

Section Four - Recommendations

4.0 The way forward - recommendations

4.1 Using these recommendations

Managing willows

The recommendations included in this report are not a prescription for action, but a tool to assist regional land managers to prioritise willow management. The [Willows National Management Guide](#) is now available (Holland Clift & Davies 2007), and is the most up to date resource for willow management methods and developing willow management plans. Willow management should not be considered in isolation as the aim of willow management is to protect and restore natural resources.

The aim of willow management ***should never be focussed only on willow removal***, but should consider the aims of willow management and the best methods for achieving those aims. For example, whilst eradication of some species might be desirable and achievable for NRM outcomes, environmental factors are not the only considerations that land managers are faced with.

Social and economic factors can be more, or less, important than environmental outcomes (depending on who you talk to). The Willows Weed Risk Assessment takes these factors into account, for information on which willow taxa are likely to be valued, see question 2 in the [impacts assessment](#) which considers the horticultural and/or agricultural value of each taxon.

Managing conflicting views

Rather than being simply a matter of identifying and removing the worst-ranked weeds, natural resource management can follow more of a decision-tree approach, where some decisions terminate the discussion and determine the outcome. Retaining heritage trees is one example.

We recognise that different approaches to willow management are warranted where the recommendations from this report are at odds with community sentiment or economic gain. For example, *S. babylonica* rated as a high risk willow, but it is often a valued tree in the landscape. It is also only present in Australia as female trees. Where community sentiment and heritage value demand the trees be retained, and where the trees are currently not having an adverse impact on the environment, a willow management plan could focus on preventing their spread. Surveys could identify suitable pollinator willows within several kilometres of the heritage tree(s). Removing these pollinators would greatly reduce the risk of these willows spreading by seed. This species is capable of vegetative reproduction, but it is not a common occurrence, making it a much lower risk.

Weeping willows are not just weeping willows

One of the big problems with managing weeping willows is that ***not all weeping willows are S. babylonica***. Many weeping willows are a form of *S. x sepulcralis*, a hybrid between *S. babylonica* and *S. alba*. This taxon can be male or female and may even have flowers of both sex on the one tree, making it self-fertile and a highly invasive offspring of *S. babylonica* and *S. alba*. These weeping willows cannot be managed *in situ* to reduce their risk of spread. The only way to achieve this, is to remove them. This removal should not occur until a rehabilitation plan for the area has been made.

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4.2 General recommendations

Through this project, we have significantly improved our knowledge of the extent and potential impacts of willows. However, there are clearly still knowledge gaps, and in many areas we still seriously lack information on which willow taxa occur where. We need to continue to update our data.

As new information becomes available we can then update our priorities, and be able to continue to make informed decisions.

Updating mapping data

It is recommended that regions continue to map and update their willow records using the [Mapping Tools](#) developed for willows. This data can be used to better inform priorities. For example, a continued effort in mapping will enable you to use this information to alter regional weed risk assessment scores. This can potentially lead new priorities and improved decision making. The supplementary information provided as part of this report will help you do this.

To enable regions to continually update mapping data, and have this included as part of the national dataset, it is recommended that an interactive web-based mapping database be developed.

Maintaining and developing skills

To ensure that people have adequate skills to continue mapping willows (and to address staff turnover) it is recommended that identification refresher training is run within regions, using regional expertise. A full [Workshop Kit](#) containing all the relevant information (including invitations, session plan, presentations, and resource sheets) is provided in association with this report, for any region or state interested in running a workshop themselves for their area.

As recommended from the workshops series during this project (Wadley and Holland Clift, 2007), for future national workshop series “consider the use of state-based facilitators to deliver workshops for each state”. From this, it is recommended that train the trainer workshops be considered to enable states or regions to run their own workshops.

Summary of general recommendations

- All regions to continue mapping new areas and update data in existing areas, and feed this information back to the National Willows Program.
- Develop an interactive web-based mapping database for storage of national datasets and use by willow managers.
- Regions continue to develop their willow identification skills and run refresher training.
- For national workshop series, consider the use of state-based facilitators to deliver workshops for each state.
- Run “train the trainer” workshops to train state-based facilitators, and enable states to run their own willow workshops.

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4.3 On-ground management recommendations

The following recommendations are for very high and high priorities in each state and are a tool to assist state and regional land managers to prioritise willow management. For further information on moderate or lower ranked priorities please refer to the relevant prioritisation matrix.

[Regional prioritisation matrices](#) can be used to develop local or regional priorities, [The national perspective as a case study for regional prioritisation](#) (below) is provided as a tool to guide these decisions.

States and regions with no willows

All States: prevent incursion

Some regions in Australia currently have no records of willows occurring and this should be kept this way. Regions include:

- **New South Wales:** Western
- **Northern Territory:** Northern Territory
- **Queensland:** Burdekin, Cape York, Cape York - Northern Gulf, Desert Channels, Mackay, Whitsunday, Maranoa Balonne, Northern Gulf, South West, Southern Gulf, Torres Strait, Wet Tropics
- **South Australia:** Alinytjara Wilurara, Eyre Peninsula, Kangaroo Island, SA Arid Lands
- **Western Australia:** Avon, Northern Agricultural Region, Rangelands

In these regions, land managers responsible for identifying new incursions should be taught to identify willow taxa in the first, second and third priority lists (see [Regional Prioritisation Matrices](#)), particularly where neighbouring regions have willows. Monitoring should occur in areas of high climatic suitability. A program to remove these willow taxa from public and private gardens would also reduce the risk of these willows establishing in the above regions.

Northern Territory

Very High Priority – Northern Territory

Prevent establishment

Although there are currently no records of willows in the Northern Territory, there is the potential for the very high priority taxa, *S. babylonica*, *S. exigua* and *S. nigra* to establish (see the [National Maps](#) for these species).

Climate and habitat here is highly suitable in the far south, and of moderate or likely suitability in central areas, and the far north of the territory. These areas need to be monitored for these willows, starting with the far south, and eradicate any willows as they are found.

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States with outlier willow populations

Queensland

Very High Priority – Queensland

Prevent establishment

It is of national importance to ensure the following willow taxa do not establish in this state:

- *S. exigua*: there are large areas of suitable climate and habitats for the establishment of this willow in Queensland.
- *S. daphnoides*, *S. glauca* and *S. triandra*, whilst of national importance, are unlikely to establish in Queensland, as climatic conditions are not suitable.

S. exigua should be monitored for and eradicated if found as a very high priority. Monitoring efforts should focus firstly in areas of very high climatic suitability (red) and sequentially in areas of high, moderate or likely suitability (see Figure 17 below). For example monitoring for *S. exigua* should firstly include the Border Rivers, Desert Channels, Fitzroy, Maranoa Balonne, and South West NRMs, which have large areas of very high climate match. This would be followed by areas of suitable climate and habitat such as Burdekin, Burnett Mary, Condamine, Mackay Whitsunday, Northern Gulf, South East, and Southern Gulf NRMs.

S. exigua is relatively unknown therefore it is a recommendation that information be developed to help land managers identify these willows.

High Priority – Queensland

Eradication

Identify male catkins on any willow species, and remove male willows to prevent nearby female willows spreading via seed.

S. babylonica and *S. matsudana* have only been introduced into Australia as females, so the potential for spread of these two taxa would be based on the availability of compatible male plants of other taxa, or the spread of these taxa by vegetative means (via twigs and branches). Regular monitoring for this is required.

Several other high priority willow taxa have potential distributions in parts of Queensland and appear to be present only as single specimens or infestations, including: *S. x rubens* in South East NRM; *S. alba* in Condamine NRM; and *S. x pendulina* and *S. fragilis*, in one location each in Border Rivers NRM. If these willows are able to be eradicated this should occur as a matter of high priority.

Prevent establishment

Monitor for incursions of *S. cinerea* and *S. nigra*, and eradicate immediately if found. These taxa have been known to spread large distances by seed and can explode in population within just a few years, given in the right conditions. These taxa exist in Border Rivers and Fitzroy NRMs, respectively in Queensland. These two species are also present in the Border Rivers/Gwydir and Northern Rivers; and the Namoi and Northern Rivers NRM regions respectively in Northern New South Wales and have the potential to spread from there into southern Queensland.

S. x sepulcralis and *S. purpurea* are not known to be present in Queensland, so monitoring for incursions in susceptible NRMs should be a high priority.

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South Australia

Very High Priority – South Australia

Prevent establishment

It is of national importance to ensure the following willow taxa do not establish in this state:

- *S. exigua* has suitable habitats and climates in parts of all the South Australian NRMs, in particular the Arid Lands NRM has large areas that are highly and moderately suitable. There are also highly suitable areas in the north of Alinytjara Wilurara and on the Eyre Peninsula. Kangaroo Island and the Murray river are also likely places for the establishment of this species.
- *S. daphnoides* most of the suitable habitat for *S. daphnoides* is in the Adelaide and Mount Lofty Ranges and Kangaroo Island NRMs, however, there are also small suitable areas in the Northern and Yorke, Murray Darling Basin and South East NRMs.
- *S. triandra* is capable of establishing in all NRMs in South Australia, but suitable climates and habitats are confined to the southern half of the state.

These taxa should be monitored for and eradicated if found as a very high priority. Monitoring efforts should focus firstly for taxa with areas of very high climatic suitability (red) and sequentially other taxa or areas of high, moderate or likely suitability (see Figures 16 - 19 below).

Some of these taxa are relatively unknown therefore it is a recommendation that information be developed to help land managers identify these willows.

High Priority – South Australia

Eradication

The following willow taxa should be considered for eradication in South Australia:

- *S. x rubens*, *S. nigra*, *S. cinerea*, *S. alba*, *S. babylonica*, *S. x sepulcralis* and *S. fragilis*.
- Note that *S. babylonica* is often valued in the landscape and there may be opposition to its removal. This is not the only management option available for this species. See "[Managing Conflicting Views](#)" for more information.

Prevent establishment

Other high priority taxa for South Australia include *S. purpurea*, *S. viminalis*, and *S. x pendulina*, however, there are no mapped infestations of these taxa in the state. They should be a priority for monitoring for establishment, which may involve providing land managers with information to help them identify these willows.

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Western Australia

Very High Priority – Western Australia

Prevent establishment

It is of national importance to ensure the following willow taxa do not establish in this state:

1. *S. exigua* and *S. triandra* have the potential to invade parts of all NRMs in Western Australia, however, whilst *S. exigua* has an extensive potential distribution, suitable climates and habitats for *S. triandra* are confined to the south-western part of the state.
2. *S. daphnoides* may establish in the Rangelands (WA) and South Coast Region NRMs.

These taxa should be monitored for and eradicated if found as a very high priority. Monitoring efforts should focus firstly for taxa with areas of very high climatic suitability (red) and sequentially other taxa or areas of high, moderate or likely suitability (see Figures 16 - 19 below).

Some of these taxa are relatively unknown therefore it is a recommendation that information be developed to help land managers identify these willows.

High Priority – Western Australia

Eradication

Eradicate grey sallow (*S. cinerea*) from its two known locations around Perth (Bayswater and Armadale). Continue to monitor for further incursions or sites of grey sallow or its close relative, *S. x reichardtii*.

Two other willow taxa appear as high priorities in NRMs in Western Australia:

- *S. x sepulcralis*, which appears to occur only in one location in the South West Region, and should be eradicated.
- *S. babylonica* appears to be present only in the South Coast, South West and Swan regions. It should be managed to prevent further spread and where there is community support it should be eradicated as a high priority (see "[Managing Conflicting Views](#)").

Managing the sexes

There are very few male plants known to occur in Western Australia, with less than 10% of plants identified as male during surveying. Male willows should therefore be made a high priority for management whenever they are discovered, to prevent the chance of them pollinating female willows (including *S. babylonica*) and enabling their spread by seed.

Plants that have fragile branches and are growing along waterways should also be prioritised for management, as they may quickly and easily spread downstream.

Protect assets

Monitor and protect Ramsar sites from invasion of nearby seeding willows found in townships of and streams around: Forrestdale and Thomsons Lakes, Peel-Yalgopus System, Muir-Byenup System, and Becher Point Wetlands.

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States with established willow populations

Australian Capital Territory

High Priority – Australian Capital Territory

Eradication

The mapping data for the Australian Capital Territory indicates that all of the very high priority taxa appear to be either not naturalised: *S. triandra*, *S. daphnoides* and *S. viminalis*; or infesting less than 100 hectares and likely to be eradicable: *S. nigra*, *S. cinerea*, *S. alba*, *S. babylonica*, *S. purpurea*, *S. x sepulcralis*, *S. fragilis* and *S. x pendulina*.

Note that for *S. babylonica*, the section “[Managing conflicting views](#)” may be useful, as this species is often valued in the landscape.

Protect assets

Where eradication is not feasible, management should focus on [Asset protection](#) and preventing the spread of [Seeding Willows](#)– see the relevant sections in this report for more information.

Coordinating efforts with other regions and states (New South Wales and Victoria) should be a high priority to minimise impacts from willows that cannot be eradicated.

For further information see high priorities for New South Wales and Victoria (both below).

New South Wales

Very High Priority – New South Wales

Prevent establishment

It is of national importance to ensure the following willow taxa do not establish in these state/s or territory/s:

1. [S. exigua](#) in Border Rivers/Gwydir, Central West, Hawkesbury/Nepean, Hunter/Central Rivers, Lachlan, Lower Murray/Darling, Murrumbidgee, Namoi, Northern Rivers and Western CMAs.
2. [S. daphnoides](#) is capable of establishing in Southern Rivers CMA and in the eastern-most parts of the Lachlan, Murray and Murrumbidgee CMAs and the southern tip of Hawkesbury/Nepean CMA.
3. [S. triandra](#) may establish in Central West, Hawkesbury/Nepean, Lachlan, Lower Murray/Darling, Murray, Murrumbidgee, Southern Rivers and Sydney Metro CMAs.

These taxa should be monitored for and eradicated if found as a very high priority. Monitoring efforts should focus firstly for taxa with areas of very high climatic suitability (red) and sequentially other taxa or areas of high, moderate or likely suitability (see Figures 16 - 19 below).

Some of these taxa are relatively unknown therefore it is a recommendation that information be developed to help land managers identify these willows.

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High Priority – New South Wales

Eradication

The following willow taxa should be targeted for eradication in New South Wales:

- *S. cinerea* in Hunter-Central Rivers, Northern Rivers and Southern Rivers CMAs;
- *S. babylonica* in Lower Murray Darling CMA; and
- *S. nigra* in Murray CMA.

Note that for *S. babylonica*, the section “[Managing conflicting views](#)” may be useful, as this species is often valued in the landscape.

Other willows that pose a high risk and may be eradicable from the state include:

- *S. viminalis*, which is only recorded in Southern Rivers and Murrumbidgee CMAs;
- *S. purpurea*, only recorded in Southern Rivers, Murrumbidgee and Murray CMAs; and
- several taxa that may be under-recorded in the mapping database, but appear to be eradicable, including *S. x sepulcralis*, *S. alba*, and *S. x pendulina*.

Protect assets

The remaining two high priority taxa in the CMAs in New South Wales are *S. fragilis* and *S. x rubens*. Both appear to be beyond eradication in the short term, however should be managed to prevent spread to high value assets. See “[Asset Protection](#)” for more information.

In addition, these populations should be managed to prevent their spread by seed, either by removing female willows within a 1km radius of *S. fragilis* and male *S. x rubens*, and/or removing female *S. x rubens* from within a 1km radius of any suitable male willow pollinators. For a list of suitable pollinators or recipients, see the Excel spreadsheet “Willows Database”.

Coordinating efforts with other regions and states (Australian Capital Territory and Victoria) should be a high priority to minimise impacts from willows that cannot be eradicated.

For further information see high priorities for Australian Capital Territory (above) and Victoria (below).

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Tasmania

Very High Priority – Tasmania

Prevent establishment

It is of national importance to ensure the following willow taxa do not establish in this state.

- *S. glauca*: this willow's potential distribution is confined to Tasmania and should be monitored in those areas that have suitable areas for its establishment.
- *S. exigua*: has a potential distribution confined to an area around Launceston.
- *S. daphnoides* and *S. triandra* have areas of very high suitability

These taxa should be monitored for and eradicated if found as a very high priority. Monitoring efforts should focus firstly for taxa with areas of very high climatic suitability (red) and sequentially other taxa or areas of high, moderate or likely suitability (see Figures 16 - 19 below). For example *S. daphnoides* (Figure 18) and *S. triandra* (Figure 18) should be the highest priorities for monitoring, firstly in areas of very high climate match (red). This is to the east of the state, and the very northern-most part of the west of the state, particularly around the towns in these regions, as these species are most likely to be found in gardens, being an ornamental with coloured shoots and fragrant catkins respectively.

Some of these taxa are relatively unknown therefore it is a recommendation that information be developed to help land managers identify these willows.

Mapping of *S. babylonica*

Whilst the mapping database shows two *S. babylonica* records in Tasmania, suggesting that it may be eradicable, and contributing to its allocation to the very high priority category, this is almost certainly a gross underestimation of the distribution of this species in the state. Given its high potential for invasiveness and impacts, its distribution should be mapped more accurately to determine its management priority and options. Note that *S. babylonica* is often valued in the landscape and there may be opposition to its removal. This is not the only management option available for willow management. See "[Managing Conflicting Views](#)" for more information.

High Priority – Tasmania

Eradication

The following willow taxa should be targeted for eradication in Tasmania:

- *S. cinerea*, *S. alba*, *S. purpurea*; and the rarely eradicable and difficult to distinguish *S. fragilis* and *S. x rubens*.
- Two weeping willows: *S. x pendulina* and *S. x sepulcralis* also appear to be eradicable, but again, this may be an underestimation of their distribution, due to the common perception that weeping willows are not a weed.

Prevent establishment

S. nigra and *S. viminalis* appear to be absent from the naturalised records in Tasmania. Large parts of the state are suitable for their establishment, so all efforts should be made to ensure they do not spread.

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Victoria

Very High Priority – Victoria

It is of national importance to ensure the following willow taxa do not establish in this state:

- *S. exigua* in Corangamite, Glenelg Hopkins, Goulburn Broken, North Central, North East, Port Phillip and Westernport, Wimmera, although its potential distribution is limited in these CMAs and often the climate match is only likely.
- *S. daphnoides* and *S. triandra* in all CMAs, except that *S. daphnoides* has no potential distribution in the Mallee CMA.

These taxa should be monitored for and eradicated if found as a very high priority. Monitoring efforts should focus firstly for taxa with areas of very high climatic suitability (red) and sequentially other taxa or areas of high, moderate or likely suitability (see Figures 16 - 19 below).

Some of these taxa are relatively unknown therefore it is a recommendation that information be developed to help land managers identify these willows.

High Priority – Victoria

Prevent establishment

There is the potential for *S. viminalis* to establish in all CMAs in Victoria, however, there are no recorded naturalised populations. Monitoring for this species should aim to prevent its establishment.

Eradication

The following willow taxa should be targeted for eradication in Victoria:

- *S. purpurea* in the North East and East Gippsland CMAs;
- *S. x pendulina* in the Corangamite, North East and Port Phillip CMAs; and
- *S. nigra* from Goulburn Broken, North East and West Gippsland CMAs.

Other high priority taxa that may be eradicable from particular CMAs in Victoria are:

- *S. x sepulcralis* and *S. fragilis* (in some CMAs)*
- *S. cinerea*, from Glenelg Hopkins and North Central CMAs
- *S. babylonica*, from Wimmera and Glenelg Hopkins CMAs.

*These two taxa appear eradicable from specific CMAs, although they are almost certainly under-reported in the mapping database. Their current distributions are small in number, but spread across almost every CMA, making them appear (probably erroneously) to be eradicable from the state. Further mapping of these taxa may be required.

Note that *S. babylonica* is often valued in the landscape and there may be opposition to its removal. This is not the only management option available for this species. See "[Managing Conflicting Views](#)" for more information.

Protect assets

Management options for other high priority taxa, such as *S. x rubens* and *S. alba*, and in areas where other taxa are found to be beyond eradication, include Asset Protection and, where possible preventing the spread of [Seeding Willows](#) – see the

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relevant sections in this report for more information.

Coordinating efforts with other regions and states (New South Wales and Australian Capital Territory) should be a high priority to minimise impacts from willows that cannot be eradicated.

For further information see high priorities for Australian Capital Territory and New South Wales (both above).

4.4 The national perspective as a case study for regional prioritisation

The willow weed risk assessment collated and produced a large amount of information about the thirty-five willow taxa that were assessed. The information is presented in this report at both a national and regional (CMA/NRM) scale. The recommendations for the national approach to willow management can be emulated at the regional level by following a similar procedure utilising the appropriate:

- [regional prioritisation matrix](#),
- [regional ranking](#),
- [invasiveness and impact assessments](#) and associated [confidence scores](#), and
- [present and potential distribution maps](#).

Beginning with the prioritisation matrix (see Figure 15; for common names see Figure 13b, Section 3), the willows with the highest priority for management appear in the top left (red) square.

Distribution score	Invasiveness and Impact score		
	H	M	L
H	<i>S. triandra</i> * <i>S. daphnoides</i> * <i>S. glauca</i> * <i>S. exigua</i> *	<i>S. caprea</i> <i>S. pentandra</i> * <i>S. x mollissima</i> <i>S. eriocephala</i> * <i>S. myricoides</i> <i>S. aegyptiaca</i> * <i>S. elaeagnos</i> * <i>S. myrsinifolia</i> *	<i>S. integra</i> 'Hakuro-nishiki'*
M	<i>S. x rubens</i> <i>S. nigra</i> <i>S. cinerea</i> <i>S. alba</i> <i>S. babylonica</i> <i>S. purpurea</i> <i>S. x sepulcralis</i> <i>S. viminalis</i> <i>S. fragilis</i> <i>S. x pendulina</i>	<i>S. alba x matsudana</i> <i>S. gracilistyla</i> * <i>S. x reichardtii</i> <i>S. x calodendron</i> <i>S. x sericans</i> <i>S. matsudana</i>	<i>S. chilensis</i> 'Fastigiata' <i>S. alba</i> var. <i>caerulea</i>
L			<i>S. x 'Boydii'</i> ^

Figure 15: Prioritisation matrix at a national scale - Scientific names

* Not known to be naturalised in Australia ^ No potential distribution in Australia

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Potential distribution of the four National **Very High Priority** willows

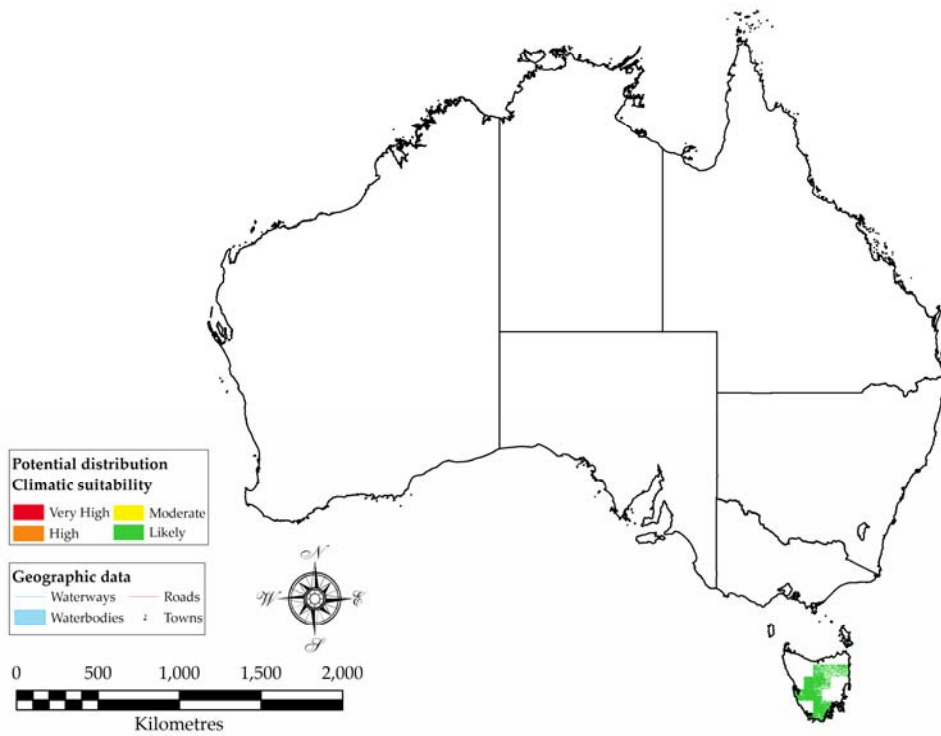


Figure 16: Potential distribution of *S. glauca*

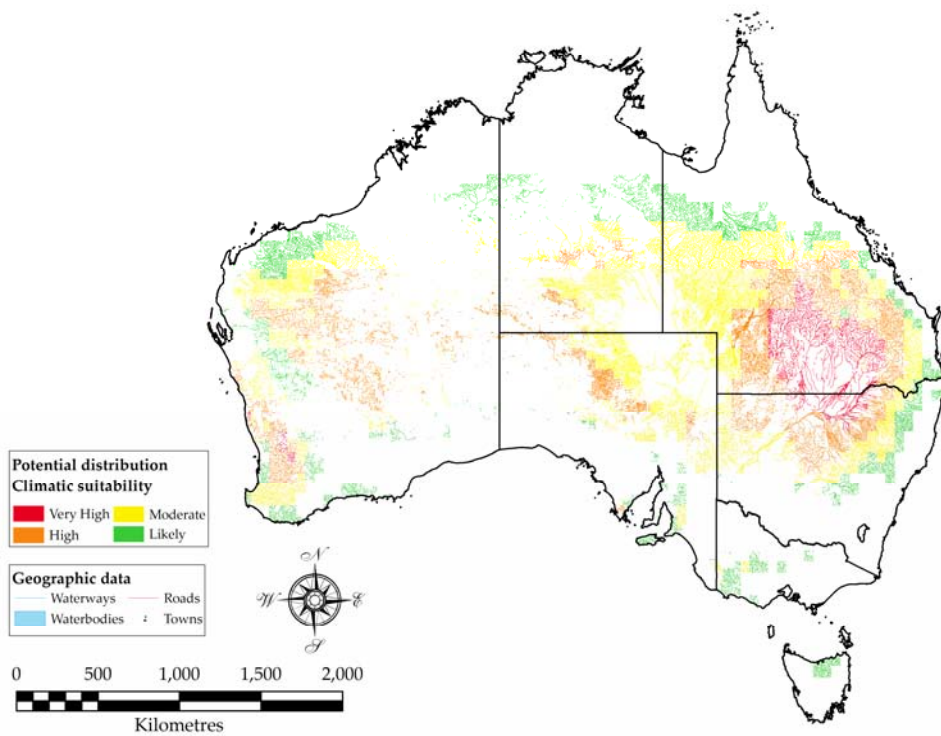


Figure 17: Potential distribution of *S. exigua*

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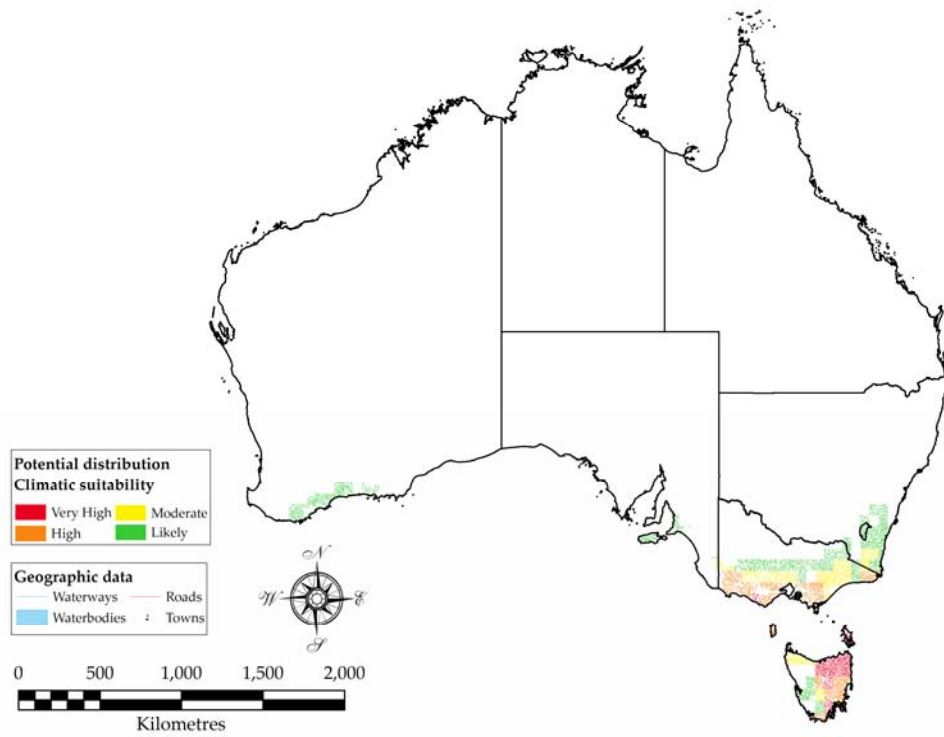


Figure 18: Potential distribution of *S. daphnoides*

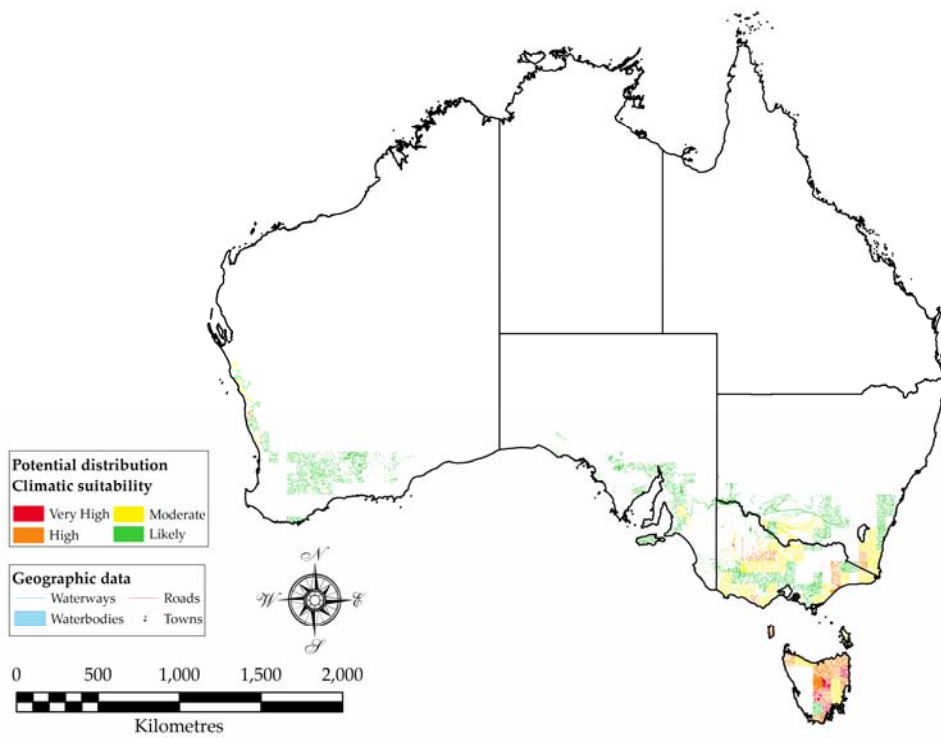


Figure 19: potential distribution of *S. triandra*

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National management priorities for willows

Very High priority taxa

Non-naturalised taxa with a very high potential to become weedy in Australia: *S. triandra* (almond willow), *S. daphnoides* (violet willow), *S. glauca* (arctic grey willow) and *S. exigua* (sandbar willow).

Monitoring and incursion response

From a national perspective, the willows with the highest management priority are not yet known to be naturalised in Australia. Due to their high potential for invasiveness and impacts, a monitoring and incursions response program should be established to help prevent them from becoming naturalised. These taxa include:

- *Salix triandra* (almond willow)
- *S. daphnoides* (violet willow)
- *S. glauca* (arctic grey willow) and
- *S. exigua* (sandbar willow).

These taxa should be monitored for and eradicated if found as a very high priority. A monitoring program should target areas where there is very high climatic suitability (red) and sequentially areas of high, moderate or likely suitability (see Figures 16 – 19).

S. triandra and *S. daphnoides* were chosen for assessment because there was evidence that they had naturalised beyond their native ranges, a good predictor of their ability to naturalise in Australia. *S. triandra* was included in the New South Wales plant census (APNI), however, no naturalised records have been found. *S. daphnoides* is naturalised in New Zealand. *S. glauca* and *S. exigua* were assessed because they have already been introduced to Australia and they exhibit traits that are considered common to many invasive species.

S. glauca was of particular interest, as it belongs to the subgenus *Chamaetia* (alpine/arctic/mountain willows). As an entire subgenus, the *Chamaetia* received a very low invasiveness and impact score (see Table 8, Section 3), based on the biology and ecology of taxa from this subgenus that have been introduced to Australia (except *S. glauca*). The risk assessment of *S. glauca* resulted in a high impact score for this species and a moderate invasiveness score, which put it into the high risk category, based on the sum of its weighted invasiveness and impact scores. Its potential distribution was confined to Tasmania. Therefore, whilst of national importance, monitoring efforts for *S. glauca* should focus on Tasmania and effort made to ensure it is never introduced to this state.

Removal from gardens to reduce spread

The reason for the introduction of *S. glauca* to Australia was not discovered. However *S. exigua*, *S. triandra* and *S. daphnoides* are all considered highly ornamental (as described in question 12 of the invasiveness assessment, and question 2 of the impacts assessment). Since *S. glauca* and *S. exigua* are the only two of these four taxa that have yet been introduced to Australia, a program to encourage their removal from gardens could reduce the chance of them becoming weeds in Australia. In addition, monitoring should be targeted to those areas with suitable climates and habitats, as illustrated by their potential distributions, to ensure early detection and immediate removal of any naturalised plants (see “Monitoring and incursion response” and Figures 16-19, above).

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S. exigua (Figure 17) has potential distribution in all states, but not in all NRM/CMA. Prior to this project, Queensland and Western Australia did not consider willows to be a high priority for management within their states. The results of this project show that there are large areas within these two states with a suitable climate and habitats for the establishment of this willow..

Suitable climates and habitats for *S. daphnoides* (Figure 17) and *S. triandra* (Figure 19) were limited to southern Australia in large parts of Victoria and Tasmania, and some areas in Western Australia, South Australia and southern New South Wales.

Few land managers are likely to be familiar with these species so they will need to be provided with information to help them identify these willows.

Summary of recommendations

Encourage the removal of the Very High risk willow taxa (*i.e.* *S. daphnoides*, *S. exigua*, *S. glauca*, and *S. triandra*) (red in Figures 16 - 19) from gardens to reduce the chance of them becoming weeds in Australia.

Establish a monitoring and incursions response program for Very High risk willow taxa, targeted to areas with suitable climates and habitats for these species, to respond to the establishment of these taxa in Australia, should this occur.

Develop and provide information on identification of little known highest risk species to improve awareness of state, regional and local land managers to these species.

High priority taxa

All the species in the second-highest priority group (*i.e.* *S. alba*, *S. babylonica*, *S. cinerea*, *S. fragilis*, *S. nigra*, *S. purpurea*, *S. viminalis*, *S. x pendulina*, *S. x rubens*, and *S. x sepulcralis*) are known to be naturalised in Australia and, whilst their distribution scores reflect a lesser potential for spread than the previous group (*i.e.* Very High priority), they have the same potential for invasiveness and impact. In regions where it is feasible, these taxa should be targeted for eradication and should certainly be a focus of control programmes.

Eradication

Using the regional prioritisation matrices as a coarse filter, willow taxa that were present in an NRM/CMA but probably capable of being eradicated (were of the highest priority in that NRM/CMA) included:

- *S. cinerea* in Hunter-Central Rivers, Northern Rivers and Southern Rivers CMAs in New South Wales.
- *S. babylonica* in Lower Murray Darling CMA in New South Wales; South East NRM in South Australia; and NRMs North and South in Tasmania.
- *S. nigra* in Murray CMA in New South Wales, and West Gippsland CMA in Victoria.

These willows should be a national eradication priority, although this may be controversial for *S. babylonica* in some areas, as noted at the [beginning of this Section](#). In addition, due to being considered less invasive, *S. babylonica* may have been under-reported and is likely to be more prevalent than our records would suggest. Further mapping of these three potentially eradicable species, in particular, is required to determine the feasibility of their eradication. At the scale of the

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NRM/CMA, regional priorities for eradication can also be determined using the process above.

Protect high value assets

Willows from the High priority group may pose a lower threat than those in the highest priority group, but their impacts can still be high where they do establish. For willows in this group, that are beyond eradication, management priorities can be informed by the risk they pose to national assets.

See "[National Case Study for prioritising willow management based on asset protection](#)".

Summary of recommendations

High priority willow taxa (*i.e.* *S. alba*, *S. babylonica*, *S. cinerea*, *S. fragilis*, *S. nigra*, *S. purpurea*, *S. viminalis*, *S. x pendulina*, *S. x rubens*, and *S. x sepulcralis*) should be targeted for eradication as a focus of control programmes, in regions where this is feasible.

For willows in this group that are beyond eradication, inform management priorities by the risk they pose to national assets.

Conduct further mapping of *S. cinerea*, *S. babylonica* and *S. nigra* to determine the feasibility of their focus for national eradication.

Moderate priority taxa

Determine true risk

These willows (*i.e.* *S. aegyptiaca*, *S. caprea*, *S. elaeagnos*, *S. eriocephala*, *S. gracilistyla*, *S. matsudana*, *S. myricoides*, *S. myrsinifolia*, *S. pentandra*, *S. alba x matsudana*, *S. x calodendron*, *S. x mollissima*, *S. reichardtii*, and *S. x sericans*), with moderate invasiveness and impact scores, indicate that they pose a lower risk than the higher priority taxa. However, for several of these willows, there was little information available to assess their risk, so the moderate score for invasiveness and impact may be an under-estimation of their true risk. This includes *S. myricoides*, *S. myrsinifolia*, *S. pentandra*, *S. x calodendron* and *S. x sericans*. These taxa should be a priority for further research as they may pose a greater risk than their assessments currently indicate.

Monitoring for non-naturalised willows

A large number of the willows in this group have not naturalised in Australia, including *S. aegyptiaca*, *S. elaeagnos*, *S. eriocephala*, *S. gracilistyla*, *S. myrsinifolia*, and *S. pentandra*. A program to encourage the removal of these species from gardens could reduce the chance of them becoming weeds in Australia. Monitoring for naturalisations of these species should be targeted to those areas with suitable climates and habitats, as illustrated by their potential distributions. Again, because these willows have not yet naturalised in Australia, few land managers are likely to be familiar with these species so they will need to be provided with information to help them identify these willows. However, as these willows pose a lower threat than higher priority willows, they may be addressed at a later stage than higher priority willows, or less-intensively.

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Protect high value assets

Whilst these willows pose a lower threat to biodiversity and valued assets, seeding willows in this group should be targeted for control where they threaten high value areas (Ramsar sites), such as the naturalised *S. caprea* and *S. alba x matsudana*; as well as taxa with the potential to hybridise to produce offspring that can naturalise, such as *S. matsudana*.

Summary of recommendations

Encourage the removal from gardens of, monitor and provide information on *S. aegyptiaca*, *S. elaeagnos*, *S. eriocephala*, *S. gracilistyla*, *S. myrsinifolia*, and *S. pentandra* to reduce their potential threat.

Seeding willows (especially those able to hybridise, *i.e.* *S. caprea*, and *S. alba x matsudana*; and *S. matsudana*) in this group should be targeted for control where they threaten high value areas.

Conduct further research on the biology and ecology of *S. myricoides*, *S. myrsinifolia*, *S. pentandra*, *S. x calodendron* and *S. x sericans*, as they may pose a greater risk than their assessments currently indicate.

Lowest priority taxa

Determine true risk

These four willows (*i.e.* *S. alba* var. *caerulea*, *S. chilensis* 'Fastigiata', *S. integra* 'Hakuro-nishiki' and *S. x 'Boydii'*) appear, at a national scale, to be a low priority for management. All of these willows, except for *S. chilensis* 'Fastigiata', are not known to be naturalised beyond their native range. The lack of information on the impacts of these species is an indication that they may not have high impacts. However, there was also very little information available on the basic biology of these plants. For *S. integra* 'Hakuro-nishiki', *S. x 'Boydii'*, and the subgenus *Chamaetia* in particular, there was no information found to answer almost half of the invasiveness questions. Further research on these willow taxa is required before they can be considered truly low risk.

Summary of recommendations

Conduct further research on *S. alba* var. *caerulea*, *S. chilensis* 'Fastigiata', *S. integra* 'Hakuro-nishiki' and *S. x 'Boydii'* to determine whether they are truly low risk.

Seeding and hybrid willows

Seeding willows

In addition to the regional prioritisation matrices, the invasiveness assessments can also be used to target willow taxa for management, within each prioritised group. For example, eliminating seeding willows will reduce the distance that willows can spread from up to one hundred kilometres by seed, to several kilometres within a waterway by vegetative means.

Willow taxa known to spread by seed (scored H for invasiveness question 14) are:

- *S. aegyptiaca*

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- *S. alba*
- *S. caprea*
- *S. cinerea*
- *S. nigra*
- *S. purpurea*
- *S. triandra*
- *S. viminalis*
- *S. alba* x *matsudana*
- *S.* x *rubens*
- *S.* x *sepulcralis*.

Hybrid willows

The [Invasiveness and Impact Assessments](#) associated with this report can be used to list the willow taxa that are able to hybridise with each other. Willows that are able to cross with other willow taxa to form viable hybrids that can themselves naturalise include:

- *S. alba*
- *S. alba* var. *Caerulea*
- *S. babylonica*
- *S. cinerea*
- *S. caprea*
- *S. fragilis*
- *S. chilensis*
- *S. matsudana*
- *S. alba* x *matsudana*
- *S.* x *rubens*.

The GIS data accompanying to this report can be used to determine which of each pairing are found within several kilometre's radius (the approximate distance that pollen is known to disperse) of each other.

Male vs female willows

Further mapping will usually be required to determine the gender of each pair, and then a decision can then be made either to remove the female (that may be pollinated by more than one male in close proximity), or the male (that may pollinate more than one nearby female). The decision to remove one or the other may be related to their ranking or priority within the region, or may be due to one gender being vastly outnumbered by the other within the hybridising population. See the Willows National Management Guide (Holland Clift & Davies 2007) for more information on prioritising and executing seeding willow management.

Summary of recommendations

Determine which seeding and hybrid willows you have, and where these are within your region (use [Seeding Willows](#) and the GIS database to determine this).

Conduct further mapping to confirm the gender of hybridising willow pairs, and remove one or the other based on recommendations above (eg. level of priority from relevant regional matrix).

Section Four – National Case Study

4.5 National case study

Prioritising willow management based on asset protection

Choosing assets to protect

Willows determined in this report as high risk may pose a lower threat than those in the highest priority group, but their impacts can still be high where they do establish. In cases where willows in this group are beyond eradication, management priorities can be informed by the risk these willows pose to high value assets.

As a national-level case study for prioritising willow management based on asset protection, the National Willows Taskforce decided to map willows around Ramsar sites. Ramsar sites were chosen as they are internationally recognised high value assets, and clearly demonstrate high value assets on a National scale.

Selecting populations to manage

Since willow seed can spread up to one hundred kilometres, we identified seeding willows within this distance from Ramsar sites as populations to target for control (see Figure 20). A national map of both assets (Ramsar sites) and threats (present and potential distribution of priority willow taxa) shows that the high priority willows capable of spreading to Ramsar sites by seed include *S. alba*, *S. cinerea*, *S. nigra*, *S. purpurea*, *S. viminalis*, *S. x rubens* and *S. x sepulcralis*.

In addition, those able to cross with other willow taxa to form viable hybrids that may pose a threat to Ramsar sites include *S. babylonica* and *S. fragilis*, (for species-level detail at a regional scale see the layered PDF, [Ramsar](#), accompanying this report).

Directing resources

Three Ramsar sites were selected as part of this case study for on-ground investigation. The sites were chosen due to potential threat of willows, which had been previously reported in or near these sites. The three sites, all in New South Wales were:

1. The Gwydir Wetlands, Gingham and Lower Gwydir (Big Leather) watercourses: located 60km west of Moree on private land across 4 farm enterprises.
2. Narran Lake Nature Reserve: located 75km North West of Walgett near Brewarrina.
3. Macquarie Marshes Nature Reserve: located south west of Walgett near Carinda.

Resources were directed to these three sites for on-ground mapping and ground truthing. A mapping project officer visited each of these sites and carried out extensive on-ground observation for any willows within and near the vicinity.

Ramsar sites were also investigated during on-ground mapping in southwest Western Australia, as a separate task from priorities developed for this case study.

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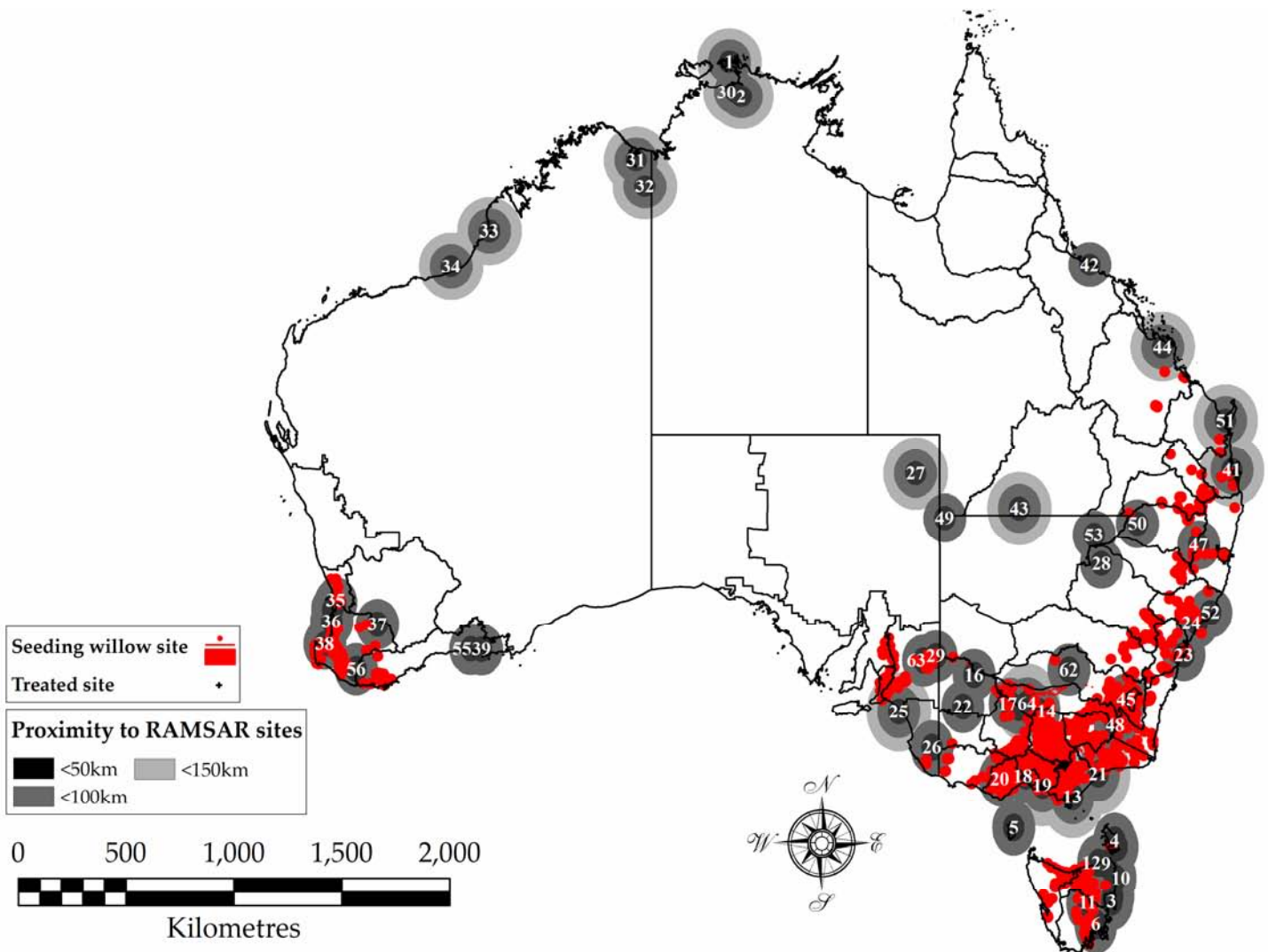


Figure 20: Presence of seeding willows in relation to Ramsar sites
 This [Ramsar](#) map is also available as a layered PDF in the *Supplementary Information Section*

What was found?

No willows were found in or near the vicinity of the New South Wales sites. This would suggest that either the willow taxa had been misidentified, or had been completely removed from the area. Had willows been found, they would have been assigned a high priority to direct on-ground management efforts.

In Western Australia, no willows were found within any of the Ramsar wetlands. However, seeding willows were confirmed nearby and have potential to spread into these important wetlands (for further information see “[Ground Truthing](#)” in section 3.1).

This case study can be used as an example of how, and where, to direct on-ground mapping resources in order to protect highest priority assets first.

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4.6 Legislative recommendations

National prioritisation to inform weed legislation.

In 1999, willows (except *S. babylonica*, *S. x calodendron* and *S. x reichardtii*) were listed as one of Australia's twenty Weeds of National Significance (WoNS), due to their highly invasive nature and impacts on stream and wetland hydrology and biodiversity (Thorp & Lynch 2000). This listing was based on an assessment of willows at the genus level. New evidence brought to light in this report, and a risk assessment that focussed at the species level suggests that it may be appropriate to change the willows listed as WoNS.

Willows currently listed as WoNS

As previously stated, it was not possible to assess every willow species, hybrid or variety that has ever been introduced to Australia. However, in an attempt to gain an overview of the whole genus, invasiveness and impact assessments were done for the three subgenera:

- *Salix* subgenus *Salix* (tree willows)
- *S.* subgenus *Vetrix* (shrub willows, including osiers and pussy willows), and
- *S.* subgenus *Chamaetia* (alpine, dwarf or mountain willows).

The results (in Table 8) show that the subgenera *Salix* and *Vetrix* achieved high scores, while the subgenus *Chamaetia* had a low score. However, one member of this subgenus, *S. glauca* did have a high score, and at a national scale it was identified as one of the highest priority taxa for management.

S. subgenus Chamaetia

The "Very High" priority attributed to *S. glauca* by this assessment does limit the ability to generalise about the weed risk of willows based on the subgenus that they belong to. Whilst most of the willows in subgenus *Chamaetia* are likely to have low invasiveness and impact scores, before the subgenus is deemed safe, each taxon will need to be investigated to determine if it has become a weed elsewhere (as this study was unable to find a single member of subgenus *Chamaetia* that had become a weed, including *S. glauca*), and if its biological traits and/or ecology suggest that it might be more invasive than is usual in members of the subgenus.

Whilst it is not possible to definitively generalise about the weediness of willows, based on which subgenus they belong to, probably many of the subgenus *Chamaetia* could be removed from the WoNS list.

Subgenus Salix and S. subgenus Vetrix

Several members of subgenus *Salix* and subgenus *Vetrix* had very low scores:

- *S. chilensis* 'Fastigiata' and *S. alba* var. *caerulea* (subgenus *Salix*);
- *S. integra* 'Hakuro-nishiki,' (subgenus *Vetrix*)
- *S. x* 'Boydii' (probably a cross-subgenus hybrid).

These willows might also be considered safe enough to remove from WoNS. As has been previously stated, however, further research on several of these willow taxa (subgenus *Chamaetia*, *S. integra*, *S. x* 'Boydii') is required before they can be considered truly low risk.

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Willows currently exempt from WoNS

Of the willows that are currently exempt from WoNS, *S. babylonica* had a high invasiveness and impact score, and *S. x reichardtii* and *S. x calodendron* had moderate scores. The national rankings of the thirty-five willow species, hybrids and varieties, based on the sum of the weighted invasiveness, impact and distribution scores, were:

- *S. babylonica* at number eleven (of thirty-five taxa)
- *S. x reichardtii* at twenty
- *S. x calodendron* at twenty-three.

At the regional scale, *S. babylonica* appears in the top ten ranking in every CMA/NRM except for the South Coast Region in Western Australia, where it is ranked at number twelve. *S. x reichardtii* and *S. x calodendron*, by comparison never scored higher than thirteenth ranking, with 26th the lowest ranking for either of these hybrids.

The case for *Salix babylonica*

Based on the outcome of this weed risk assessment, it would appear that *S. babylonica* should not be exempt from WoNS listing.

Factors that gave *S. babylonica* a high invasiveness score include:

- Brittle branchlets (Argus 1986) that enable it to establish easily by vegetative means.
- Leaf leachates from this species that inhibited the germination of rice (Koul *et al.* 1991); the production of compounds seriously affecting at least some plants.
- The ability to grow very quickly, indeed Geoff Carr (pers. comm.) states that “no willow will grow faster”.
- Despite being present only as female plants in Australia, this species backcrosses with its offspring: male/hermaphrodite *S. x sepulcralis* and *S. x pendulina* (Cremer 1999), both naturalised hybrids.
- As a result it produces ample seed and seedlings in some rivers. Some of the resulting hybrids are clearly more vigorous than their mother and include males, females and bisexuals and often produce seed and seedlings vigorously (Cremer 2003).
- Occurs in grassland, shrubland, roadsides, wasteland, riverbanks, rocky outcrops (Henderson 1995); along rivers, on damp valley bottoms (Skvortsov 1999); heathland and shrubland, riparian habitats, freshwater wetlands (Weber 2003). This indicates that the species may be able to invade undisturbed natural ecosystems.

Factors that gave *S. babylonica* a high impact score include the ability to:

- Choke up channels and reduce stream flow (van Kraayenoord *et al.* 1995)
- “Form dense thickets along streams that shade out native riparian species and affect the invertebrate fauna of wetlands and rivers by changing and reducing the species composition and richness” (Weber 2003).
- Present a menace to foundations and drainage systems with far-spreading roots (Newsholme 1992).

In addition, it is worth noting that many participants to the willows workshops began the day thinking that they only had “weeping willows” that were not a problem in their

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waterways. By the end of the workshop, these participants had learnt that not all weeping willows are *S. babylonica*, that many are self-fertile *S. x sepulcralis*. The exemption of *S. babylonica* from WoNS listing resulted in the persistence of the belief that all weeping willows are not weedy, or invasive. Clearly, not all weeping willows are the same taxonomically, but also, this risk assessment has found that *S. babylonica*, perhaps surprisingly, is much higher risk than was originally thought.

The case for *Salix x reichardtii* and *S. x calodendron*

Salix x reichardtii and *S. x calodendron* appear in the Moderate priority group for half the CMA/NRM regions, and in the Low priority group for the other half. The lower risk posed by these hybrids is a combination of moderate invasiveness and impact scores, but also potential distributions that are confined to the south of Australia. Large parts of the country are not suited to the establishment of these willows however, the exemption of these willows from WoNS listing has complicated compliance with state legislation because it is difficult to distinguish these two willows from *S. cinerea*, a parent of both these hybrids, and a highly invasive species, with devastating impacts.

Anecdotally, landowners have been known to claim that they have the exempted *S. x reichardtii* to avoid carrying out an order to control *S. cinerea* on their land. The weed risk assessment cannot provide a clear recommendation for the WoNS listing of these two willow taxa at a national scale. However, regional rankings and management priorities identified in this report may be used to declare these willows noxious under state or local laws where they pose the largest risk, or where their similarity to *S. cinerea* provides a loophole for compliance with state legislation.

Summary of recommendations

With further research the following willows **could be removed from the WoNS listing**, as well as state or local legislation:

- *S. chilensis* 'Fastigiata' and *S. alba* var. *caerulea* from subgenus *Salix*;
- *S. integra* 'Hakuro-nishiki,' from subgenus *Vetrix*;
- *S. x 'Boydii'*
- many of the subgenus *Chamaetia* (except *S. glauca*).

S. babylonica should be **added to the WoNS listing**, and considered for declaration as noxious under state and local laws.

Regional rankings and management priorities identified in this report may be used to declare *Salix x reichardtii* and *S. x calodendron* as noxious under state or local laws, where appropriate.

Section Four - Achievements

4.7 What have we achieved?

Key outcomes

It is clear that the following key outcomes (some of which are expected to become important outcomes over the longer term) relating to the initial project aims have been achieved:

Training willow managers in willow identification techniques, the willow sawfly and willow mapping:

Although the workshops were primarily organised in order to update willow mapping information, they played a major role in increasing the knowledge, attitudes, skills and aspirations of willow managers across Australia. Participants commented that the workshops were relevant, timely and very good in updating and increasing their knowledge of willows, particularly in the areas of willow identification, willow sawfly and management priorities.

Creating and/or updating regional maps highlighting where willow occur:

The project played a major role in the creation and updating of regional willow distribution maps and generated considerable interest in the mapping of willows within regions. To many regions, this project highlighted the distinct lack of willow distribution information in their region and inspired them to continue to update this.

Two particular highlights were the confirmation of and rapid response to *Salix cinerea* in the Mt Lofty Ranges, South Australia, and the discovery of *Salix nigra* in Grafton, New South Wales, and southern Queensland. This mapping information will be further refined, and will then feed into the weed risk assessment process to be conducted in the next phase of this project.

Enhancing willow practitioner networks on a national and regional level:

The workshops provided a clear networking opportunity for willow managers working within a region. The workshops evaluation showed that on average twenty participants (ranging from 8-28) attended each workshop, with an average of nine organisations (ranging from 2-16) represented. Of the 410 responses in evaluation forms, only 3% said that the workshop did not increase their networks with other willow managers, and this only occurred within regions where there was a small number of organisations represented.

Providing sound evidence based process for setting on-ground priorities at a national and regional level:

As a result of this project there is now a sound evidence-based process for setting on-ground priorities for willow management at state and local scales, and the toolkit to do this. Every region in Australia now has a matrix prioritising willow taxa for management based on risk; Very High, High, Moderate and Low. This information is accompanied by a series of maps with current and potential distributions to determine which areas management should focus on. This enables a more objective, scientific process to management than was previously possible, allowing willow managers to set priorities for on-ground management that provide the greatest environmental and economic benefits.

Enabling credible decision making to manage conflicting views of willows:

The information derived from this project will enable legislative decisions to be made, focussing on willows with the greatest or lowest risk. Making legislative changes can

Section Four - Achievements

more effectively manage conflicting views and uses of willows and the willow problem. This evidence-based approach will help build credibility in future decision making and management activities at the local through to the national level.

Providing a benchmark in which to measure progress

All of the above outcomes have provided a means in which progress can be measured, against future data of the same nature. As data is updated our knowledge will improve, and we can measure this against data and knowledge from this project. For example, our relative knowledge of willow distribution, and potentially willow spread should improve over time. Similarly, by mapping control effort as a part of updating this project we will be able to see how continued efforts of the National Willows Program has impacted on existing willows infestations.

We now have a benchmark to see how we are improving awareness of the willow threat, current knowledge as derived from this project can be seen in Figure 21.

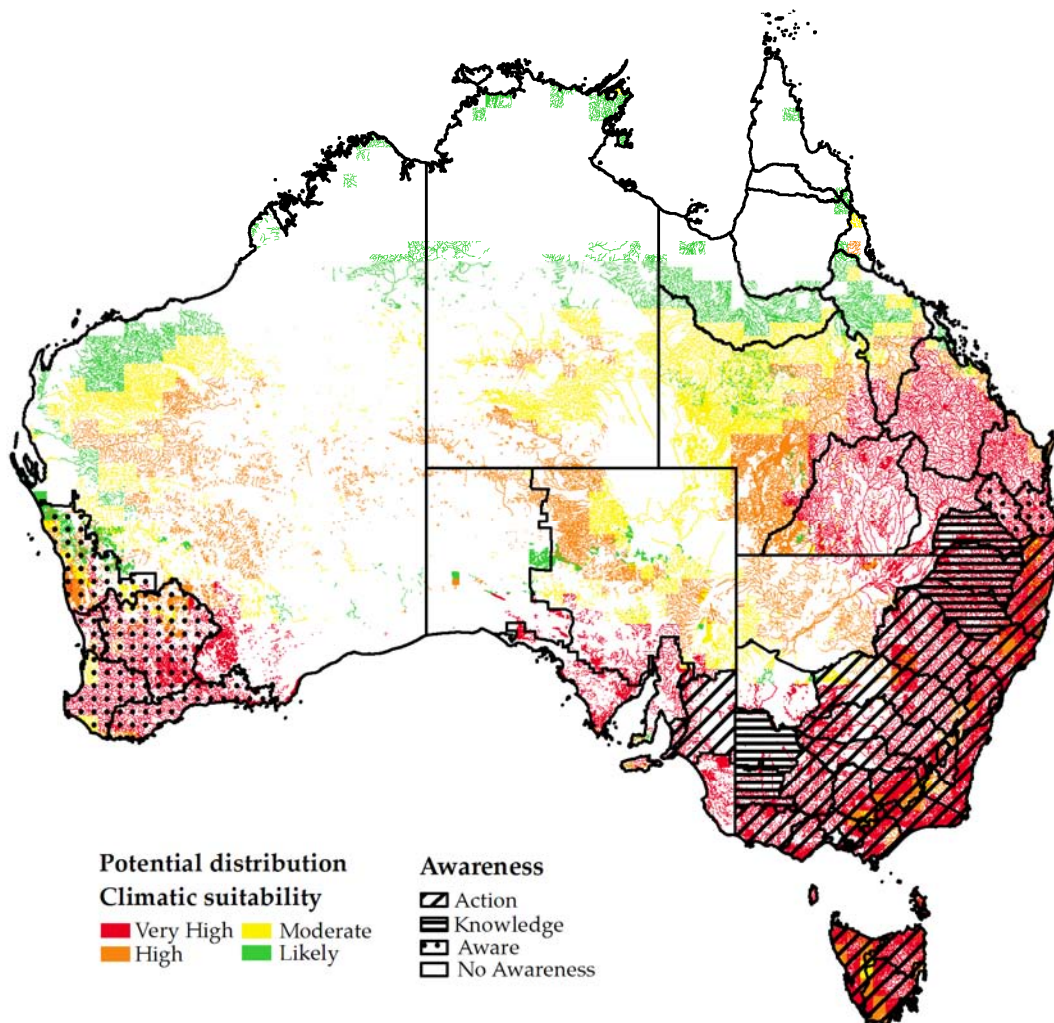


Figure 21: Awareness of the willow threat in all regions across Australia

One important aspect about this project has been its success in both the process and the results achieved. This provides an excellent model that can be used to map, prioritise and manage other weeds.

Section Four - Achievements

Future directions of the National Willows Taskforce

Through this project, we have significantly improved our knowledge of the extent and potential impacts of willows, and can now manage what we know. We know which willows we have, which willows are highest priority for management, and where they exist. This information and the recommendations from this report will be used to further implementation of the *National Willows Strategic Plan*.

Benchmarking information will also provide strong direction for the NWT to facilitate and direct resources into the places most needed. For example, in Figure 21 (above), by comparing regional awareness of willows with potential distribution we can see:

- where best to direct awareness raising efforts (eg. very high potential distribution with no awareness)
- which regions may need information or training to better manage willows (eg. those aware of the willows threat, but not yet actively managing)
- which regions are currently actively controlling willows and could therefore coordinate such efforts.

Over the duration of this project it has become apparent that the National Willows Taskforce is nearing the end of a strategic phase and will now begin to enter a management phase.

There are clearly still knowledge gaps, for example, in many areas, we still seriously lack information on which taxa occur where, and we need to continue to improve our knowledge over time and adapt our priorities as new information becomes available. Although these knowledge gaps exist, the information and recommendations from this report will be an essential step for the NWT in this transition to a management phase. A transition that will lead to improved and informed willow management to stop willows destroying our waterways and wetlands.