Section 3

Controlling and removing willows

Controlling and removing willows

Effective control of willows requires planning, resources, skills and appropriate equipment. Before deciding how to control willows, ask yourself again, 'Why am I controlling the willows in the first place?'

Planning, site preparation and rehabilitation

Have you conducted the appropriate planning and site preparation?

Controlling willows can be a very dangerous activity and, if done poorly, may result in more damage than good. Appropriate planning and site preparation is absolutely critical before starting any control activities. See Section 2 Managing willows, for help to plan works and prepare your site.

Before starting any control works, have you determined the appropriate rehabilitation methods?

If you are not planning to rehabilitate your site, why are you controlling the willows in the first place? See Section 4 Site rehabilitation, for more information.

Choosing a control technique

Weigh up the pros and cons

This section outlines a range of techniques to control and remove willows, recommended by a group of experienced practitioners in willow management from across Australia. To determine which of these best match your specific situation, it is important to weigh up the pros and cons of each method, taking into account factors such as site conditions, scale of the project, willow taxa and resources.

Consider your specific situation

To help you to make decisions about management we have provided as much detail as possible on each technique. Even so, how each is applied will be the subject of considerable variation between people and there are many specific situations where you may need to adopt an alternative technique or vary these methods.

Trial and refine new approaches, but don't reinvent the wheel.

This information is by no means prescriptive. It is intended as a guide to help determine the best method for each situation based on current evidence. We need to continue to trial and refine new approaches and promote these to others working on willows across Australia.

There is no, one best method for controlling willows – it all depends on your situation.

Important considerations

When choosing a technique and method of application:

- Choose the method that is appropriate for your situation and level of skills.

  Some of the methods in the following pages are extremely efficient and cost effective, but rely on well-trained and experienced operators to get a good result. The skill level of the operator may be the difference between success and disappointment.

- Carefully consider the advantages, disadvantages and cautions given for each method.

  On-ground practitioners are constantly learning the downsides of methods that were considered 'best practice' in the past. In some cases, these downsides can be difficult to predict and are not seen until many years after control (for example, after severe weather events, such as floods or storms). It is important to keep an open mind and recognise that if it hasn't happened to you, then that doesn't mean it won't.

- Be extremely cautious when applying these techniques to any situation.

  Willow control is a difficult, dangerous and expensive process. Like all waterway management activities, it is best to start small and gradually learn from and adapt your management over time.

- Carefully check relevant policies and regulations in your state or local government area and ensure that you have the necessary permits for operation, such as permits for working on waterways, access to private land, cultural heritage, boat operation, burning, occupational health and safety and chemical use.

  Before starting any willow control operations, you should ALWAYS check and follow any relevant policies and regulations in your state or local government area.

Which method should I use?

When choosing a control method, it is important to weigh up the pros and cons of each method, taking into account factors such as the type, density and size of willows, the site conditions and the conditions downstream.

A detailed check list that will help you to choose the most appropriate control technique is included as Appendix 2. This will also help to provide a sound basis for justifying your decision with landholders, the community and your investors.

Once you have identified potential control techniques from the check list, you will also need to consider:

- negotiations with the community, landholders and investors
- availability of resources, including funding, labour and equipment
- timing of control works
- skill level of operators, and
- potential external inputs to the site, such as seeding willows or willows growing upstream of the site.

Using chemicals

Before using herbicides on willows:

☑ **Ensure the product is registered for the purpose.**

When using herbicides, always read and adhere to the label instructions or appropriate off-label permits. The Australian Pesticides and Veterinary Medicines Authority (APVMA) regulates the registration of herbicides in Australia. The APVMA website (www.apvma.gov.au) has a searchable database of registered chemicals and current off-label permits.

☑ **Consider the proximity to water and the risk of contaminating waterways.**

Herbicides should be used in a way that does not contaminate waterways. See 'Using herbicides near water' in this section, for further information.

☑ **Manage for off-target impacts.**

When poisoning willows, other nearby plants may be affected and the risks of this must be considered and managed where necessary. Even cut-and-paint methods may have off-target impacts, as some nearby trees may have their roots grafted to the willows. When working near rare or threatened species, contact the appropriate flora and fauna officer in your area to confirm whether your chosen treatment techniques are appropriate.

☑ **Ensure that users have appropriate training and safety equipment.**

Anyone using chemicals should have an appropriate training certification for the use of chemicals in your state or territory and should be wearing appropriate safety equipment for the chemical being used, including shirt and trousers (or overalls), rubber boots and gloves. Permits can be obtained following the satisfactory completion of a ChemCert Australia Inc. accredited Farm Chemical Users Course. Contact your local TAFE or other Registered Training Organisation for further details.

☑ **Ensure that you comply with state and/or local government legislation, particularly chemical use, pollution and native vegetation laws.**

Using herbicides near water

Herbicides are to be used in a manner that does not contaminate waterways. Some herbicide formulations are specifically registered for use in aquatic areas. It can sometimes be difficult to distinguish between an aquatic and riparian environment when willows may be growing in both.

If in doubt, use a herbicide registered for use in an aquatic area.

For guidelines on the use of herbicides in and around waterways, refer to:

Ainsworth, N. and Bowcher, A. (2005) *Herbicides: guidelines for use in and around water.* CRC for Australian Weed Management

This fact sheet aims to assist people responsible for riparian and aquatic weed management by providing information and specific recommendations. It is available for download from *www.weeds.crc.org.au/documents/gl01_herbicides_water.pdf*

Always seek site-specific advice if you are unsure of herbicide impacts.

Which chemicals to use?

There are several chemicals specifically registered for controlling willows.

When using herbicides, always read the label

Chemicals are not to be used for any purpose or in any manner contrary to the label unless authorised under appropriate legislation. Before using a herbicide for the control of willows, or any other weed, read and adhere to the instructions and conditions for use on the label. By law, you must read the label (or have it read to you) before using any herbicide product. The same applies for off-label permits. Always follow the label and permit directions.

Further information

For further information on chemicals registered for use on willows, the APVMA website (www.apvma.gov.au) has a searchable database of registered chemicals and current off-label permits.

Seek advice from your local chemicals supplier and always read the label.

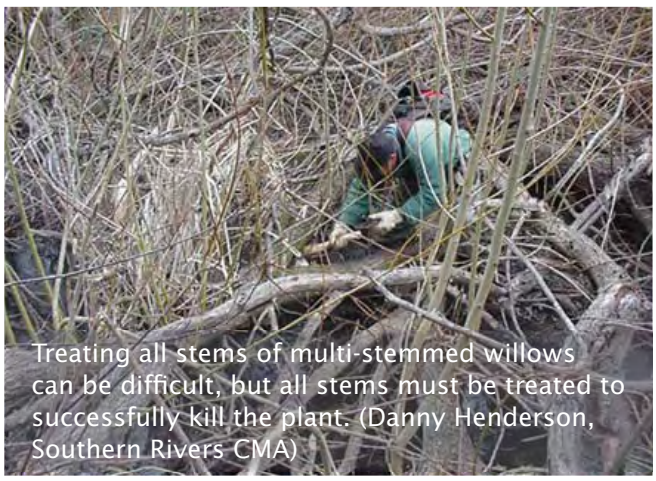
Herbicides currently registered for use on willows

Active Ingredient	States and territories where products are registered for use on willows	Formulation(s)	Application method	Comments
Glyphosate	All states and territories	Aqueous concentrate, soluble concentrate, liquid, suspension concentrate	Foliar application, stem injection, cut stump	Foliar spraying registered for trees < 2m high Some, but not all, glyphosate products are registered for use in aquatic areas
Picloram	All states and territories	Gel	Cut stump only	Not registered for use in aquatic areas
Picloram / Triclopyr	All states and territories	Non-aqueous concentrate (requires mixing with diesel)	Cut stump only	No products registered for use in aquatic areas

What can affect the success of chemical control?

Some potential causes of chemical control failure are:

- ☒ **Time of year** – generally the cut and paint and stem injection methods are effective throughout the year, however, in some areas, people have found the results to be unpredictable in spring.
- ☒ **Timing of application** – if the chemical is not applied immediately (within < 30 seconds) following cutting, the cut may seal up and the chemical will not be effectively absorbed.
- ☒ **Dirty willow leaves** – if leaves are dirty (for example, covered in silt from flood waters), foliar-applied herbicides can be less effective.
- ☒ **Cuts too deep or shallow or too far apart when stem injecting** – when cuts are too deep or shallow or too far apart, the chemical uptake may not be sufficient to kill the trees. The chemical will only be transported through the sapwood, which is just beneath the bark. This can be particularly challenging when working on horizontal limbs or inside the limbs at the base of multi-stemmed willows.
- ☒ **Rainfall or rising floodwaters** – herbicides can be washed off cut stumps or foliage if there are rains or rising floodwaters soon after application.
- ☒ **Not all stems were treated** – although often difficult, all stems in multi-stemmed willows must be treated to completely kill the plant.
- ☒ **Degree of stress** – willows may be under stress due to seasonal conditions and, therefore, not actively transporting fluids (including chemicals) through the trunk.
- ☒ **Clay soil in the cut** – the clay particles may bond with and neutralise the chemical.



Treating all stems of multi-stemmed willows can be difficult, but all stems must be treated to successfully kill the plant. (Danny Henderson, Southern Rivers CMA)

When can I control willows?

Willows can be effectively killed at any time of year, but other site-specific factors should be carefully considered when determining the timing of control works.

The best timing for control works will vary depending on a number of site-specific factors. These may include:

- **The climate** – for example, working in drier conditions and outside fire restriction periods.
- **What you are trying to protect at the site** – for example, conducting control works at times when they will have least impact on vulnerable plants or animals in the area.
- **Other activities being undertaken in your area** – for example, control of other weeds, planting or erosion control works.
- **Risks of soil disturbance, bank damage in wet conditions and risks of floods occurring during works.**

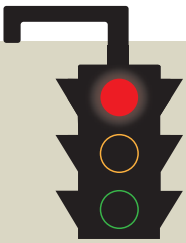
For a long time, people have believed that willow control can only be conducted during spring and summer, when the plants are in full leaf. Experienced willow managers, however, have gradually learned that willows can be effectively controlled at any time of the year if other site-specific factors allow.

West Gippsland Catchment Management Authority has been controlling willows for over 10 years. When they started, they believed that the chemical would only transfer through the plant when it was in full leaf, so they only controlled willows at that time of year. As the demand for control works increased, they started to push the boundary and conduct works further into autumn and winter.

They found that chemical control was just as effective at killing willows during autumn and winter, when the plants were apparently dormant, as they were in spring and summer, when the plants were in full leaf.

Detailed review of control methods

Machinery options



Stop and think!

Before choosing this method, consider:

- Occupational health and safety and WorkCover responsibilities or insurance.
- Potential damage to the river bank and adjacent vegetation by machinery, such as excavators, and how you will manage this.
- Matching the size of excavator to the size and scope of the works, considering the length of reach and lift required and the machine's impact on the river bank.
- The experience of your operators. All tree felling and chainsaw operators should be licensed and experienced with working with willows. Even operators who are very experienced with felling other tree species may need to adjust their techniques with the help of an experienced willow feller.
- How many people you will need for the operation.
- Fire restrictions, as this may mean that you need to defer your operation.
- Where the willows will be felled and moved to (see 'Waste management methods' towards the end of this section). You will need to find and decide on appropriate site/s for your chosen waste management method and prepare these areas appropriately.

Suitable for: Willows greater than 150 mm in stem diameter.

Advantages and Disadvantages: Refer to the table, 'Suitability, advantages and disadvantages of mechanical options', below.

How: There are several variations on these methods depending on your resources, skills and accessibility.

The advantages and disadvantages of each of these methods should be carefully weighed up against each other. Thorough planning is required to ensure a safe and effective job is conducted, with minimal impact to the river bank.

The main mechanical options include:

a. Excavator plus tree feller with chainsaw

- A qualified tree feller cuts the trees in situ using a chainsaw and immediately paints or sprays the sapwood layer of the stump with chemical.
- An excavator lifts the willows and stacks them into tightly woven piles above the flood level.
- In some cases, mesh litter fences / booms are erected across the waterway to catch twigs and branches floating away from the site.
- Material out of reach of the excavator (for example, mid-stream willows) may need to be dragged into reach, before lifting onto the stock pile.
- The banks are raked with a stick rake mounted on the excavator and then hand raked to remove all remaining willow material.

b. Excavator with a built-in grabber, chainsaw attachment and poison applicator

- An excavator prunes the trees in a top-down fashion and places the material on a heap behind the machine for processing or burning.
- Once pruned, a final cut is made to the main trunk and the poison is immediately applied, preferably with the spray nozzle visible from the operator's cabin.
- In some cases, mesh litter fences or booms are erected across the waterway to intercept downstream movement of twigs and branches.
- The banks are raked with a stick rake or environ comb attached to the excavator grab, before moving to the next tree.

c. Tree feller with a chainsaw and team to manually cut up and stack material

- Works are planned so that there is a significant distance between the feller/s and people clearing up and feeding fires.

  Note: *Burning is often the only waste management technique available for this method, as other techniques require machinery to move the material. See 'Waste management methods' towards the end of this section.*
- A qualified feller cuts the trees in situ using a chainsaw and paints the sapwood layer of the stump with chemical.
- Chainsaw operators cut the material into small pieces that can be moved manually.
- Other workers collect the material (starting with the smallest branches first), pile it into heaps and burn immediately.
- The site is raked and all pieces are picked up and placed on piles for burning.

  Note: *If you are unable to burn immediately, you may need to consider using a different control method.*

d. As per a) – c) but plants are first poisoned, via stem injection, 2-3 months before their removal

- Trees are stem injected (see 'Stem injection and leave standing' later in this section, for possible techniques).
- Within 2-3 months after stem injection, machinery is used, as per a) – c) above, to remove and manage the material.

Caution: Method d) must only be used where you are able to return to the site within 2-3 months following treatment. There have been many situations where works have been delayed (for example, due to seasonal conditions or funding issues) and willows have been left standing for too long. If willows are left too long following stem injection, they can become brittle and dangerous and pose a hazard to operators or others passing by. In particular, old trees with a hollow or rotten centre (which may not be obvious when looking at it) can be very prone to falling over or breaking.

An excavator working with 2 fallers with chainsaws is generally the preferred method for mechanically cutting, painting and removing willows. (Sarah Holland Clift, DPI Victoria)

Suitability, advantages and disadvantages of mechanical options

These should be carefully weighed up before selecting a control method.

An excavator working with 2 fallers with chainsaws is generally the preferred method for mechanically cutting, painting and removing willows. (Sarah Holland Clift, DPI Victoria)

Specialised excavator heads can cut and apply herbicide in one action. (DPI Victoria)

Occupational health and safety is a major issue when felling willows. (DPI Victoria)

If poisoning prior to removal, trees must be cut down within 2-3 months following treatment. (DPI Victoria)

Method	Suitable for
a) Excavator plus tree feller with chainsaw	Sites with access for machinery. Areas where there is significant risk to infrastructure or people if willows are left standing.
b) Excavator with a built-in grabber, chainsaw attachment **or** **grapple (forestry) shear and poison applicator**	Sites with access for machinery. Areas where there is significant risk to infrastructure or people if willows are left standing.
c) Feller with a chainsaw and team to manually cut up and stack material	Situations where there is little or no money for the work, but substantial, free labour available (for example, Landcare groups, Work for the Dole). Working in sensitive environments where there is no access for heavy machinery.
d) Poison prior to removal	Areas where there is a significant risk of damage to downstream infrastructure or risk to people and property. Sites you are confident you can return to within 2-3 months of poisoning, to remove trees.

Advantages	Disadvantages
Allows you to cover large areas and handle large weights, thus reducing labour and manual handling. Less impact on the bank, as the excavator (if it is large enough) can lift branches, rather than dragging them. Useful for problem trees that would otherwise be dangerous to fell, as it can manage willows on uneven or sloping ground or terrain.	High cost and requires licensed operators. Machine hire will be expensive compared to the chainsaw operator and other staff, so to get the best value for your dollar, you should balance your resources to keep the excavator working continually. Weight and vibration can cause soil disturbance on the river bank. Requires access for heavy machinery (for example, gates, bridges, cattle grids). Can be very messy. Risk of twigs or pieces being pressed (planted) into ground by machinery. Risk of downstream colonisation from fallen twigs or pieces. Occupational health and safety needs to be given high consideration with machinery and on-ground operators working on the same site. As the percentage of native vegetation increases, the machine has to work slower to preserve the surrounding native vegetation.
For suitable willows, the excavator can complete the entire operation without the need for additional fellers or poison applicators. Reduces the risk to people on site, as no one is required to stand under the willows or near machinery. Some machines have a poison system with the spray nozzle visible from the operator's cabin for application immediately after cutting. Some machines have a grab and cutter bar that rotates through 360 degrees, enabling them to harvest willows of all sizes and shapes.	High cost and requires licensed operators. Generally slower than method a), as multiple cuts are required. Lacks a degree of flexibility as, without a rotating head, it can be difficult to adjust the grab to deal with whole willows (for example, multi-stemmed trees and shrubs). May only be effective at removing the upper branches, with a chainsaw feller still needed to fell the main trunk. Requires access for heavy machinery (for example, gates, bridges, cattle grids). In some regions, the machinery required is not commonly available. If a machine-based poison applicator is used, it can be difficult to see if the chemical has been sprayed effectively onto the trunk. A chainsaw operator may still be required to fell trees out of reach of the excavator. A second excavator may be needed to help clean up the site.
Cutting willows into smaller-sized pieces and dealing with smaller areas at a time makes it easier to clean up sites. Removes the risk of twigs or pieces being pressed (planted) into ground by machinery.	Slow and very labour intensive; more on-site planning and preparation will be needed before felling. Much more precise felling techniques are required, compared with machinery. Some willow trees cannot be safely felled without machine assistance and it is not feasible to operate chainsaws on difficult terrain. It is difficult to judge the tension in willows; saws will become jammed, even by very experienced operators. Waste material has to be dealt with almost immediately, as it is often too difficult to manually move it out of the potential flood zone. The wood piles created are more prone to dispersal during floods than large, tight piles created by machinery. Manual handling means that occupational health and safety becomes a major issue. Access to the amount of labour required is not always possible or cost effective.
Reduced risk of regeneration from stem fragments left behind after operation. Wood hardens in first 3 months, making it easier to cut down. Dead timber can be burned immediately as it is piled, if not prevented by fire restrictions.	The overall cost of control (stem injection then felling later) can be greater than cutting the tree down green. Not appropriate for shrub willows, such as grey sallow (*S. cinerea*), due to their many stems – consider stem injection and leave standing. Site must be revisited within 3 months following stem injection to remove the material. If the project is delayed and trees are left standing too long, trees can become very brittle, hard and unpredictable, posing a problem to operators and chainsaws when felling. Dead trees may cause log jams in flood events, posing a significant infrastructure risk (for example, to bridges and fences). If stem injecting does not completely kill the tree, it may become extremely difficult to kill later. Timing of revegetation, fencing and follow-up control works may be more disrupted than if cutting the tree down green. Need to monitor and evaluate any changes in the risk to the public or infrastructure.

Left: An excavator making light work of willow removal. (DPI Victoria) Right: A long-reach excavator is useful where access is difficult. (Melbourne Water)

Types of machinery

"Newer machinery is often much faster than old machinery, which can help to speed up operations and reduce costs. Good machine operators lift material whenever possible to minimise drag."

Mal Gibson, West Gippsland CMA, Victoria

Using machinery to remove willow branches and stems can speed up willow control where there is suitable access. Machinery used in willow removal operations includes:

Excavators

Excavators are often the preferred machinery for use, as they can lift and therefore minimise the need to drag material. Dragging willows can cause significant damage to banks and result in many branches breaking off that will need to be picked off the site.

When choosing an excavator it is important to consider:

- the length of reach needed for the job (i.e. length of boom)
- the pressure of the excavator on the river bank (i.e. the weight of the machine and the width of tracks), and
- the type of head on the excavator.

An excavator with a log grab or claw that closes from 2 sides (commonly used in forestry) is generally the preferred option for removing willows. Other variations include a bucket and thumb (an ordinary grab bucket with a hydraulic attachment) and a 4 in 1 (commonly used on front-end loaders and back hoes).

"Use excavators around 20 tonnes or more. The long reach is important as less movement is required, which helps to reduce soil compaction in the riparian zone."

Andrew Ford, Mersey NRM, Tasmania

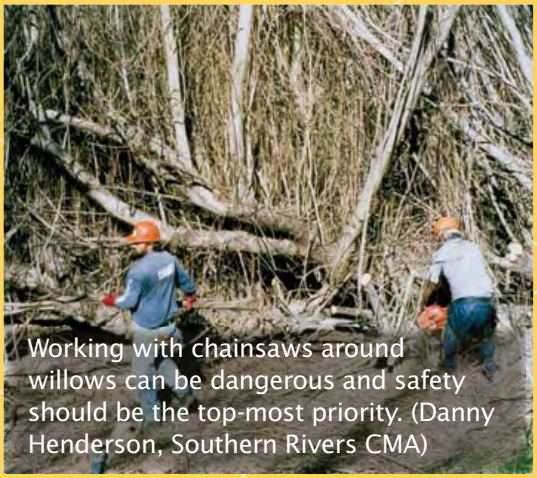
This excavator has a specialised head so that cutting, herbicide application and removal can be done in one operation. (DPI Victoria)

Chainsaws

"A professional and experienced chainsaw crew is vital for safe and effective felling of willows."

Tim Cox, Consultant / Project Manager, Central New South Wales

Willow trees should only be felled by professionals. If using chainsaws, an 18-inch bar is normally required. Chainsaw operators require a chainsaw operator's licence (contact your local



Working with chainsaws around willows can be dangerous and safety should be the top-most priority. (Danny Henderson, Southern Rivers CMA)

Willows should only be felled by professional and experienced chainsaw operators. (Danny Henderson, Southern Rivers CMA)

TAFE or other registered training organisation for further details). Working with chainsaws around willows can be particularly challenging because of the multi-stemmed habit and brittle nature of many willows and the unsafe site conditions in many situations.

"Crack willows have unusual timber pressures and can be extremely dangerous and unpredictable. It is critical that correct felling techniques are used. Always have several chainsaws and multiple people on site for safety as, even with the correct technique, saws can be jammed."

Andrew Ford, Mersey NRM, Tasmania

Rubber-tyred skidder/front-end loader

Since excavators have become more advanced (with the inclusion of hydraulic systems), rubber-tyred skidders have become a less-preferred option for willow management. Rubber-tyred skidders are primarily used for winching and are most efficient when there is an excavator working with them to rake and prepare the material. Skidders are mainly useful when controlling willows in areas where an excavator cannot reach (for example, in the middle of a channel), or where the distance to the stockpile is long (for example, more than 100 m). They are less stable than excavators and are not appropriate for use on multi-stemmed trees or shrubs, such as crack willow or grey sallow.

Tractors

Tractors with suitable attachments such as a front-end loader, 4-in-1 bucket, root rake and winch and chains can be used for manoeuvring logs and trash into stockpiles. This may help speed clean-up operations. Excavators, however, are generally preferred for clean-up operations, as they can lift the material and therefore minimise impacts caused by dragging material, such as damage to river banks and branches breaking off.

Tractors can speed up clean-up operations. (Melbourne Water)

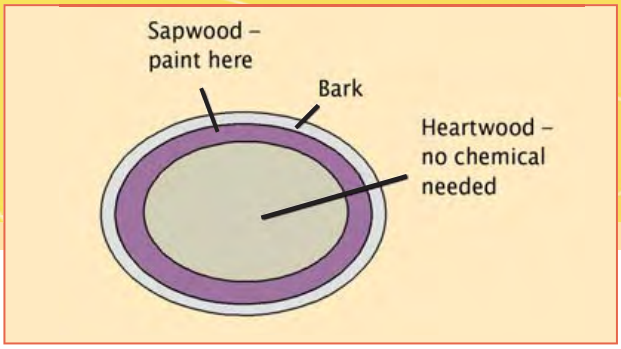
Skidders are primarily for winching and may be useful if the distance to the heap is long (for example, more than 100 m). (DPI Victoria)

Chippers and grinders

Chippers and grinders can be used for mulching willow material, but this can be expensive and the amount of material that will be produced should never be underestimated. See 'Waste management methods' towards the end of this section, for more information on mulching.

Caution! Care should always be taken when using machinery along river banks, as significant damage may be caused.

Cut and Paint: Paint the sapwood only



Non-machinery: Cut, paint and remove

Stop and think!

Before choosing this method, consider:

- Occupational health and safety issues. For safety, people should work outside the arc of the tool being used. This can be easy to forget in this type of small operation, but it is particularly important if using a brush cutter with a chainsaw disc.
- Where to apply the chemical. For plants with a stem diameter greater than 10 mm, chemicals need only be applied to the sapwood (just beneath the bark).
- How will you capture and remove any smaller branches that may break off in the process of removing a larger branch?
- What will you do with the material once it has been removed? (See 'Waste management methods' later in this section for more information). Before cutting limbs and seedlings, be sure you have somewhere to place the debris where it can dry out over the next six to eight weeks and not be swept away in the next rise in the river or take root and grow.


A range of equipment (Willow Warriors Inc.)

Suitable for:

- use on plants up to 200 mm in stem diameter.

  Note: *The methods included here are not all strictly 'non-mechanical', as they also include the use of brush cutters and limbing chainsaws.*

Advantages:

☑ By cutting the stems, it is easier to identify any stems that have not been treated.

Debris can be removed from the flood-prone area, thus preventing the risk of damage to downstream infrastructure caused by large amounts of smaller debris.

Disadvantages:

☒ Requires easy access to a location where offcuts can be placed outside the flood-prone area to dry out for at least 6-8 weeks. This may mean carrying offcuts some distance from the site, which can significantly slow down control works.

How:

1. Limbs and seedlings are cut as close to the ground as possible with a horizontal cut, to avoid spikes or tripping hazards.
2. Chemical is applied to both the trunk and cut stem to reduce the risk of re-sprouting.

   Note: *For stems less than 10 mm, chemical is applied to the whole cut. For stems greater than 10 mm, chemical is applied just to the sapwood layer (just beneath the bark).*

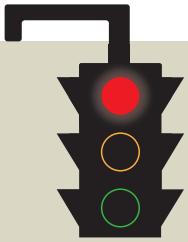
If working near water, a method is needed to capture and remove smaller debris that may break off larger branches.

The equipment that you choose will generally depend on the stem diameter of the willow.

Stem diameter	Recommended materials
10 mm	Secateurs
Between 10 and 20 mm	Loppers
Between 20 mm and 50 mm	Bush saw, folding saw, brush cutters or long-handled forestry loppers (preferably the hooked by-pass style, rather than the anvil type).
Between 50 and 100 mm	Heavy duty brush cutter using a circular blade with chainsaw teeth riveted to it – this has the advantage of operators being able to stand rather kneel when working.
Up to 200 mm	Small limbing chainsaw with a 300-400 mm bar.

Stem injection: Cut to the correct depth
(Water Wise No. 3: Exotic trees along waterways. Mount Lofty Ranges Catchment Program and Environment Protection Agency, Department for Environment, Heritage and Aboriginal Affairs, Government of South Australia)

Stem inject and leave standing



Stop and think!

Before choosing this method, consider:

- Public liability issues or the potential risk of damage to downstream infrastructure in floods. A thorough risk assessment should be conducted before considering this method, to determine if it is safe to leave the willows standing, once dead, to rot down over time.
- Appropriate personal protective equipment (PPE), including gloves to protect the hands from chemical and glasses to protect the eyes from accidental splashes or being poked by twigs or branches.
- Mixing a dye with the chemical so you can easily see where it has been applied or spilt.
- The number of people required. Low-skilled operators can work in pairs, with one person chiselling and the other injecting the chemical and then rotating tasks to reduce the risk of repetitive strain injury (RSI).

Suitable for:

- Isolated trees and scattered stands in difficult-to-access areas where there is low risk to people, property and downstream infrastructure.
- Grey sallow (*S. cinerea*) and other taxa in swamps, spring soaks, wetlands or billabongs, or in areas where willows are spreading through remnant vegetation and where there is no appropriate access to machinery.
- Willows with less than 100 mm diameter trunks in difficult-to-access locations.
- Areas where use of machinery or mechanical removal may cause damage to surrounding remnant native vegetation.

Advantages:

☑ Lower cost than other methods, as willows are treated in one operation and no waste removal is required.

☑ Reduced risk of regeneration from stem fragments left behind after operation.

☑ Can be used by low-skilled operators, as the tools are simple to operate, easy to maintain and are associated with lower risk of injury.

Disadvantages:

☒ Can be unsightly to see dead willows left standing.

☒ Risk of damage to people, property or downstream infrastructure.

☒ Larger trees with thick bark can be difficult to treat with this method.

☒ Can be difficult to stem inject horizontally growing limbs.

It is often easier to cut, paint and remove the limb, rather than stem inject. If you choose to stem inject, ensure that you make cuts in the bottom of the limb, and be aware that you will be cutting with the grain and thus a longer split will be made.

How:

Trees are stem injected and dead trees are left standing to eventually break down and decay. There are various methods of doing this, depending on the equipment that is used. These are outlined in further detail in the table, 'Application of stem injection methods using different types of equipment'.

For all methods a) – d) (outlined in the table, 'Application of stem injection methods using different types of equipment' on the following page):

1. Trees are stem injected around the entire stem or trunk and underneath the lowest shoot or branch, ensuring that cuts or drill holes are:
   - **a maximum of 2-3 cm apart** – if a wider gap is left, the plant can survive on this sap stream
   - **horizontal** – to avoid the chemical from pouring out one side of the cut
   - **at an angle of 45 degrees down into the white sapwood** – if the notch is too deep or too shallow the chemical may not be absorbed into the sap flows (see 'Using chemicals' on earlier in this section, for more information) and
   - **clean of mud or soil** – as clay particles can bond with the glyphosate and neutralise it.
2. Chemical is applied within 30 seconds (and within 10 seconds, where possible) to improve the chances of successfully killing the tree.
3. Where there are forks in the limb close to the ground, the inside of each fork is treated.
4. The site is monitored 6-8 weeks later to re-treat any surviving limbs – if parts of the plant have survived, the sapwood will still be white.
5. Dead trees are left standing to fall and break down naturally, unless regular monitoring and review indicates that further action is required to manage the debris.

Application of stem injection methods using different types of equipment

Method	When to use	Limitations	How
a) Chisel and mallet	Easy for low-skilled operators, as tools are low-tech and low maintenance. Note: for low-skilled operators, a 250 ml applicator bottle is often better than an injection pack. If you have large numbers of willows on one site, however, a well-maintained injector pack is more efficient.	There is a risk of applying too much chemical and spilling it over the applicator bottle or gloves – to avoid this, ensure that the hole in the applicator nozzle is no more than 2 mm in diameter.	Holding a 25 mm wide chisel at 45 degrees to the stem, use the mallet to cut a horizontal notch downwards into the white cambium layer of the trunk or stem. Push the chisel down to open the cut and then pull it out. It is important the notch is made downwards and horizontal to hold the chemical in. Inject 2 ml of undiluted chemical into the cut, from either an injector pack or a 250 ml applicator bottle.
b) Axe and injector pack ***Note:*** *For multi-stemmed willows, where you need to get in tight between limbs, use a chainsaw instead of the axe.*	Allows the operator to work independently, with the axe or tomahawk in one hand and injector gun in the other. When used by trained operators, can be much faster than the chisel and mallet method. The injector pack allows the operator to set the amount of chemical to be applied.	There is more risk associated with swinging an axe or tomahawk than using a chisel and mallet. The main risk is of the axe deflecting off the limb and hitting someone, particularly with an inexperienced operator. Injector pack requires daily cleaning and oiling of seals and injectors to prevent leaks. Injectors with glass cylinders need to be protected from breakage.	Use the axe or tomahawk to cut a notch at 45 degrees to the stem and apply 2-5 ml of undiluted chemical (as the cuts are larger than if using the mallet and chisel).
c) Cordless drill and injector pack	Most effective for large trees with thick bark, horizontal limbs and limbs growing close together.	Only practical where batteries can be recharged each night and 5 or 6 spare batteries can be carried with the operator, as batteries only last for about 90 minutes each. Small drills are ineffective.	Drill a hole across the cambium layer rather than into it, to reduce the number of drill holes and chemical needed.
d) Scrap and paint	On small, scattered seedlings where it would be difficult to avoid off-target damage from foliar spraying. To follow up small areas of regrowth at stem injection sites. On seedlings up to 2 cm in diameter that cannot be hand pulled and where it is difficult to find a dry place to leave cut stems (for example, willows growing in the bed of a river with steep or muddy banks). On willows with branches growing up out of the water (including wetlands).	Labour intensive; area needs to be checked thoroughly, as stems are small and may be difficult to detect until a follow-up visit.	Using the edge of any tool (chisel, secateurs or axe), scrape 20 mm off the green bark down to the white cambium layer and smear chemical along the scrape. For stems over 1 cm in diameter, apply to two sides of the stem.

"To reduce any potential risks to people from leaving willows standing, we place signs near access points to the river, warning people that willows have been treated and may fall at any time."

Jeff Cottrell, Friends of the Colo Inc., New South Wales

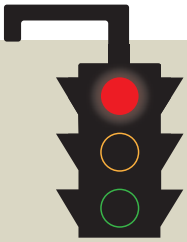
Can large willows be controlled without using chemicals?

Most willows will coppice profusely after they are cut down. A small amount of chemical applied to the stump will help prevent this. If, however, you are determined to control willows without using any chemicals:

1. Lop as close to the ground as possible.
2. Split trunks with an axe to let decay organisms in.
3. Follow up in 6-8 weeks to remove any new shoots.
4. Split trunks with an axe again.
5. Follow up again, by removing any new shoots.
6. Repeat steps 4-5 again and again and again, until no new shoots emerge.

Any attempt to control willows without using chemicals needs to be done with the recognition that a very large labour input over a long time period will be needed to achieve successful results.

Foliar spray and leave (seedlings up to 2 m)



Stop and think!

Before choosing this method, consider:

- The potential for spray to drift and cause non-target damage. This may be reduced by reducing the pressure on spray units to produce a bigger droplet size.
- The information outlined in 'Using chemicals' earlier in this section.

Hand pulling a willow seedling along the Queanbeyan River. (Sarah Holland Clift, DPI Victoria)

Suitable for:

- Willow seedlings under 2 m high, particularly in areas with numerous seedlings, where hand pulling is not possible and debris control and aesthetics is not an issue.
- Regrowth from cut stump method.

Advantages:

☑ Low cost, as large numbers of willows can be treated in a short period of time.

Disadvantages:

☒ Risk of non-target damage.

☒ Generally restricted to spring and summer, when foliage is dense.

☒ Silt on leaves from recent floods may affect the uptake of the chemical.

Caution: Do not spray directly over the water body.

How:

1. Registered herbicide is sprayed onto foliage to run off, using a backpack sprayer or handgun applicator.
2. May be conducted with the assistance of a helicopter, 4 wheel drive vehicle, quad bike, boat or amphibious vehicle, each with a spray unit attached.

Hand pulling

Suitable for:

- The control of small seedlings and rooted fragments (up to 2 years old).

☑ Hand pulling is a simple and effective approach for controlling small willow seedlings and rooted fragments while they are still small.

It is generally only possible to hand pull seedlings in their first one to two years of growth, so early detection and control of new willow growth is essential.

Willows often encroach into or overhang the water so it may be necessary to use a herbicide registered for use in an aquatic area. (Sarah Holland Clift, DPI Victoria)

Controlling willows growing in water

Trees growing in water are notoriously difficult to kill, however effective treatment is possible.

Willows in the water can be treated using stem injection, by applying chemical to the base of the tree (where possible) and to the limbs where they emerge from the water.

Where branches are growing through the water and have grown root masses:

1. Lift the branch out of the water.
2. Cut off the root mass and apply chemical to the branch still attached to the main tree (note: the chemical must be registered for use in aquatic areas).
3. Hold the branch out of the water for 30 seconds after applying the chemical and then let it fall back into the water.

Always use a chemical registered for use in aquatic areas

To ensure success, you should return to the site within six to eight weeks to re-treat any surviving limbs. Leaves on branches that are less than 2 m high may also be foliar sprayed after the taller limbs have been treated by stem injection. These branches may also require re-treatment.

Where the water or mud is deep, the use of boats is recommended to get around and treat waterside limbs. Inflatable boats with heavy-duty plastic, to reduce the chance of punctures, are preferred, as operators can slide comfortably on the ends or sides of the boat rather than having to work out of the solid hull of a canoe or kayak and risk over balancing. Waders may also be used, but are more dangerous and require more effort than working from a boat.

Note: *Waders can cause drowning if the operator falls over in deep water and the waders fill with water. If choosing to use waders, ensure that all people wearing waders receive adequate safety training and that there are people on shore watching and ready at all times to respond to any emergencies.*

Other control methods

Removal of whole tree 'roots and all'

When willow control works were first begun, removal of the entire tree, roots and all, was common practice. In many cases, this has caused significantly more damage than it alleviated by destabilising banks and leaving them prone to erosion. It has also turned landholders and the broader community against willow removal in some areas. In some cases, removal of the entire willow may still be warranted, for example, where the willow stump or root mat will continue to cause a mid-stream obstruction, flow deflection or channel shallowing.

Removal of the whole tree is not recommended unless you plan to completely change the structure of the water course.

As the roots take time to decay, they may provide a degree of erosion protection until the site can be rehabilitated.

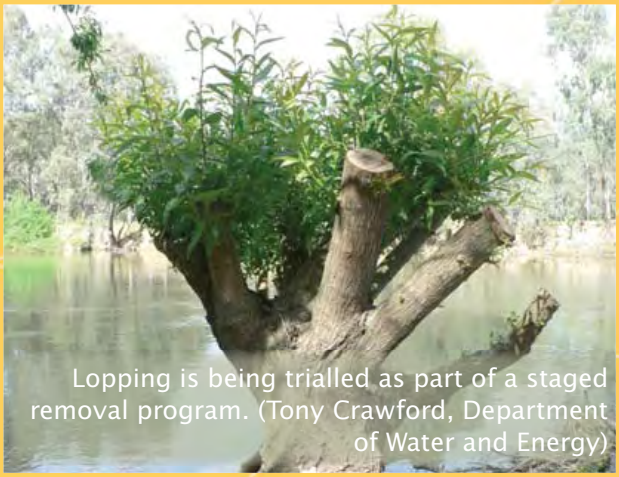
Developing new techniques

The staged replacement of willows

A large-scale riparian native revegetation program has started along the upper reaches of the Murray River around Albury-Wodonga, but is being impacted in places by the presence of dense stands of willows.

There is a major concern that, if the willows are totally removed and replaced with native seedlings, further bank erosion will occur and the native seedlings will be lost before they reach maturity.

This has led to a staged replacement program of willows to natives. This involves keeping the willows alive so that they can still perform some function of erosion control, until the native plants have matured. Removal and maintenance of parts of the willow canopy is important to allow better light conditions for the emerging native seedlings.



Lopping is being trialled as part of a staged removal program. (Tony Crawford, Department of Water and Energy)

As the rate of willow canopy regrowth is rapid, compared to native seedling growth rates, a maintenance lopping program is required. This may be needed every second year at each site, until the native vegetation has matured.

To determine the best ways of retarding the rate of regrowth of willows following lopping, trials are currently being undertaken by the Murray River Works Unit of the NSW Department of Water and Energy. These trials are investigating ways of lopping just the landside branches and treating these lopped branches to minimise coppicing.

Once the native vegetation has established well enough to assist in the control of stream bank erosion to an acceptable rate, the willows are then killed by stem injection. Only small lengths of stream bank (less than 200 m) will be done this way, so as to minimise potential willow debris issues.

It is hoped that this method will allow willows to help control erosion until native vegetation has established, while requiring low maintenance in terms of lopping and having minimal impact on the establishment of the native seedlings.

For further information or to discuss your ideas, contact River Works Unit, NSW Department of Water and Energy, Albury, Ph 02 6024 8880.

Biological management of willows

Willows have not yet been declared a target for biological control and no biological control agents have been deliberately introduced for willows in Australia. Overseas research, however, indicates that biological control has great potential as a willow management tool. To help protect the current investment being made in willow management, biological control is currently being investigated (Adair *et al.* 2006). Further investment in biological control, however, still needs to be secured to enable this work to progress further.

It is important to remember that biological control will never eradicate willows and will always need to be integrated with the above control methods.

Willow sawfly

The recent arrival of the willow sawfly (*Nematus oligospilus*) into Australia has sparked much interest from both willow managers and the community. It is unclear how willow sawfly arrived in Australia, but it was not deliberately introduced. The larval stage feeds on willow leaves and large populations of larvae can defoliate adult willow trees.

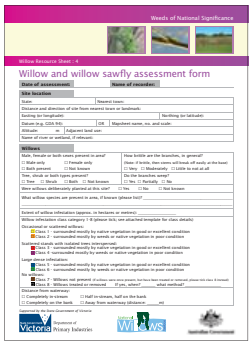
The sawfly is now widespread across New South Wales, Victoria and eastern South Australia. It is not yet known how sawfly will affect willows in Australia. It is possible that a mixture of outcomes will occur across Australia, with some areas experiencing significant impacts from willow sawfly, and other areas not impacted to any significant extent.

Do not become complacent about management just because sawfly is present.

It is important to still continue using other control techniques to manage willows in areas where sawfly exists, as it may not have any significant impact on willows in many areas.

Research is currently under way to understand the potential impacts of sawfly and to help develop a broader range of willow management options than is now available.

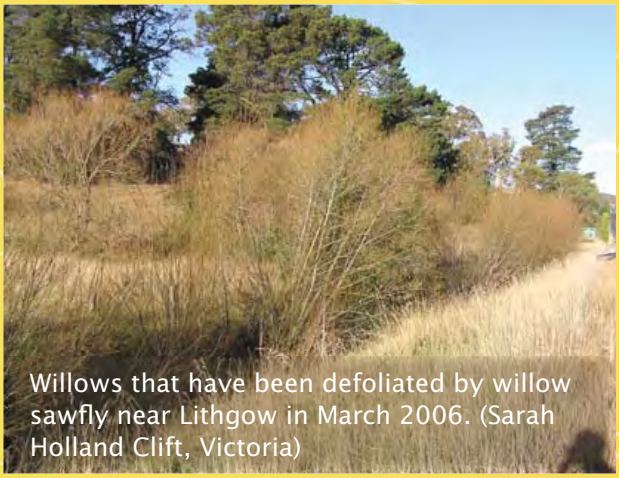
For further information on the willow sawfly, refer to the: *National Willows Program Resource Kit, Willow Resource Sheet 3: Willow sawfly (Nematus oligospilus).* This is available for download at www.weeds.org.au/WoNS/willows.


Weeds of National Significance

Willow Resource Sheet – 4

Willow and willow sawfly assessment form

Willow sawfly larvae. (Sarah Holland Clift, DPI Victoria)



Willows that have been defoliated by willow sawfly near Lithgow in March 2006. (Sarah Holland Clift, Victoria)

Waste management methods

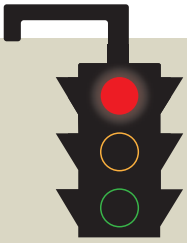
Do not underestimate the scale of the waste produced

Willow removal activities produce an enormous amount of material that needs to be managed. Responsible management of debris is critical to avoid re-growth from fallen branches and potential debris issues in flood events. Further research is required to come up with new waste management methods that can deal with large amounts of willow material.

Currently, there are only a few waste management methods available, which include:

1. **Piling and burning**: The most widely used method of removal.
2. **Mulching**: More expensive than burning and generally limited to urban areas and the removal of small infestations.
3. **Feed to stock, furniture and firewood**: Of limited use for very small amounts of willow material.

Piling and burning



Stop and think!

Before choosing this method, consider:

- Burning control measures and fire restriction periods. You should strictly adhere to 'burning' control measures specified by the relevant local government or state authority, particularly during fire restriction periods and on 'smog alert days'.
- The policies and regulations for burning in your state and local government area. In particular, advise your local government fire officer and CFA of your proposed activity, time of operation and location.
- The potential for smoke and ash pollution to affect nearby population centres.
- The risk of debris becoming a hazard to boating and infrastructure if moved in flood waters.
- The risk of fire spreading and threatening houses, infrastructure and nearby vegetation.
- Access to adequate fire-fighting equipment (for example, a water pump and hose, knapsack, bucket and rake hoe), in case of spot fires caused by sparks.

Advantages and Disadvantages of Piling and Burning

Advantages	Disadvantages
Reduced costs, as disposal is conducted on site.	Pollution
Reduced risk of regeneration from debris.	Risk of debris becoming a hazard to boating and infrastructure if moved in flood waters.
	Risk of fire spreading and threatening houses, infrastructure and nearby vegetation.
	Limited time period available, due to fire restrictions in many areas.
	Suitable machinery is required on site to stoke the burning piles.

Using an excavator to stack willow material, ready to burn, in West Gippsland, Victoria. (Sarah Holland Clift, DPI Victoria)

Working in remote environments: *S. cinerea* (grey sallow) on the Wingecarribee Swamp cannot be burned, so cut stems are painted with chemical, to prevent regrowth, and piled to gradually break down naturally. (Sarah Holland Clift, DPI Victoria)

Piling and burning is generally the preferred waste management method for willow material, because:

- It is cheap and simple, compared with mulching.
- It creates space for revegetation and fencing activities.
- The risk of regeneration from willow debris is reduced.
- It leaves a clean site, clear of debris that looks more aesthetically pleasing.

How to pile and burn?

1. Stack the material in tight piles on high ground, preferably outside the flood zone.
   a. If it is not possible to stack piles outside the flood zone (in some cases, the flood zone can be over 6 km from the river), use common sense and ensure that the material is stacked out of the creek bed and outside revegetation and fence lines.
   b. Stack piles tightly by intertwining branches into the heaps to resist break up in flood waters. Smaller heaps are more efficient and reduce travel times for excavators. Build the heaps by first placing small, dead and dry timber at the bottom and then larger logs on top.
   c. Stacking piles tightly is critical to help prevent material from breaking up and causing significant debris issues during flood events.
   d. With logs over 600 mm in diameter, run a chainsaw cut one third of the way through the log, at metre intervals along the log. This allows the heat to drive out any remaining moisture and allows fire to rapidly penetrate into the log.
2. Allow the piles to dry (for up to 6 months if possible, depending on climate and site conditions).
3. Burn on site.

   Note: *Burning material before it has completely dried can create significant amounts of ash and smoke pollution. Unburnt piles within the flood zone, however, can create significant debris issues in flood events, particularly if they are not stacked tightly enough.*

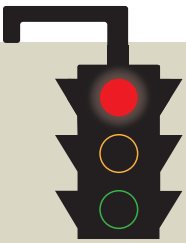
Work for the Dole crew stacking willow material by hand, ready to burn, near Blessington, Tasmania. (Sarah Holland Clift, DPI Victoria)

Working near towns or in urban areas

Smoke pollution and the risk of fire to nearby houses, infrastructure or vegetation, means that burning is often not an option in highly populated areas. An alternative is to truck the material off site and out of town to burn it. If cost is the major factor, it is still often cheaper to carry the material out of town to burn, than to chip the material on site.

If burning is not an option, consider mulching as an alternative, particularly if works are small scale and there is a use for the mulch on or near the site (for example, in a caravan park).

Mulching



Stop and think!

Before choosing this method, consider:

- Mulching creates a huge amount of material that needs to be managed. The material needs to be placed somewhere and often this is at a significant cost.
- Is there a local use for the mulch?
- At larger scales, the mulching process is extremely resource and plant intensive.
- In urban areas, it is generally still cheaper to truck the material off site and out of the town to burn, than to mulch.
- Good access to the site is required.
- Compost heaps have been known to spontaneously combust, on occasion.
- Mulch from willows has been known to regenerate if not chipped small enough, so regular follow up is essential.
- The risk of rogue willow chips flying from the chipper and hitting people nearby.

Willow wood can be chipped on site and reused as mulch. It can be expensive however, and must be chipped finely (<15 mm diameter) to minimise the chance of pieces re-shooting.

The wood should be chipped to the smallest size possible (<15 mm diameter) to prevent the chips from regenerating.

How to mulch?

Large-scale operations require:

- A truck with a tub grinder on the back.
- An excavator fitted with a grab attachment for feeding the tub grinder.
- If leaving the mulch on site, a wheel loader to move the chips.
- If transporting the mulch off site, truck tippers to carry away the material – you will be surprised at how much material is created and, therefore, how many truck tippers you will need!

Some contractors with large tub grinder set ups may provide their own excavator and operator to conduct both the willow control and disposal activities. Before engaging a tub operator, ask for the tub grinder specifications (for example, the maximum log diameter and length it will process) and ensure that they meet your needs.

Small-scale operations require:

- A trailer-type chipping unit (these can be hired from many municipal shires) towed by the truck that receives the chips.
- People to feed the unit by hand, for willow limbs smaller than 100 mm diameter.

Advantages and Disadvantages of Mulching

Advantages	Disadvantages
Reduced transport costs (compared to removal of trees) and reduced costs of buying mulch if used on site. Mulch will help in site rehabilitation – a good 10 cm-thick layer will help to reduce weed invasion and therefore reduce the cost and effort required in revegetation. Less pollution than burning.	The cost of mulching operations can be substantial. Good access to the site is required. Mulch could wash into rivers after a flood and cause pollution. Compost heaps have been known to spontaneously combust, on occasion. Mulch from willows has been known to regenerate – this must be monitored!

Other waste management methods

Feed to stock

Willow material left after removal operations may be fed to stock or other animals. Research from New Zealand suggests that the feed value of willows is 65-70% dry matter digestible, which is about the same as lucerne hay. Willow leaves are also high in protein, zinc and magnesium, which are important elements for animal health. Sodium (salt) levels can be low, however, so if little or no pasture is available, a salt block may be also needed.

Note: *Given the negative impacts and highly invasive nature of willows, it is not recommended, or legal in most cases, to grow willows as feed for stock.*

Furniture

The use of willows for making furniture is very specific and will not remove much material. People who want to make furniture from willow wood are highly selective and generally only choose specific pieces of good, straight timber, leaving you with a lot of material still to dispose of. In Tasmania, this method has been successfully combined with mulching or burning techniques, where large, straight trunks are milled for furniture, while the smaller branches are burned or chipped for use as mulch.

Much of the willow material cut down during control activities will not be useful for making furniture, so you will always still need an alternative waste management method for the remaining material.

Firewood

Willow wood is not recommended for use as firewood for the purpose of home heating. In Australia, slow combustion wood heaters are not designed to burn softwood, as they are built to an Australian Standard to burn hardwood only. While willow wood could be used in an open fireplace, it burns quickly, creates substantial amounts of smoke, leaves virtually no coals and provides limited heat. Alternative and better performing fuel woods are preferred by fireplace users. If, however, willows are going to be burnt anyway, using it for firewood provides an additional use and reduces the need to use native timbers for fuel.

Mulching is generally limited to small-scale jobs where there is a specific need for the resultant mulch. (left: Melbourne Water, right: DPI Victoria)

Additional resources

Weed management

CRC for Australian Weed Management (2004) *Introductory weed management manual.* Department of Environment and Heritage, Canberra. (Available on www.weeds.crc.org.au/documents/manual.pdf)

Using herbicides in and around water:

Ainsworth, N. and Bowcher, A. (2005) *Herbicides: guidelines for use in and around water.* CRC for Australian Weed Management. (Available on www.weeds.crc.org.au).

Biological control of willows:

Adair, R., Sagliocco, J. and Bruzzese, E. (2006). Strategies for the biological control of invasive willows (Salix spp.) in Australia. *Australian Journal of Entomology*, 45, 259-267.

Willow sawfly:

(All available on www.weeds.org.au/WoNS/willows)

Ede, F. (2006) *National Willows Resource Kit: Resource Sheet 3 – Willow Sawfly (*Nematus oligospilus*)*, edited by S. Holland Clift, Department of Primary Industries, Victoria.

Ede, F. (2006) *Willow sawfly (*Nematus oligospilus*) in Victoria: Status report, July 2006*. Department of Primary Industries, Victoria.

Ede, F. (2006) *Willow sawfly activity in Victoria: the 2006 / 2007 season*. Department of Primary Industries, Victoria.