

Athel Pine

National Best Practice Management Manual

Managing athel pine and other *Tamarix* weeds in Australia

July 2008



Australian Government



This manual is sponsored by the Australian Government and supported by the Northern Territory Government's Department of Natural Resources, Environment and The Arts (NRETA).

The Northern Territory Government respects Indigenous cultures and makes every attempt to ensure that this document contains no material that is offensive to Indigenous Territorians.

This manual is intended to provide information only. Readers rely upon all information contained in the manual entirely at their own risk. It is not intended to, nor does it constitute, expert advice. While all care has been taken in the preparation of this manual, the Northern Territory Government does not accept any responsibility for any loss or damage that may result from any inaccuracy or omission in the information contained within, or for any loss or damage which may be incurred as a result of the use of any of the control techniques or products referred to in this manual.

The naming of individual products (including herbicides) does not constitute any form of preference or criticism of any competitor of, or alternative to, the named product.

Control costs mentioned in this manual are indicative only and based on 2007 figures unless otherwise stated.

© Northern Territory Government 2008

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without written permission from the Northern Territory Government.

Requests and enquiries concerning reproduction and rights should be addressed to:

NRETA
PO Box 496
Palmerston NT 0831 Australia

For copies of this manual please contact:

WoNS National Athel Pine Coordinator
NRETA
PO Box 496
Palmerston NT 0831 Australia
Ph: (08) 8999 4567

Manual compiled by the National Athel Pine Management Committee and funded by the Australian Government. Project Officer hosted by Department of Natural Resources, Environment and The Arts (NRETA), Northern Territory. About 170 relevant references were reviewed.

Expert interviews were conducted with around 20 land managers. This manual represents a rigorous review of successful and legal *Tamarix* control methods practiced in Australia.

Photography and maps: Kellie Agar, Dave Albrecht, Natasha Baldyga/Department of Primary Industries Victoria, Jim Balnaves, Chris Brown, Sylvia Clarke, Andrew Davies, Bryn Davies, Will Dobbie, Tom Dudley, Jonah Gouldthorpe, Land Management Staff Department of Natural Resources and Water Queensland, Greg Patterson, John Pitt, John M Randall/The Nature Conservancy, Barry A Rice/The Nature Conservancy, Les Tanner/North West Weeds, Tourism NT, Sam van Wyngaarden, Sandy Leighton, Kirk McDaniel, Michelle Foale, Prue Dufty and Mark O'Connor.

Editing and proofreading: National Athel Pine Management Committee, NRETA Weeds Publications Review Committee and Kerry Sharp.

ISBN 10: 1 920772 85 5

Authors

Principal author: Jonah Gouldthorpe, Dept. Natural Resources, Environment and The Arts, Northern Territory (NRETA).

Participating authors: Sylvia Clarke, Wayne Clarke, Ashley Harvie, Sandy Leighton, Bethan Lloyd, Kirk McDaniel.

At the time of publication, the National Athel Pine Management Committee membership included: Kellie Agar/Dept. Environment and Conservation WA, Deb Agnew/South Australian Arid Lands NRM Board SA, Chris Brown/Dept. Natural Resources, Environment and The Arts NT, Colleen Costello/Community representative, Charles Curry/Southern Gulf Catchments QLD, Jim Forwood AM (Chairman), John Gavin/South Australian Arid Lands NRM Board SA, Peter Gray/Dept. Primary Industries NSW, Don Mackenzie/Bourke Shire Council NSW, Garry Pidgeon/Dept. Primary Industries and Fisheries QLD, John Pitt/Rural Solutions SA, Shauna Potter/Dept. Water, Land and Biodiversity Conservation SA, John Thorp/National Weeds Management Facilitator and Steve Wingrave/Dept. Natural Resources, Environment and The Arts NT.

Acknowledgements

The Australian Government funded preparation of the manual.

Preparation of the manual was hosted by NRETA and overseen by the National Athel Pine Management Committee.

Weeds of National Significance Coordinators gave important assistance in preparation of the manual.

Participating authors, contributors and photographers shared their time and information generously. Their contribution to the manual including personal communications and quotes is gratefully acknowledged.

Private and community land managers kindly shared their time and experiences with the National Athel Pine Management Committee. Their stories contribute significantly to the management and case study sections of the manual.

Valuable editing and proofreading was undertaken by the NRETA Weeds Publications Review Committee, editor Kerry Sharp.



Athel pine has been widely planted across inland Australia as a shade tree

Foreword

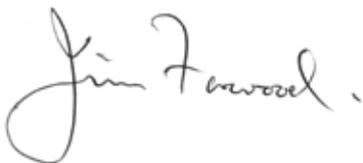
Athel pine, tamarisk and smallflower tamarisk could become some of Australia's worst weeds, with the potential to infest inland drainage systems across all mainland states and the Northern Territory. Because of its potential impacts on the Australian people, environment and economy, athel pine has been nominated as one of the country's 20 worst weeds, or a "Weed of National Significance".

Fortunately these weeds have a limited distribution at the moment, and now is the time for land managers to move against athel pine, tamarisk and smallflower tamarisk. We know that for every dollar spent acting early on a weed problem, we save \$16 in reactive weed control down the track. A relatively small investment now will safeguard our water supplies, grazing lands and unique wildlife against the negative impacts of these weeds forever.

This manual brings together the best management practices available to date on control options for athel pine, tamarisk and smallflower tamarisk. It also illustrates successful control programs with case studies that demonstrate how these weeds can be managed effectively in Australia.

I speak for all members of the National Athel Pine Management Committee in recognising that all land managers, be they primary producers, community groups or government, need to live up to their responsibilities and work together to overcome the threat posed by athel pine, tamarisk and smallflower tamarisk.

This manual will be an asset to any land manager dealing with this suite of weeds and I give it my highest recommendation.



J.B. Forwood AM
Chairman
National Athel Pine Management Committee

Contents

Introduction.....	6
A Weed of National Significance	6
A national approach	6
Using the manual.....	6
1. Ecology and threat	
1.1 Description	8
1.2 Life cycle, reproduction and spread	12
1.3 Origin and history of spread.....	14
1.4 Distribution.....	15
1.5 Potential spread	16
1.6 Impacts.....	17
2. Managing athel pine, tamarisk and smallflower tamarisk	
2.1 Planning	20
2.2 Identify which <i>Tamarix</i> species you are dealing with	21
2.3 Combine two or more control options for success, then follow up	22
2.4 Control options.....	22
2.4.1 Preventing spread	22
2.4.2 Mechanical clearing	24
2.4.3 Herbicides.....	26
2.4.4 Hand pulling.....	30
2.4.5 Flooding	30
2.4.6 Biological control	30
2.5 Suitability of control options for <i>Tamarix</i> - summary	31
2.6 Choosing a program for <i>Tamarix</i> control	32
2.7 Revegetation	33
2.8 Monitoring progress with photo points.....	33
3. Case studies	
Finke River, NT – integrated techniques against athel pine (<i>Tamarix aphylla</i>)	37
Florina Station, SA – Lessons learned on tamarisk (<i>Tamarix ramosissima</i>)	40
Lake Boonderoo, WA – Lessons learned on tamarisk (<i>Tamarix ramosissima</i>)	43
Avon River, WA – Lessons learned on smallflower tamarisk (<i>Tamarix parviflora</i>)	46
Successful tamarisk control in the USA (<i>Tamarix ramosissima</i>)	49
4. Further information	
4.1 Weed contacts – phone numbers and web sites.....	52
4.2 Declaration status	53
4.3 Mapping standards and photopoints.....	54
4.4 Off-label permits for <i>Tamarix</i> and woody weed control	54
4.5 Mechanical clearing - permits and enquiries.....	55
4.6 Protecting Indigenous cultural heritage	56
4.7 Machinery hygiene guidelines	56
4.8 Herbaria	57
4.9 More information on controlling athel pine.....	57
4.10 References	58

Introduction

A Weed of National Significance

Athel pine (*Tamarix aphylla*) is one of the worst weeds threatening inland Australia today. It was identified as a Weed of National Significance (WoNS) in 1999 because of its invasiveness, its potential to spread and its impacts on the environment and primary industry. Although athel pine has already overrun 600 km of the Finke River in central Australia with devastating results, its potential impact in Australia has hardly been realised. Most of this country's inland river systems, lakes, springs, waterholes and bore drains are at risk.

Athel pine has been introduced around the world for shelter and erosion control. It arrived in Australia in the 1930s and was widely planted for shade and windbreaks into the 1970s. Athel pine has naturalised - or gone wild - at only 20 locations, but any of Australia's thousands of domesticated athel pine trees could potentially start a devastating new infestation.

Athel pine threatens Australia's pastoral industry because it dries up or salts the waterholes, springs and rivers where stock could otherwise drink and makes mustering difficult and expensive. It threatens the environment by out-competing the river red gums, coolbahs and endemic herbs which birds, reptiles and invertebrates rely on for food and shelter. Finally, athel pine impacts on the Australian people by damaging the natural landscapes we value.

Australia's state and territory governments have taken the threat from athel pine seriously by making it a "declared", or "noxious" weed. This imposes restrictions on growing or selling athel pine, and in many instances obliges all land managers - government, private or community - to control this weed on their land.

Athel pine has two close relatives – tamarisk (*Tamarix ramosissima*) and smallflower tamarisk (*Tamarix parviflora*) – which have recently naturalised and demonstrated their potential to become equally serious weeds in Australia. Tamarisks have invaded a million hectares of river systems in south western USA, forcing out endemic plants and animals and sucking up to 27 million megalitres of water out of rivers every year. This manual recognises the threat these weeds pose to Australia and looks in detail at their control.

A national approach

A national strategy was developed in 2001 to tackle the current and potential threat from *Tamarix* weeds to the nation. The vision of the *Weeds of National Significance athel pine (Tamarix aphylla) strategic plan* is "Protecting Australia's biodiversity, landscape and industries from athel pine (*Tamarix aphylla*)" but the plan also establishes the need to deal with tamarisk and smallflower tamarisk at a national level. The plan's four outcomes are:

1. The prevention of new infestations of athel pine
2. The eradication of all athel pine occurrences in riparian zones
3. The management of athel pine in non-riparian areas
4. The coordination of strategic athel pine management nationally.

Implementation of the strategic plan is led by the National Athel Pine Management Committee, a group comprising community, agency and industry representatives.

Using the manual

Section 1 of this manual outlines the ecology and threat of athel pine, tamarisk and smallflower tamarisk. Section 2 discusses proven control options and talks about how to plan and prioritise work and deliver a program which leads to eradication. Section 3 showcases successful Australian and overseas programs against these weeds. Section 4 gives useful links, contact numbers and ideas about where to find more information on weed and land management.



CHAPTER 1

Ecology and threat



1.1 Description

Three different weeds are dealt with here.

Athel pine or athel tree (*Tamarix aphylla*) is an evergreen tree to 15 metres tall with rough grey-brown to black bark on older stems. It can be single stemmed or multi-stemmed, with trunks usually up to 40cm thick.^{1,2,3,4} Bark on new stems is smooth and reddish-brown to grey-green in colour.⁵ Athel pine's specific name, "*aphylla*" means, "without leaves". Its leaves are so shrunken that they are not visible. Instead, it harvests energy from the sun through its drooping grey-green needles, which look like pine or sheoak needles.

The segments of athel pine needles are only 1 to 2 mm long, compared to sheoak needles which are 5 to 10 mm long. Athel pine needles often have coating of salts excreted on their surfaces, which gives them a whitish colouration. Athel pine has tiny pinkish-white flowers borne in 3 to 5 cm long clusters on the ends of branches. Each flower has five petals.^{1,3,4}

Athel pine is the only *Tamarix* weed which is declared across all states and nominated as a Weed of National Significance.

Tamarisk (*T. ramosissima*) is a semi-deciduous shrub or small tree from 1 to 6 m tall with multiple stems. Bark on older stems is rough and grey-brown in colour, while bark on new stems is smooth and reddish-brown.^{5,6} Tamarisk has tiny leaves 1.5 to 3.5 mm long, which grow closely to its branches and overlap each other. Both the leaves and small branches are usually bright green in colour but may yellow or drop off during periods of drought stress or during winter. For this reason tamarisk is said to be "semi-deciduous". Tamarisk flowers have five petals.^{6,7}

Smallflower tamarisk (*T. parviflora*) is a semi-deciduous shrub or small tree up to 6 m tall with multiple stems. New bark is brown to deep purple in colour.⁵ Flowers of *T. parviflora* are small, pinkish-white in colour and have four petals. The four-petal flowers of smallflower tamarisk distinguish it from athel pine and tamarisk, which have five-petal flowers.^{6,7}



Tamarisk loses its leaves and small branches during winter or drought stress

All *Tamarix* species in Australia have extensive, deep woody root systems capable of penetrating as far as 50 m underground in search of water.^{1,2,4,5,8,9,10,11} Fruit and seeds of all three species are similar in appearance.

The fruit of all species is a very small pointed capsule with 3 to 5 “valves”, or parts. There are numerous tiny (0.17 by 0.45 mm for tamarisk) seeds, each with a tuft of hair to aid in wind and water dispersal.^{1,3,4,9,12} In athel pine and smallflower tamarisk, the petals may fall off the fruit prior to maturity. In contrast, the petals of tamarisk, persist on the fruit at maturity.⁵

Researchers in the USA have recently discovered likely hybrids between athel pine and tamarisk. These plants have athel pine trees as the seed source and are intermediate in appearance between athel pine and tamarisk.¹³

Differences between athel pine, tamarisk, smallflower tamarisk and sheoak are illustrated in Table 1.1.



Athel pine flowers and fruit are borne in clusters at the ends of branches



Tamarisk has tiny leaves which grow closely to its branches and overlap each other

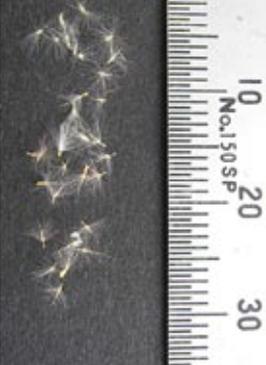
Table 1.1 Differences between athel pine, tamarisk, smallflower tamarisk and oaks/sheoaks

	ATHEL PINE	TAMARISK	SMALLFLOWER TAMARISK	OAK/SHEOAK
FORM		 Sam van Wyngaarden	 Tom Dudley	
OLD BARK AND TRUNK			 Tom Dudley	 Bryn Davies
NEW BARK			 Tom Dudley	
BRANCHES AND LEAVES	 North West Weeds			



1. ECOLOGY AND THREAT

Table 1.1 Differences between athel pine, tamarisk, smallflower tamarisk and oaks/sheoaks

	ATHEL PINE	TAMARISK	SMALLFLOWER TAMARISK	OAK/SHEOAK
INFLORESCENCE		 <small>Jim Balnaves</small>	 <small>John M Randall - The Nature Conservancy</small>	
FLOWERS	 <small>North West Weeds</small>	 <small>Kellie Agar</small>	 <small>Barry A Rice - The Nature Conservancy</small>	
FRUIT	 <small>Tom Dudley</small>	 <small>Tom Dudley</small>	 <small>Tom Dudley</small>	
SEEDS	 <small>North West Weeds</small>	 <small>Tom Dudley</small>	 <small>Tom Dudley</small>	 <small>Michelle Foale</small>

1.2 Life cycle, reproduction and spread

Because of the limited information available on the life cycles of athel pine, tamarisk and smallflower tamarisk in Australia, the life cycles of all species are dealt with together.

Athel pine and tamarisk flower after three years and produce as many as 500,000 seeds per tree annually.^{4,9} Seeds can travel at least eight km on the wind¹² or floating on water. Athel pine flowers in summer in Australia, but timing of seed set and seed fall is not established. In the USA, tamarisk and smallflower tamarisk flower and set seed for at least five months from spring until autumn.^{4,12}

Fresh tamarisk seed is highly viable, but viability drops off relatively quickly. Athel pine seed may remain viable for only a few weeks after falling from the parent plant.⁴ Tamarisk seed may last longer if kept warm and dry: viability of stored tamarisk seed in a laboratory trial was high after 200 days when seed was stored at low relative humidity, but had dropped to zero viability by 294 days.¹⁴ Hot, dry conditions in central Australia may favour longer survival of seed.

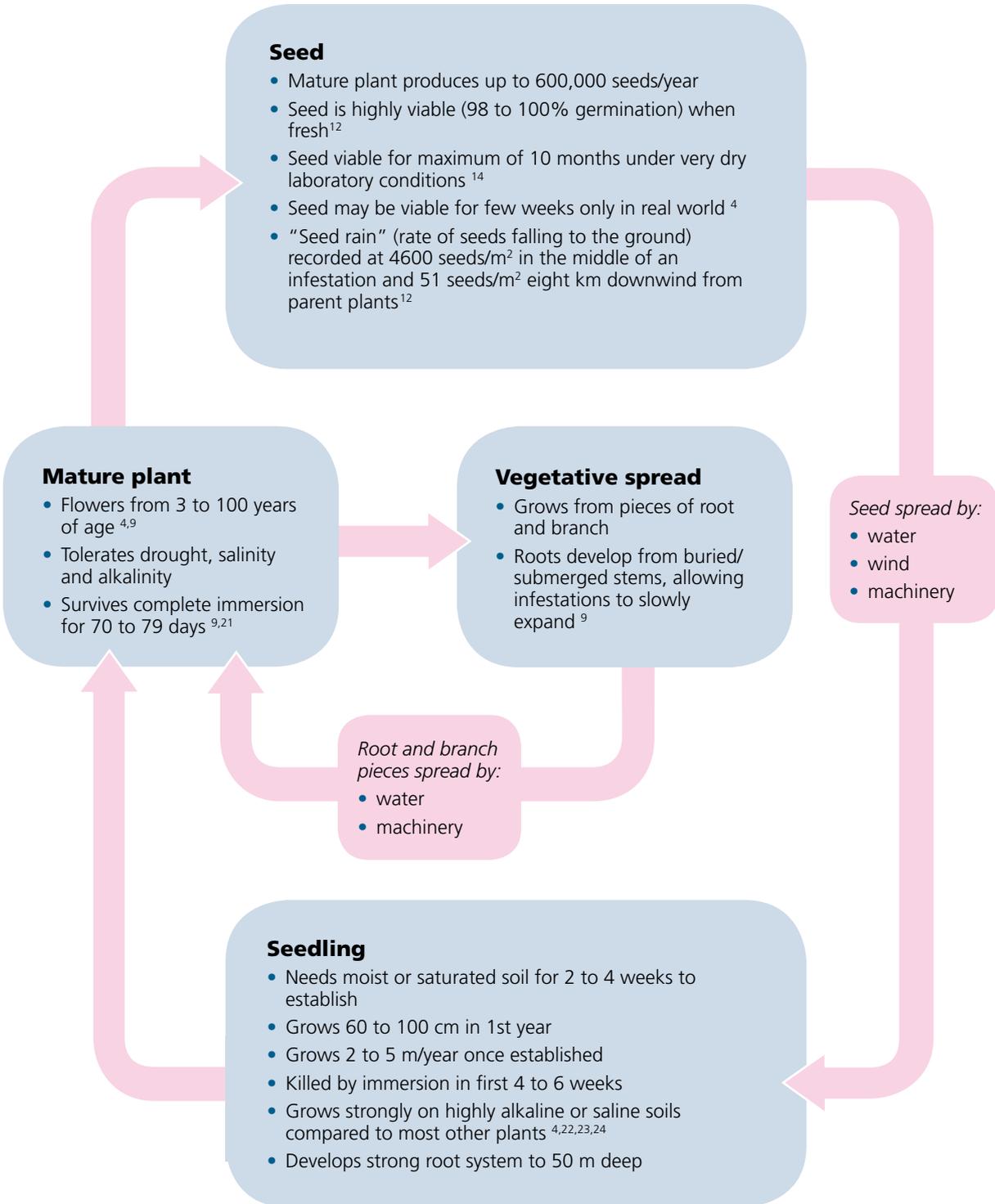
Athel pine and tamarisk seeds must come to rest on moist ground within a few weeks of being set in order to grow. The high moisture requirement of athel pine seedlings is illustrated by the widespread establishment of this weed along the Finke River during exceptionally wet years and floods in 1974, 1988 and 1997.²

Seedlings develop rapidly once established, forming a strong woody root system which reaches as deeply as 50 m into the soil and rock profile.^{1,8,15} Athel pine and tamarisks are said to be “phreatophytes”, that is, plants which seek out ground water.¹⁶ Whereas these weeds will tap into subsurface water if possible, they have an exceptional ability to tolerate drought conditions.^{1,8,10,15}

Athel pine and tamarisks can reproduce and spread vegetatively from pieces of stem and root.¹⁷ In Australia, early propagation of athel pine was undertaken successfully using cuttings.¹⁸ More recently, much of the expansion of athel pine in the Finke River is attributed to vegetative reproduction through the spread of branches and roots in floods.^{1,4,19} Earthmoving machinery contaminated with fragments of athel pine roots and branches is suspected of starting new infestations in central Australia.²⁰



Life cycle of athel pine, tamarisk and smallflower tamarisk



1.3 Origin and history of spread

Athel pine originates from arid to semi-arid northern Africa and western and southern Asia, where it grows around oases and on sand dunes.^{5,25} The natural range of tamarisk is western and southern Asia through to China and Korea.^{5,12} Smallflower tamarisk originates from southern Europe and possibly northern Africa.^{5,26}

Athel pine was introduced to Australia in the 1930s via California and was first planted at Whyalla, SA. From there it was introduced to Broken Hill, and cuttings were widely distributed around Australia by the Broken Hill Proprietary Company Ltd.

The weed continued to be planted across semi-arid Australia from the 1940s to the 1970s as a shade and windbreak tree at homesteads, bores and communities, and to stabilise mobile or eroding land.^{2,19,27} More recently, athel pine was planted to remediate former mine sites and tailings storage facilities.²⁸

Athel pine's domesticated or deliberately planted range in Australia is much larger than its naturalised, or wild, range. Naturalised infestations have originated from deliberate homestead, stockyard or mine site plantings e.g.¹⁹ On this basis, potential for spread or expansion of range is high, given the widespread nature of plantings.

The history and spread of both tamarisk and smallflower tamarisk in Australia is not established.



Athel pine planting at Woodstock, near Townsville, Queensland



1.4 Distribution

Naturalised athel pine, tamarisk and smallflower tamarisk are distributed across Australia at the following sites:^{29,30}

Athel pine

New South Wales – Darling River, Bourke.

Northern Territory – Finke River: Walker Creek/
Palmer River: Karinga Creek: Ross River: Renner
Creek: Helen Springs.

Queensland – Kings Gully, Mt Isa: outside the
Mt Isa Mines site: Flinders River, Hughenden:
Gemfields area, Emerald: Dawson River
catchment near Cracow: near Rockhampton.

South Australia – Finke River: Kenmore Park:
Lake Starvation and Tilcha Flow on Quinyambie
Station: Mt Fitton and Mt Searle Stations,
Flinders Ranges: Muloorina Station.

Western Australia – Gascoyne River, Carnarvon:
two mines sites near Laverton:

Tamarisk

New South Wales – Barwon River, Walgett:
Menindee Lakes: Imperial Lakes, Broken Hill:
three sites near Deniliquin: Condobolin: one site
each on Central Coast and South Coast.

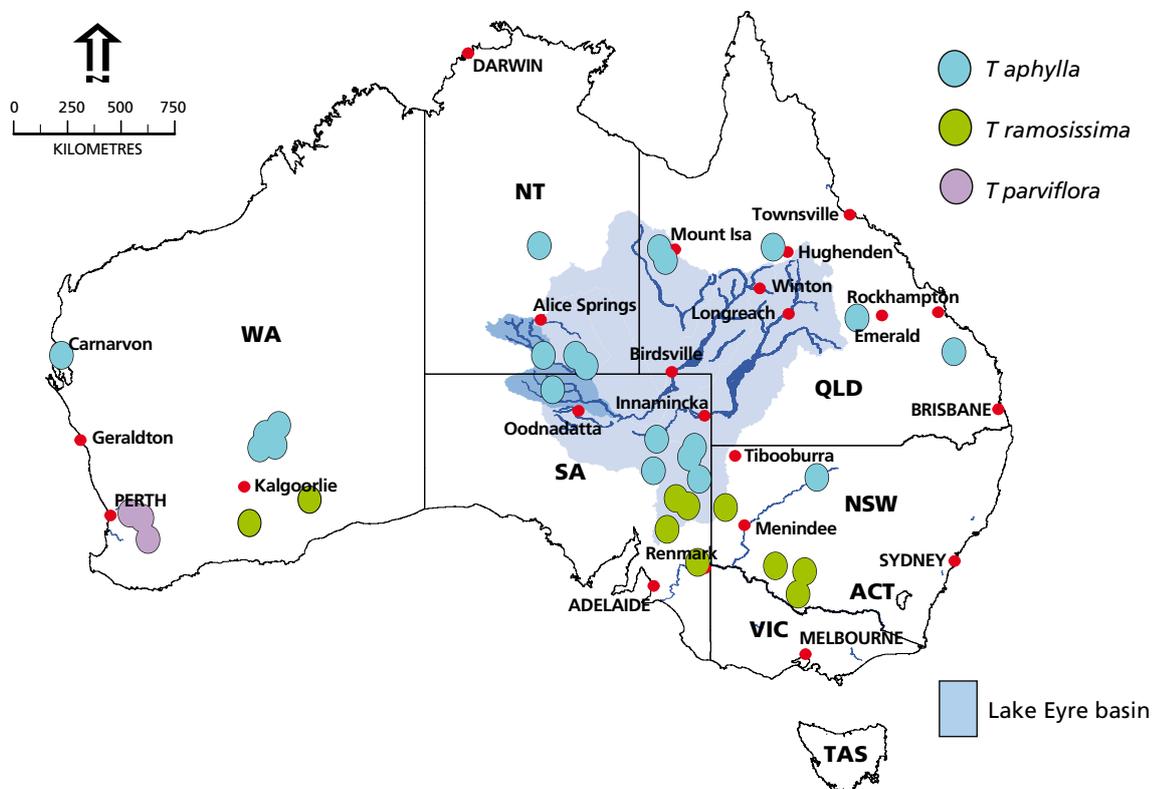
South Australia – Florina Station, Mannahill:
Frome Downs: Teetulpa Station, Yunta: Murray
River at Berri, Blanchetown, Riverland area.

Western Australia – Lake Boonderoo and
Norseman stormwater dam.

Smallflower tamarisk

Western Australia – Avon River at Toodyay,
Northam and York.

Distribution of naturalised *Tamarix* species in Australia

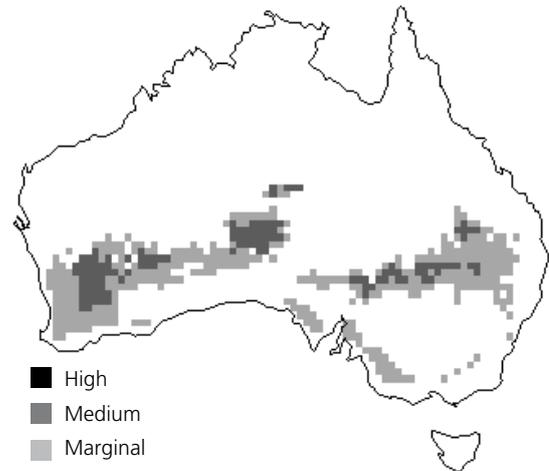


1.5 Potential spread

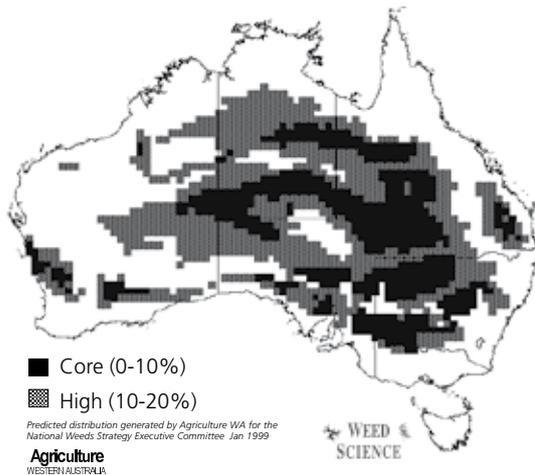
Athel pine could potentially infest rivers, creeks, drains and waterholes of inland Australia across all states and territories except the ACT and Tasmania. The map shows the area of Australia where athel pine is likely to become a serious weed in the future if its spread is not contained.

The potential spread of tamarisk and smallflower tamarisk in Australia is relatively limited compared to that of athel pine. The maps show the area of Australia where tamarisk and smallflower tamarisk are likely to become serious weeds in the future if their spread is not contained.

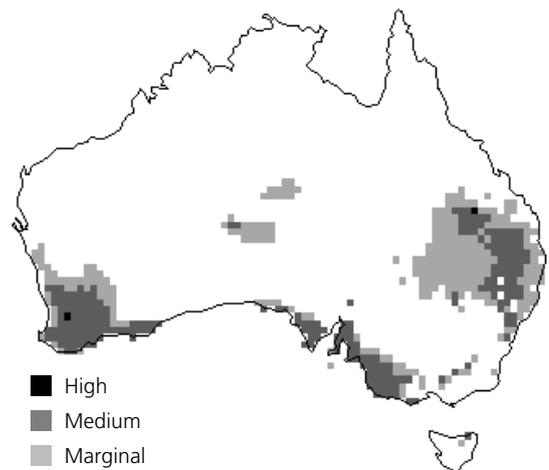
Potential range of tamarisk across Australia based on climate



Potential range of athel pine across Australia based on climate



Potential range of smallflower tamarisk across Australia based on climate





1.6 Impacts

Athel pine and tamarisks have an unusual ability to extract salts from the soil and groundwater then excrete them through their leaves and branches.³¹ Impacts include:

- Increased surface soil salinity
- Vegetation reduced to a few chenopod and salt-tolerant grass species which can grow under or near athel pine
- Expansion of athel pine and tamarisk infestations at the expense of most other vegetation ^{2,4,10}
- Shading, competition and displacement of other plant species
- Accelerated rusting of roofs, gutters, fences, trailers, water mains, buildings and foundations overhung by athel pine trees.^{32,33}



Athel pines causes accelerated rusting of steel structures

Tamarisk has a reputation in the USA as a heavy consumer of ground water and flowing water.^{10,21,34,35,36} Impacts are:

- Estimated water consumption by individual tamarisk plants of 122 to 757 litres/day
- Annual water consumption of 4.4 to 27 Ml of water per hectare of infestation.

Athel pine impacts on the pastoral industry are:

- Reduced availability and accessibility of water for stock ^{2,3}
- Increased mustering costs.³⁰ Per hectare mustering costs in woody weed infestations may be over six times higher than for clean areas ³⁷
- Productivity losses through lost pasture and top feed.³⁸



Athel pine impacts on the pastoral industry

Both athel pine and tamarisks drop large amounts of leaf and needle litter. This litter forms a dense, salt-laden mat over the ground, with many associated impacts:

- Reduced invertebrate abundance ²⁷
- Reduced abundance and diversity of birds and reptiles ²⁷
- Reduced diversity of indigenous plants under tamarisk ⁸
- Increased fire frequency under tamarisk. ^{9,39}



Athel pine reduces the diversity and abundance of endemic birds and reptiles

Replacement of indigenous eucalypt trees by athel pine leads to:

- Reduced availability of fallen and standing hollow logs
- Reduced abundance and diversity of birds and reptiles dependent on hollow logs ²⁷
- Reduced availability of persistent slabs of bark on red gum trunks, and the lizards which shelter under bark.²⁷

Tamarisk infestation affects the animals which live in the water of infested rivers and creeks:

- In the USA, clearing tamarisk from the riparian zone of a stream increased the abundance of indigenous fish species ⁴⁰
- Tamarisk infestation reduced the abundance and diversity of invertebrates in USA streams. ⁴¹

The Finke River system supports the most diverse fish fauna of any central Australian catchment,⁴² which may be important in terms of potential impacts from *Tamarix* weeds.

Dense infestations of athel pine and tamarisk are highly effective at trapping and accumulating sediment during flood events. Impacts from sediment build-up include:

- Alteration of river courses
- Creation of further flooding where it slows the flow of water
- Creation of erosion by forcing water to flow hard against banks. ^{1,10,19,43,44}



Athel pine depletes rivers, waterholes and groundwater

Athel pine has the potential to affect central Australian tourism through its impacts on the aesthetics, visitor experience and cultural heritage of natural areas.²⁹

Athel pine was planted widely for shade and wind breaks in the twentieth century ¹⁸ and is highly valued as a shade tree in some central Australian communities today.⁴⁵ Some communities are totally dependent on athel pine for shade trees.⁴⁶



CHAPTER 2

Managing athel pine, tamarisk and smallflower tamarisk



2.1 Planning

Plan a *Tamarix* control program, do the work, follow up and succeed. Planning helps you to use your weed control budget effectively and to work out how to follow-up properly before you start. The following suggested planning process has six steps.

1 Define the weed, problem areas and priorities:

- Make a property or control area map from a satellite image, aerial photos, existing maps or drawn from eye
- Identify which *Tamarix* species you are dealing with
- Map athel pine or tamarisks to standard from *A field manual for surveying and mapping nationally significant weeds* (see Section 4)
- Identify landmarks, vegetation, assets and infestations of the weed
- Use transparent overlays or GIS to keep the map tidy and superimpose layers
- Work out priorities for each infestation. Control patches/infestations in the following order (highest priority first):
 - Single trees in otherwise clean areas i.e. deliberately planted
 - Small, outlying or easy infestations
 - Upstream infestations
 - Upwind (prevailing summer/autumn weather) infestations
 - Core infestations.
- What are your responsibilities to the law, your neighbours and community with respect to athel pine?
- Consider local, catchment or regional priorities and plans.

2 Determine control options:

- Identify what equipment, machinery or labour is already available for economical management options
- Does any legislation affect what you can do – land clearing, threatened species, cultural heritage, threatened species, river works, herbicides, fire? Get permits as necessary
- Always get an expert opinion on the river morphology and the potential impacts of mechanical disturbance to banks and channels, if controlling weeds in or near waterways. Include this information and any recommendations in your plan
- Decide which methods to use for initial control, follow-up and monitoring.

3 Develop a financial plan:

- Estimate management costs for each infestation. Include running costs and labour
- Seek professional advice before committing a large amount of money
- Integrate costs into short- and long-term budgets
- Identify whether any financial incentives, grants, low-interest loans or labour programs are available to help out
- Account for the cost of follow-up in the future (often underestimated).



4 Carry out the weed control:

- Prevent the spread of *Tamarix* weeds by cleaning down machinery
- Different control options may be effective in different seasons. Balance this against time/labour availability
- Be flexible to allow for weather conditions
- Integrate *Tamarix* control with other management e.g. woody weed control, earthworks, maintenance
- Prepare a timetable for *Tamarix* control for the next five years.

5 Monitor progress:

- Plot progress on your map (from step one) and record what you did in detail
- Check treated areas for regrowth annually, or as indicated by monitoring
- Regularly inspect creeks, drains, waterholes and springs for new outbreaks
- Document control costs and assess the effectiveness of each method
- Take photos at the same point over time, to show progress against *Tamarix* weeds. Use the method outlined in *A field manual for surveying and mapping nationally significant weeds* (see Section 4).

6 Follow up what you started:

- Follow up all treated infestations annually, or as indicated by monitoring
- Use the most suitable follow-up method for your situation.

2.2 Identify which *Tamarix* species you are dealing with

Management options are different for athel pine, tamarisk and smallflower tamarisk. Use Table 1.1 in Section 1 (pages 10 and 11) to help you identify species. Collect a specimen, get it identified by your local/regional weeds officer then send it to your state herbarium (see Section 4 for contact details for herbaria).



Identify which *Tamarix* species you are dealing with

2.3 Combine two or more control options for success then follow up

One-off control efforts will not kill athel pine, tamarisk or smallflower tamarisk completely. Because these weeds have a strong, resilient root stock, achieving 100% kill in the first control round can be difficult. These weeds can all regrow vigorously after cutting or clearing and this regrowth must be killed in turn. To achieve long-term eradication of these weeds, you will need to integrate, or combine, at least two control methods.

Start by removing these weeds using mechanical clearing or herbicides.

Follow up any regrowth with herbicide or other treatment(s) in the second and subsequent years.

Consider the following points when deciding on control options:

- Size, density and species of the infestation
- Short and long-term objectives of the project
- Accessibility and type of land infested
- Type and amount of endemic or desirable vegetation present.

2.4 Control options

2.4.1 Preventing spread

Preventing the spread of a weed is the most cost-effective form of weed control. For every \$1 spent on keeping clean areas free of athel pine and tamarisks now, up to \$31 can be saved on their control in the future.⁴⁷ This means not planting *Tamarix* species in Australia. It also means cleaning down earthmoving machinery and vehicles at the site of operation to prevent spread of *Tamarix* seeds, roots or branches.

Cleaning down can be as simple as knocking off clods of soil, roots and branches from the outside of the machine with a crowbar and stiff brush, and brushing out the cab (and tray) with a dustpan and brush. Cleaning down can also involve using high pressure water or compressed air to thoroughly remove soil from equipment.

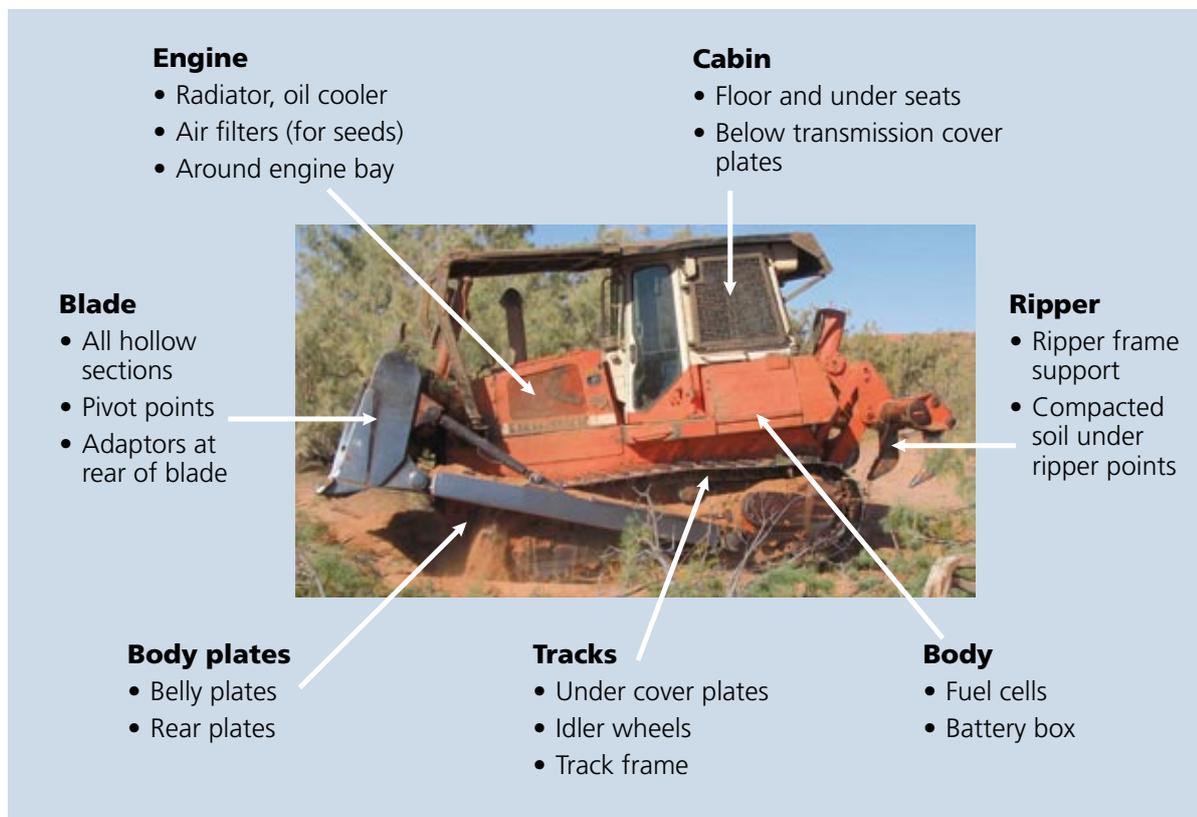
See Section 4 for more information on cleaning down earthmoving equipment and vehicles. Contaminated earthmoving equipment is a known pathway for the spread of both athel pine and tamarisk.^{20,48}



Cleaning down machinery is the best and cheapest form of weed control (© State of Victoria, Department of Primary Industries 2004: wash-down with high pressure hose from *Machinery Hygiene, LC0425*)



Problem areas for bulldozers - soil and weed contamination



Removing athel pine, tamarisk or smallflower tamarisk debris from the flood zone after clearing is an important step in preventing its spread. These weeds can propagate from fragments of root or branch transported in floodwaters, as demonstrated by the spread of athel pine along the Finke River ²⁰ and tamarisk in the USA.^{17,48} Where practicable, pile or windrow debris away from creek/river channels or landwards of lake edges.



Pile or windrow debris away from flood zones where practicable

2.4.2 Mechanical clearing

Cost: medium, depends on owned versus hired machinery, transportation costs

Most useful for:

- Large infestations of *Tamarix* weeds
- Isolated large trees where machinery is readily available.

Disadvantages of mechanical clearing:

- Erosion risk associated with clearing
- Clearing will always require monitoring and follow-up herbicide use
- Clearing during hot weather can be hard on machinery and traction is a problem ²⁰
- Failure to remove roots will result in excessive regrowth ^{2,20,49}
- It leaves debris which can spread and start new infestations.

Key points for success with mechanical clearing:

- Remove the crown and taproot of each tree to at least 1 m depth - use the bucket of a tractor, loader or excavator, or the blade of a bulldozer to dig out the stump of the tree after pushing it over
- Carry out mechanical clearing during hot or dry weather for greatest effect ^{17,43}
- Remove debris from the flood zone where practicable
- Follow up with a herbicide or other treatment.



Remove the root crown and taproot to a depth of at least 1 m



Land Management staff Dept Natural Resources and Water

Blade ploughing is effective on smaller trees, dense regrowth and seedlings

Experience with mechanical clearing of *Tamarix* weeds in Australia is limited. The following paragraphs summarise land managers' experience with clearing *Tamarix* in Australia and the USA.

Blade ploughs, root rakes and stick rakes with cutter bars on bulldozers are suited to controlling dense seedling or regrowth athel pine.² However, using these methods on mature trees results in small regrowth with large rootstocks, which is difficult to kill using herbicides.⁴⁹

Blade ploughing of trees up to 40 cm thick in flat parts of the river bed has been successful on the Finke River using a bulldozer with 3 m rear-mounted equipment.^{43,50} Blade ploughing of trees up to 40 cm thick, if desirable, requires a D8 or equivalent bulldozer.⁵¹

Mechanical clearing of tamarisk and smallflower tamarisk in the USA has produced mixed results. Bulldozing, followed by root ploughing, root raking, windrowing and burning after three years killed 97 % of a tamarisk infestation, but was expensive.⁵²

The same authors report a 97-99% kill of tamarisk following grubbing or clearing with a bulldozer.⁵³ Clearing with D7 to D8 or equivalent bulldozers followed by root ploughing and root raking gave effective but expensive and non-selective control at another USA site.¹⁶

The same authors reported that using a large excavator with a grab to pull individual trees killed 80-95% of the infestation and was highly selective.

Tamarisk and smallflower tamarisk have been cleared in Australia using a bulldozer and backhoe respectively. See case studies in Section 3 for details.

Always get an expert opinion on the river morphology and the potential impacts of mechanical disturbance to banks and channels when planning mechanical clearing in or near waterways. Adjust your approach according to this information and take note of any recommendations.

2.4.3 Herbicides

As at February 2008, no herbicides were registered for use on athel pine, tamarisk or smallflower tamarisk in Australia. Legal control options for these weeds using herbicides are established through a number of “off-label permits”, issued for the generic off-label control of athel pine or “environmental weeds”, using specified herbicides.

This generic approach allows for use of herbicides against athel pine, tamarisk and smallflower tamarisk in accordance with situations, rates and methods as specified on the permits.

Permits are issued on a state-by-state basis which means that a herbicide permitted for use against athel pine in one jurisdiction (e.g. Northern Territory) may not be permitted in another state (e.g. South Australia).

This manual details herbicide options which have been trialled and/or are available in Australia. It is the reader’s responsibility to ensure that their herbicide use complies with either a currently registered product label or an off-label permit, or other relevant state legislation governing the control-of-use of herbicides.

Herbicide labels are legal documents and herbicide users are required to abide by instructions on labels. Label instructions include important information for preventing unacceptable risks to operators, the general public, the environment and other off-target assets including crops. This information is presented through application details, general instructions, precautions, storage and disposal information, first aid and safety directions.

The effectiveness of some herbicides is reduced if stored for prolonged periods at high temperatures or in sunlight. It is therefore important that all users read and understand instructions on the label before using a herbicide. Users can also get a “material safety data sheet”, or MSDS from the reseller at the time of purchase or later at the manufacturer’s web site. The MSDS gives detailed safety information about a herbicide and is a useful companion to the label.

Some herbicides contain ingredients which can remain active in the soil for prolonged periods (e.g. picloram). These herbicides have the potential to damage non-target vegetation near the site of application, or to contaminate surface or groundwater. Carefully consider whether such herbicides are suited to controlling *Tamarix* weeds in your situation.



Read the entire label including booklet, MSDS and relevant permits before using a herbicide - the label must remain on the container



FOLIAR SPRAY

Cost: high

Most useful for:

- Extensive seedlings
- Extensive regrowth
- Shrubs and trees less than 3 m tall ^{2,44}
- Following up regrowth after mechanical clearing.^{49,54}

Disadvantages of foliar spray:

- Labour intensive
- Not practical to spray shrubs over 3 m in height ²⁰
- May cause off-target impacts when target weeds are growing among indigenous vegetation, in gardens or near waterways ²⁸
- Gives poor results with poor quality turbid or cloudy water.²⁰

Key points for success with foliar spray:

- Spray all green branches and leaves on a plant with herbicide mix until wet to the point of runoff

- Always use a surfactant or oil (e.g. Nufarm Pulse® Penetrant, BS1000 Bio-degradable Surfactant or Uptake™ Spraying Oil) in the herbicide mix. This improves the effectiveness of the treatment significantly
- After mechanical clearing, allow regrowth to reach a height of at least 1 m to give sufficient branch/leaf area to absorb enough herbicide to kill the plant's roots ²⁰
- Use good quality water free from turbidity or cloudiness.²⁰

An extensive successful program of foliar spray using Starane™ 200 Herbicide at 10 ml/l in water plus Nufarm Pulse® Penetrant was undertaken on the Finke River until 2008. This herbicide contained 200 g/l fluroxypyr as the methylheptyl ester. Withdrawal of this herbicide from sale means that at the time of publication, this option was no longer available to Northern Territory land managers. Remaining permitted herbicide options for foliar spraying of *Tamarix* weeds in Australia are summarised in Table 2.1.

Table 2.1 Permitted herbicides for foliar spraying of *Tamarix* weeds

Active ingredient(s)	Trade name example	Rate and carrier	State permitted
Fluroxypyr 200 g/l	Farmoz Flagship® 200 Herbicide	5 ml/l in water	QLD
Triclopyr 600 g/l	Garlon™ 600 Herbicide	17 to 35 ml/l in diesel	ACT, NT
		1.7 to 10 ml/l in water	NT, QLD, TAS WA



Wait until regrowth is at least 1 m tall before foliar spraying

BASAL BARK

Cost: very high

Most useful for:

- Small infestations
- Inaccessible plants or infestations ^{4,28,43}
- Plants with smooth bark and trunks up to 10 cm thick ²⁰
- Sites where weed control needs to be highly selective
- Control at any time of year ^{55,56}
- Sites where debris from treated *Tamarix* could propagate new plants.

Disadvantages of basal bark:

- Labour-intensive ^{10,20}
- Uses up to five times more herbicide mix than the cut stump method of treatment ⁵⁶
- Not practicable where trunks are covered in small branches at ground level.

Key points for success with basal bark:

- Wet the bottom 30 cm of the circumference of each stem completely from the root crown upwards, using a herbicide solution
- Ensure that every stem on a multi-stemmed tree is covered
- Clear any accumulated debris and sediment from around stems prior to basal barking
- Use this method only on plants with smooth bark.

Several proven, permitted herbicide options are available for basal bark treatment of *Tamarix* weeds in Australia, as summarised in Table 2.2. Herbicides containing 600 g/l of triclopyr as the butoxyethyl ester (e.g. Garlon™ 600 Herbicide) are the preferred option for athel pine in Australia and tamarisk in the USA.^{10,43}



Basal bark spraying – wet the bottom 30 cm of the stems completely with herbicide mix

Table 2.2 Permitted herbicides for basal bark treatment of *Tamarix* weeds

Active ingredient(s)	Trade name example	Rate and carrier	State permitted
Fluroxypyr 200 g/l	Farmoz Flagship® 200 Herbicide	35 ml/l in diesel or kerosene	QLD
Triclopyr 600 g/l	Garlon™ 600 Herbicide	17 ml/l in diesel	NT, QLD
Triclopyr 240 g/l + picloram 120 g/l	Access™ Herbicide	17 ml/l in diesel	QLD, WA



CUT STUMP

Cost: very high

Most useful for:

- Very small infestations
- Inaccessible plants or infestations
- Plants of any size, including trees with rough bark and trunks more than 10 cm thick ^{4,20}
- Sites where weed control needs to be highly selective
- Control at any time of year. ^{55,56}

Disadvantages of cut stump:

- Labour-intensive ^{10,20}
- Involves risk to the operator from chainsaw and falling limbs
- Creates debris which could spread and start new infestations.

Key points for success with cut stump:

- Cut the stems/trunks low and level (less than 15 cm tall) – this may require several cuts
- Paint or spray the cut surface (and stem sides as applicable – see label) with herbicide mix within 30 seconds of making the cut
- Remove debris from the flood zone where practicable.

Getting plenty of herbicide mix onto the cut stump immediately after making the final cut is essential for effective control.^{20,57} If herbicide mix is not applied immediately then the stump begins to “seal up” and not enough herbicide will be absorbed into the stump to kill the roots.

Several proven, permitted herbicide options are available for cut stump treatment of *Tamarix* weeds in Australia, as summarised in Table 2.3. Herbicides containing 600 g/l of triclopyr as the butoxyethyl ester (e.g. Garlon™ 600 Herbicide) are the preferred option for athel pine in Australia and tamarisk in the USA.^{10,43}



Cut the stump low and level...



then spray or paint with herbicide within 30 seconds

Table 2.3 Permitted herbicides for cut stump treatment of *Tamarix* weeds

Active ingredient(s)	Trade name example	Rate and carrier	State permitted
Picloram 43 g/kg	Vigilant Herbicide Gel	Ready to use	All states
Triclopyr 600 g/l	Garlon™ 600 Herbicide	17 to 35 ml/l in diesel	ACT, NT, SA, TAS
Triclopyr 240 g/l + picloram 120 g/l	Access™ Herbicide	17 ml/l in diesel	QLD, WA

2.4.4 Hand pulling

Cost: very high

Most useful for:

- Seedlings under 60 cm tall in sandy soil
- Small areas of low-density seedlings⁴⁵
- Sites where weed control needs to be highly selective
- Control at any time of year
- Control without herbicides.

Disadvantages of hand pulling:

- Labour-intensive⁴⁵
- Not effective on larger plants
- Not effective in heavier soils.⁵⁸

Key points for success with hand pulling:

- Remove pulled plants from the flood zone where practicable.



Hand pulling is effective on seedlings under 60 cm in height

2.4.5 Flooding

Cost: variable

Most useful for:

- Tamarisk infestations in regulated waterways.

Disadvantages of flooding:

- Slow-acting
- Not selective – will kill most vegetation.

Key points for success with flooding:

- Combine with mechanical clearing for best results.

Land managers in the USA have used flooding to successfully control tamarisk infestations. Seedling tamarisk is killed by four to six weeks of continuous inundation.⁹ Mature tamarisk plants are killed by at least 10 to 12 weeks of continuous inundation.^{9,15} Mechanical clearing of tamarisk followed by flooding may give best results.⁵⁹

Researchers in the USA reported 99% of tamarisk killed by mechanical clearing followed by 28 months of continuous inundation.¹⁷ Flooding is not tested or proven as a control method for *Tamarix* weeds in Australia but may be applicable. A site-by-site assessment of its suitability as a control method would be required in Australia.

2.4.6 Biological control

No biological control options existed for *Tamarix* weeds in Australia as at February 2008. Extensive trials and releases of *Diorhabda elongata*, a leaf-eating beetle which targets tamarisk, have been undertaken in the USA. This agent was found to have an impact on the vigour of tamarisk⁶⁰ and was also found to eat athel pine to a lesser degree.⁶¹

Unfortunately, early releases of the species below 37° latitude failed because of day length effects on the beetle.⁶² All *Tamarix* infestations in Australia are below 37° latitude. More recent research has found varieties of the beetle which may succeed below 37° latitude.⁶³

Northern Territory Government employees working on athel pine on the Finke River have observed extensive dieback of infestations. This dieback appears to be caused by a pathogenic organism which has not been identified. This dieback will be investigated further to identify the organism responsible and any prospects for widespread biological control.⁵⁸



2.5 Suitability of control options for *Tamarix* - summary

Suggested control methods for athel pine, tamarisk and smallflower tamarisk infestations at different sizes and stages of growth are summarised below in Table 2.4.

Table 2.4 Control methods for athel pine, tamarisk and smallflower tamarisk

Control option	Situation					
	Few, scattered or inaccessible trees	Few, scattered or inaccessible seedlings	Few, scattered or inaccessible regrowth 1 to 3 m tall	Dense trees	Dense seedlings	Dense regrowth 1 to 3 m tall
Mechanical clearing						
Excavating (dozer, excavator, loader, tractor)	Low			Very good		Low
Blade ploughing				Low	Very good	Low
Stick raking/cutter bar					Very good	Low
Ripping				Very good	Very good	Very good
Root raking				Low	Very good	Very good
Hand pulling		Very good				
Chemical control						
Foliar spray	Low	Very good	Very good		Very good	Very good
Basal bark	Low	Very good	Very good		Low	Low
Cut stump	Very good	Low	Low		Low	Low
Flooding				Low	Very good	Very good

Key

Suitability of control option: = low = moderate = very good

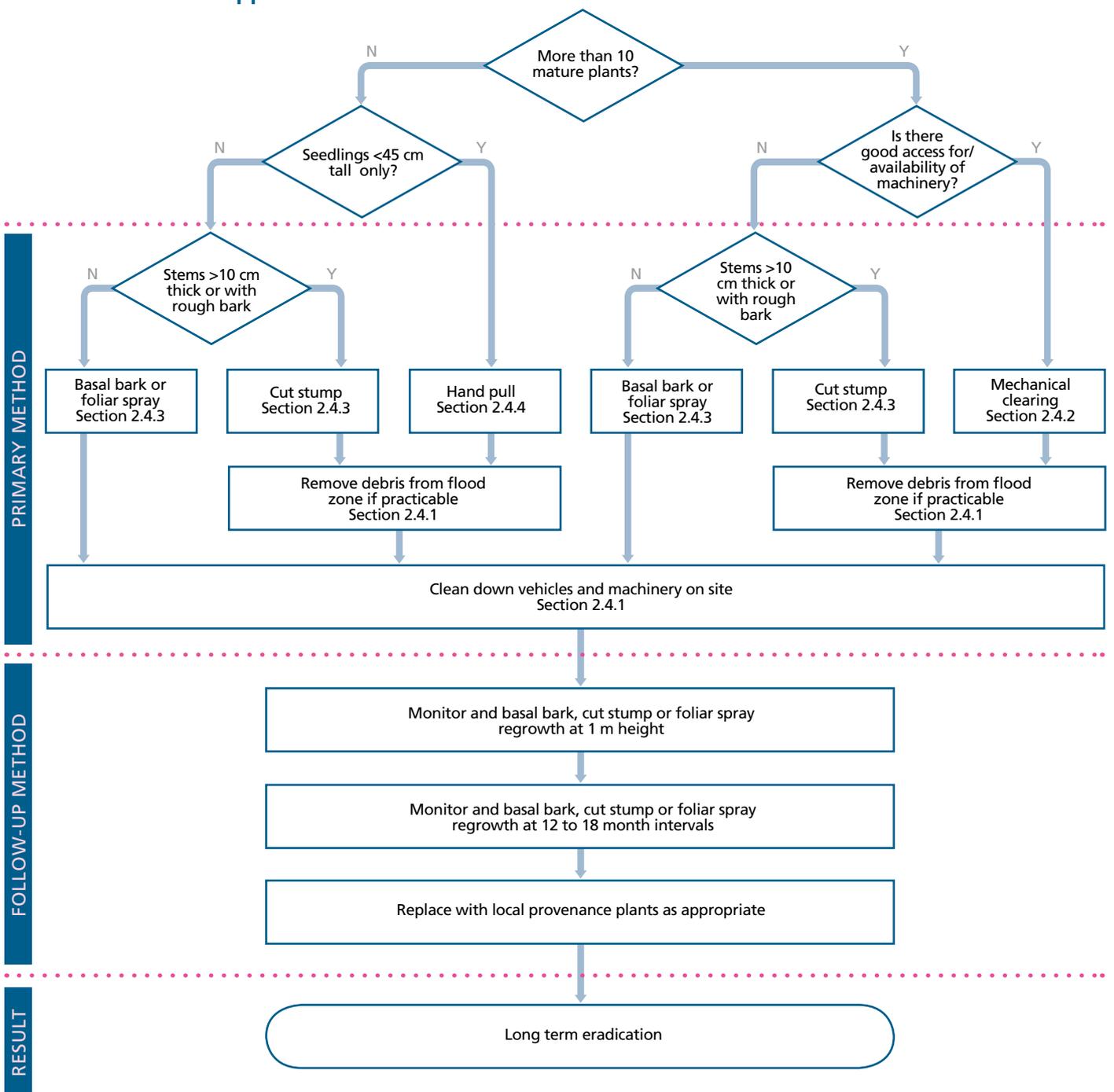
2.6 Choosing a program for *Tamarix* control

Develop a control program for athel pine, tamarisk or smallflower tamarisk based on the type of infestation you have to treat and the options available to you. Use the following Decision Support Tree to help you choose a suitable program.

Before you follow any of these programs it is important that you:

1. Develop a five-year *Tamarix* control plan (see Section 2.2 for detailed instructions)
2. Work out your primary control, or knockdown and follow-up methods
3. Prevent further spread of these weeds (see Section 2.4.1)
4. Prepare to monitor treated areas for regrowth, including with the use of photopoints.

Decision Support Tree for *Tamarix* control





2.7 Revegetation

Deliberate revegetation will not always be practicable at the scale or on the type of sites where athel pine, tamarisk or smallflower tamarisk are being removed but should be undertaken wherever feasible.

Replanting suitable shade trees where existing athel pine shade trees have been removed may be important. Suitable replacement trees are local provenance, salt tolerant tree species. “Local provenance” refers to indigenous plants which are genetically adapted to your area. Remember that plants from other parts of Australia or the world could become weeds themselves if planted in the wrong spot.

Contact your local agricultural or environmental agency, weeds officer or Greening Australia office for information on replacement trees suited to your area.

When establishing replacement shade trees, plant a variety of species. This will ensure that at least some individual trees survive, and will indicate best choices for replanting in the future. Deep, long watering at planting and afterwards until trees are established will allow trees to develop a deep, strong root system which will help them survive drought in the future. Shallow, frequent watering is strongly discouraged.⁴⁶

2.8 Monitoring progress with photo points

Monitor your progress against athel pine using photopoints. Photopoints are a “photographic record of changes at a site over time”.⁶⁴ For detailed information on using photopoints, refer to *A field manual for surveying and mapping nationally significant weeds*.



CHAPTER 3

Case studies



Case studies

This section of the Athel Pine National Best Practice Management Manual showcases successful programs against athel pine, tamarisk and smallflower tamarisk from around Australia and overseas.

The case studies given feature a number of common key points which have contributed to successful weed control. These points are:

- Three *Tamarix* species in Australia are potentially invasive across a range of environments and states. Correct identification of *Tamarix* species contributes to effective planning and control programs
- Popular herbicides with glyphosate as their active ingredient are generally not effective against athel pine, tamarisk and smallflower tamarisk. More specialised herbicides are required to kill these weeds. Land managers need to pay close attention to correct application methods and conditions in order to achieve satisfactory kill rates
- When controlling athel pine, tamarisk and smallflower tamarisk by mechanical clearing, removal of roots as well as top growth is essential to achieve satisfactory kill rates. Removing the roots of these plants will reduce regrowth following clearing
- Follow-up and monitoring is an essential component of any control program against athel pine, tamarisk or smallflower tamarisk. Follow-up and monitoring must be budgeted for when planning a control program against these weeds.



Finke River, NT

Integrated techniques against athel pine (*Tamarix aphylla*)

Sandy Leighton and Jonah Gouldthorpe



Australia's worst athel pine infestation has been treated along 400 km of the Finke River in the Northern Territory and is now under follow-up control. Future programs will target remaining downstream infestations on 200 km of the river.

The Finke River is an ancient river system that starts its journey in the Western MacDonnell Ranges, about 150 km west of Alice Springs and may reach Lake Eyre during extreme floods. It is a unique system that has significant natural, cultural and economic values as well as being an icon of central Australia.

Athel Pine was first planted as a shelter tree around homesteads, communities, stockyards and bores in the region during the 1940s and 1950s. However, it was not until the 1970s and 1980s that the true weed potential of this species was recognised, by which time an infestation had developed along 600 km of the Finke River.

This period of sudden and rapid expansion corresponded to several large summer floods, which are thought to have provided the perfect environment for seed germination and establishment. The importance of preventing spread when controlling athel pine was also illustrated during this period by dumping of cut trunks and branches in the Finke River at Hermannsburg, which were promptly distributed by a major flood, propagating new infestations. From 1989 onwards the Northern Territory Government began to trial various chemical and mechanical control techniques.

Following on from these trials, a strategic approach targeting upstream infestations, using an integrated mechanical and chemical control program, was initiated in 1994. By 1998, some 130 km of the upper Finke River from Glen Helen Gorge to the Stuart Highway had been treated.

Since then, additional downstream infestations have been treated along a further 260 km of river to Horseshoe Bend homestead, and on Finke River tributaries including Rudall Creek, Ellery Creek, Lilla Creek, Hugh River and Karinga Creek. Works included bulldozing and blade ploughing of extensive infestations on Horseshoe Bend Station by the lessees, Peter and Libby Morphett, who used a bulldozer with a three metre rear-mounted blade plough to undertake the work. Peter explained that blade ploughing opened up infestations which were too dense to control by other methods and gave good control on trees up to 40 cm thick.



Larger plants are cut stump treated with Garlon in diesel

The on-going follow-up chemical control of seedlings and regrowth is overseen by the Northern Territory Weed Management Branch within the Department of Natural Resources, Environment and The Arts.

Herbicide choices and rates used reflect years of trials and experience working out what kills Finke River athel pine most effectively: smaller plants are foliar sprayed using Starane™ 200 Herbicide at 10 ml/l plus Nufarm Pulse® Penetrant in water, while larger plants are basal bark or cut stump treated with Garlon™ 600 Herbicide at 17ml/l in diesel. Getting a good result with foliar spray has hinged on using good quality water free of suspended sediments.

In 2004, a thorough survey of the lower reaches of the Finke River was completed from below Horseshoe Bend to the South Australian border, highlighting further areas that require control. In 2006, an Australian Government *Defeating the Weed Menace* grant was obtained for the *Progression of downstream control of Athel Pine along the Finke River*, to treat a severe 20 km infestation below Horseshoe Bend homestead. Mechanical control works were undertaken on this infestation from June to August 2007.

These works included blade ploughing of large areas infested with seedlings, and bulldozing and deep ripping of larger trees by contractors. Outlying infestations were treated by NRETA Weed Officers using Starane™ 200 Herbicide at 10 ml/l plus Nufarm Pulse® Penetrant in water.

This long-term program has resulted from a partnership between the Northern Territory and Australian Governments and has also seen partnerships developed with station lessees and Aboriginal communities in central Australia, such as the Indigenous Tjuwanpa Ranger program coordinated by the Central Land Council, and CDEP participants from Titjikala Community.

The Australian Government, Northern Territory Government and some station lessees have borne the significant cost of this work, with the control bill amounting to about \$2 million of external funding and in-kind work at March 2008.

Many individuals and changing government departments have been involved in the work over time, and the passing on of knowledge and monitoring from person to person has been important for maintaining continuity in the athel pine control program.



Successful foliar spraying depends on using quality water



Large areas of athel pine were bulldozed in 2007

Chris Brown, Regional Weeds Officer with Northern Territory Government, explained that the top priority for athel pine control in the future would be to monitor treated sites annually and follow-up regrowth with herbicides.

It makes sense to concentrate limited resources on keeping previously treated areas free of athel pine before tackling new infestations. Chris also flagged new opportunities against athel pine on the Finke.

The Northern Territory Government hopes to trial aerial spraying of an imazapyr herbicide, subject to appropriate permits, and will also investigate the biological control potential offered by dieback observed in athel pine along parts of the river recently.

Control of athel pine on the Finke River has been a 20-year project which has achieved major successes. Monitoring and follow-up will be the key to safeguarding clean areas into the future as control efforts move downstream towards the South Australian border.

Florina Station, SA

Lessons learned on tamarisk (*Tamarix ramosissima*)

Ashley Harvie and Jonah Gouldthorpe



Ashley and Jeanette Harvie, Rural Solutions SA and the South Australian Arid lands NRM Board have battled to achieve tamarisk control on Florina Station, South Australia, but are now on track to succeed.

Florina Station is a 42,000 ha sheep grazing property on the Barrier Highway 150 km west of Broken Hill. The Harvies, who have leased Florina for 23 years explained that the tamarisk there formed an infestation through nearly 2 km of Snakey Creek.

The Harvies first tackled the infestation in 2000 using a dozer to push and pile tamarisk, then burned the debris where possible the following year.

Regrowth from roots occurred, which was 1 to 2 m tall and flowering when Rural Solutions SA (part of Department of Primary Industries and Resources South Australia) initiated an annual follow-up program by contractors using herbicides in 2003. Dow AgroSciences advised them to trial Garlon™ 600 Herbicide plus a wetting agent in water as a foliar spray, but unfortunately the results were poor.

Vigorous 1 to 2 m tall regrowth from the 2003 round of control was followed up in 2004, again using Garlon™ 600 Herbicide both as a foliar spray in water and as a basal bark/cut stump spray in diesel. Results were disappointing again, possibly due to dry seasonal conditions or the difficulty in differentiating between seedling and regrowth tamarisk.

Further mechanical clearing was undertaken in 2005, using a dozer to uproot and pile tamarisk trees within the creek. The piles did not burn consistently and some of the cleared material took root.



Tamarisk in flower at Florina Station

John Pitt



Remains of bulldozed and sprayed regrowth tamarisk

With additional funding provided by the South Australian Arid lands NRM Board, a contractor sprayed the regrowth once in March 2007 using Starane™ 200 Herbicide plus a spraying oil in water. This was followed up with a second round of spraying after brownout a few weeks later, which killed any bushes missed the first time.

This killed 95% of the tamarisk infestation, and the board's Mark O'Connor believes that they have "cracked" the secret of treating tamarisk. A final round of spraying in March 2008 dealt with any further regrowth.



Regrowth tamarisk at Florina Station prior to follow-up treatment



Same plants 12 months after foliar spray with Starane™ 200 Herbicide

Many lessons have been learned during the work against tamarisk at Florina Station. Herbicide treatments are not always successful and different application methods, stage of growth and growth conditions all influence the effectiveness of herbicides against tamarisk.

Significantly, growth from some dozed tamarisk material showed that cleared debris must be removed from the flood zone where possible and that some form of follow-up treatment using herbicides is essential to achieving eradication.

Ashley Harvie estimates that tamarisk control at Florina Station has cost in excess of \$40,000. Ashley contributed time to spraying the weed and accommodated contractors who performed much of the herbicide work.

In spite of setbacks along the way, Ashley is upbeat about his progress and believes that only 20% of the tamarisk remains to be treated: “The good thing about it is it’s getting controllable now. It’s heartening...”, he says. Future work against tamarisk on Florina Station will involve monitoring treated sites for regrowth and foliar spraying annually in spring using Starane™ 200 Herbicide (or equivalent) in water.

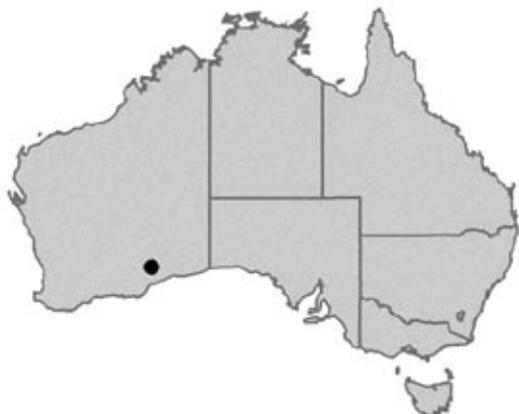
Years of work have resulted in successful control of tamarisk and the infestation will eventually be beaten at Florina Station.



Lake Boonderoo, WA

Lessons learned on tamarisk (*Tamarix ramosissima*)

Sylvia Clarke and Jonah Gouldthorpe



A significant wetland on the western edge of the Nullarbor Plain has been saved from invasion by tamarisk, thanks to alert land managers.

Lake Boonderoo is located on Kanandah Station 320 km east of Kalgoorlie. The lake lies on the end of an ancient drainage system which flows after cyclonic rain events and is one of only two brackish lakes in the Goldfields-Nullarbor region of Western Australia.

Lake Boonderoo is an important habitat for birds and invertebrates as it dries up, becoming increasingly saline. Tamarisk was discovered in the Lake's shoreline in 2005 and its extent confirmed when station lessee Mark Forrester flew over the Lake and saw that up to 30 km of its margin was infested with young tamarisk trees. A total of about 250 ha had been covered by the weed.

Work began to eradicate the tamarisk in June 2006, when staff from Western Australia's Department of Environment and Conservation (DEC), the Rangelands NRM Coordinating Group and Mark Forrester undertook cut stump treatment of about 70 ha of infestation. They used chainsaws and brushcutters to cut shrubs down then sprayed stumps using Access™ Herbicide in diesel at 1:60. At the same time a 10 x 10 m trial plot of basal bark treatment was established. Mature tamarisk trees, which were a potential seed source for the lake side infestation, were also removed from the nearby Kanandah homestead.

Cut stump treatment on a further 120 ha of infestation was undertaken in October 2006, again using Access/diesel mix. Photopoints and vegetation monitoring plots were established at this time to track progress against the weed.



Lake Boonderoo is an important habitat in the Goldfields-Nullarbor region of WA

Another round of treatment including follow-up on previously controlled tamarisk was undertaken by DEC staff from March to April 2007, using cut stump with Access in diesel. Smaller bushes were cut with a brushcutter and larger bushes with a chainsaw.

The initial treatments used on tamarisk at Lake Boonderoo were not all effective. In particular, the cut stump treatment from October 2006 resulted in a lot of regrowth. This is attributed to:

- High temperatures at the time of application
- Herbicide not applied quickly enough after cutting to penetrate stumps
- Health of trees. However, the kill rate was better during the June work when trees were brown and senescing, whereas they appeared to be growing well in October
- Insufficient herbicide applied
- Brushcutters were used more extensively than chainsaws in October, but why this would have an impact is unclear.

Results from the basal bark trial were also disappointing, the reasons for which are unclear.

In 2007, follow-up control was programmed for July, but was postponed until October to allow plants to recover from apparent frost stress. A crew of three DEC staff undertook two days of foliar spraying using Nufarm Arsenal® Xpress Herbicide (an imazapyr/glyphosate herbicide) in water, which has been successfully used against tamarisk in the USA.

Effectiveness of this treatment is still being monitored but early indications are that it is an improvement on previous treatments used at Lake Boonderoo. At the time of writing, a further round of spraying using Nufarm Arsenal® Xpress Herbicide was programmed for April 2008.

Work on tamarisk at Lake Boonderoo has cost at least \$170,000 to March 2008, not including significant in-kind contributions from the Forrester family. Funding sources have included the DEC *Saving Our Species* Biodiversity Conservation Initiative, the DEC Remote Regions Nature Conservation Program and Rangelands NRM Coordinating Group.



Up to 30 km of the Lake Boonderoo margin was infested with young tamarisk trees



3. CASE STUDIES



Chainsaws and Access™ Herbicide were used to cut stump tamarisk

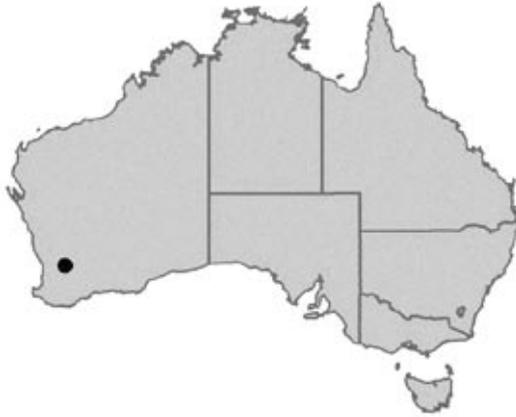
The land managers involved in tamarisk control at Lake Boonderoo will tailor their techniques in the future so that teams of one cutter and two sprayers are on hand to ensure all stumps are treated within 30 seconds of cutting. Monitoring of treated sites will continue, to track the recovery of indigenous vegetation following tamarisk removal, evaluate the effectiveness of the control methods used and detect any regrowth of tamarisk.

In summing up the importance of tamarisk control at Lake Boonderoo, DEC's Goldfields Regional Manager Ian Kealley says: "It is critical to address the tamarisk problem early before the extent of the infestation makes it impractical and beyond financial resources available. The specialist BCI/SOS and NRM projects allowed an immediate response and continual follow-up is critical. With ongoing work, control will be achieved and this important wetland will be protected".

Avon River, WA

Lessons learned on smallflower tamarisk (*Tamarix parviflora*)

Bethan Lloyd, Wayne Clarke and Jonah Gouldthorpe



Bringing smallflower tamarisk under control has been a long term goal for Toodyay Friends of the River. The Toodyay Friends of the River Incorporated (“the Friends”) is a landcare group who look after the Avon River in Toodyay, 85 km east of Perth.

They have been working since 1997 to clear dense infestations of smallflower tamarisk from remnant riparian vegetation and the river banks, with mixed results. The Friends’ first attempts involved chopping down the plants then trying to dig the roots out, but the thickets of smallflower tamarisk were impenetrable and most regrew from roots or stumps remaining in the soil.

The Friends’ Wayne Clarke explained that attempts at foliar spray with glyphosate only burnt the tops off the plants resulting in regrowth, while stem injection was difficult to undertake and was also followed by lots of regrowth. Cut stump treatment with glyphosate didn’t work either.

By 2006, the Friends realised that they were not making much progress with control of the smallflower tamarisk and that the enormity of the thickets was far beyond the small volunteer group’s capacity. The Friends applied for funding through the Australian Government’s *Community Water Grants* to assist with smallflower tamarisk removal and other works along the Avon River.



Smallflower tamarisk infests riparian vegetation and banks along the Avon River east of Perth



There was strong regrowth from roots and stumps after plants were cut down

Gaven Donegan, Project Officer for the Friends, was able to secure a front-end loader and operator from the Shire of Toodyay for over one week. The machine was used to dig out the smallflower tamarisk thickets during summer, and the debris was piled away from the flood zone to dry out and be burnt over winter.

Toodyay Friends of the River waited for the expected regrowth to occur, then attempted to control the regrowth by foliar spraying with glyphosate.

This was successful on plants which had regrown from small pieces of root or branch and had limited root systems, but did not kill those plants growing from larger taproots. To control the larger regrowth plants, the Friends cut back the regrowth, scraped back the bark to expose the cambium layer, then painted a triclopyr/picloram herbicide on to the exposed area.

They continue to have success with this process, but estimate it will take a number of further visits to the regrowth areas before they are completely successful.

Toodyay Friends of the River have learned a lot about smallflower tamarisk control over the years. Cut stump treatment of these weeds is labour intensive and is only practical where few smallflower tamarisk trees exist or many hands are available to do the work. Mechanical clearing can offer a quick solution to dealing with dense or extensive smallflower tamarisk.



A front-end loader can be used to dig out thickets during summer



Debris was piled away from the flood zone and burnt over winter

On the other hand, mechanical clearing leads to abundant regrowth which needs to be treated with herbicides. Following-up this regrowth with foliar spray is effective only where adequate foliage (at least 1 m tall) is present to absorb enough herbicide to kill the root stock.

It is difficult to put a dollar value on the work undertaken against smallflower tamarisk at Toodyay, but many stakeholders have contributed significant time to the weed control. Toodyay Friends of the River typically put in 45 person hours per month on tamarisk removal through a regular monthly meeting, as well as individuals' time in between.

This represents over 5000 person hours of work against smallflower tamarisk. The Northam office of Western Australia's Department of Water organised for a team of work camp prisoners to undertake manual removal of smallflower tamarisk from the river three days a week over a three month period.

The Shire of Toodyay has also spent considerable time removing smallflower tamarisk from the river. Department of Water has invested in herbicides and diesel for smallflower tamarisk control through its 12-year Avon Rivercare project.

The persistence and dedication of Toodyay Friends of the River has been a key to success in controlling smallflower tamarisk on the Avon River. Volunteer groups such as the Friends contribute thousands of person hours of weed control as well as expert local knowledge and continuity to control programs. Without their commitment, labour-intensive weed control, follow-up and monitoring in sensitive environments would not be practicable or affordable.

Areas previously infested with smallflower tamarisk will need to be watched closely for regrowth for a number of years. Toodyay Friends of the River have "given" each member a section of the river to monitor for regrowth, with the group to follow up collectively as needed.

Wayne Clarke stresses the importance of monitoring and following up previously treated areas of smallflower tamarisk: "The last thing we want is to have spent all that money then go back a few years later and find it all covered again".

Successful tamarisk control in the USA

(*Tamarix ramosissima*)

Kirk McDaniel



An area of dense tamarisk infestation has been successfully restored to native riparian vegetation on the Bosque del Apache National Wildlife Refuge, Rio Grande in New Mexico state, USA.

Tamarisk (called "saltcedar" by Americans) has infested nearly one million hectares of riverside vegetation in the western USA, primarily along the Rio Grande and Colorado Rivers. Replacement of indigenous vegetation with tamarisk has resulted in impacts including reduced diversity of native animals,⁴⁰ changed fire frequency⁹ and water loss through heavy transpiration.³⁶

The devastating impacts of tamarisk in the USA serve to warn Australian land managers of the potential of athel pine, tamarisk and smallflower tamarisk to invade and degrade vast areas of this country.

Bosque del Apache National Wildlife Refuge is a 23,000 ha reserve which protects river front, floodplains and foothills around the Rio Grande near Socorro, New Mexico. The refuge is a nationally significant feeding and resting ground for migratory birds, is an important recreation place and also supports primary production. Unfortunately, the refuge has a long history of invasion by tamarisk.⁶⁵

Control of Tamarisk at Bosque del Apache National Wildlife Refuge began in the 1940s and continues to the present. Trial plots for comprehensive tamarisk control were established in 1987 and treated using a variety of methods.

In the autumn of 1987, tamarisk growing in a 61 ha trial area tagged as "Unit 28", was sprayed from the air by fixed wing aircraft using imazapyr herbicide plus wetting agent in water. In the summer of 1988, the apparently dead top growth was chained using two D7 bulldozers, and the debris burned on the ground. By 1989, heavy regrowth from roots covered the area and this was removed by root ploughing and root raking, again with a bulldozer. Debris was piled, burned, then buried.



Tamarisk following aerial spraying in Unit 28

More regrowth from roots occurred in 1990 so larger plants were removed using cut stump treatment and imazapyr herbicide. Smaller plants were foliar sprayed in both 1990 and 1991, again with imazapyr. The duration of the required follow-up control graphically illustrates the vigour with which tamarisk can resprout from roots following initial removal of top growth. Total costs for tamarisk control in the Unit 28 trial plot were about \$2137 p/ha at current Australian prices.

In a 37 ha trial area called "Unit 30", researchers used a D7 bulldozer fitted with various implements as the primary control method. Firstly, in winter, top growth was removed by dozing stems near the surface then pushing the debris into piles for burning. After removing all top growth, roots were severed in the summer using a root plough pulled behind the bulldozer then the bulldozer was fitted with a root rake which pulled the roots from the soil. All root debris was windrowed and burned.

Limited regrowth from roots occurred in this trial area and no follow-up herbicide treatment was required. Total costs for tamarisk control in Unit 30 were about \$1559 p/ha at current Australian prices.



Root ploughing and root raking were used to remove tamarisk in Unit 30

Following tamarisk control, all trial areas were replanted using local provenance indigenous plants.

Vigorous regrowth of tamarisk from roots in Unit 28 provided a number of lessons in successful tamarisk control, namely that: after treatment with herbicides, plants must be left undisturbed for a least 12 months to let the herbicide do its work; mechanical clearing must remove roots as well as top growth to be successful, and regrowth from mechanical clearing usually needs to be followed up with more than one round of herbicide treatment. Success in Unit 30 illustrated that mechanical control methods which remove roots of tamarisk provide a high level of control.

Experience with tamarisk control across the USA indicates that long term regrowth and survival of tamarisk after treatment is reduced where indigenous trees are doing well.⁶⁶ Where practicable, establishing local provenance plants and maintaining environmental conditions to suit plantings is an important element in long term follow-up after weed control.

Successful control programs against tamarisk at Bosque del Apache National Wildlife Refuge demonstrate that, while control of *Tamarix ramosissima* is difficult, it is achievable provided that treated plants are monitored and followed up in the years after primary control.

This case study is adapted from: Taylor JP, McDaniel KC. Restoration of saltcedar (*Tamarix* sp.)-infested floodplains on the Bosque del Apache National Wildlife Refuge. Weed Technology 1998;12:345-352.



The same site at Unit 28 following tamarisk removal



CHAPTER 4

Further information



4.1 Weed contacts – phone numbers and web sites

State	Agency	Phone number	Web site
ACT	Parks, Conservation and Lands	13 22 81	www.tams.act.gov.au/live/environment
NSW	Dept. Primary Industries	1800 680 244	www.dpi.nsw.gov.au
NT	Dept. Natural Resources, Environment and The Arts	(08) 8951 9210	http://www.nt.gov.au/nreta/natres
QLD	Dept. Primary Industries and Fisheries	13 25 23	www.dpi.qld.gov.au
SA	Dept. Water, Land and Biodiversity Conservation	(08) 8303 9620	www.dwlbc.sa.gov.au
TAS	Dept. Primary Industries and Water	1300 368 550	www.dpiw.tas.gov.au
VIC	Dept. Primary Industries	13 61 86	www.dpi.vic.gov.au
WA	Dept. Environment and Conservation Dept. Agriculture and Food	(08) 9334 0333 (08) 9368 3333	www.naturebase.net www.agric.wa.gov.au



Karinga Creek August 2004



4.2 Declaration status

Athel pine is a declared, or “noxious” weed in all states and territories. Its legal status as at July 2008 is described state-by-state in the following paragraphs. Tamarisk and smallflower tamarisk do not have any legal weed status in Australia.

Australian Capital Territory

Class 4: Prohibited pest plant. A pest plant whose propagation and supply is prohibited.

New South Wales

Class 5: Restricted Plants under the *Noxious Weeds Act 1993*. Class 5 noxious weeds are plants that are likely, by their sale or the sale of their seeds or movement within the state or an area of the state, to spread in the state or outside of the state.

Northern Territory

Class B: Growth and spread to be controlled – Alice Springs region outside of town areas.

Class C: Not to be introduced to the Territory under the *Weeds Management Act 2001*.

Queensland

Class 3 weed under the *Land Protection (Pest and Stock Route Management) Act 2002*. Athel pine is established in the State and has, or could have, an adverse economic, environmental or social impact. A pest control notice can only be issued for land that is, or is adjacent to, an environmentally significant area. Class 3 plants cannot be sold. Species declared as Class 3 may be subject to local legal control outside environmentally significant areas.

South Australia

Class 10 & 11 under the *Natural Resources Management Act 2004*. Restricts sale only. South Australian legislation is currently under review to enable NRM authorised officers to require landholders to control athel pines deemed to be threatening watercourses.

Tasmania

Declared plant under the *Weed Management Act 1999*. Details on actual restrictions or measures are contained in the weed management plan for athel pine. Importation, sale or distribution of athel pine or anything contaminated with its propagules is prohibited. All land managers must control any athel pine with the aim of eradication.

Victoria

Restricted Weed under the *Catchment and Land Protection Act 1994*. Plants that do not occur in Victoria, but pose an unacceptable risk of spread if they were sold or traded.

Western Australia

P1 Prevention of trade, sale or movement under the *Agricultural and Related Resources Protection Act 1976*.

4.3 Mapping standards and photopoints

A *field manual for surveying and mapping nationally significant weeds* establishes a nationally agreed set of data to collect when mapping weeds. It also details how to monitor weed control using photopoints. A *field manual for surveying and mapping nationally significant weeds* can be downloaded for free or ordered as a free hard copy from the web site:

<http://www.daff.gov.au/brs>

> Land Management Sciences

> Weeds

> A field manual for surveying and mapping nationally significant weeds
Available in: PDF, Hardcopy and CD

4.4 Off-label permits for *Tamarix* and woody weed control

As at March 2008 current permits which allowed control of athel pine or tamarisks using proven methods were as follows:

State/territory	Active constituent	Permit number	Expiry date
Australian Capital Territory	various	PER9460	Sept 2011
New South Wales	-	No permit	-
Northern Territory	fluroxypyr and triclopyr	PER9936	June 2012
Queensland	various	PER7485	June 2009
South Australia	triclopyr	PER8897	May 2011
Tasmania	various	PER8949	Dec 2011
Victoria	-	No permit	-
Western Australia	various	PER9655	Mar 2012

In most cases, the permits referred to above are for the generic control of environmental weeds in specified situations, using a limited number of products. These permits may therefore not have been issued specifically for athel pine, tamarisk or smallflower tamarisk control, but are issued to allow the generic application of specified products to control various environmental weeds.

Land managers can search for off-label permits at the Australian Pesticides and Veterinary Medicines Authority web site:

www.apvma.gov.au

> Search for Permits



4.5 Mechanical clearing - permits and enquiries

Any land manager undertaking earthworks should call 1100 “Dial before you dig”.

Land managers undertaking earthmoving or other works along waterways in New South Wales should contact their CMA and the Department of Lands (1300 052 637) for information.

Land managers clearing vegetation in riparian areas in Queensland should contact the Environmental Protection Agency (1300 130 372) for information.

The clearance of ‘significant’ large trees in South Australia, including non native trees, in some metropolitan and fringing local government areas may require an approval from local councils under the significant tree provisions of the Development Act 1993. Contact your local council.

Land managers undertaking earthmoving or other works along waterways in Victoria should contact their CMA for information.

Land managers undertaking earthmoving or other works along waterways in Western Australia should contact their local government authority as a first point of call, then the following agencies:

Department of Environment and Conservation (DEC) – If infestations are growing in native vegetation which may be damaged by their control, land managers must contact the DEC’s Native Vegetation Conservation Branch to enquire about permits (08) 9219 8746.

www.naturebase.net

- > Document Downloads
- > Land
 - > Native Vegetation Conservation
 - > Fact sheets

Swan River Trust – In a Swan River Trust management area refer to the trust for advice (08) 9278 0900. See the Trust’s web site for details of its management area.

www.swanrivertrust.wa.gov.au

Department of Water (DoW) – A permit may be required for works along waterways and in catchment areas. Contact DoW prior to clearing infestations and ask to speak to the relevant regional office about whether the work requires a permit (08) 6364 7600.

www.water.wa.gov.au

- > Contact us

4.6 Protecting Indigenous cultural heritage

Mechanical clearing of *Tamarix* weeds could affect Indigenous cultural heritage sites.

Contact the relevant organisation in your state to find out your responsibilities in respect to Indigenous cultural heritage sites.

State and agency	Telephone number	Web site
Australian Capital Territory ACT Heritage Unit	13 22 81	http://www.tams.act.gov.au/live/heritage
New South Wales Dept. Environment and Climate Change	(02) 6883 5354 (north west)	www.environment.nsw.gov.au/licences
	(02) 6298 9701 (south)	
Northern Territory Aboriginal Areas Protection Authority	(08) 8952 6366	www.nt.gov.au/aapa
Northern Territory Dept. Natural Resources, Environment and The Arts Heritage Branch	(08) 8951 9247	www.nt.gov.au/nreta/
Queensland Dept. Natural Resources & Water	(07) 3238 3838	www.nrw.qld.gov.au
South Australia Dept. Premier and Cabinet	(08) 8226 8900	www.premcab.sa.gov.au
Tasmania Aboriginal Heritage Office	(03) 6233 6613	www.aboriginalheritage.tas.gov.au
Aboriginal Affairs Victoria	1800 762 003	www.dvc.vic.gov.au/aav
Western Australia Dept. Indigenous Affairs	(08) 9235 8000	www.dia.wa.gov.au

4.7 Machinery hygiene guidelines

Detailed instructions for preventing the spread of weeds by machinery and vehicles can be accessed at the following web sites:

www.dpi.vic.gov.au

- > Information Notes Series
 - > Weeds
 - > General
 - > Machinery Hygiene

www.dpiw.tas.gov.au

- > Weeds, Pests & Diseases
 - > Weeds
 - > Managing Weeds
 - > Washdown Guidelines



4.8 Herbaria

State/territory	Herbarium	Telephone number
Australian Capital Territory	Australian National Herbarium	(02) 6246 5108
New South Wales	National Herbarium of New South Wales	(02) 9231 8111
Northern Territory	Northern Territory Herbarium	(08) 8951 8792
Queensland	Queensland Herbarium	(07) 3896 9325
South Australia	State Herbarium of South Australia	(08) 8222 9308
Tasmania	Tasmanian Herbarium	(03) 6226 2635
Victoria	National Herbarium of Victoria	(03) 9252 2300
Western Australia	Western Australian Herbarium	(08) 9334 0500

4.9 More information on controlling athel pine

www.weeds.org.au

- > Weeds of National Significance
 - > Weeds
 - > athel pine

Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council and Forestry Ministers. Weeds of national significance athel pine (*Tamarix aphylla*) strategic plan. Launceston: National Weeds Strategy Executive Committee, 2000.

CRC Weed Management. Weed management guide athel pine or tamarisk – *Tamarix aphylla*, 2003.

Fuller M. Agnote athel pine (*Tamarix aphylla*). 1998.

Rangelands NRM Coordinating Group. Athel pine on Western Australian mine sites, no date.

4.10 References

1. Agriculture and Resource Management Council of Australia and New Zealand, Australian and New Zealand Environment and Conservation Council and Forestry Ministers. Weeds of national significance athel pine (*Tamarix aphylla*) strategic plan. Launceston: National Weeds Strategy Executive Committee, 2000.
2. Brown C, Grace, B. Athel pine in the Northern Territory: a strategic approach to eradication. In Managing weeds in a changing climate: 15th Australian weeds conference papers and proceedings, Adelaide: Weed Management Society of South Australia, 2006.
3. CRC Weed Management. Weed management guide athel pine or tamarisk – *Tamarix aphylla*, 2003.
4. Fuller M. Agnote athel pine (*Tamarix aphylla*). 1998.
5. Baum BR. The genus *Tamarix*. Jerusalem: The Israel Academy of Sciences and Humanities, 1978.
6. Leighton S. *Tamarix* species – how to tell the difference. Northern Territory: Department of Natural Resources, Environment and The Arts, 2007.
7. Gaskin JF, Schaal BA. Molecular phylogenetic investigation of U.S. invasive *Tamarix*. Systematic Botany 2003;26(1):86-95.
8. Di Tomaso JM. Identification, biology and ecology of saltcedar. In Proceedings the saltcedar management workshop, Rancho Mirage, 12 June 1996.
9. Di Tomaso JM. Impact, biology, and ecology of saltcedar (*Tamarix* spp.) in the southwestern United States. Weed Technology 1998;12:326-336.
10. Hart CR, White LD, McDonald A, Sheng Z. Saltcedar control and water salvage on the Pecos River, Texas, 1999-2003. Journal of Environmental Management 2005;75:399-409.
11. Hollingsworth EB, Quimby PC, Jaramillo DC. Control of saltcedar by subsurface placement of herbicides. Journal of Range Management 1979;32(4):288-291.
12. Young JA, Clements CD, Harmon D. Germination of seeds of *Tamarix ramosissima*. Journal of Range Management 2004;57(5):475-481.
13. Gaskin JF, Shafroth PB. Hybridization of *Tamarix ramosissima* and *T. chinensis* (saltcedars) with *T. aphylla* (Athel) (Tamaricaceae) in the southwestern USA determined from DNA sequence data. Madrono 2005;52(1):1-10.
14. Wilgus F, Hamilton KC. Germination of salt cedar seed. Weeds 1962;10(4):332-333.
15. Lesica P, Miles S. Ecological strategies for managing tamarisk on the C.M. Russell National Wildlife Refuge, Montana, USA. Biological Conservation 2004;119:535-543.
16. Tamarisk Coalition. Options for non-native phreatophyte control, March 2006.
17. Taylor JP, McDaniel KC. Restoration of saltcedar (*Tamarix* sp.)-infested floodplains on the Bosque del Apache National Wildlife Refuge. Weed Technology 1998;12:345-352.
18. Broken Hill Proprietary Company. *The evergreen athel tree*, 1948.
19. Fuller MR. The invasion and control of *Tamarix aphylla* on the Finke River, Central Australia. In Proceedings volume II 10th Australian weeds conference and 14th Asian Pacific Weed Science Society conference, 1993.
20. C Brown, B O'Hanlon. Face-to-face interview, 11 February 2008.
21. Zavaleta E. The economic value of controlling an invasive shrub. Ambio 2000; 29(8):462-476.
22. Bell DT, Wilkins CF, van der Moezel PG, Ward SC. Alkalinity tolerance of woody species used in bauxite waste rehabilitation, Western Australia. Restoration Ecology 1993;1(1):51-58.
23. Department of Agriculture and Food Western Australia, October 2004, viewed 05 February, 2008. http://www.agric.wa.gov.au/content/lwe/salin/smeas/plant_salt_tolerance.htm.
24. Ladenburger CG, Hild AL, Kazmer DJ, Munn LC. Soil salinity patterns in *Tamarix* invasions in the Bighorn Basin, Wyoming, USA. Journal of Arid Environments 2006;65:111-128.



25. Parsons WT, Cuthbertson EG. Noxious weeds of Australia. Collingwood, CSIRO Publishing, 2001.
26. Carpenter AT. Element stewardship abstract for *Tamarix ramosissima*, *Tamarix pentandra*, *Tamarix chinensis*, *Tamarix parviflora*, saltcedar, salt cedar, tamarisk. Arlington, Virginia, The Nature Conservancy, 1998.
27. Griffin GF, Stafford-Smith DM, Morton SR, Allan GE, Masters KA, Preece N. Status and implications of the invasion of tamarisk (*Tamarix aphylla*) on the Finke River, Northern Territory, Australia. *Journal of Environmental Management* 1989;29:297-315.
28. Rangelands NRM Coordinating Group. Athel pine on Western Australian mine sites, no date.
29. Leighton S. Tamarisk – a real risk for New South Wales. In Proceedings of the 14th Biennial NSW Weeds Conference, University of Wollongong, Wollongong, 25-27 September 2007.
30. Leighton S. Athel Pine – a real risk for Queensland. Proceedings of the ninth Queensland Weeds Symposium, 2007.
31. Waisel Y. The glands of *Tamarix aphylla*: a system for salt recretion or for carbon concentration? *Physiologia Plantarum* 1991;83:506-510.
32. D MacKenzie. Telephone interview, 19 March 2008.
33. L Tanner. Telephone interview, 27 March 2008.
34. Duncan CA, Jachetta JJ, Brown ML, Carrithers VF, Clark JK, Di Tomaso JM, Lym RG, McDaniel KC, Renz MJ, Rice PM. Assessing the economic, environmental, and societal losses from invasive plants on rangelands and wildlands. *Weed Technology* 2004;18:1411-1416.
35. Krza P. It's "bombs away" on New Mexico saltcedar. *High Country News*, 10 November 2003.
36. Owens MK, Moore GW. Saltcedar water use: realistic and unrealistic expectations. *Rangeland Ecology and Management* 2007;60:553-557.
37. Spies P, March N. Prickly acacia national case studies manual: approaches to the management of prickly acacia (*Acacia nilotica* subsp. *indica*) in Australia. Queensland: Department of Natural Resources, Mines and Energy, 2004.
38. N Turner. Face-to-face interview, 15 February 2008.
39. Wiesenborn WD. Saltcedar impacts on salinity, water, fire frequency and flooding. In Proceedings the saltcedar management workshop, Rancho Mirage, June 12 1996.
40. Kennedy TA, Finlay JC, Hobbie SE. Eradication of invasive *Tamarix ramosissima* along a desert stream increases native fish density. *Ecological Applications* 2005;15(6):2072 – 2083.
41. Bailey JK, Schweitzer JA, Whitham TG. Salt cedar negatively affects biodiversity of aquatic macroinvertebrates. *Wetlands*, 2001;21(3):442-447.
42. Department of Environment, Water, Heritage and the Arts, 16 November 2007, viewed 14 February 2008, <http://www.anra.gov.au/topics/rangelands/overview/nt/ibra-fin.html#fauna>.
43. Fuller M. Athel pine (*Tamarix aphylla*) control in central Australia: history and future directions. Alice Springs, Department of Primary Industries and Fisheries, 1996.
44. Leighton S. National tamarisk trips report 2007. Unpublished report to the National Athel Pine Management Committee, 2007.
45. W Dobbie. Telephone interview, 18 February 2008.
46. P Barker. Face-to-face interview, 18 February 2008.
47. National workshop on the prevention of weed spread. A national workshop held on 25 to 26 February 2005.
48. Pearce CM, Smith DG. Saltcedar: distribution, abundance, and dispersal mechanisms, northern Montana, USA. *Wetlands* 2003;23(2):215-228.
49. Leighton S. Athel pine control suggestions. Unpublished report to the National Athel Pine Management Committee, 2007.

50. P Morphett. Face-to-face interview, 11 March 2008.
51. Centralian Land Management Association, Department of Primary Industry and Fisheries. Eradication of athel pine, and monitoring response in the Finke River system, 1998.
52. McDaniel KC, Taylor JP. Saltcedar recovery after herbicide-burn and mechanical clearing practices. *Journal of Range Management* 2003;56:439-445.
53. Taylor JP, McDaniel KC. Revegetation strategies after saltcedar (*Tamarix* spp.) control in headwater, transitional and depositional watershed areas. *Weed Technology* 2004;18:1278-1282.
54. Duncan KW. Individual plant treatment of saltcedar. In *Proceedings: saltcedar and water resources in the West symposium*, San Angelo, 2003.
55. Baldwin T. Herbicide options: control of saltcedar with Garlon (triclopyr). In *Saltcedar management and riparian restoration workshop*, Las Vegas, September 17 and 18 1996.
56. Neill B. Putting it all together: management strategies and implementation. In *Saltcedar management and riparian restoration workshop*, Las Vegas, September 17 and 18, 1996.
57. M O'Connor. Telephone interview, 27 February 2008.
58. C Brown. Face-to-face interview, 28 February 2008.
59. J Pitt. Face-to-face interview, 20 March 2008.
60. Hudgeons JL, Knutson AE, Heinz KM, DeLoach CJ, Dudley TL, Pattison RR, Kiniry JR. Defoliation by introduced *Diorhabda elongata* leaf beetles (Coleoptera: Chrysomelidae) reduces carbohydrate reserves and regrowth of *Tamarix* (Tamaricaceae). *Biological Control* 2007;43(2007):213-221.
61. DeLoach CJ, Lewis PA, Herr JC, Carruthers RI, Tracy JL, Johnson J. Host specificity of the leaf beetle *Diorhabda elongata deserticola* (Coleoptera: Chrysomelidae) from Asia, a biological control agent for saltcedars (*Tamarix*: Tamaricaceae) in the western United States. *Biological Control* 2003;27(2003):117-147.
62. Milbrath LM, DeLoach CJ. Host specificity of different populations of the leaf beetle *Diorhabda elongata deserticola* (Coleoptera: Chrysomelidae), a biological control agent of saltcedar (*Tamarix* spp.). *Biological Control* 2006;36(2006):32-48.
63. Milbrath LR, DeLoach CJ, Tracy JL. Overwintering survival, phenology, voltinism, and reproduction among different populations of the leaf beetle *Diorhabda elongata* (Coleoptera: Chrysomelidae). *Environmental Entomology* 2007;36(6):1356-1364.
64. McNaught I, Thackway R, Brown L, Parsons M. *A field manual for surveying and mapping nationally significant weeds*. Canberra: Bureau of Rural Sciences, 2006.
65. United States Fish and Wildlife Service. 2008, viewed 1 April 2008, <http://www.fws.gov/southwest/refuges/newmex/bosque/about.html>.
66. Bay RF, Sher AA. Success of active revegetation after *Tamarix* removal in riparian ecosystems of the southwestern United States: a quantitative assessment of past restoration projects. *Restoration Ecology* 2006;16(1):113-128.