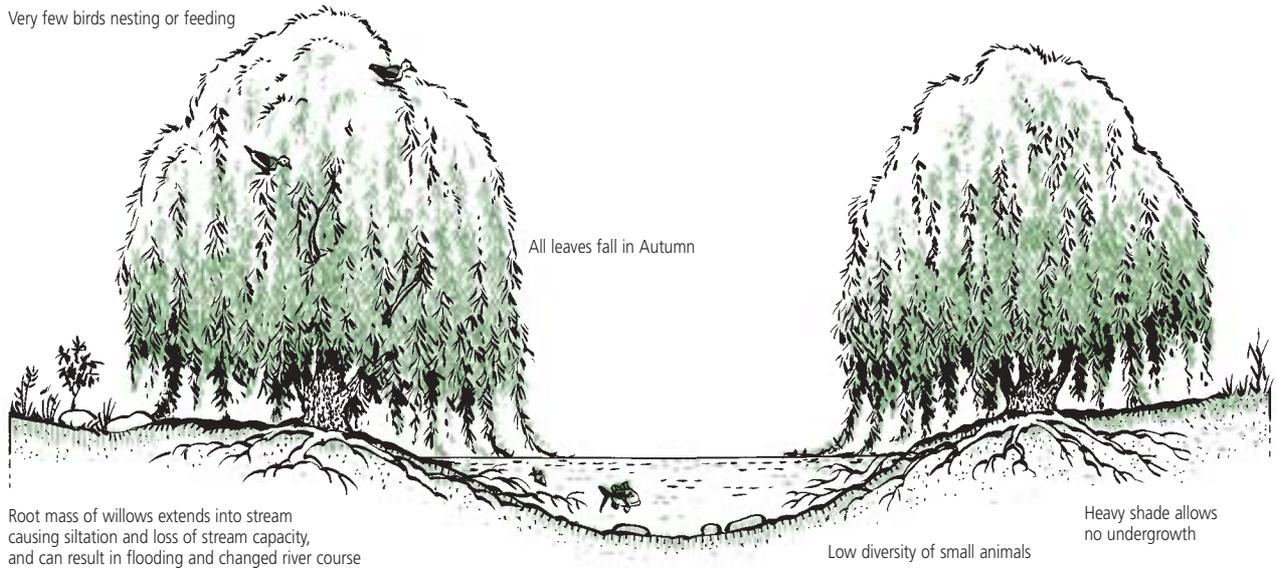


Figure 1. Graph showing the difference in abundance of arthropods in native as against willow trees. Adapted from Greenwood et al., 2004, p. 487.



The benefits of native vegetation in riparian areas



The effects of willows in riparian areas

Both illustrations Paul Lennon. Modified from 'Willows along watercourses: their impact compared to natives', Landcare Notes, no. LC0119, 1998, North East & Murray Willow Management Group.

Barmuta, 1999; Schulze & Walker, 1997). Some aquatic animals (including introduced species like the carp) make use of the habitat provided by willows, but overall the dense shade and lack of riparian inputs means that areas heavily infested by willows are largely devoid of native aquatic food-chains. Willows do not provide the riparian nesting hollows needed by many species of birds and mammals, and because their wood decomposes quickly they do not provide the large woody pieces that are crucial for in-stream habitat and flow complexity.

Willows are extremely hardy plants which can spread aggressively and often displace native vegetation. They can be very difficult to control. Willow seed or pollen can spread several kilometres from the parent tree, meaning that willows are capable of invading areas that were previously considered safe from the threat. Given the ability for willows to spread via seed or pollen across regions or states, it is important that land managers do not become complacent about willows and assume that where seed has not been a problem in the past this will remain the case.

Widespread seeding willows: Adding another dimension to the willow problem

River managers need to be aware of seeding populations of willows in nearby stream zones. Certain species of willows are able to produce viable seed and infest sand and gravel bed streams and exposed works sites. For example, on the Delatite River in the Goulburn Broken catchment in Victoria, seeding willows were removed along a short section, and instream works were initiated to provide improved fish habitat. The site was supported by fencing to reduce grazing pressure and the site revegetated with native vegetation.

However, willow germination at the site following the works highlighted the importance of ensuring all possible threats to the system are identified prior to any works being carried out. At the time of the initial project planning, the willows that were present and nearby weren't seeding so steps were not put in place to account for this occurring post-works. The learning from this experience is that it is important that seeding willows in adjacent areas are managed as part of an integrated works program.

Willow seedlings on the Delatite River, thought to be hybrids of *S. fragilis* (crack willow) and *S. alba* var. *vitellina* (golden upright willow) which are located a few hundred metres downstream.



The biology of willows

It is important that managers understand the biology, ecology and spreading methods of willows to ensure that they are being managed appropriately. Detailed information on this is covered in:

1. The Weeds of National Significance (WoNS) Strategic Plan for Willows [www.weeds.org.au/docs/wilstrat.pdf].
2. 'Willow Management for Australian Rivers' by Kurt Cremer [<http://www.hoadley.net/cremer/willows/docs/key2.doc>].

How do you recognise them?

Willows come in various shapes and sizes ranging from the large and easy to recognise weeping willow (*S. babylonica*), to smaller shrub varieties that are sometimes hard to recognise as willows. Different willows respond to different management (e.g. some herbicides work better on some species than on others) so it is important to know which species you are dealing with.

A good key to help identify willows has been produced by Kurt Cremer *Key to Willows (Salix) in Rural Australia* [www.ffp.csiro.au/publicat/articles/willows/willkey3.htm/].

Below and inset: *S. vitellina* and *S. vitellina* seedling.
Bottom: *S. babylonica*.



Unfortunately, willow identification in Australia is particularly difficult due to the large number of hybrids, some of which have developed since their arrival. Rather than spending vital resources on identifying plants, which may be new hybrid combinations, it is much easier to simply control those which pose a current or potential nuisance or threat. Where spread by seed is the main concern, it may be possible to determine whether plants are female and then target these for removal.

Seeding species to watch out for include:

- ~ *Salix cinerea* (pussy willow/grey sallow)
- ~ *Salix nigra* (black willow)
- ~ *Salix alba* var. *vitellina* (golden upright willow)
(hybridises with *S. fragilis*)
- ~ *Salix x rubens* (golden crack willow/basket willow)
(a hybrid willow which often contains characteristics of *S. fragilis*, *S. alba* and *S. alba* var. *vitellina*)

Note: The weeping willow (*S. babylonica*) in Australia is a female tree that has been known to hybridise with other willows, with some resulting hybrids being potentially more invasive than the parent. While *S. babylonica* is excluded from legislation, its ability to hybridise with other species means it should be considered with caution.



Below and inset: *S. cinerea*.

Good planning leads to successful management of willows

There are many good reasons to remove willows from stream banks, but it is important that thought is also given to what will replace them, especially where prevention or control of erosion is a management objective. In some situations there will be sufficient adjacent vegetation, especially grass and reeds, to quickly colonise the surfaces formerly covered or shaded by the willows. In other cases it will be necessary to replant the cleared areas, preferably using local native species. The objective is to replace the cover and stabilisation of the banks, and to prevent re-invasion by willows or other weeds.

This emphasises the importance of developing a well-considered plan for willow removal, that includes specific funding and actions to either ensure rapid regeneration from adjacent native plant species, or replanting/reseeding of native species as the willows are taken out or killed. A staged approach has proven successful, in which one third of the willows are killed in consecutive years, or removal is completed over a five-year period, with replanting of native species as part of each treatment.

The clearing of willows in this area was not followed up and no revegetation occurred. As a result other weeds have taken over and now pose a fire risk. Many willow stumps are also resprouting.



Developing a willow management plan

It is important to carefully plan projects for willow control and stream rehabilitation to ensure that funds are not wasted, and that the long-term outcomes are achieved in full. This is particularly the case if the willow control is to be done in 'one hit', which often suits landholders and catchment or stream managers who do not have the funds for repeat visits by a works crew and large machinery. The plan, and the project budget, should include periodic follow-up to ensure eradication and no re-infestation of willows, as well as adequate regeneration of native species. A planned project over several years of gradual willow removal and replacement with native species may cost more, but success is much more likely. This section describes the steps required in prioritising and planning willow removal.

The main steps are:

1. Defining project objectives.
2. Scoping the problem (identifying willow distribution, and assets that are threatened by them).
3. Determining priorities.
4. Working with the community.
5. Planning for short term consequences of willow removal.
6. Willow control/removal.
7. Revegetation and follow up.
8. Monitoring and evaluation.

Involvement of the local community throughout the whole process, from planning through to monitoring and evaluation, will result in better ownership and success of a project.

A planned project over several years of gradual willow removal and replacement with native species may cost more, but success is much more likely.

Improving riparian values in the Goulburn-Broken Catchment

Rather than focusing solely on eradication of willows in the catchment, the Goulburn-Broken Catchment Management Authority (GBCMA) bases its willow management strategy in the context of restoring and improving the environmental condition of rivers and riparian zones throughout the catchment. As a result, willow removal is coupled with the removal of other weeds, such as Hawthorn, and does not occur until the landholder has agreed to carry out long term maintenance, partially fund revegetation and exclude stock from the riparian zone. All remnant native vegetation is left on-site to provide new recruits for natural regeneration to occur.

Area of willow removal where extensive revegetation has taken place.





Willow removal has taken place along the Coal River to protect the historic Richmond Bridge.

1. Defining project objectives

Removing willows, if carried out without adequate planning, can have unintended, adverse consequences which may outweigh the positive effect of removing them. Plans that aim to improve overall stream health, or protect a valued species or community are much more likely to have a positive overall impact than those which simply aim to remove the willows.

The purpose and objectives of the project should be specified clearly (essential for later evaluation), and thought should be given to all the possible consequences, including potential for a short-term increase in erosion and water temperature, release of sediment deposits, and risk of removed willow parts moving downstream and/or resprouting. To this end, plans to remove willows must be coupled with adequate site rehabilitation and follow-up maintenance. This integrated plan should be used to prepare an indicative budget for the project that will cover all the key activities needed.

2. Scoping the problem

A willow management plan should begin with a thorough site investigation in order to determine which willow species and sexes are present, their abundance and their capacity to seed or spread vegetatively (see references and list of management contacts on page 19 for more information). Even if your area has been willow free in the past, the proliferation of seeding willows now means that very few areas across south-eastern Australia are safe from invasion. It is often useful to map infestations so that you have a clear idea of what you are dealing with. The development of Global Positioning Systems means that data on willow locations and history of control at different sites can be easily recorded and retrieved. Mapping the location of infestations over time also gives the opportunity to demonstrate the success or failure of the project.

Identifying the existence and location of assets that may be under threat from the invasion of willows is also useful. Significant native riparian communities and endangered species should be mapped and the threat posed by willows assessed. Willows also have the potential to damage significant structures. For example, willows were removed along the Coal River near Hobart, Tasmania due to the significant threat posed from flood debris to a historic bridge.

3. Determining priorities

There are simply too many willows in Australia for us to remove them all. We need to set priorities for managing this menace. The Tasmanian report *Strategic Planning for Willow Management in Tasmania* (www.tct.org.au/wilo1a.htm) is an excellent framework for priority based planning of willow management. It is based on the premise that the position of the willow infestation directly influences the risk it poses to the natural environment.

The Tasmanian plan sets the following priorities at the regional scale:

1. The control of seeding willows ('Priority willow taxa').
2. Protecting high conservation values, including:
 - ~ threatened species,
 - ~ significant vegetation communities, and
 - ~ sites of geo-significance.

Priorities at the catchment scale include:

3. Sites where the capacity of the system to recover is high.
 - ~ Sites in relatively good condition where remnant native vegetation is present and the willow infestation is low.
4. Headwater infestations.
5. Areas upstream/close to healthy native vegetation.

The Tasmanian document also includes a template site assessment sheet (www.tct.org.au/wilo1e.htm) which highlights the important issues to consider when prioritising willow management.

Priority management of seeding willows in Tasmania

Seeding willows are a significant problem in Tasmania as they have the potential to invade new areas and threaten the values of pristine wilderness. In Tasmania, seeding willows are still considered to be rare. As a result, they have been labelled as ‘priority willow taxa’ and their removal is considered to be the number one priority of willow management in the State.

For this reason, the discovery of the first known population of *Salix cinerea* seedlings on a road cutting along the Huon Highway in 2003 prompted the regional weed officer to take action. A thorough search was undertaken of the surrounding area until the likely source of the seedlings was discovered and destroyed. So far, well over 100 seedlings have been removed as well as some larger trees. Plans are currently in place to remove the remaining population. Although the road cutting itself is not ecologically important, any propagules from this site have the potential to invade sites several kilometres away, including the nearby healthy wet eucalypt forest which includes significant areas of intact native riparian vegetation. Other populations of seeding willows have since been identified in other parts of the State and are being prioritised for control.

“Seeing Tasmania’s first significant naturalised population of seeding willows is like going back in time and standing looking at Australia’s first introduced blackberries. We have a chance to do something to protect Tasmania from even greater willow invasion.”

Andrew Crane, Regional Weed Management Officer, Tasmania



Main photo: Dead *S. cinerea* trees thought to be the parents of the roadside seedlings. Small photo: *S. cinerea* seedling.

4. Working with the community

Public education and knowledge is paramount to achieving the goals of a willow management program. Many members of the public love the look of willows, and do not share the manager’s concern about their invasive ability and threatening weed status. Landholders also like willows because of their use as stock fodder and their perceived usefulness in stabilising stream banks. All too often willow removal efforts fail due to the refusal of an upstream landholder to conduct willow control on their property.

It is imperative that all parties are made aware of the weedy nature of willows and their detrimental impacts on rivers and their in-stream life. People need to be aware of the potential consequences of not acting and what they can do to help, and should have the opportunity to participate in planning or commenting on the control program. Unless this information is made available, landholder or community opposition to willow removal will persist.

5. Planning for short term consequences of willow removal

When a dense stand of willows is removed, it is common for the stream to go through the following sequence. First, the fine root mat rots down, releasing a slug of fine, nutrient rich sediment into the stream. Secondly, a wave of erosion can pass up the stream. With the shading from the willows gone, the water heats up. The combination of warm water and nutrient rich sediments often leads to algal blooms. These effects can last for a year or two. It is important to be prepared for these short term changes and to inform the community so that it is understood as a phase in the longer term restoration process.

6. Willow control/removal

Once the decision to control willows in an area has been made, the manager must then decide on the most suitable methods to use. There is no set perfect solution when it comes to willow control, and along



Cut and paint method of willow control.



Frill and fill control method.

a single river reach several methods may need to be employed. Where the individual willow is growing, the size of the tree and the stability of bank should all be considered. In general five options are recommended:

1. Hand removal of seedlings.
2. Foliar spray of smaller plants.
3. Cut and paint.
4. Drill and fill.
5. Frill and fill.

The table on page 13 describes each method, the situations they are best suited for, and the benefits and limitations of each. This information should not be considered exhaustive as new methods are being trialled constantly. Willow control fact sheets are also available from organisations such as Greening Australia.

Common pitfalls

- ~ Herbicide not applied to cut stump quickly enough. Note: A good idea is to fell the tree fairly high up the trunk first then make a second cut across the stump and paint this immediately.
- ~ Drill holes or cuts not made around the entire trunk, or branches missed.
- ~ Holes cut or drilled too shallow or too deep.
- ~ Broken branches left in stream or on bank.

Contractors

The use of contractors is common when you plan to remove more than a few willows. Their previous experience can also be a considerable asset. It is essential that contractors (and everyone else involved in control) are made aware of the extremely weedy nature of willows, their ability to sprout from the smallest twig, and their capacity to reshoot if poisoning is not carried out correctly. A good idea is to pay contractors for the job done rather than a per hour fee. This means that if the first treatment is unsuccessful, they are obliged to repeat the exercise at their own cost. This also means that contractors will take more care to ensure that the work is done correctly the first time.

Safety issues

Occupational Health and Safety is a major issue that needs to be considered during both planning and project implementation, given the dangers of felling trees, using large machinery near water and the potential for fragile branches to easily break, etc. The need for safe work practices and sound experience in willow control is another reason why competent contractors are essential.

The threat from private gardens

Despite legislation outlawing the sale and distribution of willows in Tasmania, many nurseries continue to sell these plants. A tactic used by some is to relabel plants as one of the three species excluded from changes to legislation in that state/territory. Since plants look similar in their early stages, it would take an experienced taxonomist to tell the difference. Some grafted willows have different sexes for the rootstock and scion, so providing the two are the same or compatible species, or if they are hybrids, suckering of the rootstock could lead to seed production and spread.

Despite appearances, this hedge is actually a willow. Thought to be a hybrid of *S. caprea*, different parts of this grafted plant produce both male and female flowers and it produces viable seed.





Community involvement

Willow removal is often a time consuming project and employing contractors can be expensive. The involvement of volunteers is valuable so that ongoing work can occur within the local community. This gives the community more ‘ownership’ of the project. However, ensuring groups have adequate training and supervision is essential. The involvement of volunteers in willow control works is usually limited to certain situations, due to the potential hazards of major control works. Volunteers can play a valuable role in revegetation works, fencing and hand removal of seedlings or foliar spray of smaller plants. In some cases, volunteers have also played a critical role in managing isolated trees along remote rivers, using drill and fill, or frill and fill methods. Guidance for community groups is made even simpler by referring to manuals such as that produced by the CRC for Weed Management, ‘Weed control methods for community groups’ (www.weeds.crc.org.au/documents/manual_module_two.pdf).

Burnt willow material from on-site disposal.



Although not specifically for willows, it contains useful information on integrated weed management ideas and instructions for safe herbicide use. Unfortunately, the cost of insurance is becoming a prohibitive factor in the use of volunteers for many projects, including willow removal, so it is important to check the situation with local authorities before commencing a project.

Herbicide use

Herbicide use is controlled by legislation in each state and territory and restrictions apply. By law, herbicides must only be used in accordance with the manufacturer’s label. It is important to ensure that the correct herbicide is used for the method it was designed and registered for, so check the product label before use. If working near a waterway, it is also important to check that you are using a product which is permissible in this situation.

A full list of products registered for use on willows is available at: http://www.apvma.gov.au/pubcris/subpage_pubcris.shtml search pest name ‘Salix’.

Disposal of willow material

In situations where the river is considered wide enough to handle debris and where issues of public liability from falling dead trees is not a problem, treated trees may be left in situ to decay naturally. However, in most cases trees will need to be cut down at, or following treatment, and all material disposed of. In areas where access is easy, material can be taken off site, however, in many cases access is difficult, making burning in situ the only option.

Table of recommended willow control methods

	Best suited for	Method	Benefits	Limitations
 	Seedlings <1 metre.	Pull seedlings out by hand.	Requires no herbicide or specialised tools.	Can only be used on small seedlings and is surprisingly difficult.
	Treatment of recently infested areas (trees <2 metres tall) and management of regrowth after initial treatment.	Use approved herbicide and spray foliage. Be careful to minimise herbicide contact with non target species or the watercourse.	Less labour intensive than other methods.	Possibility of affecting non target species and waterway. Can only be undertaken in calm, clear conditions.
	Trees or limbs not overhanging stream. Areas where leaving dead trees could create issues of public liability.	Cut trunk off below branches and immediately apply herbicide registered for purpose. Remove all plant material to prevent regeneration.	Treatment, removal and clean up are immediate. There is minimal herbicide use, wastage and contamination. Roots can be left intact to stabilise bank.	Felling live willows can provide a source of new material. Thorough clean up or pre-treatment is necessary.
	All trees with diameter at breast height >10 centimetres.	Make holes or cuts 20–30 centimetres deep at short intervals around trunk below branches and immediately inject registered herbicide.	The tree dies before it is removed, decreasing the chances of material breaking off and becoming new plants. Roots can be left intact to stabilise bank.	Slow process. Many will need more than one treatment. All trunks of each tree must be treated.

7. Revegetation and follow-up

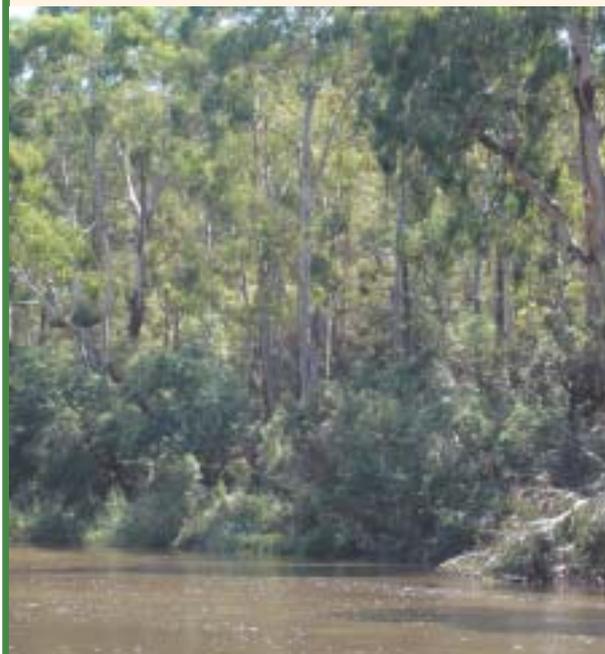
Rehabilitation and follow-up activities are critical to the success of a willow management project and must be planned from the outset. Without these, funds spent on willow control works may be wasted due to re-invasion or regrowth of willows, invasion of other weeds, or the emergence of other environmental problems such as erosion. Local, regional and catchment authorities are good sources of information and advice about revegetation methods, as are Greening Australia and local Landcare/Bushcare groups. Funding must be included in the project budget for these follow-up activities. For this reason, if the project has only a limited budget, it is much better to target a smaller section of willows and allow funding for follow up and maintenance, than to clear a large section which, without follow-up, will almost inevitably be re-invaded by willows or other weeds. When regular monitoring is carried out, resprouts or new seedlings are detected early. By dealing with willows while they are young or recently resprouting, treatment is much cheaper, easier and has a higher chance of success. Landholders can be a key contributor to this process and make the difference between success and failure, a vital benefit of their involvement from the planning stage.



Resprouting *S. cinerea* following unsuccessful stem injection.

Mapping, monitoring and removing the willows at Warrandyte — a joint effort

Parks Victoria has been mapping willow infestation along the Yarra River at Warrandyte State Park since 1994. Willow control first began in 1997. Since then, most of the Park has been treated, and current maps show that very few willows remain along most sections of river within this ecologically significant area.



The relative success of this operation appears to be based on three main factors:

Co-operation — Due to the patches of significant remnant riparian vegetation found within the Park, willow control at Warrandyte has been a high priority for Parks Victoria, Melbourne Water and the Friends of Warrandyte State Park, all of whom have worked together towards the goal of a willow free Park.

Regular monitoring — One of the rangers, David Van Bockel has been committed to mapping the willow infestation for several years now. The maps enable David to know where the willows are located in the Park, where treatment has occurred, and which areas need checking to ensure that re-infestation does not occur.

Retreatment — Rather than spending all funding on new projects, a large part of the control program involves monitoring and treatment of regrowth. This means that any broken branches or surviving trees are detected early and treated. In general, control continues each year with work starting at the same point upstream, travelling past previously treated sections to search for regrowth, then moving down to treat new areas.

Healthy native bush is now replacing willows at Warrandyte.



Regular monitoring is required, even in areas of revegetation.

8. Monitoring and evaluation

Monitoring of the treated project site for several years after initial control is vital. Even in projects where all control is undertaken correctly, willows will almost always resprout from broken branches, or from cut stumps. In addition, where bare ground is exposed, these areas may be susceptible to invasion by seeding willows. No control method is 100 per cent effective the first time. Periodic monitoring for resprouting or re-infestation from adjacent areas is a crucial part of the project, and should be included in the plan and budgeted for. Monitoring and follow-up treatment may cost less than 10 per cent of the total budget, but can make or break the project's success.

Monitoring data also provides the basis for evaluating the overall success or otherwise of the willow control project. It is important for all those involved to revisit the project purpose and objectives set during the planning stage, and to evaluate whether or not they have been achieved. Reporting this evaluation to the community and funding agency is an integral part of good project management, as well as building public support and justifying continued funding. The evaluation also provides an opportunity for those involved directly in the work to review and improve the methods used for each stage of the project — monitoring and evaluation is the pre-requisite to adaptive management and continuous improvement.

A national approach to willow management

In 1999, willows (except *S. babylonica*, *S. x calodendron* and *S. x reichardtii*) were listed as one of Australia's 20 Weeds of National Significance (WoNS), due to their highly invasive nature and impacts on stream and wetland hydrology and biodiversity. The WoNS program provides a focus on weeds for which a nationally coordinated action program would bring greatest benefits. To help guide national coordination of willows, the National Willows Strategic Plan (2001) was published in 2001, with the vision to 'stop willows destroying our waterways and wetlands'. The Plan aims to deliver three primary outcomes:

- ~ stop further spread of willows,
- ~ manage the existing areas of willows, and
- ~ gain community support in managing the willow problem.

Some of the major challenges to achieving these three goals include preventing further trade and planting; identifying and preventing the spread of key taxa; effective on-ground management including mapping, control, follow up and replacement with indigenous vegetation; the development and integration of biological control methods; and regulation of industries and people using willow taxa (e.g. the nursery and cricket bat industries).

The National Willows Taskforce was established in August 2005 in order to facilitate progress towards the National Willows Strategic Plan. The role of the National Willows Taskforce is to facilitate, improve and encourage strategic national action by coordinating the implementation of the National Willows Strategic Plan. In addition, the taskforce will set priorities and identify funding and resource sharing opportunities for the management of willows across Australia. The taskforce has developed a Willows National Priority Action Framework to help guide investment in willow management. For a copy of the Framework or National Strategic Plan or any further information on the National Willows Program, go to www.weeds.org.au/WoNS/willows.

Appendix 1:

Responsibilities under legislation

As part of the WoNS process, each state and territory made a commitment to prohibit the deliberate trade and distribution of all WoNS. Given the widespread distribution of willows and various issues with species and hybrids, the enforcement of legislation is complex and needs to be strategic and consistent across a given region. State legislation is one tool used to support efforts for management of WoNS listed species. Most willows are now banned from trade or distribution in all Australian states and territories, and the control of certain willows is required in some areas. For a summary of the current legislative status of willows in each state/territory, go to www.weeds.org.au/WoNS/

willows, and click on 'Declaration status of willows in Australia'.

In relation to further introduction of willows into Australia, the importation of plants or seeds of all *Salix* species must be approved by the Animal and Plant Programs Branch, Department of Agriculture, Forestry and Fisheries, Canberra and the importation of *S. bebbiana* and *S. exigua* is prohibited by the Australian Quarantine Inspection Service (AQIS).

Note: Some states also have restrictions on the clearing of riparian land so it is important to contact the relevant state authority before undertaking major works (see willow management contacts).

Current declaration status of willows in each state/territory across Australia

Changes in the legislative status of willows in Australia will be incorporated into the website: www.weeds.org.au/WoNS/willows

State/territory	Areas where legislation exists	Class/status	Willow species affected	Legal restrictions
Australian Capital Territory	Whole of ACT	Declared pest plant	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	A plan must be prepared to control the spread of these plants.
New South Wales	Whole of NSW	Control Class 5	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	Control Class 5 Control Objective: to prevent the introduction of those plants into NSW, the spread of those plants within NSW or from NSW to another jurisdiction. The requirements in the <i>Noxious Weeds Act 1993</i> for a notifiable weed must be complied with. (Refer to Sections 12, 15, 16, 28, 29, 30, 31, 32 and 40 of the <i>Noxious Weeds Act 1993</i> .)
	Albury City, Bellingen Shire, Blue Mountains City, Clarence Valley, Greater Hume Shire, Gundagai Shire, Junee Shire, Narrandera Shire, Tumbarumba Shire, Tumut Shire and Wagga Wagga City Councils	Control Class 3	Black willow (<i>Salix nigra</i>)	Control Class 3 Objective: to reduce the area and the impact of those plants in parts of NSW. Must be fully and continuously suppressed and destroyed.

State/territory	Areas where legislation exists	Class/status	Willow species affected	Legal restrictions
New South Wales	Blue Mountains City Council	Control Class 3	Grey willow (<i>Salix cinerea</i>)	Control Class 3 Objective: to reduce the area and the impact of those plants in parts of NSW. Must be fully and continuously suppressed and destroyed.
Northern Territory	Whole of NT	Schedule Class A/C	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	To be eradicated (A) and not to be introduced into the Territory (C).
Queensland	Whole of QLD	Class 1	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> , <i>S. x chilensis</i> (syn. <i>S. humboldtiana</i>), <i>S. matsudana</i> and <i>S. reichardtii</i>	A Class 1 pest is not commonly present in Queensland and, if introduced, would cause an adverse economic, environmental or social impact. Class 1 pests established in Queensland are subject to eradication from the state. Landowners must take reasonable steps to keep land free of Class 1 pests. It is a serious offence to introduce, keep or supply a Class 1 pest without a permit issued by the Department of Natural Resources, Mines and Water. Penalties of up to \$60,000 apply.
	Whole of QLD	Class 3	Tortured willow (<i>S. matsudana</i>) and pencil willow (<i>S. chilensis</i> (syn. <i>S. humboldtiana</i>))	Class 3 pests are established in Queensland and have, or could have, an adverse economic, environmental or social impact. The primary objective of Class 3 listing is to prevent sale, therefore preventing the spread of these pests into new areas. Landholders are not required to control Class 3 plants unless their land is adjacent to an environmentally significant area. It is a serious offence to supply a Class 3 pest without a permit issued by the Department of Natural Resources, Mines and Water. Penalties of up to \$15,000 apply.
South Australia	Whole of SA	Class 11 Category 3	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	NRM Act (2004) Class 11, Category 3: Cannot sell the plant or any plant material.

State/territory	Areas where legislation exists	Class/status	Willow species affected	Legal restrictions
Tasmania	Whole of TAS	Declared weed	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	A person must not import or allow to be imported into Tasmania any willows. A person must not sell or otherwise distribute any willows or any thing carrying willows. An Inspector may, by serving a notice on the owner of any place, require that owner to implement any of the measures described in the statutory willow management plan or any other measures consistent with it. Any thing found to be contaminated with willows may be removed to storage at an appropriate approved quarantine place. A Regional Weed Management Officer will determine whether removal to storage at any of these facilities or treatment/ destruction of material in situ is most appropriate.
	Glamorgan/Spring Bay Municipality	Zone A Eradication	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	Management objective for Zone A is eradication.
	Whole of TAS except Glamorgan/Spring Bay Municipality	Zone B Containment	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	Management objective for Zone B is containment.
Victoria	Whole of VIC	Restricted weed	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	Not to be sold or traded.
Western Australia	Whole of WA	P1	All willows (<i>Salix</i> spp.) except <i>S. babylonica</i> , <i>S. x calodendron</i> and <i>S. x reichardtii</i>	Entry into the state and the trade, sale or movement of plants or their seeds is prohibited.

S. babylonica.



Appendix 2: Willow management contacts

Australia	National Willows Coordinator — Sarah Holland-Clift. Victorian Department of Primary Industries. Tel: (03) 5226 4831. E-mail: sarah.holland-clift@dpi.vic.gov.au Website: www.weeds.org.au/WoNS/willows
ACT	ACT Government. Canberra Connect: 132 281. Website: www.act.gov.au/index.jsp
New South Wales	NSW Department of Primary Industries. Hotline: 1800 680 244 (for all weed reports). E-mail: weeds@agric.nsw.gov.au Website: www.agric.nsw.gov.au
Queensland	Department of Natural Resources, Mines and Water. Hotline: 1800 803 788 (for all weed reports). General inquiries: (07) 3896 3111. Website: www.nrm.qld.gov.au
South Australia	Department of Water, Land and Biodiversity Conservation. Animal and Plant Group. Tel: (08) 8303 9500. Website: www.dwr.sa.gov.au/biodiversity/pests/apcc.html
Tasmania	Department of Primary Industries and Water. Tel: 1300 368 550. Website: www.dpiwe.tas.gov.au
Victoria	Department of Sustainability and Environment. Customer Service Centre. Tel: 136 186. E-mail: customer.service@dse.vic.gov.au Website: www.dse.vic.gov.au
Western Australia	Department of Food and Agriculture. Tel: (08) 9368 3666. E-mail: info@agric.wa.gov.au Website: www.agric.wa.gov.au



Willows growing into the channel of the Lachlan River in the central-west of NSW.

Appendix 3: References

A. Useful guides

- Strategic Planning for Willow Management in Tasmania*, The Tasmanian Conservation Trust [www.tct.org.au/wilo]. A useful summary of some important facts about willows.
- Weeds of National Significance: Weed Management Guide. Willow (Salix spp.)* [www.deh.gov.au/biodiversity/invasive/publications/pubs/salix.pdf]. This fact sheet, published by the Natural Heritage Trust and the CRC for Weed Management, contains concise details on the problems associated with willows, key species to be aware of and some basic information on control. Its colourful illustrations and clear headings and descriptions mean it is likely to be useful for landholders and the community.
- Weeds of National Significance: Willow Strategic Plan*, 2000, Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), Australian and New Zealand Environment and Conservation Council and Forestry Ministers, National Weeds Strategy Executive Committee, Launceston. The full national strategy for willow control in Australia.
- Willow Control*, Greening Australia, 2003, 3 pages [www.greeningaustralia.org.au/NR/rdonlyres]. A good summary of control methods.
- Willows — friend or foe*, 2005, Department of Primary Industries, Water and Environment, Tasmania [www.dpiwe.tas.gov.au/inter.nsf]. A one page summary of willow management issues in Tasmania.
- Willow Management for Australian Rivers*, K. Cremer, 1999, *Natural Resource Management*, special issue December, pp. 2–22, The Australian Association of Natural Resource Management. A thorough overview of willow biology, breeding and identification, together with management strategies.



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