15th Biennial NSW Weeds Conference 2009

The Old and The New
(Changes in Weed Management)

Monday 14 - Thursday 17 September 2009
The Crossing Theatre, Narrabri, NSW, 2390
www.weedsconference.com

Conference Proceedings

15TH BIENNIAL NSWWEEDS CONFERENCE 2009

15th Biennial *NSW Weeds* Conference

The Old and The New
(Changes in Weed Management)

2009

Northern Inland Weeds Advisory Committee

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Narrabri Shire
Heart of the North West

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The 15th Biennial NSW Weeds Conference would like to acknowledge the generous support of the following sponsors:

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Invitation to Attend

The organising committee of the 15th Biennial NSW Weeds Conference are delighted to extend an invitation to you to participate in this year's conference "The Old and The New' (Changes in Weed Management). The Conference is to be held at The Crossing Theatre, Narrabri from 15 - 17 September 2009.

Narrabri Shire has long been renowned for its agricultural wealth in beef, wheat, sheep, and cotton as well as the natural beauty of the nearby Mt Kaputar National Park, with its volcanic peaks which provide a spectacular contrast to the fertile plains beyond. The Conference venue is The Crossing Theatre. This purpose built convention centre and entertainment precinct is located on the banks of the Namoi River and is the cultural and social heart of the Narrabri Shire.

The conference will provide many opportunities for making new contacts and for renewing ongoing friendships. The field tours will allow attendees to see "big farming" or to explore the natural world of Mt Kaputar and the Nandewar Ranges.

Above all else, we extend to you the country hospitality of Narrabri Shire, and we look forward to your attendance and participation in the 15th Biennial NSW Weeds Conference, 2009.

Kind Regards

Philip Blackmore
Conference Chair

15th Biennial NSW Weeds Conference Organising Committee

Philip Blackmore	NSW Department of Primary Industries - Conference Chair
Syd Lisle	NSW Department of Primary Industries
Birgitte Verbeek	NSW Department of Primary Industries
Elissa James	Narrabri Shire Council
Bill Birch	Narrabri Shire Council
Lee Amidy	Gunnedah Shire Council
Peter Scott	Liverpool Plains Shire Council
James Browning	New England Weeds Authority
Scott Kermode	New England Weeds Authority
Cr Maria Woods	Northern Inland Weeds Advisory Committee
Andrew Schweitzer	Namoi Catchment Management Authority

Conference Organiser

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Ph: + 61 2 6799 6866 Fax: + 61 2 6799 6888
Email: secretary@weedsconference.com
www.narrabri.nsw.gov.au

Who should attend?

- Government Representatives including, Local, State and Federal
- Private Sector Representatives including, Contractors and Consultants
- Environmental Organisations
- Community Groups including, Bushcare and Landcare Volunteers
- Farmers
- Members of the general public

Why attend?

We are on the cusp of significant change in the way the NSW Government supports public weed management. These changes and other questions will be addressed at the 15th Biennial NSW Weeds Conference to be held at The Crossing Theatre, Narrabri from the 15th to 17th September 2009.

The conference theme is "The Old and the New" (Changes in Weed Management). The program has a broad range of presentations across this theme to cater for the interests of all who will be attending. The conference has attracted speakers from across Australia.

Conference delegates will have the opportunity to hear about the success and challenges of specific weed management campaigns, new weed control techniques and future opportunities revealed through new research. New technologies will be showcased and an extended session on the new approach to noxious weed grant funding will be extremely topical for all local control authorities.

A particular feature of this conference will be presentations from many weeds officers. These presentations will cover a range of topics including:

- the changing roles of weeds officers
- organisational structure for noxious weed management
- species management and
- new approaches to inspection

Keynote Speaker

Professor Leslie Weston is Strategic Research Professor, Plant Biology and Weed Science at Charles Sturt University, Wagga Wagga.

Professor Weston is a highly regarded weed scientist with an extensive academic career. She has specialities in the utilisation of allelopathy, weed competitiveness and weed ecology and genetic variation.

Professor Weston came to Charles Sturt University after 10 years as Associate Professor, Alternative Weed Management Systems at Cornell University, Ithaca, N.Y, USA.

Conference Program Day 1

Day 1

Tuesday - 15th September 2009
Opening Session

8:30	Welcome to Country	
8:35	Welcome to Conference - Mayor	
8:45	Conference Opening – Minister	
9:00	Keynote Speaker - Professor Leslie Weston	
9:30	Headline Speaker - The PECA Principle - Scott Charlton	
10:00	Morning tea	
Mid Morning Session Concurrent Sessions	Weeds & NRM	Response to new weeds
10:30	• CMA Report - Andrew Schweitzer	• Mexican Feather Grass incursion response in Victoria - Vic DPI
11.00	• Managing Weeds for Biodiversity Conservation - Leonie Whiffen	• Pathway Risk Analysis for weed spread and best practice for detection of weeds on Aust. Farms - Prof. Brian Sindel
11:30	• Defeating the Weed Menace R&D - Dr Judy Lambert	• Ponded pasture grasses and the potential for introduction of invasive weeds - Des Boorman
12:00	Lunch	
Mid Afternoon Session Concurrent Sessions	Education and Awareness	Aquatic & Environmental Weed Management
1:00	• Old Dogs New Tricks - Steven Honeywood & Jodie Bartlett-Taylor	• Lippia: Ecology and potential for bio-control - Dr Mic Julian
1:30	• Engaging landholders in weed ID - Clare Edwards	• Alligator Weed and Cabomba bio-control research - Dr Shon Schooler
2:00	• Spreading the Word on Weeds - Education and Awareness principles from the WoNS programs - Hillary Cherry	• Control of Environmental Weeds: an Integrated Framework for Natural Resource Management - Dr Matt Colloff
2:30	• Miconia in Northern NSW - An example of cross-border, multi jurisdiction cooperation - Ross Garsden	• Long term control of Maderia Vine and Cats Claw Creeper - Tony Cook
3:00	Afternoon tea	
Afternoon Session Plenary Session		
3:30	NRM capacity building for LGA's - Geoff Hudson - LGSA	
4:00	NSW Invasive plant species incursions plan - Scott Charlton - 15 minutes only	
4:15	The new NSW Weeds Grants allocation process - Lisle, Carter, Verbeek	
5:15	Session Ends	
5:20	NSW Noxious Weeds Officers Assoc. AGM	
6:30	Dinner at Narrabri RSL Club	

Conference Program Days 2 & 3

Day 2
Wednesday - 16th September 2009

7:30	Breakfast
8:30	Technology Expo
Mid Morning Session	New Technology
10:00	Dow Agroscience - Chris Love
10.30	Robotic Aircraft for Aquatic Weed Detection - Salah Sukkarieh
11:00	Weed Tracer - Mark Daley, Mike Whitney LPSC and Andrew Schweitzer
11:30	Splatter Gun - Ken England NPWS (DECC)
11:45	Namoi CMA
12:00	Reg Kidd - NWAC Chairman
12:15	Lunch
12:45	Tours
6:30 for 7:00	Conference dinner

Day 3
Thursday - 17th September 2009

Morning Session Concurrent Sessions	The Changing Roles of Weeds Officers	Organisational Approach
8:30	• Multi-skilling - Roger Smith	• NSW Local Government Weeds Survey 2007/08 - Rob Williamson & Sean Brindle
8:55	• A Busy Life - Terry Schmitzer	• Structures for weed management - Ian Turnbull
9:20	• Reflections, connections, and as I see it - Peter Scott	• The Riverina Eastern Noxious Weeds Authority - Robert Ferguson
9:45	Morning tea	
Mid Morning Session Concurrent Sessions	Terrestrial Weed Management	Aquatic and Environmental Weed Inspection and Control
10:15	• Silverleaf nightshade – silverleaf nightmare or just a bad memory? - Dr Rex Stanton	• Natural Disasters and Weed Dispersal - Brian Worboys and Kevin Folpp
10:40	• The Hudson Pear Task Force: a coordinated weed management program in Western NSW - Ian Kelly and Claire Bergin	• Water Lettuce Eradication in the Dumaresq River (Qld-NSW border) - John Conroy
11:05	• Exploring Management Options to Make More Productive Use of African Lovegrass - Luke Pope	• Alligator Weed control in the Richmond River catchment - Rod Ensbey- Robert Ferguson
11:30	• Serrated Tussock - an on-farm approach - James Browning	• Development of a sub-catchment model for NW inspections in the Blue Mountains - Chris Dewhurst
11:55	• Cineraria lyratiformis - Wendy Bushell	• Backyard Blitz in Brooms Head - Reece Luxton
12:20	Lunch	
Afternoon Session		
1:30	Gingham Watercourse Water Hyacinth - Paul Sullivan and Philip Blackmore	
2:00	NSW Weed Risk Management System - Stephen Johnson	
2:30	Aboriginal Green Teams - Wayne Deer	
3:00	Conference Overview - Cr Maria Woods	
3:30	Afternoon tea and Conference Close	

Field Trips

Date: Wednesday 16 September 2009
Time: 12.45pm - 5:00pm
Cost: Included in Full Delegate and Wednesday Day Registrations.

Two field trip itineraries have been arranged for delegates to enjoy. These feature tourist attractions of Narrabri Shire as well as visits to broad acre farms and agricultural research stations to view weed control measures utilised at these facilities.

Field Trip One

Delegates will commence their field trip outside The Crossing Theatre where they will be greeted by their tour host. A scenic ½ hour bus trip from Narrabri will take them to Sawn Rocks, one of the Shire's most spectacular attractions at the foot of the Nandewar Ranges. There, they will be met by National Parks and Wildlife Services staff who will guide them to this geological wonder. The staff will explain how Sawn Rocks was formed as well as detail any weeds problems they have experienced within the wider National Park and the measures taken to alleviate the problems.

Following the visit to Sawn Rocks, delegates will be transported to Auscott, one of Australia's leading cotton growers/processors. Auscott plays a primary role in this industry and enjoys a first class international reputation in shipping and marketing. Delegates will be shown around the impressive facilities including the cotton processing gin which is operated to the highest standards in the world. Delegates will get a chance to experience large scale irrigation activities and while touring the property will discuss with farm managers and agronomists the farming techniques, water use efficiency and science used in running this large operation.

Field Trip Two

Delegates will commence their field trip outside The Crossing Theatre where they will be greeted by their tour host. A 20 minute bus trip will take them to the CSIRO Australian Telescope Compact Array, the largest and most powerful radio telescope in the Southern Hemisphere. The array, consisting of six 22 metre antennas and is capable of receiving signals one thousand times higher in frequency than FM radio stations. Delegates will enjoy a guided tour of the operations and antennas.

After visiting this science hub they will travel onto Wee Waa, the oldest town in the Namoi Valley. Along the way will be a stop at Seplin Estate Wineries. The Widauer family established their vineyard on these fertile chocolate loam soils. With the warm summer sun, the grapes produce excellent sugar and colour which result in an early harvest. The Widauer family have a superb range of award winning red and white wines and ports. Enjoy a drop in their cellar door which is a refurbished school woodwork room dating back to 1934 or take a tour of the vines.

From the winery delegates will then travel through Wee Waa and onto the Australian Cotton Research Institute. This scenic trip will take delegates on a trip through the flood plains next to the Namoi River. At the Australian Cotton Research Institute delegates will be met by scientists and be given a tour around the grounds and facilities. Delegates will view cotton trials and learn about the research being conducted through the institute.

Breakfast Expo

Date: Wednesday 16th September 2009
Time: 7.30am - 10.00am
Venue: Foyer and Lawns of the Crossing Theatre

A feature of this year's conference will be the morning breakfast expo held in the foyer and on the lawns of The Crossing Theatre. Delegates will be able to observe practical demonstrations of current and developing weed technologies.

Social Program

Welcome Reception

Date: 14th September 2009
Time: 5.30pm - 7.30pm
Venue: The Crossing Theatre - Foyer
Dress Code: Smart Casual

You are invited to attend the conference welcome reception. This is an opportunity to welcome you to the conference and for you to meet fellow delegates whilst enjoying drinks and canapés.

One ticket is included in full registrations. Please indicate your intention to attend on your registration form.

Additional tickets cost: $35.00p.p inc GST

Informal Conference Dinner

Date: 15th September 2009
Time: 6.30pm
Venue: RSL Club, Narrabri

Unwind with friends and colleagues over a relaxing buffet dinner at the Narrabri RSL Club.

One ticket is included in full registrations. Please indicate your intention to attend on your registration form.

Additional tickets cost: $35.00p.p inc GST

Conference Dinner

Date: 16th September 2009
Time: 7.00pm - 12 midnight
Venue: The Crossing Theatre, Narrabri
Dress Code: Smart Casual

Enjoy an evening of delicious food, fine wine and entertainment at Narrabri's finest entertainment venue, The Crossing Theatre. This is an opportunity for you to get together with new and old friends for a fun-filled evening.

One ticket is included in full registrations. Please indicate your intention to attend on your registration form.

Additional tickets cost: $75.00p.p inc GST

Conference Field Trips

Date: 16th September 2009
Time: 12.45 - 5.00pm
Departure: The Crossing Theatre

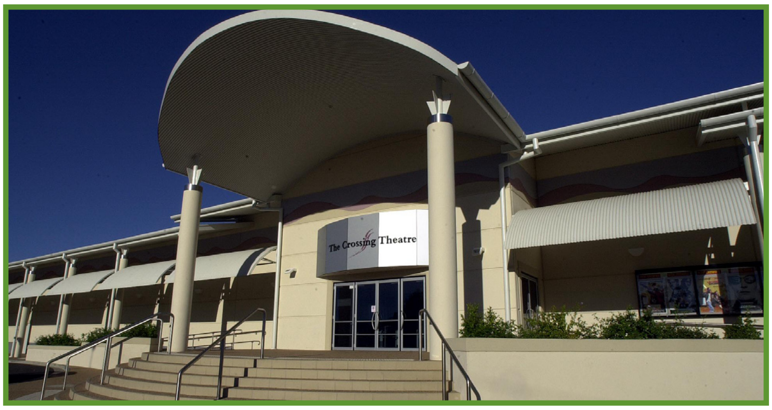
Two very interesting field trip options have been developed for delegates to experience taking in tourist attractions, agricultural and research sights.

Field Trip 1 - Sawn Rocks and Auscott
Field Trip 2 - CSIRO Australian Telescope Compact Array, Seplin Estate Winery and the Australian Cotton Research Centre.

Additional Tickets Costs: $25.00p.p inc GST

General Information

Venue: The Crossing Theatre
Newell Highway
Narrabri NSW 2390
www.crossingtheatre.com.au



The Crossing Theatre is the main function centre for Narrabri Shire and the North West region of New South Wales. The Crossing Theatre is an impressive and contemporary multi purpose venue that opened in July 2003. It is located in the town of Narrabri on the banks of the picturesque Namoi River.

Accommodation

There are a number of excellent accommodation options in the Narrabri Shire ranging from Motels, Bed and Breakfast and Caravan Parks with self contained cabins. The shires accommodation guide has been placed on the conference website which contains all contact details. It is the delegates own responsibility to arrange their accommodation. If you require any assistance or have any questions in relation to accommodation, please contact our Visitor Information Centre on (02) 6799 6760.

Narrabri Shire...How do I get there? Narrabri Shire is a transport hub and is situated on the crossroads of the Newell and Kamilaroi Highways. It is equal driving distance to Sydney and Brisbane.

Road: The Newell Highway runs from Melbourne to Brisbane through some of Australia's most productive agricultural country. The Kamilaroi Highway intersects Narrabri Shire drawing tourists from the New England Highway.

If passenger transport is what you need Narrabri Shire is serviced by coach companies who travel from Brisbane, Melbourne and Sydney and all towns in between.

Rail: CountryLink's Sydney train service, stops at the towns of Boggabri and Narrabri. This line travels through the Hunter Region and Newcastle on its journey to Sydney.

Air: The town of Narrabri has a twice-daily Aeropelican service to Sydney. The travel time to Sydney by plane is little over 1 hour. To book online or view their timetable go to www.aeropelican.com.au.

Distances from Narrabri Shire

DISTANCES	TRAVEL TIMES
Sydney - 560km	6 hours
Brisbane - 580km	6 hours
Tamworth - 180km	2 hours
Dubbo - 280km	3 hours
Melbourne - 1,105km	12 hours
Canberra - 695km	8 hours

Distances within Shire

DISTANCES WITHIN SHIRE	TRAVEL TIMES
Narrabri-Wee Waa	35mins
Narrabri-Boggabri	40 mins
Narrabri-Edgeroi	20mins
Narrabri-Bellata	30mins
Narrabri-Pilliga	1hour
Narrabri-Gwabegar	1.2 hours

What else can I see in the Narrabri Shire?

If you like variety in an area, then Narrabri Shire is sure to have what you're looking for. Our Shire covers 13,000 km, and is the heart of the rich Namoi Valley in North West NSW. It is renowned for the production of some of the world's highest quality wheat, cotton, fat lambs and beef. The presence of several research facilities in the Shire bears testimony to this. All this is joined by a wealth of excellent tourist attractions for the visitor to enjoy.

The Newell and Kamilaroi highways run through the Shire bringing people from all compass points. Our Shire proudly offers major attractions to our local tourists, overseas visitors and many businesses.

The clarity of the air has encouraged the scientific growth of the Australia Telescope Compact Array of radio telescopes, sometimes referred to as 'the big woks'. The natural wonder of the Nandewar Ranges and Mt Kaputar National Park will keep even the most reluctant of bushwalkers enthralled, while the state-of-the-art Australian Cotton Centre is sure to impress.

Add farm holidays, historical museums, Yarrie Lake, artesian bore baths, art shows or visiting cultural productions to this mix and you're guaranteed many fun filled days in Narrabri Shire. The Crossing Theatre, showing the latest release movies, modern shops and a warm welcome also await, promising unforgettable memories of your visit.

For more information and brochures on these fabulous attractions please call into the Narrabri Shire Visitor Information Centre and the staff would be more then happy to help you with your enquiries.

- The Australia Cotton Centre - From Field to Fabric
  Open: 7 days, Monday - Friday 8.30am - 4.30pm, Weekends 8.30am - 2pm
  Allow: 1 - 2 Hrs

- Mt Kaputar National Park
  Pronunciation of Kaputar: Cap-you-tar
  Distance - 52kms one way East of Narrabri
  Allow: Minimum 3 Hrs

- Sawn Rocks
  Distance - 33kms one way on the Bingara Rd
  Allow: 2 Hrs

- CSIRO Australia Telescope
  Open: 7 days, 8.30am - 4.30pm
  Allow: 1 Hr

- Namoi Echo Museum - Wee Waa
  Open: Thursday 11am - 2pm, Friday 10am - 2pm and Saturday 10am - 4pm
  Allow: 1 Hr

- Narrabri Gaol and Museum
  Open: Saturday and Sunday 11am - 3pm
  Allow: 1 Hr

Registration

Tuesday 15th September 2009:
On arrival at the venue, conference registration will be conducted at the registration desk located in the Exhibition Room at The Crossing Theatre.

The registration desk will be open between the following times:

Monday	14th September 2009:	4.30pm - 7.30pm
Tuesday	15th September 2009:	7.00am - 5.00pm
Wednesday	16th September 2009:	7.00am - 1.00pm
Thursday	17th September 2009:	7.00am - 3.30pm

Registration and Payment
Registration brochures must be downloaded from www.weedsconference.com completed with payment option and sent to:

Weeds Conference 2009
Narrabri Shire Council
PO Box 261
Narrabri NSW 2390

Registration Type	Registration Fee
Early Bird - Standard Registration up to ***30/07/2009***	$590.00
Full registration - Standard - 1/08/2009 to 31/08/2009	$680.00
Standard Day Tuesday or Wednesday only *No day rate available for Thursday due to half day	$360.00

NB. All prices include GST.

Registration Entitlements	Full Registration	Day Registration
Conference Sessions	√	*√
Conference Satchels & Program	√	*√
Welcome Reception	√	$35.00
Official Conference Dinner	√	$75.00
Field Trip	√	*√

*Conference sessions are only accessible on designated day of each day registration.

THE DEADLINE FOR ALL REGISTRATIONS is Monday 31st August 2009
Registration or payment made after this date will incur a $50.00 late registration fee.

Payment can be made by direct debit, credit card (MasterCard or Visa) or Cheque in Australian Dollars.
Cheque must be made payable to: **Narrabri Shire Council**

Please address all registration forms and cheques to:

Narrabri Shire Council

Post: PO Box 261
Narrabri NSW 2390

Fax: (02) 6799 6888
Email: Council@narrabri.nsw.gov.au

Cancellations and Amendments
Registration cancellations and amendments must be sent in writing either by mail, fax or email to Narrabri Shire Council.

Registration cancellations received up to and including Friday 14th August 2009 will receive a full refund, less AUD $110.00 administration fee. Registration cancellations received after Friday 14th August 2009 and up to Monday 4th September 2009 will receive a 50% refund, less AUD $110.00 administration fee. No refunds will be given for registration cancellations received after Monday 4th September 2009. As an alternative to cancellation, your registration may be transferred to another person up to 15 days prior without receiving any extra cost penalty. Transfers made 14 days prior and less will incur a $25.00 transfer fee.

Disclaimer
The speakers, topics and times are correct at the time of printing. In the event of unforseen circumstances, the organising committee reserves the right to delete or alter items in the Conference Program.

Liability/Insurance
In the event of industrial disruptions or natural disasters, the Narrabri Shire Council, NSW Department of Primary Industries and Northern Inland Weeds Authority cannot accept responsibility for any financial or other losses incurred by the delegates or offer refunds on registration and social events. Nor can the Narrabri Shire Council, NSW Department of Primary Industries and Northern Inland Weeds Authority take responsibility for injury or damage to persons or property occurring during the conference to associated activities. Insurance is the responsibility of the individual delegate.

KEY FACTORS INVOLVED IN THE ESTABLISHMENT OF INVASIVE, NON-NATIVE WEED SPECIES IN THE UNITED STATES AND AUSTRALIA

– Where Will The Research Go From Here?

Leslie A. Weston
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Ecology of weed invasion.

Weeds have invaded both terrestrial and aquatic areas across Australia, with some dramatically reducing our productivity and quality of life. They have co-evolved with our systems of land use, and the methods we have developed for their management have proven to be major contributions to modern agriculture. Despite these developments, weeds continue to cost the global economy billions of dollars annually (Westbrooks 1998). In Australia, it is estimated that losses due to invasive weeds total more than 4 billion dollars annually (Cunningham et al 2004). Due to their remarkable ability to reproduce and spread, invasive terrestrial weeds are impacting our agricultural productivity, reducing the quality of our pastures and livestock, and also limiting our ability to preserve and protect the diversity of native species and landscapes (Levine 2000; Lonsdale 1999; Westbrooks 1998).

In Australia, many plant species initially introduced as food and fodder, medicinals, potherbs and ornamentals have become highly invasive. Some of these species have become invasive within years of being introduced, while others have exhibited long lag times after initial arrival before becoming widespread. It is not unusual for many weed species to have exhibited long lag times after initial arrival in Australia before becoming widespread. This has been well documented in Europe (Kowarik 1995) but is less well documented in Australia. Lag time to successful invasion may be influenced by environmental conditions experienced at the point of introduction, conditions experienced after introduction, and/or the frequency of unique introductions within a region.

There are likely many factors involved in a plant's ability to become a successful invader In a new non-native region. These included the following:

1) Ability to successfully reproduce by seed and disperse huge quantities of seed
2) Multiple means of reproduction; perennials can also reproduce vegetatively by underground plant parts
3) Ability to tolerate environmental stress and adapt to a changing environment
4) Exhibit diversity – genetic diversity versus phenotypic or morphological diversity
5) Ability to produce phytotoxins which limit the spread of neighboring plants and toxins which impact herbivores, pathogens and insects and serve as plant protectants

Although it is not currently understood what factors are implicated in a successful plant invader's ability to become highly invasive, it has become clear that rapid evolutionary change in invasive weeds, both annuals and perennials, is a common ecological phenomenon, particularly in ecosystems that are perturbed by human disturbance (Elton 1958; Levine 2000). Biological invasions that are fostered by rapid evolutionary change raise the question of the relative importance of phenotypic plasticity and potential for genetic change among weedy species.

In my research program at CSU, we are interested in the following related research ideas:

1) What are the factors that allow a non-native invasive to become most successful in an invasive site?
2) What is the time frame for invasion success? – how long after a species is introduced will it become widely invasive?
3) Which modes of reproduction and dissemination contribute to its ability to spread?
4) Does rapid genetic change in the species (since the time it was introduced) contribute to its ability to become invasive?
5) Does the plant exhibit allelopathic tendencies that contribute to invasion success ? – does it produce toxins that impact other organisms?

Black and pale swallow-wort – examples of invasion success in the Northeastern U.S. and Canada

My research program in the U.S. recently focused on the study of non-native invasive weeds that impacted pasture, cropping sites and natural areas across New York State. One set of related weeds was of great interest to us, as they are closely related perennial vines that were introduced to New York and Canada, but at different times and places. They have since invaded and their ranges of infestation have recently converged across N.Y. State. Black and pale swallow-wort (*Vincetoxicum nigrum* and *V. rossicum*) are invasive plants that were introduced into the Northeastern U.S. over 100 years ago from the Ukraine and the Iberian peninsula, respectively (Di Tommaso et al. 2005). In their native range, these vines are relatively rare and non-invasive, but in invaded areas of North American they have spread aggressively and establish dense thickets. They have replaced native flora, threatened rare populations of endangered plants and whole ecosystems in western NY, and led to reductions in insect and bird species in old-field sites (DiTommaso et al. 2005, Douglass et al. 2009). They are now moving into pasture and cropland settings where they have become problematic in no-till settings, in orchards, nurseries and pastures as well as natural settings such as parks and reserves. Some have been forced to abandon their land as they are extremely difficult to control, either chemically or using cultural practices.

Vegetatively, the two species are nearly identical and are distinguishable mainly by their flower color and follicles. Both species produce large quantities of seed, many of which are polyembryonic, meaning that they have more than one embryo producing a viable plant per seed. While these species have a large root to shoot ratio, with a large underground portion of biomass, it appears that the rhizome- like roots formed by black swallow-wort do not contribute to the species ability to reproduce or spread (Averill, 2009). Spread appears to be associated mainly with seed dispersal. Grazing animals typically avoid this species in pastures, as it produces a number of secondary products that make it unpalatable. However, if left unchecked, it rapidly spreads throughout grazing lands where it had initially established.

Black and pale swallow-wort were traditionally used as medicinals in their native ranges, containing numerous secondary products of interest. The roots of related swallow-wort species are known to contain the poisonous glycoside vincetoxin (Weston et al. 2005).

Others have reported numerous alkaloids in the stems, fruit, roots and leaves of the plant which likely contribute to its anti-fungal, anti-bacterial and anti-feedant properties. We do know that the plants, when consumed in small quantities, can be extremely toxic to grazing animals, in studies performed with goats who ingested these materials. Alkaloids are known to be potent inhibitors of DNA and protein synthesis and may play a function in interrupting neurotransmissions in mammalian systems (Douglass et al. 2009; Wink et al. 1999).

I will present some of our work evaluating both black and pale swallow-wort infestation across New York State. This work can be used as a model, in fact, for some of the studies we wish to conduct on many non-native invasive weeds in Australia. In our studies in New York State, we wished to obtain more basic information about the biology and ecology of these two little-studied weed pests, so we could better understand how to manage this species and consider the potential for the development of biocontrol strategies. In particular, we wished to study the invasive range of these two species across N.Y. State, their ability to spread across this invasive range in time, their ability to suppress other neighboring plants by production of plant toxins, or allelopathy, as well as their inherent genetic variability or genotypic diversity. We had observed that various populations exhibited great physical diversity and we wondered if this diversity also had a genetic basis versus an environmental basis. Our findings will be summarized in my presentation and are the subject of several papers by Cameron Douglass, a former student who worked on this research project for his M.S. degree, that are currently submitted for publication.

Most recently, my program in Australia has been developing, with an emphasis on root physiology as well as ecology of weeds of pasture, crop and rangelands of Southern Australia. We are particularly interested in one weed which has become widely invasive across millions of acres of pasturelands and yet has been little studied in the literature.

Paterson's curse – a noxious non-native invasive.

Paterson's curse (*Echium plantagineum*), also known as Salvation Jane or Riverina Bluebell, is a plant that has become widespread in inland Australia, from south-east Queensland, to New South Wales, to southwest Western Australia (Adams, 2000; Piggin 1982).. Paterson's curse was thought to be introduced to Australia in the 1880's from Europe as an accidental contaminant of pasture seed and as an ornamental plant. It's name is thought to derive from the experience of the Paterson family, early settlers around Albury NSW, which brought the seed from Europe to beautify their garden, but instead observed infestation of pastures and grasslands for miles around (Carter, 2009; Land Care Notes, VDPI). Originally a native of the Mediterranean, Paterson's curse has now become naturalized over 30 million hectares of grazing land. In 2002, it was estimated to cost the Australian wool and meat industries over A$125 million per year (Carter, 2009; Piggin, 1982).

Paterson's curse can completely dominate a mixed community of grasses and forbs as it is highly dominant and suppresses growth of neighboring species over time. A prolific reproducer, it has been estimated to produce up to 30,000 seed per square meter (Burdon et al., 1988; Carter, 2009; Piggin 1982). It is thought that seed remains dormant for up to 6 years in the soil seed bank, but most appears to germinate within 2 years. Seed germination is encouraged by high levels of moisture encountered in the fall and moderate soil temperatures. It is also highly resistant to drought, and dominates grasslands in exceptionally droughty conditions, germinating rapidly after drought is broken. Paterson's curse is also a serious threat to natural areas and has potential to spread to woodlands, native prairies, and dry upland slopes. Recently, it has become a noxious weed in Oregon in the USA, after first detection in 2003 (Butler, 2004).

Seed is also readily dispersed on animal fur, by bird or animal ingestion, via water and also as a hay or grain contaminant, with spread potentially associated with movement of grain and hay along the rail lines through Southern Australia. Its invasion may also have been assisted by habitat degradation as well. Livestock overgrazing and the introduction of the rabbit has caused degradation of bush and grasslands, and appears to be associated with rapid infestation by Paterson's curse (Bird, 2007; Piggin, 1982). Despite the information available in recent on-line bulletins and the few publications available, much of which appears to be anecdotal, little has been published in refereed publications on its biology and ecology or its ability to interfere with native plant growth.

Toxicity and chemistry of Paterson's curse.

Paterson's curse is known to be extremely toxic to livestock, particularly horses and pigs (Adams, 2009; Peterson and Jago, 1984). It produces a series of pyrolizidine alkaloids in its shoots which when metabolized in mammalian organs cause cell death in the liver, kidneys and lungs (Peterson and Jago, 1984). Although horses are most sensitive to these alkaloids, grazing sheep can tolerate their presence, but often show serious impacts upon wool quality and weight, up to a year after ingestion. Under normal conditions the plant is often avoided by grazing animals, likely due to its coarse leaf hairs and bitter taste. However, in droughty conditions or when Paterson's curse becomes the dominant species, it less avoidable by livestock. It is almost impossible for most livestock not to have some intake of this weed in its rosette form when pastures are green and well-established in spring. Over time, it causes gradual and accumulative liver damage in livestock (Adams, 2009).

We have recently observed that Paterson's curse exhibits unique morphological and ecological traits which would lead one to suspect that it is highly allelopathic to neighboring plants as well as toxic to mammalian systems. In particular, it exhibits two types of root hairs, long and short, both of which appear to be involved in active exudation processes in the plant (Tsai et al 2003). We have discovered that the epidermis of both its younger lateral roots and older taproots produce extremely unusual, bright red- colored chemical constituents which are localized in the outer epidermal layers of its roots. Upon microscopic investigation, the compounds appear to be contained within vesicles or vacuoles which are produced intracellularly in the epidermis of roots (McCully and Weston, personal observation 2009). Most production occurs in younger root tissue, as older sloughed off epidermal cells likely contain oxidized or polymerized by products or metabolites of these components. This oxidative process apparently turns the older roots a remarkable black or dark red color, whereas younger roots exhibit a bright red epidermal layer. Although production of unique secondary products in roots is not unknown and is reported in plants which are known producers of phytotoxins, antimicrobials and antifungal constituents (Bertin et al. 2007; Duke 2007; Weston and Duke, 2003), the production of red pigmented derivatives in higher plants is very unusual. Brigham et al 1999 reported the existence of pigmented napthoquinone derivatives of shikonin in *Lithospermum erithrorhizon* roots. In this case, pigment production could be induced by abiotic and biotic elicitors in cell culture. In the developed root itself, the pigment was observed in root tips, root hairs and outer layers of epidermal cells of lateral roots, all of which were red with the presence of the pigment. The pigment consisted of a mixture of napthoquinones, several of which were biologically active. These compounds proved to be potent inhibitors of certain soil microbes. Hyphal presence of various pathogenic fungi caused an increase in production of these constituents in cell suspension cultures.

Other plants in the borage family. Interestingly, the *Lithospermum* spp. along with Paterson's curse are members of the borage family. Borage family members are distributed worldwide and napthoquinones from these plants have been used as colorants for food, cosmetics and fabrics (Jain and Mathur, 1965; Tabata and Fujita, 1985). They also have medicinal applications and demonstrate antitumor, anti-inflammatory and antimicrobial activity (Tabata and Fujita, 1985). Shikonin and its derivatives are recognized as valuable pharmaceutical agents because of their antimicrobial properties (Brigham et al., 1999). However, it seems likely that these compounds also play an important role in plant defense in the rhizosphere (Uren, 2000). After evaluating the preliminary chemical composition of the extracts of both younger lateral and older tap roots of Paterson's curse, we have evidence that napthoquinones are also present (Weston, unpublished results 2009). Napthoquinones such as juglone are active as allelochemicals (Bertin et al., 2003; Binder et al., 1989; Weston and Duke 2003) and also in plant –insect interactions. They are known inhibitors of electron transport (Brigham et al, 1989; Hauska, 1988). Many of these compounds appear to be produced in response to multiple stresses in the environment and lead to the further production of antimicrobial compounds by plants (Bertin et al. 2003; Chappell, 1995; Dixon and Paiva, 1995; Weston and Duke, 2003). Therefore, it is of considerable importance ecologically to study the role of these unknown and recently discovered constituents produced by Paterson's curse.

Future research plans to focus on 1) identification and localization of these interesting root constituents produced by Paterson's curse, along with localization of production of the toxic alkaloids produced by the weed. 2) study of the role of these constituents in allelopathy and anti-herbivory mechanisms used by members of the Borage family 3) the basis for plant and population variation in morphology – are the differences associated with gentotype or phenotype? 4) can we develop a predictive tool to using diagnostic metabolomics in grazing mammals to predict or test for toxicity after ingestion?

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WEED categorisation- applying the 'PECA Code' in NSW

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INTRODUCTION

All weed management in New South Wales (NSW) can be classified into one of four categories: **Prevention**, **Eradication**, **Containment** and **Asset protection** (PECA). These four categories can be thought of as the invasion process of a weed species from arrival through to widespread establishment (Figure 1). The categories can be applied to specific or local situations (in terms of control and management), or to broader weed management approaches at a regional, state or national scale, as well as to weed legislation and policies.

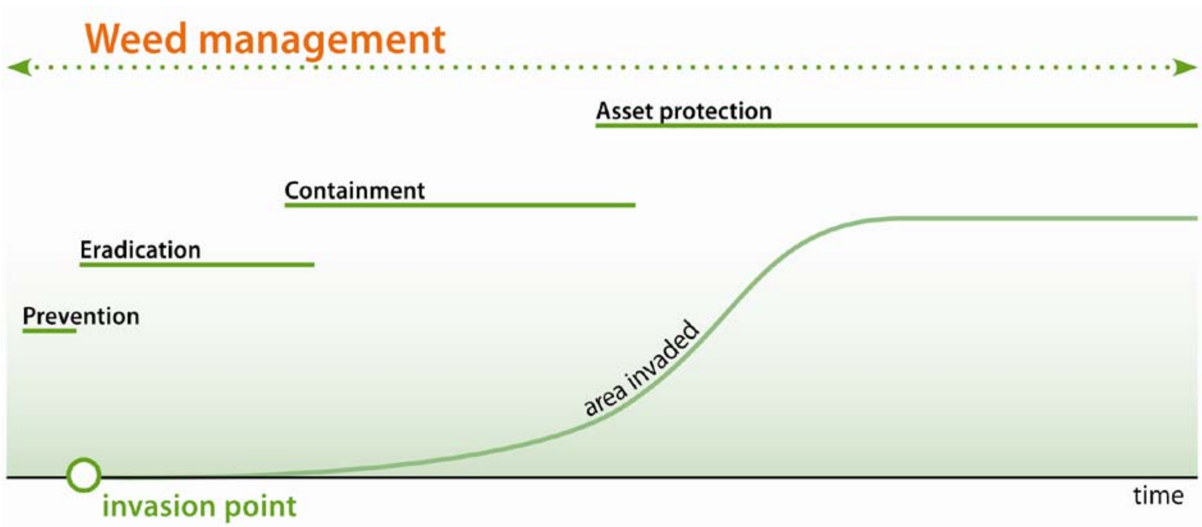


Figure 1. Typical weed invasion process and corresponding management approaches (after ARMCA et. al. 2001).

Here we present a short overview of each of the four categories together with some of the relevant major programs in NSW and a case study to illustrate the value of each category, followed by an overview of the approaches that cover all four categories.

Prevention – weed management aimed at preventing new weed species from arriving.

The most effective way to minimise the impacts of weeds and other invasive species is to prevent their arrival – in NSW (NSW Government 2008). This involves identifying species, thoroughly assessing potential invasiveness and implementing effective barriers to prevent their establishment.

Examples of relevant strategies or legislation
Below is a list of the major strategies or legislation/policies that includes elements of weed prevention in NSW:

- Australian *Quarantine Act 1908*
- NSW *Noxious Weeds Act 1993*
- NSW Incursion Plan for Invasive Plant Species
- National Prohibited and Permitted Lists
- Australian National Environmental Alert List
- Australian Agricultural Sleeper Weed List

Prevention from NSW case study - Siam weed
Siam weed (*Chromolaena odorata*) is considered one of the world's worst tropical weeds due to its quick invasion and establishment ability. It has the potential to spread across northern Australia and down the eastern coastline, displacing native vegetation and invading pastures and crops. The weed has a history of being spread large distances with human activity and could easily be spread from Queensland to other parts of the country.

A native of Central America, this species is only present in Australia in a few small infestations in far north Queensland. Although an eradication strategy is in place in Queensland, NSW is using a prevention strategy to keep it out of areas vulnerable to invasion such as the north east of the state (DEH et al. 2003). The plant is listed as a prohibited import and cannot be brought into Australia. Siam weed is also a declared Control Class 1 weed under the NSW *Noxious Weeds Act 1993*, this control class listing states that the plant must be eradicated from the land and the land must be kept free of the listed plant species. No locations have been detected in NSW (Figure 2).

Practical methods of preventing the weed spreading include: surveillance, washing down vehicles, cleaning clothing, shoes and camping gear, not removing sand or soil from contaminated areas and not moving any other product or thing that might be contaminated (DEH et al. 2003).

Siam weed is widespread throughout Asia. Of particular concern is the potential introduction of Siam weed by Australian defence force personnel returning from East Timor. The Australian Quarantine and Inspection Service (AQIS) has been actively searching for Siam weed seeds in and on personnel, equipment and materials as they leave East Timor and arrive in Australia. Despite these efforts there is a high risk of incursion into the country, and its consequent spread to other areas of Australia through military activities (DEH et al. 2003).

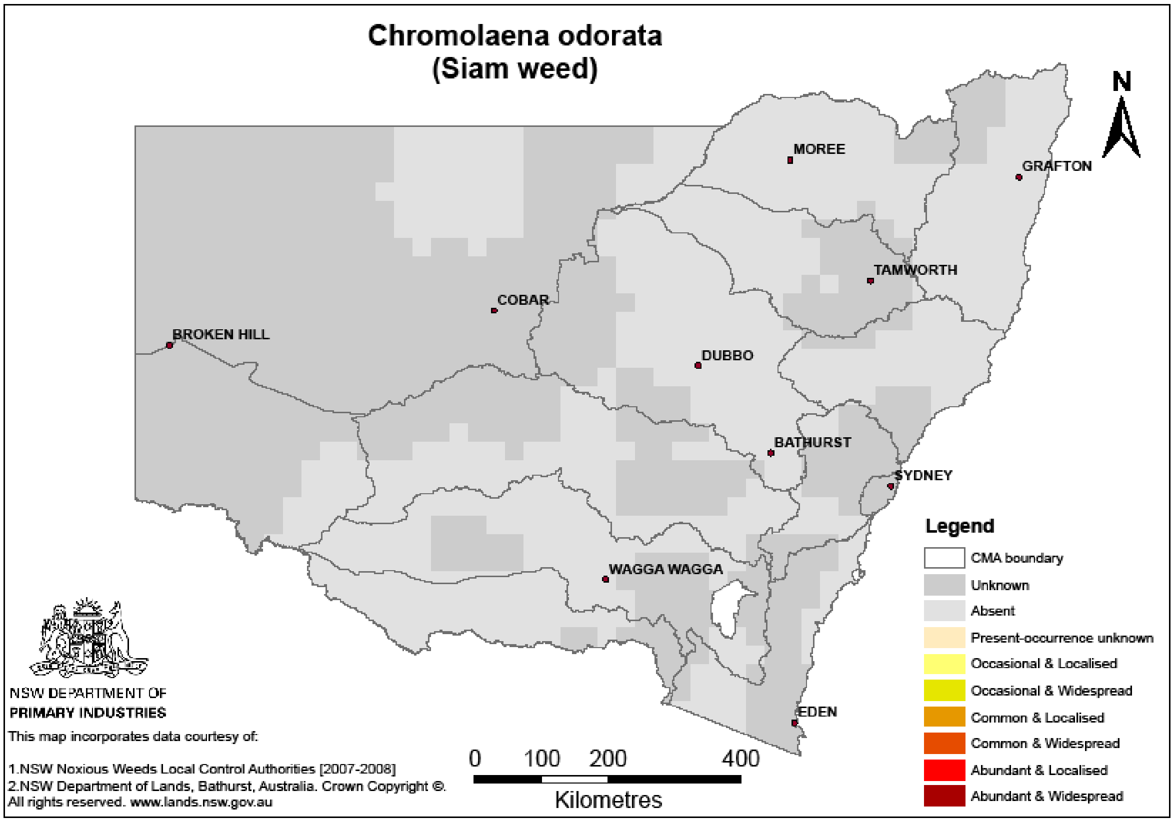


Figure 2. Siam weed (*Chromolaena odorata*) distribution in NSW (Brindle 2008).

Eradication – elimination of all plant material –of a species- from an area where re-colonisation is unlikely to occur (Meyers et. al. 1998).

Invasive species have the ability to establish in new areas rapidly and successful management is directly linked to a timely and rapid response. The challenge is to develop and deploy effective ways to eradicate introduced species before they become established. In addition, there are instances were it is strategic to undertake regional or local scale eradications. For example there are a number of national containment zones for several of the Weeds of National Significance in NSW. On the other side of which eradication strategies are being employed (e.g. (i) bitou bush plants south of Jervis Bay, and (ii) lantana plants south of Narooma).

Examples of relevant strategies or legislation
Below is a list of the major strategies or legislation/policies relating to weed eradication in NSW:

- NSW Incursion Plan for Invasive Plant Species
- NSW *Noxious Weeds Act 1993*
- Australian National Eradication Programs
- Australian National Environmental Alert List

Eradication case study – Parthenium weed
Parthenium weed (*Parthenium hysterophorus*) is a vigorous coloniser of bare ground; it is a fast growing annual with prolific seed production. Once established, it very quickly builds a large seed bank in the soil that makes eradication difficult and expensive. It is widespread in central Queensland where it causes significant production losses to the beef industry and adds to weed control costs for grain producers (ARMCA et. al. 2001).

Parthenium weed is spreading into southern Queensland where local government is attempting to contain the larger outbreaks. Despite it being widespread and having significant impact in Queensland, NSW has remained free of parthenium weed (Figure 3) thanks to the diligence of Government agencies, landowners and other stakeholders and the National WoNS program in implementing surveillance and control strategies as soon as they detect a new outbreak.

Parthenium weed spreads by seed and is not particularly adapted to long distance dispersal by wind, water or animals. The main means of long distance spread is by humans through contaminated harvesting machinery, grain, hay, seed and mud falling from vehicles (ARMCA et. al. 2001). Regular outbreaks continue to occur on roadsides and particularly on the Newell Highway.

Outbreaks on private property are often difficult to find and generally larger than those found on roadsides. Private property outbreaks have a much greater potential for establishing a permanent population of parthenium weed in NSW. In 1989, a property owner discovered a parthenium weed infestation covering 160 hectares on his property west of Gunnedah NSW. The origin of the infestation was from contaminated pasture seed the farmer had unknowingly purchased from central Queensland, the sale of which was in contravention of Queensland seeds legislation. The property owner promptly reported it to the NSW Department of Agriculture (now NSW Department of Industry and Investment) and weeds officers from Castlereagh-Macquarie County Council commenced an eradication program.

Weeds officers inspected the outbreak every month during the summer and autumn, removing any parthenium weed plants found, and burning them in a hot fire. The officers also treated the entire area, including the fire site with residual herbicide and conducted follow up inspections of the site during the following months. This significant parthenium outbreak was eradicated in four years due to early detection and an extremely thorough eradication program. Had the infestation remained undiscovered for several years, it would have developed an enormous bank of seed in the soil and eradication would have extremely difficult, if not impossible (Taken from NSW Invasive Species Plan NSW Government 2008).

Through the parthenium weed WONS program, border hygiene facilities have been installed to limit the spread of parthenium weed into NSW. In addition, an education and awareness program has helped to raise awareness of parthenium weed in western NSW and the need for quick action to eradicate it.

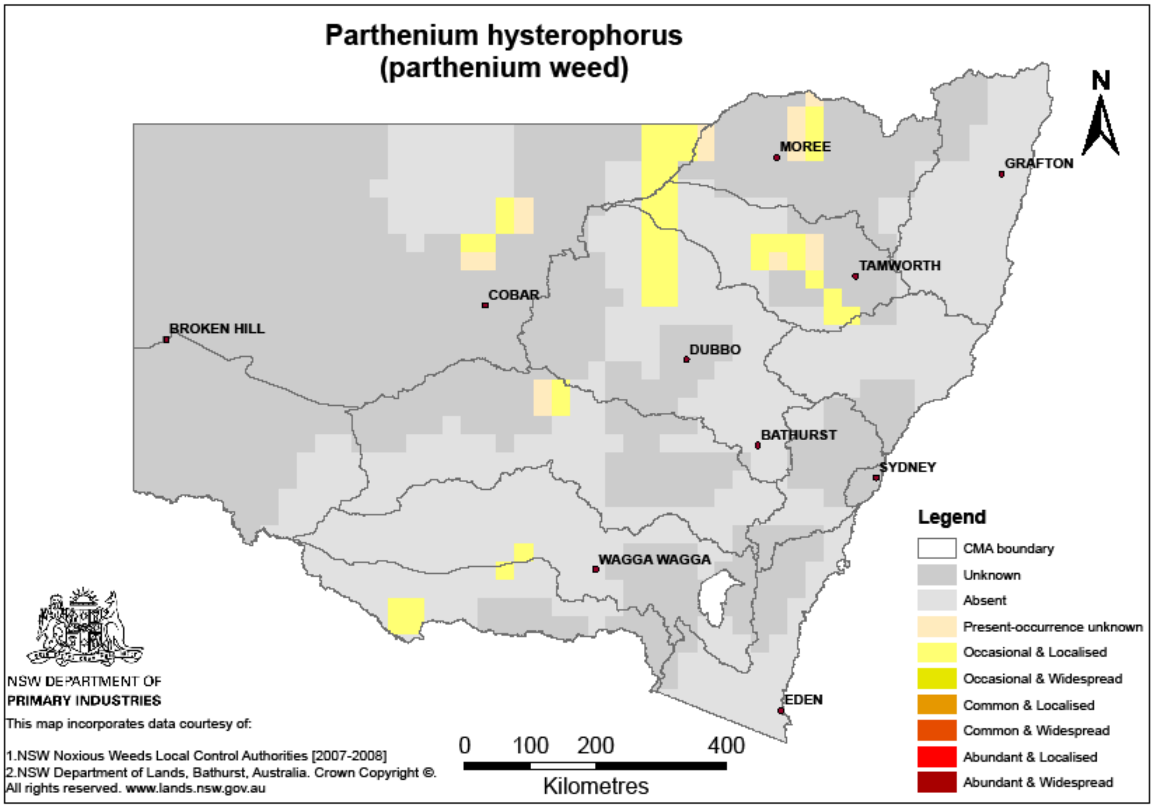


Figure 3. Parthenium weed (*Parthenium hysterophorus*) distribution in NSW (Brindle 2008).

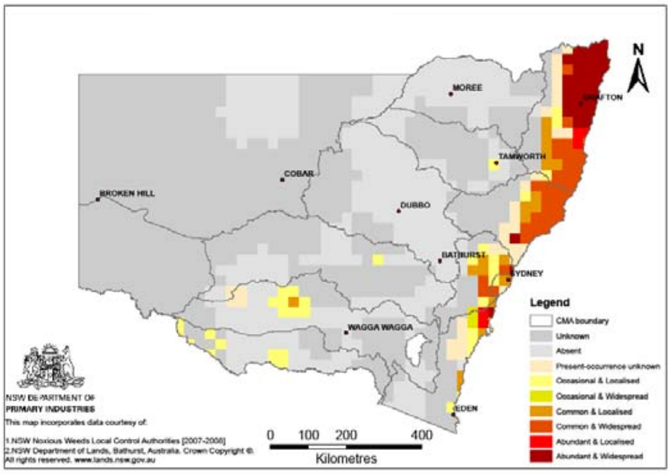
Containment – weed management aimed at reducing the spread of established weed infestations using defined geographic boundaries. Containment is used when eradication is no longer feasible or possible or to prevent further spread of widespread weeds.

Examples of relevant strategies or legislation
Below is a list of the major strategies or legislation/policies relating to weed containment in NSW:

- Weeds of National Significance containment lines (e.g. for lantana and bitou bush and boneseed)

Containment case study – Alligator weed
Alligator weed (*Alternanthera philoxeroides*) is a (WoNS) and is one of the greatest threats to rivers, wetlands and irrigation systems in Australia. First detected in NSW in 1946, it has spread to all states, has become widespread in parts of NSW (Figure 4). The weed's primary habitats are wet lowlands and the banks of fresh water bodies. From there it extends dense floating mats over the water surface choking waterways and also extends over wetlands and irrigated land. The weed is extremely difficult to control because it can grow in a wide range of habitats, and is able to reproduce from small plant fragments. Current controls have limited application and success. In most cases control programs have not prevented expansion of the larger infestations nor protected areas previously free of the weed (Oosterhout 2007).

The containment approach used in NSW aims to coordinate the management of alligator weed by preventing its further spread, and protecting high-risk sites. Priority for control is targeted at non-core infestations with the aim of eradicating outliers. While core infestations are managed with the aim of containment and reduction of spread. Eradication is not feasible in core infestations because it is too extensive and well established. Core infestation management focuses on ongoing suppression, along with containment and prevention of spread. This approach aims to gradually deplete the plant's growth over time to bring the infestation to a point where eradication is possible after a number of years (Oosterhout 2007).



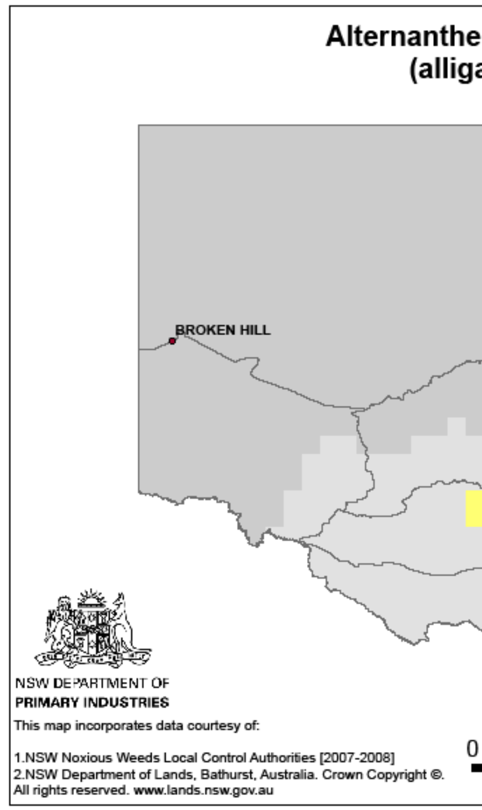


Figure 4. alligator weed (*Alternanthera philoxeroides*) distribution in NSW (Brindle 2008).

Asset protection – weed management aimed at protecting assets from the impacts of established weed species. Assets may be environmental, primary production or social (human health or cultural). Control in areas with no defined assets is a low priority within core areas.

The National Weeds Strategy outlines the need for asset protection as part of the management of widespread weeds. A similar approach is also outlined in the NSW Invasive species Plan.

Examples of relevant strategies or legislation

Below is a list of the major strategies or legislation/policies relating to asset protection from widespread weed species in NSW:

- NSW *Threatened Species Conservation Act 1995*
- NSW *National Parks and Wildlife Act 1974*
- NSW *Native Vegetation Act 2003*
- Australian Environmental Protection and Biodiversity Conservation Act 1999
- NSW Threat Abatement Plans/Priority Action Statement (PAS)
- NSW Biodiversity Strategy
- DECC/DPI/CMA weed strategies for conservation
- NSW Invasive Species Plan
- National Weed Strategy

Asset Protection case study (1) – Bitou bush

The NSW Bitou Bush Threat Abatement Plan is an asset protection strategy which ensures that biodiversity protection is the focus of control programs (DEC 2006). Bitou bush *Chrysanthemoides monilifera* is a highly invasive shrub which infests approximately 80% of the New South Wales coast. A native of South Africa, the plant is recognised as the greatest threat to NSW coastal ecosystems and coastal biodiversity. If this problem is not addressed, it is estimated that within 10 years the weed may affect the entire NSW coast line. The plant forms dense thickets that smother sand dune, headland and hind dune vegetation communities including coastal grasslands, heathlands, woodlands, swamps/wetlands and forests (DEC 2006).

Invasion of native plant communities by bitou bush and boneseed (*C. monilifera ssp. monilifera*) was listed as a key threatening process under the NSW *Threatened Species Conservation Act 1995* (TSC Act) in 1999. The Department of Environment and Climate Change and Water has finalised a Threat Abatement Plan (TAP) which proposes actions to reduce the impacts of *C. monilifera* on biodiversity, particularly threatened species, populations and ecological communities.

The Bitou TAP determines priority plant species, populations and ecological communities that are at risk (157 native plant species) and identifies locations of such biodiversity to determine priority sites for bitou control, independent of land tenure. The TAP is now being implemented at over 100 sites across almost 30 different agencies in NSW. This approach was recently acknowledged as a significant ecological restoration project in Australasia (see http://www.environment.nsw.gov.au/bitouTAP/GRNaward.htm for more information).

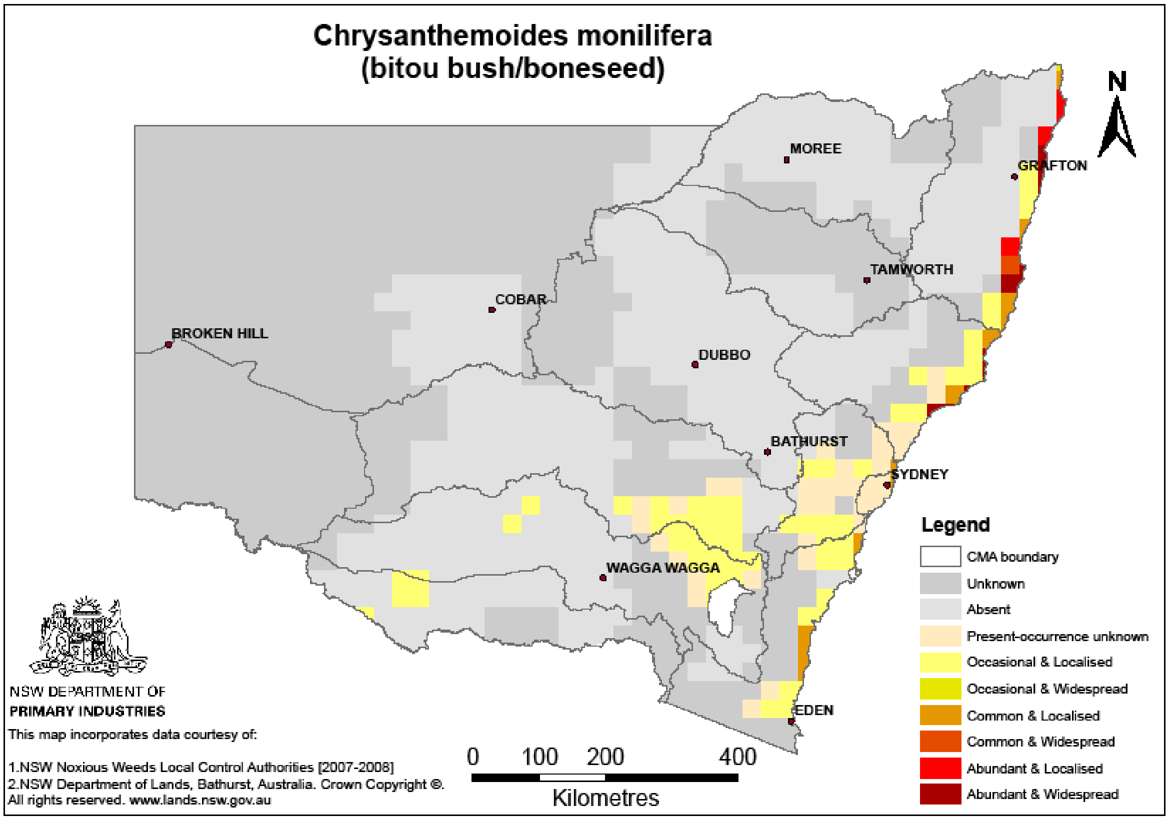


Figure 5. Bitou bush/Boneseed (*Chrysanthemoides monilifera*) distribution in NSW (Brindle 2008).

Asset Protection case study (2) – applying the Bitou TAP approach more broadly
Using the Bitou TAP approach, several other initiatives have been developed in NSW to manage weeds with respect to the protection of assets, being (i) the draft Plan to protect environmental assets from Lantana (NLMG 2009) which extrapolated and modified the Bitou TAP approach to Lantana (*Lantana camara*) nationally, and (ii) a project to establish regional weed management priorities for the conservation of biodiversity. The later project is a site-based assessment for the 13 Catchment Management Authorities in NSW to guide investment until 2015, again by modifying the Bitou TAP and Lantana approaches to all weeds on a regional basis (see www.environment.nsw.gov.au/cmaweeds).

Weed management that encompasses multiple categories

Some weed management programs, legislation and polices in NSW encompass multiple categories, or all four weed management categories. These broader strategies, programs and legislation often rely on, or build upon other strategies that are specific to one category. For example, quarantine is a specific management practice related to the Prevention category, which is also encompassed under the *NSW Invasive Species Plan*.

Examples of relevant strategies or legislation
Below is a list of the major strategies or legislation/policies relating that encompass multiple weed categories in NSW:

- NSW *Noxious Weeds Act 1993*
- NSW *Fisheries Management Act 1994*
- NSW Invasive Species Plan
- NSW Natural Resources Management (MER) Strategy
- NSW Catchment Weed Management Strategies
- NSW State and Regional Weed Management Plans
- NSW Regional Pest Strategies
- NSW Department of Environment and Climate Change Pest Management Strategies
- Australian Weeds Strategy
- Weeds of National Significance Strategies
- AusBioSec – Australian Biosecurity System for Primary Production and the Environment

Multiple approach case study – NSW Invasive Species Plan
The *NSW Invasive Species Plan* (ISP) encompasses all four weed management categories and provides the overarching framework for what the NSW Government and other stakeholders are doing to reduce the impact of weeds (and other invasive species) on the environment, economy and community. The four goals in the NSW Invasive Species Plan aim to deliver specific and measurable outcomes and actions for the management of weeds, while the four weed management categories are used to guide the different management approaches (NSW Government 2008).

Reporting and monitoring results

The implementation of each of these four weed management categories requires assessment to enable progress to be measured. In NSW a state-wide Monitoring, Evaluation and Reporting (MER) process for invasive species is being developed, based around the four categories outlined here using three indicators: (i) new incursions; (ii) emerging species; and (iii) asset protection through reducing impacts at priority sites. All weed managers stakeholders in NSW should include MER actions in their programs. In addition DECCW is implementing standard monitoring protocols as part of the Bitou TAP. These are being developed to account for varying stakeholder skills and resources. The monitoring protocols will be broadened to apply to all weed species.

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NAMOI CATCHMENT MANAGEMENT AUTHORITY INVASIVE PLANT MANAGEMENT

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ABSTRACT

The Namoi Catchment Management Authority was established in 2004 and is one of 13 CMA's across NSW.
Since 2006, the Namoi CMA has funded 35 individual weed projects and assisted in the development of publications and media advertisements.
All Namoi CMA weed projects are guided by three key goals developed by the public:

1. preventing establishment of new invasive plants and animals in the catchment;
2. limiting spread of key emerging invasive plants and animals; and
3. applying strategic control measures to existing invasive plants and animals, which include current pest and weed strategies.

The Namoi CMA has forged strong partnerships with weed professionals within the catchment, and although still new to the weed industry we see an important emerging role for all CMA's across NSW to help in the fight against weeds.

Introducing the author

I was first introduced to weeds when I was boy, my dad took a weed officer job, and over the past 20 years and countless stories, I guess it was a natural progression for me to fall into the weed industry.
My first paid job in weeds was in Canada 2001, where I sprayed weeds day in day out. Upon returning to Australia I took the next step and went to university and studied Environmental Science to further my career. After 2 years of study and no money, I applied for a catchment officer job with the Fitzroy Basin Association in Central QLD. I had many varying roles to play; however, over the time I was employed my interest was firmly embedded in weeds and pest animal management.
In 2006, I gained employment with the Namoi CMA as an Invasive Species Coordinator to implement the Invasive plants and animals program. I am still employed by the Namoi CMA and love the challenges that come with weed and people management.

THE NAMOI CATCHMENT

The Namoi Catchment Management Authority (NCMA) was established in 2004 as one of thirteen CMA's across NSW.
The Namoi Catchment in north west NSW is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south, and the Nandewar Ranges and Mt. Kaputar to the north. Major tributaries of the Namoi River include Cox's Creek and the Mooki, Peel, Cockburn, Manilla, and Macdonald Rivers, all of which join the Namoi upstream of Boggabri. Stretching from Woolbrook in the east to Walgett on the western boundary the catchment is over 350 kilometres long.

The Namoi catchment is home to around 100,000 people, in an area of approximately 42,000 square kilometres, concentrated mostly along the Namoi River and its tributaries between Tamworth and Narrabri.
Major industries include cotton, livestock production, grain and hay, poultry and horticulture.

CATHMENT ACTION PLAN

In 2004 the Namoi CMA established four over arching investment themes within the Catchment Action Plan (CAP). This plan (CAP) will guide natural resource management within the Namoi catchment until 2014.
The four themes are:

- People and their communities
- The Landscape
- Surface and Groundwater ecosystems, and
- Native Plants and animals

The native plants and animal theme covers land based (terrestrial) native vegetation and animals, including Threatened Species, Populations and Communities (flora, fauna and other life forms) listed under Threatened Species legislation; and invasive plants and animals, which are a significant threat to our local native plants and animals.
The Namoi CMA collaborated with industry groups, scientists, government agencies, the community and interested individuals to develop targets to deal with the threat posed by invasive plants.
It was agreed that activities will be focused on habitats that are cost effective to recover i.e. areas of habitat that are in a reasonable, but not ideal, condition or in areas of regionally significant vegetation that can be enhanced to achieve a healthy ecosystem through an improvement in condition or extent. Investment into rehabilitating highly degraded landscapes, which is costly and unlikely to provide long term biodiversity benefits will be limited unless it provides substantial benefits to other targets.

NAMOI CMA AND WEEDS

In 2005, NCMA contracted the Northern Inland Weed Advisory Committee (NIWAC) to develop a priority list of weeds within the catchment to invest in.
By early 2006 the NCMA had both, habitats in which to target weed invasion as well as the types of weeds to invest in.
An Invasive Species Coordinator (Andrew Schweitzer) was employed to implement this newly formed direction for the Namoi CMA. Andrew came to the NCMA from Central QLD with tertiary education in Environmental Science and several years experience in weed management in Canada and QLD.
Over the past three years the NCMA worked with NSW DPI, Regional Weed Advisory Committees, Local councils, National Parks, Livestock Health and Pest Authorities and individual landholders to established approximately 35 on ground weed specific projects.
NCMA has also developed with key stakeholders, several weed education resources and advertisements to increase people’s skills, knowledge, and capacity to invest in and adopt appropriate practices for weed management. In addition, there has been a general improvement in the attitude and understanding of weed issues by the whole community.

In 2008, NCMA embarked on an ambitious plan to develop a catchment wide weed map using existing council weeds data to improve NCMA's ability to pin point areas that require funding to reduce the threat to biodiversity.
Working in collaboration with all councils and providing state of the art weed mapping software to create a uniform data collection platform has proved to be as difficult as the NCMA thought it would be. NCMA have now got one third of the map completed and more informed decisions can now be made for those completed sections.
The NCMA is relatively new in the war on weeds, and with that infancy has come a steep learning curve to find our niche within the complex world of weed management.
The NCMA has now found its niche and is looking to the future to build on collaborative partnerships and enhance weed management across the catchment.

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MANAGING WEEDS FOR BIODIVERSITY CONSERVATION USING AN ASSET-BASED APPROACH

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ABSTRACT

Under the *NSW Invasive Species Plan*, management is divided into three areas (i) new incursions, (ii) emerging species, and (iii) reducing impacts [of established species]. Weed species encompassed under this last area are typically widespread and not likely to be eradicated, thus control efforts need to be based on asset-protection as outlined in the in *Australian Weed Strategy*. Here we discuss the approach used in NSW to protect biological assets (native species, populations and ecological communities) from widespread environmental weeds. The *Bitou Bush Threat Abatement Plan* (TAP) established a model for strategic management of widespread weeds to protect biodiversity. The asset-based approach used in this plan followed a triage system to prioritise native species for protection from bitou bush as well as sites for control. The *Bitou TAP* model has recently been adapted for lantana nationally and a draft national *Plan to Protect Environmental Assets from Lantana* has been released. In addition, the bitou bush and lantana approaches are being adapted to encompass multiple widespread weed species at a Catchment Management Authority scale in NSW.

The implementation of these strategies across all land tenures in NSW allows management to occur in a coordinated manner for biodiversity conservation, rather than as a series of individual ad-hoc decisions and a series of unconnected short-term projects. These strategies have contributed to new funding for weed management with grants from both the Australian Government and Catchment Management Authorities. In addition, a range of tools have been developed to help land managers protect native species during weed control, including (i) an identification guide to the native species at risk for bitou bush, (ii) site-specific management plans, (iii) management manuals and best practice guides, (v) educational material and (vi) standard monitoring guidelines. The incorporation of monitoring programs during the implementation of these strategies is essential to provide feedback on the effectiveness of the on-ground programs. This approach is reforming weed management in NSW by merging it with conservation to deliver threat reduction and conservation outcomes at a landscape scale.

Keywords: Key Threatening Process; prioritisation of sites; strategic planning; Threat Abatement Plan; impacts; management; biodiversity protection

INTRODUCTION

In NSW, weeds pose the second greatest threat to native biodiversity after anthropogenic destruction and disturbance of native vegetation and the associated habitat loss (Coutts-Smith and Downey 2006). Under the *NSW Invasive Species Plan* (DPI 2008), weed management is divided into three areas (i) new incursions, (ii) emerging species, and (iii) reducing impacts of established species. Weed species encompassed under the last category are typically widespread and not likely to be eradicated, thus reduction of their impacts needs to be based on asset-protection as outlined in the *Australian Weed Strategy* (NRMMC 2007). Here we discuss the approach developed in NSW to protect biological assets (native species, populations and ecological communities) from widespread environmental weeds. This asset-based approach was first developed for bitou bush, then lantana and more recently for all weeds on a regional or Catchment Management Authority (CMA) scale. In NSW, the driver for this approach has been the NSW *Threatened Species Conservation Act 1995* (TSC Act), under which the listing of weeds as Key Threatening Processes (KTPs) resulted in the development and implementation of strategies to ensure management of widespread environmental weeds focussed on biodiversity conservation (Downey et al. 2009).

Below we provide an update on the abovementioned initiatives. These initiatives establish strategic frameworks to guide and coordinate the response to widespread weeds impacting on native biodiversity, ensuring management is targeted to sites where the biodiversity benefit will be maximised. Information on the methodology to develop these strategies has been published elsewhere (e.g. DEC 2006, DECC 2007, Downey et al. 2009, Williams et al. in press).

Bitou Bush Threat Abatement Plan

Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*) is a Weed of National Significance (WoNS) (see Thorp and Lynch 2000) and is listed as a KTP under the TSC Act. Under the TSC Act, a Threat Abatement Plan (TAP) for the *Invasion of native plant communities by* C. monilifera *(bitou bush and boneseed)* (hereafter referred to as the *Bitou TAP*) was approved in 2006 (DEC 2006). The *Bitou TAP* established an approach for widespread weed management in NSW that identifies the biodiversity at risk and sites for control, along with a triage system for establishing priorities.

Three years into the implementation of the *Bitou TAP*, over 100 sites are committed to its implementation along the coast of NSW. By focusing bitou bush control on biodiversity protection and recovery, and ensuring that sites throughout the distribution of bitou bush were prioritised based on the probability of protecting the assets at risk, the likelihood of a conservation outcome is maximised. These control programs are currently helping to protect nearly 90% of the high priority biodiversity identified in the *Bitou TAP*. This collaborative effort involves 30 different agencies, numerous community groups and is complimented by grants from both the Australian Government and the five coastal CMAs.

To assess the effectiveness of this approach in protecting assets at risk, standard monitoring guidelines have been developed (Hughes et al. in press). Other tools have also been developed to help land managers to protect native species, including (i) an identification guide to the species at risk (Hamilton et al. 2008), (ii) site-specific management plans, (iii) management manuals and best practice guides (e.g. Winkler et al. 2008), (iv) a *Bitou TAP* website (www.environment.nsw.gov.au/bitouTAP), (v) a dedicated coordinator, and (vi) educational aids. The implementation of the *Bitou TAP* was also 'highly commended' for its on-ground restoration, during the search for the most significant ecological restoration projects in Australasia, by the Society for Ecological Restoration International (see http://www.environment.nsw.gov.au/bitouTAP/GRNaward.htm).

National Plan to Protect Environmental Assets from Lantana

Lantana is also a WoNS (see Thorp and Lynch 2000) and is listed as a KTP under the TSC Act. Coutts-Smith and Downey (2006) identified lantana as the most commonly recorded weed threat for all rare and threatened species in NSW, with ten per cent of all threatened species at risk from lantana invasion. It is also a significant environmental weed in Queensland (Qld), with Batianoff and Butler (2003) ranking lantana as the highest impact weed of 66 priority invasive plants in south-east Qld.

A draft national *Plan to Protect Environmental Assets from Lantana* was released for public comment in May 2009 (AWC 2009). Like the *Bitou TAP*, this plan significantly increased our understanding of the biodiversity at risk (e.g. Turner and Downey 2008, Turner et al. 2008). In addition, its development has involved collaboration between the National Lantana Management Group, 12 regional NRM bodies (including CMAs), Qld Environment Protection Agency, DECC, Greening Australia, Department of Defence, numerous local governments and private landholders. Initial lantana control has occurred under the plan at 23 sites nationally with an Australian Government grant and support from CMAs. Two Caring for Our Country grants have recently been submitted to continue its implementation over the next few years at key priority sites. This project is supported by a specific website (www.environment.nsw.gov.au/lantanaplan), which contains details on the species at risk and sites for control.

Regional Weed Management Priorities for Biodiversity Conservation

With more than 1600 naturalised plant species in NSW and around 350 thought to be impacting biodiversity, it is not feasible or sensible to develop strategies for every individual weed species as priorities and assets will often overlap. Thus the asset-protection approach has been modified to apply to multiple weed species, at a regional level, within each CMA in NSW. This project, jointly run by DECC and NSW Department of Primary Industries, commenced in late 2007. To date, priorities for 12 of the 13 CMAs have been established and reports for individual CMA have been drafted. The lists contained within these reports of ranked sites, weeds and biodiversity can be used by CMAs to guide investment and for future funding applications, including those for Caring for our Country. Draft reports detailing project outcomes and options for implementation for each CMA are due for release in June 2009. Additional site nominations can still be received until late 2009; these will be included in the revised final reports to be completed by December 2009. For more information on this project see the website (www.environment.nsw.gov.au/cmaweeds).

SUMMARY

Recognition that widespread weeds are no longer eradicable, with the exception of outlier populations, has shifted the focus of many weed management programs to asset-protection. The *Bitou TAP* established a system for determining and ranking biological assets at risk from weeds and identifying priority sites for control in NSW. This system is now being applied to lantana nationally and all weeds at the CMA level. The success of this approach is not only dependent on a wide range of stakeholders collaborating and undertaking control, but a concerted effort to monitor the effectiveness of the control and the response of the biodiversity at risk. In NSW, merging widespread weed management with conservation should deliver threat reduction and conservation outcomes at a landscape scale.

ACKNOWLEDGMENTS

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<u>MOVING FROM THE OLD TO THE NEW:</u>

National weeds research outcomes

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ABSTRACT
Between 2004 and 2008 the Australian Government committed $44.4 million to the national Defeating the Weed Menace program to identify Australia's most threatening weeds and to implement measures for their control.

Between May 2006 and April 2009 Land & Water Australia managed the research and development (R&D) component of that program on behalf of the Department of Agriculture, Fisheries and Forestry and the Department of the Environment, Water, Heritage and the Arts.

The goal of this 3-year R&D component was to generate new knowledge to prevent the development of new weed problems, to reduce the impacts of existing weeds of national priority, and to build capacity for their management into the future. Between June 2006 and November 2008, 27 projects were directed to:

- assessing risks of different pathways of weed ingress
- investigating the impacts of land use change on weed incursion
- developing 'best practice' early detection, survey and eradication of potential weed species
- identifying biocontrol agents for priority weed species
- developing new integrated weed management strategies that incorporate an understanding of landscape scale ecological processes
- quantifying the impacts of weeds on sustainability and the environment (including the ecological costs of weeds) and the relative benefits and costs of different weed control measures
- providing knowledge to support a national information system for weeds.

Land & Water Australia places strong emphasis in all of its R&D programs on generating knowledge products designed to maximise uptake of the information generated, and thus on helping landholders and the agencies that support them to adopt new information that will help them move from old to new ways of managing natural resources. As the program drew to a close in April 2009, key cross-project learnings were drawn from the program and formed part of the input to future national weeds R&D.

Key words: weeds R&D, national priorities, key learnings, making research outcomes relevant

THE PROJECTS

Twenty-five projects addressing a broad sweep of weeds-related issues were contracted through two open calls for proposals. Together these projects (see Table 1) saw an investment of some $4.54 million of DWM funding, together with $4.31 million of cash and in-kind contributions from weeds research organisations and interested third parties.

Table 1. DWM R&D themes and projects

Research theme & sub-themes	Projects	Lead researcher/ Lead organisation
Developing 'best practice' early detection, survey & eradication	Managing weeds under future scenarios for environmental flows in the Murray River	Dr Matt Colloff* CSIRO Entomology
Assessing risk of different pathways of weed ingress	Modelling climate change impacts on 'sleeper' and 'alert' weeds	Dr John Scott CSIRO Entomology
	Pathway risk analysis for weed spread within Australia	Prof. Brian Sindel* University of New England
	Serrated tussock: Managing native pastures to prevent invasion	Dr Aaron Simmons/Prof. David Kemp Charles Sturt University
Identifying biocontrol agents for priority weed species	Biological control and ecology of alligator weed	Dr Shon Schooler CSIRO Entomology
	Development of new biocontrol agents for parkinsonia	Dr Tim Heard CSIRO Entomology
	Improving management of salvinia in temperate aquatic ecosystems	Dr Bertie Hennecke/Assoc. Prof. Kris French University of Wollongong
	Importation and release of a new biological control agent for Scotch broom	Dr Jean-Louis Sagliocco DPI Victoria
	Boneseed rust: A highly promising candidate for biological control	Dr Louise Morin CSIRO Entomology
	Enhancing noogoora burr biocontrol in northern Australia	Dr Louise Morin CSIRO Entomology
	Importation, rearing and field release of the cape broom psyllid	Mr Ken Henry SA Research & Development Institute
Land use change impacts on weed incursion	Land use effects on soil nutrient enrichment: Risks for weed invasion	Dr Elizabeth Lindsay/Dr Saul Cunningham CSIRO Entomology
	Effect of land use and peri-urban development on aquatic weeds	Dr Lauren Quinn/Dr Shon Schooler CSIRO Entomology
	Understanding and determining mechanisms to prevent wed invasion in coastal vegetation	Dr Tanya Mason/Assoc. Prof. Kris French University of Wollongong
Developing new integrated weed management strategies at landscape scale	Developing a model for environmental weed management in fragmented landscapes	Mrs Melissa Herpich Department for Environment & Heritage, SA
	Optimising management of core mesquite infestations across Australia	Dr Rieks van Klinken CSIRO Entomology

	Elucidating relationships between distribution and invasion in riparian zones	Dr Fiona Ede DPI Victoria
Developing efficient methods for surveying and eradicating agreed emergent weeds	Best practice on-ground property weed detection	Prof. Brian Sindel* University of New England
	Exploring agents of change to peri-urban weed management	Ms Jo Harding Upper Murrumbidgee Catchment Coordinating Committee
	Cost-effective surveillance of merging aquatic weeds using robotic aircraft	Dr Salah Sukkarieh* University of Sydney
Quantifying the impacts of weeds on sustainability and the environment.	Quantifying costs and benefits of buffel grass	Dr Margaret Friedel CSIRO Sustainable Ecosystems
	Pinus radiata in bushland: Assessing the issues in the Green Triangle	Mrs Melissa Herpich/Dr Andrea Lindsay Department for Environment & Heritage, SA
	Quantification of the environmental and control costs of weeds	Dr Samantha Setterfield Charles Darwin University
	Evaluating the environmental benefits from managing WoNS in natural ecosystems	Dr Adele Reid/Dr Louise Morin CSIRO Entomology
	Ecological, economic and social considerations in spray control of hymenachne	Prof. Bob Miles Central Queensland University

* Papers presented at this conference

Two additional projects were commissioned later in the program, each directed to addressing gaps in new knowledge about weeds. A study of the needs of potential end-users of a national information system for weeds indicated clearly that priorities other than biosecurity surveillance loom large as potentially benefiting from a nationally coordinated information system on weeds.

Several jurisdictions also invest heavily in the development of biological control agents for weeds. However, our understanding of how best to select target weeds for which biocontrol will become an important part of management remains limited. Within the DWM R&D program one project was directed to developing a framework to improve the targeting of weed biocontrol projects within Australia. There are opportunities to further develop this framework and to use it in conjunction with the recently adopted Weed Risk Management Protocol (Standards Aust. 2006).

PROGRAM RESULTS & RECOMMENDATIONS

The DWM R&D program represents a significant Australian Government investment in weeds research directed to addressing both public good and rural production aspects of weeds management. LWA's experiences and feedback provided by participants during the management of the DWM R&D program, feedback obtained during forums such as the future directions forum hosted and facilitated by LWA at the 16th biennial Australian Weeds Conference held in Cairns in May 2008, and comments provided to the external evaluation team led by Dr Jeff Coutts at the conclusion of the program have all influenced recommendations on future directions for weeds research at the national level.

In addition to the results obtained in each of the individual projects, a synthesis of the program's overall outcomes highlights some key areas for future research.

A whole-of-systems approach and landscape-scale perspectives are important in understanding and managing weeds. Both short- and longer-term interactions between weed invasion and changing land and water use are critical, especially in peri-urban, aquatic, riparian and floodplain ecosystems.

As the impacts of human-induced climate change take hold both an increased awareness and understanding of the likely responses of invasive plants to changed moisture availability and temperature and improved methods of surveillance of weed spread become increasingly important. Not only can the bringing together of climate modelling and plant responsiveness assist. The application of unmanned aircraft technologies, spectral analysis and learning algorithms used in defence and other areas has much to offer in weed detection and treatment in otherwise inaccessible areas.

An important gap in the DWM research portfolio was in its lack of focus on social and institutional influences on weed management. Although there was no specific theme addressing social and institutional factors, several of the projects completed provided a focus on these. Weeds are a major and enduring problem. Without active, engaged people (landholders and managers, practitioners working at a regional level and policy and program managers as well as researchers), willing and able to work on these problems, weeds will continue to degrade both production land and areas of high biodiversity, recreational and aesthetic value, and the ecosystems that support all of these.

The DWM R&D program also highlights the benefits to be had from early planning both to generate knowledge in ways that will maximise adoption and the need for monitoring and evaluation of outcomes beyond the life of a funded project. With support and facilitation, research teams welcome such activities. However there will always be tensions between the expectation that researchers will focus their effort on what they do best - conducting good science - and the need for that science to reach its end-users (both on-ground and in policy and programs) in formats that can be shown to be effective.

ACKNOWLEDGMENTS 10PT

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Final reports from each of the DWM R&D projects can be accessed at www.lwa.gov.au/weeds

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VICTORIA'S RESPONSE TO A MEXICAN FEATHER GRASS INCURSION

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ABSTRACT
Mexican feather grass (*Nassella tenuissima*), a declared State prohibited weed under the *Catchment and Land Protection Act 1994*, was inadvertently imported into Australia and supplied to a number of retail chain stores throughout Victoria between January and May 2008.

Mexican feather grass poses a serious threat to the vitality of Victorian agribusiness and environmental values. Drought tolerant, unpalatable to stock and difficult to control, it has the potential to occupy more than 500 million hectares in Australia.

In May of 2008, the morphological determination of a specimen by the National Herbarium of Victoria confirmed Mexican feather grass, leading to the investigation of over 180 plant traders, both in Victoria and interstate.

The Department of Primary Industries response to such a large scale incursion utilised the Australasian Inter-service Incident Management System (AIIMS) to coordinate over 80 staff throughout the six month Response Phase.

Investigations were hampered by incorrect plant labelling and poor record keeping by sections of the nursery and garden industry. The concurrent trade of a closely related species added confusion to the retrieval of an estimated 10,000 plants.

With recovery efforts occurring throughout winter, climate controlled glasshouse facilities forced plants into early maturity, hoping to permit morphological determination. By drawing on DNA identification techniques, the Department is building its capability to accurately identify immature specimens.

Through intercepting the trade of seeds and plants; assisting retailers conducting product recalls; targeted publicity campaigns and inspecting over 150,000 urban properties, the Department has successfully recovered 65% of the plants originally distributed. Victoria has been a key participant in the coordination and liaison with interstate agencies and contribution to the national Consultative Committee for Exotic Plant Incursions (CCEPI) for Mexican feather grass.

The focus of the Recovery Phase is in on-going surveillance and the formulation of a national approach to the coordinated management of the incursion. Through the engagement of the Weed Spotter network (2,000 members) and the recruitment of postal workers; meter readers; local government staff and landscapers it is intended that the remaining Mexican feather grass plants will be found and eradicated.

INTRODUCTION

History of Mexican feather grass in Victoria and Australia

Mexican feather grass is a relatively new, high risk weed, both in Victoria and Australia. The first record of its introduction to Australia is believed to have been via the nursery industry in NSW, publicised in 1998 (*Jacobs et. al.*) where it had been incorrectly marketed as a native Australian species "Elegant spear grass", probably *Austrostipa elegantissima*. How and when this first introduction occurred has not been reported.

The first recorded Victorian introduction of Mexican feather grass occurred at a Mt Macedon nursery, also in 1998, where plants were sold labelled as its synonym *Stipa tenuissima*. Since this first introduction, there were at least four other unrelated introductions of Mexican feather grass detected until 2002. As the species was not a declared noxious weed and staff resources of limited capacity to respond, the extent of trade and distribution is unknown but is estimated to have been small. Further research into its potential distribution and observations of the devastating impacts of incursions in New Zealand (ie. *McLaren et. al. 1999*) lead to the 2003 declaration under the *Catchment and Land Protection Act* (*1994*) of *Nassella tenuissima* as a State prohibited weed.

State prohibited weeds are the highest category of noxious weed under the *Catchment and Land Protection Act (1994)* and either do not occur in Victoria, or are present and can reasonably be expected to be eradicated. The risks posed by Mexican feather grass places sole responsibility for its eradication on the Secretary of the Department of Primary Industries. Between it's declaration in 2003 until early 2008 no new introductions of Mexican feather grass were detected in Victoria.

Mexican feather grass is a declared noxious weed in all Australian states and territories, accept for Tasmania. The classification of the species on a state by state basis may be semantically inconsistent; however, the intent is harmonious with plants prohibited from sale and a target of statewide eradication. The Australian Quarantine Inspection Service (AQIS) prohibits the import of both *Nassella tenuissima* and its synonym *Stipa tenuissima* as seed and nursery stock for growing. Despite these strict controls, the process is not infallible. Seeds may be accidentally or deliberately imported; bypassing controls mislabelled as a species on the permitted list, or surreptitiously carried into the country by international travellers (M. Stretter, AQIS, pers. comm.).

Discovery of a new Mexican feather grass incursion

During the 10th May 2008, an off duty DPI officer first detected what was thought to be a declared noxious weed for sale at a large retail chain store. The plants were *Nassella* like in appearance and were displayed in unlabelled decorative pots for purchase as a Mother's Day gift. As none of the plants on display were in flower, confirmation of their identity was not possible. It was not until the 12th May 2009, when officers discovered a mature plant with flowers present at a neighbouring store of the same chain that the potential magnitude of the incursion was perceived. Submission of this flowering specimen to the National Herbarium of Victoria confirmed officer's suspicions; Victoria had an incursion of Mexican feather grass.

With the cooperation of the nursery management at the large retail chain store, officers revealed that the plants had been stocked in stores for only a few days. Records indicated plants may have been available for sale from as far ranging locations as Ballarat in the west of the state to Morwell in the east with over 30 different stores potentially still stocking Mexican feather grass. Information was obtained by officers indicating plants suspected of being Mexican feather grass may have been traded interstate. This information was quickly passed onto interstate counterparts.

METHODS

Framework for response to a major weed incursion

Faced not only with a large-scale plant retrieval, but also a potentially complex investigation into the supply of the Mexican feather grass plants, DPI utilised a modified AIIMS structure to manage the incursion (*Australasian Fire Authorities Council*, 2005). Designed for responding to emergency situations, The AIIMS structure is ideal for managing a weed incursion as it determines specific roles and responsibilities for those involved in the response, provides a clear chain of command and allows for the expansion and contraction of resources as the size and complexity of the impact changes.

The coordination of both the recovery of the plants and the investigation into the supply chain was through a centrally located Incident Management Team (IMT). The IMT was headed by an Incident controller whom holds ultimate responsibility for the management of the incursion. The Incident controller was supported by three interconnected units, Planning, Operations and Logistics. The Planning unit was tasked with orchestrating the plant recovery, coordinating the statewide product recall of the plants, overcoming plant identification hurdles and publicising the incursion. The Operations unit recovered the plants from the stores, conducted interviews of plant traders and executed search warrants where potential breaches of legislation were identified. A Logistics unit provided the resources to accommodate over 30 staff at any one time, from all parts of the state during the six months of the Response phase.

Investigating how it happened

Within days of discovering the first Mexican feather grass plants at retail outlets, Authorised Officers had interviewed the wholesaler who had allegedly supplied them to the retailer. Officers were told two grass species had allegedly been given to the wholesaler as a trial from a major seed importer, with no records as to what species were supplied. The investigation into the Mexican feather grass incursion revealed such practices were commonplace throughout many sectors of the nursery and garden industry. Invoice details were poorly documented, including; the quantity of product supplied against that which was invoiced as well as the descriptions of products reflecting the packaging and not the plant species they contained. This dramatically increased the workload for the Operations unit, forcing them to inspect many retail stores with no knowledge if Mexican feather grass plants had been supplied.

Uncovering the alleged source of the supply of seed was a wind fall for the incident response, occurring fairly early on in the incursion. What hampered investigations was the concurrent trade of two closely related grass species, one of which was discovered to be Mexican feather grass. As both species had been imported into Australia, DPI immediately notified AQIS of potential breaches of import conditions. The alleged labelling of both species as *Stipa* grasses added a significant amount of confusion when attempting to recover the plants. The risks posed by Mexican feather grass meant officers needed to pursue all trade routes of either of the two grass species allegedly sold by the major distributor. Trade routes for both of the species were extensive. Multiple tiers of supply and distribution were identified with trade to South Australia, Queensland, New South Wales and the Australian Capital Territory. In Victoria, over 180 nurseries were inspected and interviewed in relation to the distribution of Mexican feather grass. Communication between DPI and all interstate counterparts occurred immediately the incursion was identified which improved the accuracy of the intelligence gathering and strengthened the response. This liaison was ongoing through the investigation and continues today.

As inspections were occurring in late autumn/winter, neither species of grass were in flower, making formal differentiation almost impossible. Authorised Officers were forced to take possession of the plants and maintain them until their identity could be confirmed.

Overcoming the hurdles of identification
Morphological determination of plants to species level was established as the standard required to meet the Department's legal obligations. A climate controlled secure glasshouse facility, featuring an automated watering system and UV lamps to increase day length was commissioned in an effort to force plants into an early maturity. The success of this approach was mixed with some plants flowering after only 4-6 weeks of exposure to these conditions whilst other plants had still not flowered after 10 months in conditions thought to be ideal. It was not until the majority of plants commenced flowering in September and October that the complete picture of the incursion was realised and confirmation of lines of investigation could be communicated.

In an effort to overcome the reliance on morphological determination, the Department looked to molecular identification methods such as those involving Deoxyribose Nucleic Acid (DNA) sequencing to identify immature Mexican feather grass plants. Utilising DNA sequencing for the determination of *Poaceae* species is in its infancy both in Australia and overseas and the laboratories were forced to request type specimens for comparison from international Herbaria. Having been successful in determining the identity of immature Mexican feather grass plants using DNA technology, the Department is better informed at responding to the next potential weed incursion, irrespective of the season when suspect plants are detected.

Recovering Mexican feather grass plants
Of approximately 10,600 Mexican feather grass plants allegedly distributed by the primary supplier, DPI officers were successful in retrieving or destroying around 5550 plants and seeds from the wholesalers and nurseries in possession of the weed. With an estimated 700 Mexican feather grass plants allegedly distributed to interstate nurseries, Victoria still had over 4,350 plants that may have been sold to the public.

In assisting stores to run voluntary product recalls for nearly 6 months and broad scale marketing and media to promote the recovery efforts, DPI were successful in retrieving 50 of the Mexican feather grass plants sold. With the spring flowering season approaching, the Planning unit were forced to act quickly and think laterally.

In obtaining the store sales records from the major retailers suspected of selling Mexican feather grass plants, the Planning team developed a strategic surveillance program to target areas where trade of plants was suspected to have been high. Officers then focussed their search efforts on recent housing subdivisions, likely to contain new gardens, within these target areas. Timed to coincide with the spring flowering, Authorised Officers inspected the front yards of an estimated 150,000 homes in the south-east, west and northern suburbs of Melbourne in a two month period. The success of the targeted inspections was encouraging with officers recovering almost 800 plants from 150 different properties.

Additional spring media coverage saw plants reported in far reaches of the state, despite the majority of sales allegedly occurring in the Melbourne metropolitan area.

Coordination of a nationwide response effort

Mexican feather grass is not just a new, high risk weed to Victoria; it also threatens economic and environmental values for the nation. A meeting of the national Consultative Committee for Exotic Plant Incursions (CCEPI) was initiated to assess the risks associated with an unrestrained incursion. Climactic modelling, supported by a cost benefit analysis highlighted the value of an early intervention program to attempt to eradicate Mexican feather grass. Based on the potential distribution and limited to suitable land use zones, Mexican feather grass was estimated to occupy a range of over 500 million hectares if left uncontrolled. The estimated potential impact of a nationwide incursion, based upon lost agricultural production, costs of control and environmental degradation was in the order of $270 million dollars over the next 30 years (*Mexican Feather Grass Economics Reference Group Sub-Committee, 2009*).

In determining if a national cost sharing arrangement was suitable for the Mexican feather grass eradication program, the CCEPI ruled that an unquantified distribution of the species meant the likelihood of eradication could not be adequately assessed. Each state is responding to their own incursions of the species with a view to eradication. Once the incursions have been delimited, a decision on the feasibility of eradication will be reviewed. With previous infestations identified in Victoria, NSW, South Australia and the ACT, as well as its recent introduction to Queensland, Mexican feather grass may already have been granted the opportunity to establish, despite the best efforts of weed management staff.

DISCUSSION

Accountability for the incursion

As the incursion unfolded, officers form the Department of Primary Industries identified several potential breaches of the *Catchment and Land Protection Act* (*1994*). Without a permit from the Secretary, it is an offence to; buy; sell, possess for the purposes of sale, display, plant or propagate, bring into or transport within Victoria, a noxious weed or parts of a plant capable of growing. Officers from the Department of Primary Industries were successful in obtaining pleas of guilt from four of the plant traders implicated in the incursion. The major distributor and three of the wholesalers were fined for their involvement in the incursion and agreed to pay compensation for costs incurred in the clean up efforts. More importantly was the voluntary agreement by each of the four traders to participate in the development of a Code of Practice for the nursery and garden industry. The Code of Practice will govern the principles and processes for the importation, propagation and distribution of plant species and their varieties, imported into Victoria from interstate and overseas. In assisting industry with the development of the code, the Department of Primary Industries can ensure appropriate standards are established while allowing the industry to produce the content, leading to a wider adoption.

Recovery of the remaining Mexican feather grass plants

With an estimated 3450 Mexican feather grass plants still unaccounted for in Victoria; the response to the incursion will be ongoing. Recovery efforts are pioneering new territories of investigation by the Department of Primary Industries staff. Investigations into the suspected purchases of Mexican feather grass via customer's credit card records is predicted to achieve in the order of 25% recovery of the remaining plants.

Surveillance will be improved by the strategic engagement of Australia Post deliverers and meter readers from utilities companies who will receive identification training and protocols to report suspect plants to Department of Primary Industries' officers. Utilising such groups increases both the intensity and the scale of coverage for the species, over and above what can be achieved by department staff alone.

Specific training of local government staff and landscape gardeners in areas where trade of Mexican feather grass was suspected to have been high should complement the aforementioned coverage by Postal workers and meter readers. This will allow Department of Primary Industries staff scrutiny of landowner's rear yards, an area normally off limits to surveillance. These training activities are focussed on the long-term reporting of Mexican feather grass incursions and may assist in the identification of infestations from 1998-2002.

Coverage will be bolstered statewide by utilising the network of 2000 Weed Spotters who will receive updated training in Mexican feather grass identification. It is hoped Weed Spotters will be able to report Mexican feather grass plants that may have been purchased in Metropolitan Melbourne and planted in rural areas of Victoria, a pattern already identified in the current incursion. Media promotion of the recovery efforts in spring is hoped to locate further infestation sites.

With an aim of complete eradication of Mexican feather grass from Victoria, recovery efforts must also focus on the treatment of existing infestation sites. Research is proposed into plant biology and improved treatment regimes ensuring best practice management is adopted.

In planning for a response to the next major incursion, the Department of Primary Industries is aiming to better align the focus of partnerships with industry, interstate agencies and AQIS.

CONCLUSION

A significant effort will be required in the next 6-12 months to recover the remaining plants and the outcomes of these new approaches to achieve this will have been realised. The Victorian Government is committed to establishing a biosecurity approach to the prevention and eradication of high risk weed species (*Biosecurity Victoria, 2009*). This incursion has been an ideal opportunity to benchmark our current strategies and be better placed to respond to the next major weed introduction. A shift in climatic zones, increased international travel/communication and the changing patterns of land use my lead to the introduction of high risk weeds. The learning's from the current incursion will form the basis of the next response.

ACKNOWLEDGEMENTS
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THE SPREAD AND DETECTION OF WEEDS ON AUSTRALIAN FARMS

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ABSTRACT
Two recent University of New England research projects funded by Land & Water Australia in the Defeating the Weeds Menace program, sought, through national surveys of weeds inspectors, other weeds professionals and landholders, to assess how weeds are spreading within Australia; identify ways to reduce these risks; assess current weed surveillance levels and practices amongst landholders and weeds inspectors; and identify ways to improve weed detection by these groups on-ground. Some of the findings are presented in this paper.

INTRODUCTION
Despite the $4 billion annual cost of invasive weeds to the Australian economy through lost agricultural production and the devastating impact of weeds on natural ecosystems, no comprehensive studies have previously been undertaken to ascertain the way that weeds spread once present within Australia, or how farmers and weeds inspectors go about detecting new weeds once they arrive.

Two recent University of New England research projects funded by Land & Water Australia, sought to assess the relative risks of sources (sites) and pathways (means) of weed spread within Australia; identify ways to reduce these risks; assess current weed surveillance levels and practices amongst landholders and weeds inspectors; and identify ways to improve weed detection by these groups on-ground.

Most recently naturalised taxa are still only locally distributed, and so it is critical to identify the primary pathways for the spread of these, as well as more widespread weeds, so as to be able to prevent movement to un-infested areas. However, if weeds do move to new areas then early detection is the first step in their control. Weeds are only ever very rarely eradicated from an area (reduced to a zero population). Those weeds that have been eradicated have been detected early in their spread. And every dollar invested in the eradication of a newly established weed results in benefits of $9.90-$26.80 (NRMMC 2007).

An evaluation of Australian and international literature identified twenty-four weed sources and seventeen weed pathways (both natural and a consequence of deliberate and accidental human activity) for weed spread (see table 1). While every effort must be made to prioritise high risk pathways of weed spread for management and regulation, the number and wide diversity of potential sources and pathways demonstrates the difficulty of the task of preventing weed spread altogether.

Weed spread pathways in Australia

- *Deliberate Spread by Humans*
    - Ornamental plant trade
    - Mail order plant trade
    - Aquarium plant trade
    - Medicinal plant trade
    - Food plant trade
    - Fodder trade
    - Revegetation and forestry
- *Accidental Spread by Humans*
    - Human apparel and equipment
    - Machinery and vehicles
    - Construction and landscaping materials
    - Agricultural produce
    - Research sites
    - Livestock movement
    - Waste disposal
- *Natural Spread*
    - Birds
    - Other animals
    - Wind
    - Water

Table 1 Ways in which weeds spread in Australia.

After scoping the issues with focus groups, three national surveys were undertaken in late 2007 and early 2008 of over 100 weed professionals, 600 landholders, and nearly 150 weed inspectors, drawing on their expertise of weed spread and detection in the Australian context.

WEED SOURCES

The survey of weeds professionals found that, of the weed sources identified in the review of literature, the most important include transport sites (roads, railways, water courses and airports), land in transition (degraded or abandoned land), pastures and rangelands, ornamental horticulture sales sites, and private gardens.

WEED SPREAD PATHWAYS

Weeds professionals were also asked to evaluate each weed spread pathway with regard to:

- its capacity to transport seeds and other propagules and facilitate weed spread;
- the effectiveness of current regulatory and management structures seeking to negate the pathway; and
- the expected importance of the pathway in the future.

Each pathway was found to have a relatively high overall capacity to facilitate weed spread. However, fodder trade, aquarium plant trade, agricultural produce, ornamental plant trade, water, and machinery and vehicles were considered particularly capable, while research sites, revegetation and forestry activities, and food plant trade were considered relatively less capable pathways.

According to farmers and weeds inspectors, weeds are most likely to spread onto farms via birds, wind, water, vehicles, machinery, livestock and fodder (Table 2). Variation in response on a state or territory, or property type basis may reflect topographic/landscape features, management philosophies, and circumstances. For example, water and floods are considered to be of minor importance in weed spread in SA where much of the state is dry and there are few major river systems.

At least 50 per cent of weeds experts surveyed considered that the current regulatory and management arrangements are inadequate for each weed spread pathway. This was particularly apparent in relation to the plant trade pathways (ornamental, aquarium, medicinal and food plants), fodder trade, and revegetation and forestry.

A variety of management improvements were suggested, including targeted education and extension activities, improved weed risk assessment processes, further research into control measures, enforced control of specific weeds and pathways, and extra staff and resources. Natural pathways were generally regarded as being difficult to regulate or manage, which suggests that the emphasis here should be on removing the source infestations.

Pathways of weed spread	**NSW**	**National**
Birds	24	28
Wind	32	28
Water	40	28
Vehicles	23	21
Livestock movement	27	19
Fodder movement	12	16
Machinery	19	15
Wildlife/vermin	15	14

Table 2 Main pathways for weed spread onto farms as identified by farmers.

THE FUTURE IMPORTANCE OF WEED SPREAD PATHWAYS

Many experts indicated that 'natural' pathways of weed spread (water, wind, birds and other animals) are likely to remain as important in the future. Pathways involving human activity that appear likely to increase in importance include fodder trade, ornamental and aquarium plant trade, agricultural produce, and machinery and vehicles.

Management of weed spread in the context of gardening and landscaping, agricultural production, and natural resource management appears likely to become more crucial over time, due to:

- the increasing popularity of gardening;
- landscape fragmentation, increased traffic movements and growth of peri-urban zones;
- the declining number of herbicides available for use in waterways; and
- projected climatic variability, leading to a need for drought-tolerant food, fodder and ornamental plant species, the movement of weed-contaminated fodder into drought affected areas, and perhaps enhancing the capacity of natural pathways to carry viable seeds and other propagules.

SUFFICIENCY OF INFORMATION

Lack of information on a pathway's importance does not generally obstruct more effective management. Nevertheless, the pathways which experts know least about and which may need further research to determine their importance in Australia are Human apparel and equipment, Food plant trade, Revegetation and forestry, Other animals, Waste disposal, Medicinal plant trade and Construction and landscaping materials.

The pathway that stands out as having the least sufficient information to design effective management strategies is Birds, followed by Other [wild] animals. Other pathways lacking effective management strategies, and in need of research include the trade in Medicinal plants, movement of weeds in Human apparel and equipment, and in Waste disposal, all pathways that tend to avoid detection by authorities.

Many respondents were unaware of past research on the particular pathway on which they were commenting, indicating a lack of effective extension or acquisition of information, even at this 'expert' level. This issue needs ongoing investigation, both at this level and that of the broader community, given the overwhelming emphasis of respondents on education, extension and publicity for better management of weed spread within Australia.

WEED DETECTION

Weeds Inspectors

The surveillance strategies of inspectors are determined most notably by their own professional judgement, legislative guidelines, and availability of resources. Target lists of weeds are used by the majority of inspectors when searching for weeds, and are particularly important in Victoria. Respondents from Tasmania on the other hand are relatively less likely to use target lists. Declaration of a new weed is viewed by a slim majority of respondents as a positive influence on farmer weed surveillance, though the intended visit of a weeds inspector is viewed as influential by over 75 per cent of respondents, perhaps being a more direct ‘threat’ than declaration.

Inspectors are most likely to target ‘high risk’ properties, with known target weeds, a history of weed introductions, located near known infestations, or for which complaints have been received. Overall, all inspectors carry out frequent inspection of locations where weeds have been found previously. Less than one fifth of inspectors inspect on an ad hoc basis. Victorian inspectors appear to be more thorough in their inspections of properties. The higher the percentage of properties inspected regularly, the greater the time usually between property visits.

Time of year appears to be the most important factor determining when inspectors look for new weeds, though this factor prompts respondents from SA, WA, NT and Victoria to look for new weeds more than it does for those from Tasmania, NSW and Queensland. The most frequently used form of transport when inspecting for weeds are passenger vehicles and on foot. Likely hospitable areas are generally targeted, though a random walk or drive is also commonly used, rather than specific transects. The average area of a paddock inspected overall is 62.8 per cent but this varied between states. For example, Victorian respondents inspect almost twice the area in each paddock than SA respondents. The surveillance and detection strategies believed to work best include regular visual inspections of properties, responding to complaints and hearing word of mouth about new weeds, and education and extension activities. Overall, respondents are reasonably satisfied with their weed surveillance strategies. Victorians are the most satisfied while Tasmanians are the least satisfied. New weeds are most often found along roads, water ways, and where livestock are fed.

To identify a new plant, weeds inspectors mostly refer to weed identification books and brochures, consult with other local experts such as agronomists and send specimens away to herbaria and botanic gardens. Nearly half of the inspectors have no problem identifying plants. However, the most commonly indicated impediment is insufficient experience.

Weeds inspectors appear to use a variety of procedures to record the occurrence of a new weed, though the most commonly indicated include using GPS to record the weed’s location, recording the location in a database, and marking it on a map. The software used includes various GIS and mapping packages, and tailored database packages including Pestinfo and IPMS (specific to Victorian weeds inspectors). While the response group was ambivalent about whether there were impediments to standardised reporting, those who see such impediments believe that the main ones are inflexible or non-standardised reporting systems. IPMS in particular is viewed by Victorian respondents as an antiquated system.

Over 74 per cent of respondents have experienced hesitance on the part of landholders to report weeds caused by the costs associated with weed control, fear of potential sanctions or enforcement, lack of interest, and insufficient knowledge. Respondents are relatively undecided overall as to whether information on the distribution of weeds on private property should be made publicly available.

Inspectors appear to undertake a range of responses to discovery of a new weed. The highest proportion carries out further searching to map the distribution of the weed. Overall, respondents have rated the level of coordination of response to weed outbreaks as being reasonably good, being rated highest in SA and lowest in the NT. Stress and burnout amongst weeds inspectors appears to be more prevalent in Victoria and WA, and less prevalent in Queensland.

Inspectors consider that landholders have a moderate commitment to weed detection overall, with only just over 10 per cent believing that landholders have a high level of commitment. The main incentives committing landholders to weed detection and control are believed to involve landholder knowledge, while the main impediments to landholder commitment involve various ‘costs’ (financial, time, staffing). The landholders assessed as least committed to weed detection are part-time farmers (absentee landholders, lifestyle farmers, and farmers with off-farm employment). For this reason, a specific extension booklet for owners of small farms entitled *Weed Detection and Control on Small Farms: a Guide for Owners*, has been developed and is available for education activities with this group of landholders (see below).

The most committed government agencies according to the inspectors include weeds authorities, and State agriculture and environment departments, while the least committed include State crown lands departments, roads authorities and the Commonwealth government.

Most (76 per cent) inspectors believe that weed surveillance could be improved through supply of increased resources and personnel, community awareness and education, and through more of their time being devoted to in-field detection work. Although less critical, improvements to weed identification would involve weed identification training for staff, landholders, volunteers and the general public, as well as dedicated weed identification resources.

Other suggestions for improving weed detection involve the themes of training and education of staff, landholders and the general public, increased government resources and funding, improving inspection techniques, and changes to legislation.

Farmers

The individual weeds of most concern to landholders overall are thistles, followed by Paterson’s curse, Bathurst burr and blackberry, though these percentages varied considerably between states, while when minor species were grouped, those weeds of most concern were other perennial broadleaf weeds (29.0 per cent), followed by other annual broadleaf weeds (24.6 per cent), perennial grasses (18.3 per cent), woody weeds (18.1 percent) and other annual grasses (9.5 per cent). Only 3.5 per cent of farmers interviewed are concerned about vines.

The great majority of farmers (84.3 per cent) check for weeds on a regular basis though most (65.3 per cent) do so while conducting other on-farm tasks.

Most farmers consider that weed declaration makes no difference to checking for weeds, though it does make a difference for a small majority of WA interviewees, suggesting more effective declaration strategy and promotion in that state. Only 4.8 per cent of landholders indicate that the impending visit of an inspector makes them change their weed checking activity, which is in contrast to the more favourable perception of this impending visit amongst weed inspectors surveyed.

Farmers believe that weed authorities should focus on making sufficient information available to landholders on target plants rather than focusing on getting landholders to simply report suspicious plants to authorities, although 28.5 per cent suggest that both strategies would be useful. More farmers than inspectors (65.3 per cent) believe that weed distribution information on private property should be made publicly available. However, NSW interviewees are less likely to agree with this than their counterparts, especially those in Queensland. Popular reasons for making the information available includes that it made landholders better informed and is in the community interest, while a relatively high proportion suggest that it is an invasion of privacy.

The majority (66.3 per cent) of farmers concentrate on watered areas of the property, boundaries, traffic areas and previous known infestation areas when checking their farms for weeds. These are the areas where most new weeds are regularly found. Even when new weeds are rarely found in these areas, a high proportion of farmers believe that they are still worth checking. Few areas of a property were considered difficult to check.

Overall, 80.2 per cent of interviewees check for weeds on average every three months or less (at least four times per year). While year-round weed checking is not unusual amongst farmers, overall, 67.3 per cent of farmers check for weeds at particular times of year, a practice relatively more common in SA and WA, presumably due to climatic conditions, such as the distinct break of rainfall in the Mediterranean climates of southern SA and WA. The spring months appear to be the most common time for weed inspection, though the pattern varies on a state and territory and property type basis, depending on when weeds are growing rapidly, such as after rain.

Motor bikes and quad bikes are the most widely used (71.3 per cent) mode of transport by farmers when undertaking surveillance for weeds, followed by passenger vehicles (57.6 per cent). Farmers from Victoria check the largest percentage of a property overall (96 per cent) while those from the NT check the lowest (71.6 per cent). Of all property types, crop farmers check the highest overall percentage (96.5 per cent) and horticulturalists the lowest (86.1 per cent). Approximately half of the farmers believe their surveillance strategy is ‘mostly effective’ while the other half said that it was ‘very effective’.

Having found an unknown weed, 74.8 per cent of farmers will ask a local professional for identification advice, while only 26.6 per cent will look the weed up in a book. Sending the weed away for identification is unusual behaviour amongst farmers. Curiosity, or wanting to know what the weed is, is the main motivation for having a weed identified, to a greater degree than concerns about spread, and possible economic losses.

When finding a new weed, 42.1 per cent of farmers will mark the site in the paddock with a stick or pole, while 36.8 per cent will make a record of it in a diary or notebook. The majority of farmers believe that impediments to reporting new weed discoveries include the cost of eradication, threat or fear of legal action, and concern over what other landholders might think.

Most farmers will either remove a new weed upon finding it or spray it as soon as possible afterwards, with only about a fifth finding out how to control the weed.

Farmers in general believe that, compared with ‘professional’ farmers, hobby farmers or rural retreat farmers are less likely to check for weeds, followed by absentee owners. Factors likely to encourage landholders to check for weeds included subsidising costs such as spray (17.1 per cent), awareness and advertising (16.4 per cent), and research and publicity into weed cost and impact (14.8 per cent). On the other hand, factors that discourage them from checking for new weeds include cost (39.4 per cent), lack of time or labour (17.1 per cent) and laziness and apathy (11.4 per cent).

Over half of all farmers rate the level of government commitment to weed control as ‘low’. However, this percentage varies between states. For example, while 72.4 per cent of Victorian interviewees and 68.2 per cent of those from Tasmania rate the level of commitment as ‘low’, only 41.9 per cent of interviewees from SA do so.

The largest proportion of farmers interviewed (22.2 per cent) have no suggestions for improving on-ground detection of weeds. However, the relatively high proportion of respondents indicating education and awareness campaigns and improved communication between weeds authorities and landholders suggests that many farmers feel inadequately informed with regard to weed control (an opinion shared by many weeds inspectors). The largest proportion of respondents overall (over 19 per cent) indicated that updated local information or weed notification was a worthwhile initiative. A significantly higher proportion of cropping farmers, compared with the overall response group, are happy with the information on weed detection currently available.

CONCLUSIONS

On the whole, this research project has shown that Australian farmers are alert to new weeds, and have a reasonably high level of commitment to detection and control of such species, whether they be so called ‘alert weeds’, ‘sleeper weeds’, ‘weeds of national significance’, or simply weeds that are well established in Australia but spreading to new areas and properties. As a group, farmers therefore need to be encouraged, and equipped where needed, to be vigilant and effective weed spotters. This may be achieved through, amongst other things, training opportunities, greater extension and educational activities, increased resources devoted to weed detection, and greater cooperation between landholders and weeds authorities.

Weeds inspectors have also been shown to play a vital role in supporting and facilitating weed detection and control. While sometimes differing in opinion to the farmers, for example on the value of an inspection visit on weed control, the legally sanctioned surveillance of weeds by inspectors complements the generally voluntary approach adopted by farmers.

While certain questions in the surveys specifically called for suggestions to improve on-ground weed detection, the assumption made here is that the predominant approaches taken by farmers and weeds inspectors are most likely to be the more effective or efficient on-farm weed detection strategies. This assumption is based on the fact that, due to their long history of involvement with weeds, many farmers and inspectors will have determined the best management practice for weeds.

There was often considerable variation between states and territories, and property types in relation to weed spread detection and reporting. Some states and territories, and landholder types were considered as performing better than others, though geographic and climatic differences, as well as enterprise differences, accounted for some of the variability. Research and extension programs aimed at improving weed detection strategies will need to take into account such variation and target specific groups appropriately.

Overall, there was seen to be a low level of government commitment to weed detection. Given the high environmental, social and economic impact of weeds, this situation needs to be remedied, since early detection is much more cost-effective than later cure.

ACKNOWLEDGEMENTS
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FURTHER INFORMATION
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PONDED PASTURE GRASSES *hymenachne amplexicaulis* (RUDGE) NEES (HYMENACHNE) AND *Echinochloa polystachya* (KUNTH) A.S. HITCHC. CV 'AMITY' (ALEMAN GRASS) AND THE POTENTIAL FOR SPREAD OF INVASIVE WEEDS

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1. Introduction

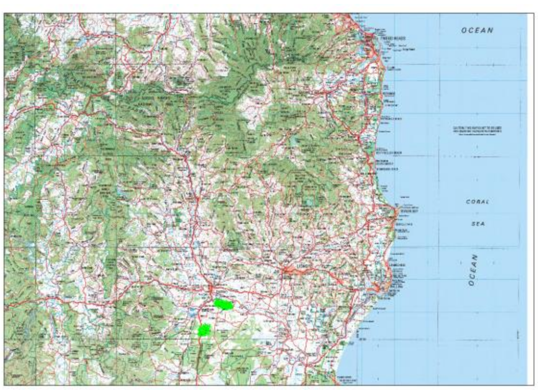
During the 1970's, 80's and 90's two grass species were promoted in Australia particularly Queensland for their use in tropical savannah production systems. The aim was to improve productivity and carrying capacity on seasonally marginal lands. These species are now collectively referred to as ponded pasture grasses.

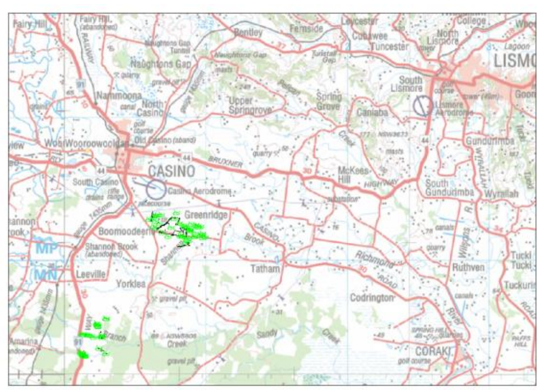
These two grasses have since been recognised as being a significant threat to aquatic ecosystems in Australia.

While the focus has been on hymenachne (Class 1 Noxious Weed and one of 20 Weeds of National Significance (WoNS)), aleman grass appears to pose a much higher risk in northern NSW. Aleman grass is yet to be formally unclassified as a serious weed.

Brachiaria mutica (Forsk.) Stapf. (para grass) introduced decades earlier is already widespread in the landscape in both riparian and dryland situations. Para grass tends to occupy drier parts of the ponded systems and may also colonise roadsides and dry cuttings. Para grass does not compete well with the ponded grasses in wet situations. This species may provide an indication of the potential for invasion by these ponded pasture new-comers.

Far North Coast Weeds (FNCW) is a county council managing 10,000 square kilometres covering 6 local government areas on the far north coast of NSW.





Figures 1 & 2 Map of extent of infestation and a close showing the Casino sites

2. Background

Hymenachne and aleman or creeping river grass have been extensively planted in ponded pasture systems in north and central Queensland for dry season grazing. In most instances the species have established extensively in wetlands and riparian areas on and off-farm where suitable situations exist. The rate at which this has occurred is alarming. Extensive infestations occur in swamps and wetlands along the Queensland coastal floodplains north from Rockhampton.

In north eastern NSW, hymenachne was thought to only occur as several small, isolated infestations around Casino and Lismore. The Lismore site was identified in mid 2008 while a new site, west of Coolangatta was only discovered in May 2009. The fact that two new sites have been found in the past year indicates that it is highly likely that it will be found elsewhere in the region.

Personal observations of aleman grass in central Queensland during October 2008 suggest that this species is substantially more invasive and would appear to outgrow hymenachne in some situations.

Observations indicate that on the north coast of NSW, aleman grass is potentially more invasive than hymenachne and poses a real and immediate threat to the region.

3. Information

Aleman grass is capable of growing in deep water, initially starting as plants anchored off the bank. This was observed in Rockhampton until January 2008. On this occasion the weed covered the river to a depth of 6m and the small gap in the centre was choked with *Eicchornia crassipes* (Mart.) Solms (water hyacinth) above the barrage. This combined infestation rendered the Fitzroy River unnavigable. When flushed out by floods in January 2008 it cost the greater Rockhampton Council $200,000.00 to remove it from the beaches around Yeppoon.

Observations within an artificial billabong near Yorklea in northern NSW indicate that aleman grass is extremely invasive and capable of producing massive quantities of biomass. This species has demonstrated its capacity to develop a floating horizon in deep water, easily capable of supporting people and livestock.

Rafts are not always solid and anecdotal reports indicate that livestock have been lost by falling through the rafts and drowning as a result of starvation or exhaustion (3 reported in one dam in a relatively short period of time).

Rafts can be extremely mobile and coherent in flood waters with the potential to cause extensive damage to farming infrastructure. Rafts can detach from the bank and become free floating usually as a result of increased flow rates typical of flood events. Such rafts can move around with wind or flow events causing prolonged or temporary access restrictions and damage to assets.

FNCW is actively targeting both species in an effort to eradicate them from the county. Aleman has been nominated as a Class 1 Noxious Weed due to the invasive nature observed in the County.

FNCW has successfully reduced the density of hymenachne and aleman grass over the past 2 years. This has been the result of a range of interacting circumstances including spraying, floods, frost, droughts, drainage and grazing regimes.

4. Scope of Infestation

Hymenachne and aleman grass occur at several sites in northern NSW. A brief account of each site is set out below.

Leeville

There are two infestation sites near Leeville the total area of infestation of both ponded pasture species is less than 3Ha covering crown and private lands.

The main infestation in this location is in Branch Creek downstream of the Bruxner Highway and comprises primarily of aleman grass with scattered patches of hymenachne throughout.

Aleman grass has completely covered the creek for nearly a kilometre. Treatment of both species in 2008 has lead to an observed recovery of the hymenachne at several small sites where it has actually repopulated some of the treated areas of aleman grass. Both species appear to be capable of growing in heavy shade under mature *Melaleuca quinquenervia* (Cav.) Blake dominated channels.

Figure 3 and 4 Aleman grass to hymenachne succession in Branch Creek in 12 months

The other Leeville infestation is located along a Crown drainage easement and consists exclusively of hymenachne as scattered clumps to $20m^2$. From this location several dams and associated drainage lines also contain small clumps.

Between these two features are several farm dams that contain single point infestations of both hymenachne and aleman grass often growing as individual plants on the mature rafts of *Salvinia molesta* D.S. Mitch. These dams have proved difficult to control due to reduced access associated with mature salvinia infestations.

Figure 5 Hymenachne growing in salvinia

Yorklea

This site is typified by extremely low lying swampy land prone to prolonged inundation following flood events. Two floods have overtopped these sites within 16 months. This continues to cause major concerns in relation to containing the infestation.

This is the primary site of infestation and consists of two constructed hydrological features a dammed up remnant channel of Shannonbrook and a ponded pasture system contained by a 1m levee. Both sites have significant coverage of both ponded pasture grasses.

North Lismore

This site was located in August 2008 on a roadside, several kilometres of the Lismore CBD. It covers 3 parcels a constructed swampy area on the upstream side a roadside drain and a drainage line in a pasture on the bottom side. Delimiting inspections have not located any hymenachne downstream to the Wilson River. The site is contained and eradication is likely within 5 years.

Cobaki

In May 2009 a small point infestation of hymenachne was located on a roadside at Cobaki near Coolangatta indicating the potential for this weed to show up anywhere in the county as a result of human movement. This occurrence demonstrates the reality that ponded pasture grasses are present in the landscape and are likely to be found at other locations within the county waiting to be found.

5. Control Experience

While control activities have focussed on hymenachne, there has been an opportunity to simultaneously control aleman grass due to its association. Control works will now focus on removing aleman grass where it has dominated riparian and channel situations of Branch Creek. This control will facilitate access to remaining hymenachne infestations.

Council is confident that these weeds can be eradicated from northern NSW with diligence within a relatively short period of time. The vegetative nature of both weeds and the relative immobility of both under normal circumstances have also significantly bolstered this confidence.

There has been no evidence of dispersal by seed, however this has not been ruled out.

Aquatic control

Water based treatments using Weedmaster Duo® has been observed to be less effective than land based treatments. This observation was confirmed at the Hymenachne Research Forum in Townsville in June 2009 where similar observations have been made in Queensland. There is a significant reduction in efficacy of the chemical when it is applied to material growing in water. This is illustrated graphically where an infestation grows on the bank and out into the water with a clear demarcation of the reduced impact on the aquatic section.

Figure 6 Clear delineation of aquatic and terrestrial response to treatment

The development of Haloxyfop as an Off-Label Permit is being investigated but is still some way from being granted.

Control efforts are still significantly hampered by the lack of suitable permitted effective herbicides.

Aerial application

Aerial application was utilised for the initial treatment due to the size and access difficulties of the site.

This produced excellent results with significant reductions in the area of coverage as well as the density of the remaining infestation.

Figure 7 & 8 Change in hymenachne composition over a 2 year period showing drainage

Physical modification of growing system

Following aerial treatments in 2007 earthworks were conducted to reduce the standing water height in the system and allow drainage of the system following recharge events.

This theoretically was a logical decision but in reality led to movement due to a flood the following year. The breaks in the wall increased erosion around the breaches leading to large rafts becoming mobile and moving up to 1km downstream.

Figure 9 a large raft of hymenachne that moved 1km in shallow flood water

Recent works have flattened the entire wall reducing channelling and erosion potential and further risk of spread.

6. Surveillance

Recent flood events in May 2009 may have moved the weeds downstream across several pasture and swampy areas requiring a targeted and systematic inspection of all properties identified as being at risk.

7. CFoC

Council has applied for funding under the CFoC program and is confident that it will receive some funding as the project targets 3 WoNS in high conservation value ecosystems and are in strategically significant locations. If successful council will be able to dedicate a full time crew to effectively delimit and control the weeds.

8. Downstream delimitation

Council has used existing GIS data to analyse potential patterns of spread and uses this information to develop inspection areas and assign priority according to risk.

All staff conducting such exercises carry a hand held GPS to ensure thorough coverage of the search area and facilitate efficient treatment activities. This provides a permanent record of what has been inspected.

9. Media releases

Council has engaged community newspapers and ABC radio on a regular basis to promote topical weed issues.

Once Council started providing regular features in printed media numerous enquiries were received as a direct result proving that targeted articles are extremely successful at disseminating information to the community. One article resulted in 30 calls relating to a class 3 weed. The determining factor for success would appear to be good quality close-up pictures that show unique features or simply allow definite identification.

10. Field Days

Council conducted two field days dealing with ponded pastures to increase community awareness. These events were promoted on radio and in print media with a good response to both (140 people attended a 1 day event and 570 a 3 day event).

Field days at larger events are an ideal way to show live specimens and interact with the community. Typically events are well attended with many people bringing in specimens for identification. Council stipulates in promotional material that specimens should be bagged to ensure no seed is spread and then if required council will dispose of the material suitably. These events have led to several property inspections where landholders believe hymenachne to be present.

11. Individual farmer engagement

Initially farmers were sceptical and mildly hostile due to the productive input these grasses contribute to their enterprises. Most have now started to actively control the weed on their properties as they can now see the big picture. This was not so obvious to them when looking from a production point of view. Engaging individual farmers is often a long process and the expectation to get engagement after a few visits is unrealistic. Eventually persistence and logic supported by good information will prevail.

12. Conclusion

Ponded pasture grasses are controllable and eradicable when the areas infested are relatively small and isolated. The biggest issue is the timely identification of new infestations.

Had the grasses been as widespread as para grass, eradication or containment would be an unrealistic objective.

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Hymenachne *Hymenachne amplexicaulis* management

OLD DOGS-NEW TRICKS: EXPLORING CHANGE IN OUR WEED OFFICERS FROM THE PAST, PRESENT AND FUTURE

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ABSTRACT
The position of Weeds Officer has come a long way from a labourer based operation to wide ranging, planned weed management process. Legislation, agency changes, increasing accountability and environmental awareness have expanded the roles and responsibilities of weed management staff in NSW.

The NSW Weeds Training Program continues to support weeds officers as their role in Australian weed management changes. Relevant training and skills recognition have complimented the diverse, hands on experience required for the job and helped lift the profile of the industry.

For many Weeds Officers, sitting in a classroom is something that was avoided at all costs. Now, training and development is an accepted and growing part of weed management culture in NSW.

This paper explores the changing demographic of our weed professionals from a training perspective and how the Weeds Training Program is developing new courses to tackle strategic weed management and meet the NSW Invasive Species Plan objectives.

INTRODUCTION
Vocational Education and Training (VET) is about bridging a gap between what people learn at school and the skills they need to do their job now. Acquiring new skills is essential for any industry to grow with technological change. VET is the most direct means of providing workers with the necessary skills to embrace industry developments.

Australian VET began in the late 1900's, then by mid 1970 what is now known as the TAFE system had begun (training.com.au). Now there are around 3,100 registered training organisations offering VET in Australia (ABS 2008).

Over half of NSW Weeds Officers surveyed in 2003 had not formally studied since leaving school. This paper compares the change in demographics of NSW weed professionals in relation to training. As well as providing comment on the role training plays in changing workplace and discussion on the vital practice of recognising informal learning in the workplace.

Information in this paper was sourced from weeds professionals employed by NSW Local Control Authorities (LCAs). Demographic information collected from the weeds training data base has been used, this sample group consists of 126 currently employed weeds professionals. Data from a survey conducted in 2003, where 114 weeds professionals participated has also been used. Throughout this paper the terms 'weeds professionals' and 'Weeds Officers' are interchangeable and refer to staff employed by NSW LCAs to manage noxious weeds.

Old dogs

From information gathered on weeds professionals currently employed in NSW, it was revealed that a quarter of staff are over 55 years of age. Since 2003 the percentage of over 60 year olds has increased from 2% to 13%. This trend is largely due to the baby boomer cohort aging which has an affect on the composition of the NSW weeds workforce.

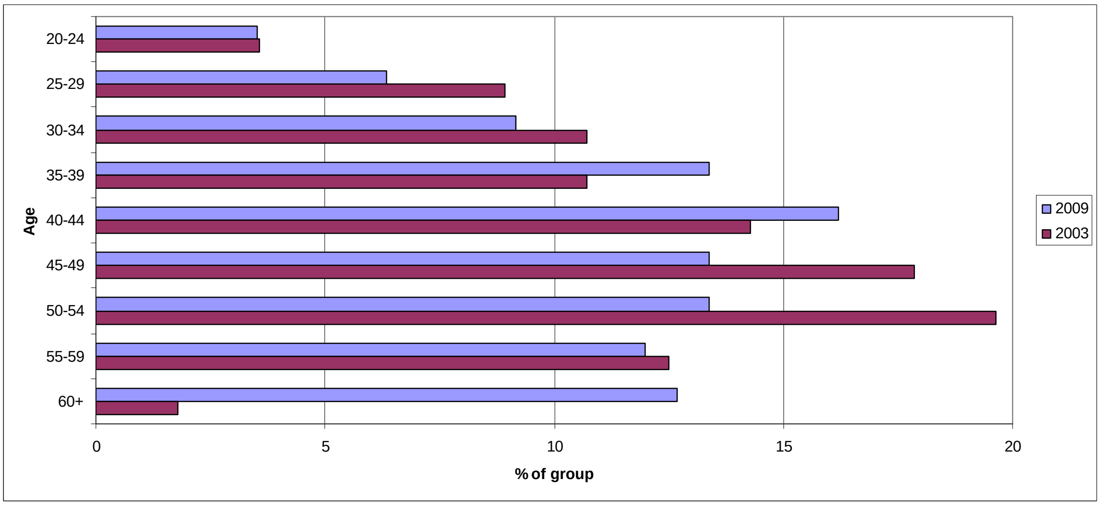

Figure 1 Age of NSW Weeds Officer recorded in 2003 and 2009

Let's look at this group more closely. Still fighting the battle with weeds, our 'old dogs', born in the late 1940's and 1950's. Secondary school in late 1960's to early 1970's was very different than now. Whiteboards did not exist, digital watches were only just introduced as was the first hand held scientific calculator. The Beatles topped the charts with *Hey Jude* along with John Farnham's song *Sadie the cleaning lady*. The Holden Monaro was a symbol of everything that was great about Australia.

Of this group 33% completed Year 12, which compares favourably to the rest of Australia at that time. In 1968 school retention rate was at 23%, rising to 31% in 1971 (ABS 2001). In the late 1960s and early 1970s, the unemployment rate stood at 2% but over the 1970s it rose gradually to 6%. Unemployment for young people (15-24 years of age) had been notably higher than for other age groups during the 1970's (ABS 2001), this contributed to a further increase in school retention rates.

Table 1 Apparent retention to Year 12 across Australia – 1967 to 1999

Year	*All Australian schools %*
1971	30.6
1974	32.9
1979	34.7
1984	45.0
1992	77.1
1994	74.6
1999	72.3

Source: adapted from ABS (2001) (Cat 1301.0)

Once leaving school in late 1960's to early 1970's, less than 4% of our 'old dogs' completed a trade certificate or apprenticeship. At this time earning a trade certificate through apprenticeship or enrolling in university or college studies were the standard opportunities to obtain a post-school qualification.

Employed by local council as a labourer weeds staff would control weeds and conduct noxious weed inspections. After work these 'old dogs' would relax with a cold can (rip top) or glass of KB, VB or DA in their hand. Not knowing of the changes that the 1980's, 1990's and beyond would bring to their workplace. They may have thought that by 2000 they would be travelling to work in something that resembles a flying saucer, but would never have imagined that one day they would be walking around in fluorescent work shirts.

Young pups

At the other end of our target group are 'the young pups', weeds officers under 30 years of age. This group represents 19% of weeds professionals in NSW. When they were entering adulthood, they watched 'The Simpsons' instead of 'The Jetsons'. Our 'young pups' have not known computers without 'Windows', and are completely comfortable with, podcasting, Bluetooth, Napster (and cybercrime), Skype, YouTube, MySpace, Facebook and 'iAnything'.

This technology rich group stayed at school longer, school retention rates were above 70% in mid to late 1990's (Table 1). From weeds professionals surveyed, 25% of the 'young pups' studied at university and 63% achieved VET qualifications prior to commencing work with LCAs. In 1996, among all Australians aged 15 years and over who held a post school qualification, 26% held a bachelor degree as their highest qualification, and 26% held a skilled vocational qualification (ABS 1999).

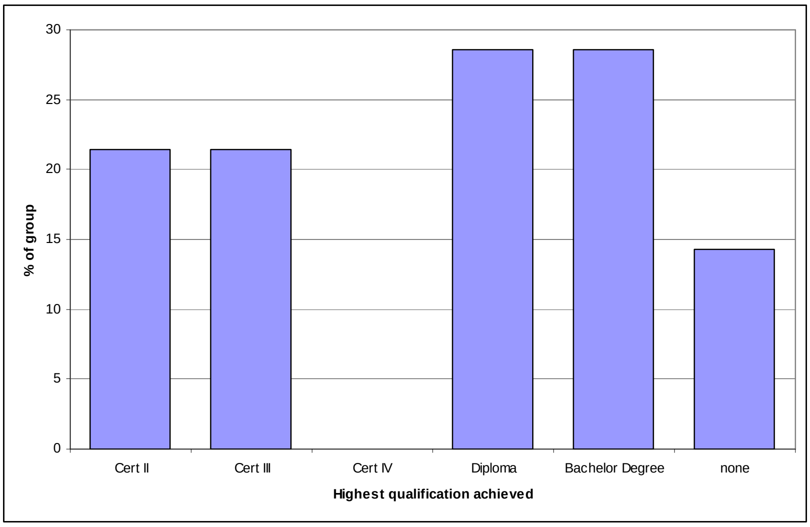

Figure 2 Highest qualification achieved by Weed Officers aged between 18-30 years

Employers across Australia began providing training for their employees in the 1990's. In 1997 most provided unstructured training such as instructions or demonstrations on the job. 35% of employers provided structured training in 1997, this is an increase of 23% in 1996 (ABS 1998).

The shift to a bigger picture weed management style has most likely been driven by recent social and environmental demands. These 'young pups' may have not known weed management before regional planning. Weeds professionals have been contributing to regional plans since 2002, hence gaining greater ownership and awareness of their regional commitments.

New dogs old tricks

Another trend we are seeing in this industry is that many new employees are joining the weed profession at a mature age. These ones are coming into the industry with few or no formal skills in the sector (similar to the 'old dogs') but with a lot of other work experience and life skills.

Of the 33 officers attending Weed Officer Induction training in 2008 and 2009, over 50% were aged between 30 and 40 and 18% were over 50 years old.

Table 2 Weed Officer ages at Induction training – 2008 to 2009

Weed Officer Induction age summary	2008	2009	Total %
under 30 years	2	7	**27%**
30 to 40 years	13	5	**55%**
over 50 years	2	4	**18%**
			100%

The job can be difficult for this group as often there is an assumption of knowledge and skills which may not be the case. They are less likely to be supported to the extent of 'young pups'. The LCA as an employer also needs to realise that these ones will have a shorter career life and need to consider a succession plan to prepare replacement on a much shorter scale.

Short training courses dealing with specific aspects of the job at well spaced intervals is ideal for this group to learn and apply the new skills they receive.

New tricks for all

Knowledge and skills are not solely gained through a structured learning environment. Non formal or unstructured learning can take place at any time in or out of the workplace. This form of learning, as you might expect occurs when a person is interested and conscientious in their work, it happens without structured tuition.

From the survey conducted in 2003, 55% of weeds officers surveyed had not completed any further training or education since school. This did not mean that they were unskilled. Of this group 16% had been working in LCA weed management for over 20 years and 30% for over 10 years.

In 1999 it was acknowledged that many NSW weeds officers are highly skilled without qualification, carrying a wealth of job experience and looking to build on that. Consequently the Skills Recognition process began. Skills Recognition involves assessment of the participants acquired skills and knowledge against the formal requirements for gaining a qualification. By doing so the person is more mentally fit deal with change in their industry.

Skills Recognition is a starting point rather than an end point. It enables the person to fill their knowledge gaps more precisely.

After 10 Weeds Officers earned qualifications at Certificate level in 1999, training was offered that complimented the current skill base in the industry. NSW Weeds Officers were offered training that was relevant to their profession and helped them interpret and implement the *Noxious Weeds Act* effectively. By the end of 2003 70% of LCAs had at least one staff member who had completed the three-stage legal training for the *Noxious Weeds Act* recommended by NSW DPI. Weeds officers across NSW tallied up over 11,000 hours of face to face training in the three years from 2000 to 2003.

Formal recognition of the skills of weeds officers has been a great boost to the profession. Between 1999 and 2003 84 Certificate II qualifications were awarded and 44 Certificate IV qualifications were awarded *(33 weeds officers gained both).* Graduates at this time were aged between 25 and 60 years of age. For the majority of this group they earned their first post school qualification.

With the introduction of nation wide training packages including weed management competencies in 2003, 36 Diplomas of Conservation and Land Management have been awarded through the Skills Recognition process. Although it is possible to earn a qualification completely by recognition of unstructured learning and job experience, the training program offered short courses to compliment this process. 68% of these qualifications were earned through a combination of short course work and Skills Recognition. Training was no longer limited to a single event in a person's life due to this nationally consistent and industry led VET system.

The Skills Recognition initiative immediately strengthened the capacity of weeds professionals. From a survey conducted of 70 weeds professionals who completed Skills Recognition, 79% agreed that "Since receiving a qualification through the Skills Recognition Program my attitude towards my work and the role I play in council has changed".

Paul Keating was quoted "…the real achievement of vocational education and training lies in its extraordinary capacity to meet changing national requirements…it used to be about young people and first time training; now it is adapting to support the training and retraining of an ageing population." (Keating 2003).

Current

Training is not necessarily about teaching it is more to do with helping participants to learn and practice skills needed in their work.

The Weeds Training Program (Training Program) aims to provide the weed industry with an enriched pool of skilled workers who use their vocational education to compliment their hands on experience. The Training Program provides courses to fill gaps in ones skill base enabling participants to earn qualifications in the most practical and efficient way.

This framework is attractive to adult learners as they can train in bite-sized chunks, completing one, two or more short courses to gain specific skills. According to a 2005 ABS survey, 5.3 million people aged between 15-69 years completed one or more work-related training courses. This is a significant rise from 1997, where only 1.5 million persons aged 15-64 years were in VET (ABS 1998).

Of the short courses offered by the Training Program, all but one are nationally VET accredited (Legal Stage One), this is a sharp increase from less than half of the courses completed between 2000 and 2003.

Future

The skills recognition process will continue to play a major role in capacity building of weed managers in NSW. From their report *Recognising non-formal and informal learning: Participant insights and perspectives,* Smith and Clayton (2009) found that as almost all of the skills recognition participants interviewed stated that they had gained much more confidence in themselves as learners.

The Weeds Officer Induction training, crucial for engaging new staff, will be continually adapted to industry needs. Some of its success can be attributed to the 'Weeds Officers training Weeds Officers' approach. This involves experienced weeds professionals delivering training to junior or new staff which will not only remain but will be expanded across the State.

The direction of the Training Program is now aligned with the goals of the NSW Invasive Species Plan (ISP). Further increasing the capacity of weeds professionals to manage invasive species is a component of Goal 4: ‘Capacity’ of the ISP.

The Training Program plans to roll out a suite of courses that will equip weeds professionals to achieve their own objectives under the ISP. This collection of short courses will include three topic areas. Firstly, assistance in adopting the changed noxious weed grant application process. This will be rolled out intensively through small group sessions across the State. Secondly, Monitoring, Evaluation, Reporting and Implementation (MERI) training will be run. Thirdly, Weed Risk Management (WRM) training will be available as face to face training as well as an external study unit. Both MERI and WRM training will be mapped to high level VET competencies.

CONCLUSION

With a large percentage of highly experienced weeds professionals reaching the twilight of their career, it is important that when they move out of the industry new weeds staff are prepared with both the formal skills and vast experience handed down by the senior officers. This succession management is a challenge to employers and trainers, to ensure that a lifetime of knowledge and skills doesn’t disappear out the door, and that the ones taking up the position are being trained in knowledge and skills to become successful and progressive weed managers.

Although the underlying principles of weed management are still relevant and applicable, strategic management systems need to become common practice. The Training Program aims to help our ‘old dogs’, ‘young pups’ and all in between by providing training and support while we all work to meet ISP Objectives.

With considerable changes to local and regional weed management, our Weed Officers are well equipped to meet this change. Weeds officers have continued to participate in short courses held through the Training Program, enforcing that weeds professionals today see training as a constant throughout their career.

Old dogs may not learn as quickly at they did when they were young but when you take the time you will realise that most old dogs can do anything that a young dog can do. The old dogs can also show the young pups a trick or two of their own!

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ENGAGING LANDHOLDERS IN WEED IDENTIFICATION AND MANAGEMENT

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The integration of technical messages with landholder experience is crucial in engaging and delivering weed extension material. Equally important is the delivery of the material using adult learning principles, being relevant and being timely. The New England Weeds Authority and the NSW Department of Primary Industries have partnered together over the last 10 years to deliver small, targeted local field days. With over 15 events and 300 participants, this paper reflects on the concept and its success.

During spring and early summer in the Armidale area, there is a cross-over when many cool season plant species are flowering at the same time as the warm season species. This allows an opportunity to run field days assisting landholders to identify some of the local and 'upcoming' weeds in their area. The species displayed are not always noxious, but may include both environmental and pasture weeds. The field days, often run over a few hours, are held in local halls or sites of interest. These days are open to all landholders and interested people in the local area. Using a hall as a venue allows for containment, with many attendees bringing their own weed samples to have identified. Organisers can use perspex containers to transport and display Weeds from outside the area or potential weeds not found in the local area, allowing attendees to observe these species first hand. If the site is suitable, the field day can venture out of the hall to investigate local weed and pasture species growing in situ.

The field days are designed for small groups, usually around 15 to 20 people. This size encourages a lot of discussion and allows time for questions to be adequately answered. The field days are often targeted at areas scheduled for inspections over the forthcoming year, allowing an opportunity for the Authority to 'meet and greet' landholders and explain their role beforehand. Often a flyer is distributed to the area via a mail-box drop, and the local media (such as newspapers and radio) may also be used. In some cases the local Landcare group is involved, or the local area committee invites the team to deliver a field day.

These 'hands-on' field days have been successful because they can be tailored to targeted areas. They are relatively short days that are well attended. Over the years, these days have also been tailored to suit rural holdings and weeds of special interest. They tend to inexpensive to run and are seen as a 'win-win' extension package for landholders, the Authority and the NSW DPI. A recent survey at one such field day revealed the majority of participants either agreed or strongly agreed that the event had improved their understanding of and ability to identify and manage many relevant local weeds.

The delivery of this collaborative activity allows the two agencies to meet their outcomes as well as addressing the NSW Invasive Species Plan goals. That is, preventing the establishment of new weeds and restricting the spread and area of existing significant weeds. It also ties in with the goal of increasing capacity for NSW landholders. The collaboration and activity is a concept that could be adapted for other areas of the state.

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10 -20 key word description of the abstract:

Combined field days allow greater identification and management of weeds.

Biography:

Clare has been the Agronomist for the Armidale district with NSW Department of Primary Industries for the last 12 years. She has had a wide experience in delivering extension materials to producers and landholders including field days, workshops and newsletters. She is on the state steering committee for Paddock Plants, a PROfarm workshop on pasture plant identification. She is a graduate (x 2) from the University of New England.

SPREADING THE WORD ON WEEDS – EDUCATION AND INFORMATION SHARING EXAMPLES FROM THE WONS PROGRAM

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ABSTRACT
Sharing weed management information and raising public awareness of weeds are fundamental actions for weed managers. This paper discusses some of the resources used by the Weeds of National Significance (WoNS) programs, including bitou bush, boneseed, willows and aquatics, to share information and raise awareness. Examples include: 1) *Weeds Attack!*, an electronic education resource for schools that uses the science curriculum to engage students in weed issues; 2) a willows toolkit that allows community members and other weed managers to plan and enact willow management using education resources such as PowerPoint presentations and interactive maps; 3) aquatic training workshops that build capacity of land managers to identify and report nationally significant aquatic weeds; and 4) an easy and free way for weeds officers to share mapping data using Google Earth™.

Key words: Education, awareness raising, mapping, information sharing, Google Earth™.

TOOLS YOU CAN USE

One of the most difficult aspects of managing weeds is raising awareness to change public perception of weeds and the impacts they cause. An aware and concerned public is willing to take action and can wield strong pressure on politicians, which can lead to increased support for programs. Thus, increasing public awareness is a crucial activity for weed managers. Sharing weed management information is also essential because weeds must be dealt with holistically across tenure boundaries. The WoNS program has a strong focus on education and awareness and many tools produced by the WoNS programs can be adapted for use at regional or local scales. This paper discusses some of the resources used by the bitou bush, boneseed, willows and aquatic WoNS programs to share information and raise awareness.

Weeds Attack! School Education

Educating the "land managers of the future" about the impact of weeds is a preventative approach that can also have immediate effects in the greater community. It has long been recognised that an effective way to reach parents is through their children: information brought home from school often ends up being discussed over the dinner table or relayed to parents and other community members by children who are eager to pass on what they have learned. Therefore, getting the 'weed message' into the school curriculum is a key goal of the bitou bush and boneseed WoNS program. In 2007, the program joined forces with the Centre for Learning Innovation

(CLI), at NSW Department of Education and Training, and NSW Department of Primary Industries to develop *Weeds Attack! Invasion of the bitou bush*, an electronic education resource that uses the science curriculum to engage students in weed issues.

"*Weeds Attack!*" is a web-based, multimedia resource with interactive learning activities that increase weed awareness through a series of challenges. Students are engaged by exciting computer games and the opportunity to do "hands-on" field work. The resource allows students to investigate the impacts of weeds on a global scale and learn about weed science principles and weed impacts to biodiversity, the environment and agriculture. *Weeds Attack!* also incorporates *Weed Warriors*, a national program that empowers students to act on weed issues using biological control agents. In NSW, students reduce the impact of bitou bush by rearing, releasing and monitoring the *Tortrix* leaf-roller moth at sites in their community. Local schools can thus contribute to important national biological control programs. Although the prototype was developed using bitou bush, it is envisaged that the resource will ultimately be adapted for each of the WoNS and all of the weeds targeted by the *Weed Warriors* program.

The *Weeds Attack!* resource was designed by education experts at CLI to directly address the science and technology curriculum, with maximum use of ICT (Information, Communication, and Technology) to increase student's ability to use laptops and other new technology. While the program was developed in New South Wales, the resource conforms to national curriculum standards to allow national adoption.

Weeds Attack! is an innovative approach to raising weed awareness among young people by educating students using integrated learning tools. This project recognises the importance of educating our children and will lead to increased weed awareness at school and at home as students share the message with their parents and the wider community. *Weeds Attack!* can be used in a classroom setting, but it can also be used as a learning tool outside the classroom as part of weed education days or other events. The resource can be used online or is freely available for download from www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/schools. Hard copies of the CD are also available from the National Bitou Bush Coordinator (www.weeds.org.au/wons/bitoubush).

The WoNS Coordinators are currently seeking funding to extend *Weeds Attack!* to all States and Territories and to include a broader invasive species message. The expanded resource, tentatively entitled *Environmental Invades*, will include feral animals and other invasive issues such as dieback (*Phytophthora*). It will also have teaching aids for existing WoNS biological control programs (*e.g.* bridal creeper, gorse), as well as a *virtual* biocontrol rearing component. In regions of Australia where biocontrol programs are not suitable, the virtual component will allow kids to learn about weed biocontrol and rear and release agents "in computer space." For more information or to become part of this initiative, please contact the National Coordinator.

National Willows Toolkit

The "*developing willow management priorities*" CD toolkit is a planning and extension tool developed as the result of a project carried out by the National Willows

Program over 2006-2008. The project consisted of comprehensive surveys of willow managers, a series of identification and mapping workshops and a weed risk assessment of 35 willow taxa. Information gained in these national workshops enabled determination of the extent of willows across Australia and prioritisation of willows for management according to their risk, as well as providing a basis for development of the willows toolkit.

The willows toolkit allows willow managers at all scales to set priorities for on-ground management that provides the greatest environmental and economic benefits and also provides a scientific basis for decision making to more effectively manage conflicting views about willows. *The toolkit enables users to*:

- view full weed risk assessment results and access the database to update your area as you collect new data
- see which willow taxa are highest risk in your region and decide where you should focus your management efforts (through matrices that prioritise willows for management in every region in Australia)
- see where willows are in your region and determine locations to focus management using interactive, scalable PDF maps
- use the national willows GIS database to create or update your own maps
- find out what the on-ground and legislative recommendations for willow management are across Australia by reading the final report.

The toolkit also provides willow managers with a number of *extension tools that can be applied to different projects*:

Mapping tools – are provided as part of the toolkit, including a willows-specific list of core and suggested attributes for data collection, a template that you can record your data on and an example of data collection.

Workshops kit – this contains all the required extension resources to enable you to run willows workshops. Registration forms and a session plan, PowerPoint presentations and photographs are all provided in the kit.

National Willows Resource Kit – this kit contains five willows resource sheets on developing willows priorities, willow identification, willow sawfly information and willow infestation classes for mapping.

The willows workshops (run over 2006-2007) have played a key role in updating willow mapping information across Australia, including the discovery of highly invasive seeding willows in South Australia, northern New South Wales and southern Queensland. They have also increased the knowledge, attitudes, skills, aspirations and networks of willow managers. Upon evaluation of these workshops (Wadley and Holland Clift, 2007) participants commented that the workshops were relevant, timely and very good in updating and increasing their knowledge of willow identification, willow sawfly and willow management priorities. Comments from some of the participants included; "*the best workshop I've ever been to. It was very well structured, interactive and helped to increase my knowledge immensely*" and "*it was very relevant, as there is a great demand for this type of information among willow managers*".

A range of other willows resources are also available to guide willow managers through the complex process of planning and conducting willow management programs. For further information or to obtain a copy of the toolkit please visit www.weeds.org.au/WoNS/willows or contact the National Willows Coordinator.

Aquatic weed training workshops

Community members can now play a pivotal role in the detection and reporting of new incursions of nationally significant aquatic weeds through aquatic weed training workshops developed by the NSW Department of Primary Industries and the National Aquatic Weeds Management Group (NAWMG). The strategic need for improved early detection and rapid response for all weed incursions is recognised in strategic weed plans from national to regional levels, as it provides the most cost effective management. It is particularly important for aquatic weeds which, due to their prolific growth rates, can rapidly entrench themselves in a catchment and quickly reach a point where they are no longer eradicable. In response, the NAWMG has helped facilitate development of a range of early detection initiatives ranging from 'active' aquatic weed survey guidelines for weed inspection programs to more 'passive' community identification tools.

One such initiative was the development in 2006 of a national aquatic weeds identification training package for community members and waterway users. Community members often serve as the 'eyes and ears' for their local catchment and hence, with the provision of some simple identification tools, they can play a vital role in the early detection of aquatic WoNS and other high priority aquatic weeds. The training package consists of a PowerPoint presentation, participant workbook and live specimens and aims to provide the community audience with:

1. basic aquatic plant recognition skills
2. the key identification characteristics of up to eight high priority aquatic weeds, including the aquatic WoNS
3. a range of aquatic weed identification resources, including workbook, ID brochures and aquatic WEEDeck
4. an opportunity to apply learned plant recognition techniques to live aquatic weed specimens
5. instructions for reporting aquatic weed outbreaks.

The training package is flexible and can be adapted to suit audiences from a community to region-wide level. It can be delivered as a full day accredited training workshop or a simple half day information session. Aquatic weed species covered by the workshop can also be tailored to be consistent with regional or state priorities. Since the release of this national training package, over 1000 community members and land managers have been trained in six states and territories. Community response to the workshops is excellent and it has proven effective, with new aquatic WoNS infestations located in NSW and QLD. More information and workshop packages are available from the National Aquatic Weeds Coordinator.

Weed mapping with Google Earth™

Weed managers often lack a common platform to share mapping data and other spatial information about weeds. A relatively easy and free application is available via Google Earth™, an internet-based, virtual mapping and geographic information program that provides imagery and other geospatial data. Google Earth™ displays satellite images of the earth's surface, allowing users to view objects from above or from oblique angles to approximately 15 meters of resolution or better.

Land managers can use Google Earth™ to superimpose weed data on top of the provided spatial imagery. Weed infestations can be mapped and data can be entered into Google Earth™ and projected on the satellite imagery. Imported data can consist of imagery (aerial or topographic maps) or vector (points, lines, paths and polygons) data. Once imported, the data can be saved in a KMZ file (Google Earth's file format for data) and emailed to colleagues or shared via the web on the Bulletin Board Systems (BBS). Data can then be viewed by anyone who has Google Earth™. This is a simple way to share information with other land managers without the need for a GIS system. For further information, tutorials and to download Google Earth™ see http://earth.google.com/userguide/v4/.

WoNS Coordinators are here to help

A range of tools, in addition to those mentioned above, such as best-practice management manuals, decision support matrices, identification guides, case studies and management strategies are available for the WoNS. The relevant WoNS Coordinators are keen to provide this information and work with community members and land managers to implement education and awareness activities that lead to better weed management. Please visit www.weeds.org.au/wons for Coordinator contact details or to download any of the tools and information mentioned here.

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<u>Miconia in northern NSW: An exercise in cross-border cooperation</u>

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Abstract:

Far North Coast Weeds has taken the lead in coordinating a cross-border, multi-jurisdiction surveillance initiative for Miconia in northern New South Wales. This paper will describe the nature of the infestation and the process for coordinating an early detection and eradication program involving numerous players on both sides of a state border.

In July 2008, Miconia (*Miconia calvescens DC, Melastomaceae)* was discovered growing 'in the wild' in the Tweed Valley, near Murwillumbah in northern NSW. The source of the wildlings was quickly identified – it turned out to be a large tree that had existed on private property nearby and had been there for over twenty years. It had been purchased from a nursery or market on the Queensland side of the border many years before.

The site is approximately 2.5 kilometres south of the QLD border. The proximity to extensive areas of steep, forested country with difficult access, extending into World Heritage national parks nearby made it a priority for delimiting the extent of the infestation.

Miconia had previously been found at two sites in northern NSW, however all previous occurrences were nursery seedlings or were still in pots at the time they were found. There had been no previous knowledge of Miconia plants reaching maturity and producing viable seed at this latitude in Australia. This was the first confirmed case of Miconia wildlings establishing of their own volition in NSW.

The knowledge that the original plant had been purchased from a nearby nursery or market in Queensland indicated a reasonable likelihood that there may be other plants in the vicinity. In April 2009, reports were received that another mature plant had been located on the other side of the QLD border, approximately three kilometres from the original site. This was subsequently verified; however the owners of the property had destroyed the plant several months prior.

This discovery of Miconia in northern NSW has provided an opportunity for development of a strategic and integrated weed eradication plan involving local control authorities from both Queensland and New South Wales. Being a Class 1 weed, the aim of the program is to rapidly determine the extent of the infestation and to systematically eliminate all plants from the region.

To eradicate a weed species all occurrences must be found, contained and treated to extinction. Even with highly effective treatments, eradication will not be attained unless all infestations are identified. (Brooks, et al 2009)

A survey to delimit the occurrence of this species in the wild is scheduled to take place in the cooler months of 2009. This paper outlines the process of building a cooperative effort in cross-border weed management and outlines some of the lessons learned.

Introduction:

Miconia is a striking plant with large, distinctive leaves and fleshy fruit. It was introduced into Australia in the 1960s and became popular with collectors in the 1980s.

Miconia is particularly suited to steep terrain in areas with high rainfall and fertile soils. Its fleshy fruits contain many seeds which are readily spread by birds. Its capacity to rapidly colonise rainforests in Tahiti and Hawaii is well documented and Miconia has already demonstrated its capacity to invade rainforests in north Queensland.

The discovery in northern NSW resulted from the sharp eyes of a weed control officer spotting something unusual while undertaking routine weed control work on private property. The size of the leaves and their striking appearance raised immediate questions of '*what on Earth is this*?' A quick search of the vicinity located a second seedling, approximately 1.5 metres in height, within 50 metres the first.

Within a day the identification was confirmed and the local Weed Inspector coordinated a systematic search of properties in the immediate vicinity in an attempt to locate the parent tree. Fortuitously, the parent tree was found on the very first property inspected. The owners were informed of the situation and advised that the tree needed to be destroyed.

The discovery was immediately reported to the Far North Coast Weeds Coordinator – Weed Control Services, and subsequently to NSW DPI and the Coordinator of the Tropical Weeds Eradication Program based in north Queensland. An inspection of the property was planned for the following week. In the interim, the parent plant had been completely destroyed by the diligent landowners; an elderly couple who would not tolerate a *'noxious weed'* on their property.

Lesson One*: When a situation like this occurs, take control early and get the right information out early to those who need it. Make sure you have obtained all necessary information and taken all samples, prior to the destruction of the plant.*

While the landowner's immediate response was commendable, it eliminated any opportunity to obtain any plant material for DNA analysis. Other features, such as stem diameter and tree height and form had to be derived from the remains of the cut stump and the photos that were taken at the time.

The landowners had a small shade-house at the rear of a shed beside the parent tree. The roof consisted of shade cloth which had been torn in places, leaving gaps where leaves and debris, including fallen seed could accumulate and fall through into the welcoming conditions inside. In recent times, a single Miconia seedling had *'self-sown'* into a hanging basket in the shade-house and the owners had subsequently potted it up. They reported that no other seedlings had ever grown under the parent tree, although it appeared to have fruited and seeded profusely over the years: the owners later commented '*pity it had to go, the birds just loved it.*'

Miconia in Australia

The history of the introduction of Miconia into Australia is well documented (Csurhes 2008) It is a striking plant: a botanical curiosity that would have universal appeal to plant collectors everywhere. Miconia was soon recognized as a potential problem when rainforest areas in northern QLD became infested and its impact on Pacific islands became more widely understood. It was first declared noxious in 1997, about 35 years after its introduction. Since 2003, a National Eradication Program funded by the Australian Governmenta as well as Queensland, NSW, WA and NT governments has focused on the areas of infestation in northern Queensland.

Miconia's self reproductive ability, fast growth, early reproduction, active dispersal of its small berries by alien and native frugivorous birds, large soil seed bank and high longevity of the seeds make it a very difficult weed to eradicate. (Meyer 2008)

Miconia appears to be particularly adept at colonizing rainforests following acute disturbance, such as cyclones. (Murphy et al 2008). There are areas in the vicinity of the parent plant that have been subject to landslip in recent times, highlighting the need for early surveillance.

There is no prior knowledge of this species producing fertile seed and establishing itself in the wild at this latitude in Australia. The very small number of seedlings encountered in the initial search suggests that this species may not demonstrate the fecundity and propensity to invade forests at this latitude.

A variety of frugivorous bird species consume fleshy fruits of invasive plants, and many of these birds are capable of defecating viable seeds away from the parent plant. If conditions are favourable, viable seeds can then germinate, potentially leading to the establishment of new weed infestations. (Vivian-Smith et al 2006)

Further, it would appear that there is a lag time between the production of seeds and the acceptance of those seeds into the diet of local or vagrant bird species. Without good knowledge of the species that were frequenting the parent plant, there is some conjecture as to what distances the seeds may have been dispersed.

Regarding the situation in northern NSW, the unknown factors were the locations where other plants had been established; the time they were established and how well they had performed since that time. There had been several instances of plants being identified in gardens and nurseries. A systematic search program had not been considered necessary in these earlier instances, as all plants had been identified and destroyed, prior to reaching sexual maturity.

There had not been any prior records of plants establishing themselves voluntarily in this region. Also, Climex modeling undertaken by Queensland Primary Industies and Fisheries, which predicts the potential habitat for Miconia in Australia (based on various climatic variables), indicated that NSW had a very low suitability match for Miconia.

Prior to the discovery of the 'wildlings' near Murwillumbah in July 2008, the region had suffered from several years of drought, despite the fact that annual rainfall can reach up to 2000 millimetres annually. The spring of 2007 had been particularly wet, followed by some flooding in January 2008. It is possible that this prolonged dry spell, followed by a wet spring and summer had provided the right conditions for seed set and the opportunity for successful germination. Regardless, this situation has proven that:

- Miconia is capable of producing viable seed at this latitude;
- Parts of northern NSW provide the climatic conditions necessary for germination and establishment, but the frost and drought sensitive nature of the species is a major constraint on potential spread;
- there are opportunistic bird species who have 'discovered' Miconia locally and have included it as an addition to their diet; and
- these birds have been able to spread viable seed locally.

The wildlings were found growing on moderately steep country, close to a drainage line under semi-closed canopy of young camphor (*Cinnamomum camphora*) trees. Camphor is a vigorous and invasive colonizer of the landscape (Murphy et al. 2008) and there would be many camphor dominated gullies in the vicinity that would provide similar opportunity for establishment of Miconia.

The subsequent discovery in April 2009 of the recent existence of another plant on the QLD side of the border, approximately three kilometres from the original find, suggests a strong likelihood that more mature plants will be found across the region.

Unfortunately, authorities in northern NSW and southern QLD did not become aware of the location of this plant until some time after it had been destroyed. The owners of the property advised that it had been there for over twenty years and claimed that in all that time, although it had flowered, it had never set seed.

Lesson two: Word of mouth can be a powerful force at local level and can work both in your favour and against you.

In this instance, it appears that word had quickly been passed around the local community that authorities were on the lookout for Miconia, following the identification of the original site. When the elderly owners of the second property became aware that these plants were going to be targeted through a systematic surveillance exercise, the plant was totally destroyed prior to any chance to take samples for DNA analysis or to verify its age, health and the viability of any seed. This would have been useful information for assessing its relationship with the other plants located nearby.

Lesson three: Encourage landowners to contact the weed control authority in order to avoid creating any reactionary response. Get information out early, particularly at the local level, to allay any fears that landowners might be held accountable for what would otherwise be an unwitting error.

Bringing the team together

The extremely limited extent of Miconia in northern NSW presents a unique opportunity for early action to effectively contain and eradicate this weed from the region. Panetta (2007 and Brooks and Galway (2008) provide guidance on the development and implementation of an effective eradication program.

Far North Coast Weeds (FNCW) is the responsible local control authority for noxious weeds in the north-eastern corner of NSW. As such, FNCW was responsible for notifying the NSW Department of Primary Industries and the Tropical Weeds team within Biosecurity Queensland and then in bringing all affected stakeholders together.

FNCW convened a meeting of local, state and national stakeholders late in 2008 to raise awareness of the situation and to plan a coordinated and strategic response. In a situation such as this, the focus was on identifying the principal stakeholders: those that own or manage the landscape. Clearly, all land tenures were vulnerable to invasion by this weed.

In addition to FNCW, the meeting consisted of representatives from:

- local government authorities from both sides of the border (Tweed Shire Council and Gold Coast City Council);
- state government authorities (NSW Department of Primary Industries and Queensland Primary Industries and Fisheries);
- local control authorities (Far North Coast Weeds and Gold Coast City Council)
- the custodians of National Parks from NSW and QLD (NSW National Parks and Wildlife Service and QLD Environment protection Authority); and
- Biosecurity Queensland, the authority responsible for managing the national eradication program for *Miconia calvescens*.

The meeting provided an opportunity to inform all responsible entities of the situation and to invite their participation in formulating an appropriate response at all levels. The outcome of the meeting was an agreed plan of action.

A strategic approach: coordinating a containment and eradication project

The agreed plan of action was to mount an initial search of the likely area of infestation, utilising trained weed-spotters equipped with hand-held GPS units to record where they had been. This would be essential for re-locating any sites of infestation and for verification that areas had been thoroughly surveyed.

The search team would be trained by experienced personnel who had been involved in the eradication program in north Queensland. The search technique involves a two-person team, working systematically up each gully and drainage line, approximately 5 metres apart, checking virtually every inch of the landscape. This technique frequently requires several sweeps up each gully, working further away from the watercourse with each pass.

The exercise requires a physically fit, intelligent and alert team of people who are capable of maintaining a high level of vigilance, conducting a thorough and systematic search, keeping on task and not willing to leave any area unchecked. It’s fairly unforgiving terrain and the sort of people that are needed are ones that really care about what they are doing and have a personal commitment to doing a thorough job. They also have to be able to cope with those creatures of the landscape that may see them as part of the menu: the ticks, leeches and mosquitoes.

The plan was to carry out the first systematic search in the cooler months of 2009. It's always good to have a plan; at least that way you can map progress and learn to cope with externalities outside your control. The region experienced three substantial flood events in the first six months of 2009 and so the surveillance program was delayed until July at the earliest.

The initial focus had been on lands in the vicinity of the site of original 'parent' plant in NSW. Previous experience from the team working on Miconia in northern QLD indicated that the majority of seed was dispersed within 500 metres of the parent tree. As the survey area was entirely within the NSW, the surveillance exercise required only one trained team from NSW.

The subsequent identification of a new site, on the QLD side of the border provides a new dimension to the plan of attack. QLD authorities may develop and train their own team for the surveillance exercise or alternatively engage the same team that will have done the work in NSW. Regardless, the aim is to ensure that a consistent approach is adopted and applied.

The next step is to undertake the surveillance and coordinate the flow of information arising from the systematic searches. Beyond that, the searches will either have located additional plants or not. Each new plant will be mapped, sampled and destroyed. The discovery of any mature wildlings (i.e. those that have reached sexual maturity) will lead to an expansion of the area of land subject to the surveillance program.

The plan involves conducting an annual re-examination of the area within 1 kilometre of any mature plant for a period of five years, following the destruction of that plant. It is recognized that weed eradication programs, such as this, often require 10 years or more to achieve their objective. It is important that progress is monitored and evaluated on a regular basis, to keep the project on track and ensure success. (Panetta 2007)

So, how will we know when eradication from this region has been achieved? The answer will emerge in time; and while we are confident that this incursion has been found and arrested early, it may prove that it has spread more widely and that eradication may not be possible. It will be at least 5 years before we can begin to have any degree of certainty and in the interim, the control program will involve a sustained effort from the participating authorities, the development of enduring partnerships and an awareness campaign that will effectively engage the wider community in this project.

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ECOLOGY, GENETICS AND THE POTENTIAL FOR BIOLOGICAL CONTROL OF LIPPIA, *PHYLA CANESCENS*

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ABSTRACT

Studies of the ecology, genetics and natural enemies of lippia, *Phyla canescens,* began three years ago with the aim of improving knowledge for management and of developing biological control. *Phyla* species have been intensively surveyed in their native range in South America to determine their distributions and their natural enemies. The natural enemies of *Phyla* species have been collected over three growing seasons. Of those two leaf beetles and two plant pathogens are being studied more intensively in Argentina as potential biocontrol agents. Greater genetic variation occurs within than between populations of lippia in Australia, and also in its native range, northern Argentina. Multiple introductions to Australia have ensured high genetic diversity in populations there. Lippia has unusually high levels of calcium and leaves have lithocysts of calcium carbonate crystals that may provide defenses against herbivores. Lippia obtains important competitive growth support from older connected ramets, significantly dries the soil where it grows and, when growing in Australia, produces more flowers.

INTRODUCTION

Phyla canescens, lippia, from South America has become a serious weed in Australia after being deliberately cultivated as an ornamental garden plant and a drought resistant substitute for lawn grass (Lucy et al. 1995). It occurs from Townsville to Victoria on the east of Australia, in South Australia and in Western Australia, but it is most important in the Murray-Darling catchments of central and northern NSW and southern Queensland. Over the past decades it has increased in density and spread to new areas (Earl 2001). It was estimated in 2001 to occur in 5.3 million h within the Murray-Darling Basin, causing production losses to the cattle industry of $38 million per annum and over $1.8 billion in lost environmental services.

Lippia is a prostrate woody herb in the family Verbenaceae that propagates by seed and fragmentation. It grows a strong, deep tap root early in establishment and prostrate, creeping stems that root at nodes taking advantage of open space. It is very competitive with pasture grasses especially in floodplain situations. It withstands inundation which also causes it to fragment and vegetative pieces are then deposited downstream. Invasion of downstream areas have been associated with particular flood events (Lucy et al. 1995; Taylor and Ganf 2005).

Lippia occurs in a range of habitats and so causes a variety of economic and environmental impacts. Its preferred habitat is floodplains but it is known to establish in areas that never flood, probably taken there by machinery or stock. Cultivation is an effective management tool but many areas such as riparian zones, pasturelands, forested areas, conservation lands, stock-routes, roadside and urban verges are not cultivated. Certain grazing management practices have been useful in limiting lippia invasion into pastures and herbicides have also been useful in the short term but these techniques are not viable in many situations (Julien et al. 2004).

In 2005 a project led by CSIRO and UNE and supported by NSW DNR under their Wetland Recovery Project began with the following objectives.

- To determine the natural enemies of lippia in its native range and if any are suitable for biological control.
- To determine the genetic variability of lippia in Australia and the origins of the Australian populations.
- To determine if *Phyla nodiflora*, the only other *Phyla* species that occurs in Australia, is native to Australia or an exotic introduction.
- To gain a better understanding of the biology and ecology of lippia in Australia.

The answers to these questions have implications for management of lippia and each interact with the others. This is a report of the research that has been conducted since 2005.

METHODS

The literature indicates that lippia is native in South America and occurs from southern Ecuador to Argentina (Kennedy 1992). However, in Australia and elsewhere there was confusion between lippia and *P. nodiflora*, so there was reason to suspect that the taxonomy of the *Phyla* species may be confused in South America. Using herbaria records as a guide, initial surveys by car sought lippia and other *Phyla* species. In addition, colleagues made collections as they travelled for other projects, e.g., in Peru and Bolivia. Samples for molecular analyses as well as herbarium specimens were collected. Wherever *Phyla* species were found in Argentina, Bolivia and Chile they were searched for insect and plant pathogen natural enemies. These were collected alive to rear or to develop cultures, or they were preserved for identification. Key areas were identified over the range of lippia in Argentina that were visited regularly to sample for natural enemies across seasons and years. In South America lippia is a plant of disturbed places and so most sampling was along roadside, waterways or urban verges.

The natural enemies found have been prioritised and several are being assessed to determine their potential as biological control agents. Lab rearing of insects, lab culturing of plant pathogens and host range tests are being conducted for several insects and one pathogen. A short list of test plants includes species of Verbenaceae that occur in both Argentina and Australia.

Field collected samples of *P. canescens*, *P. nodiflora* and *P. fruticosa* and dried leaves taken from specimens from herbaria in Australia, Argentina and USA are being analysed to determine population genetics variability and affinities. Total genomic DNA was extracted from dried leaves preserved in silica-gel. The genetics of all clones were analysed using ISSR markers. In total 12 primers were used to fingerprint individuals from all populations.

Microsatellite markers were also developed to further elucidate the genetic structure of the population and gene movement across populations and catchments (Fatemi and Gross 2008). DNA sequences from internal transcribed spacer (ITS) regions of ribosomal DNA were obtained using ITS4 and ITS5 primers. Obtained sequences were aligned using ClustalW and analysed in PAUP* version 4.10b (Swofford 2002).

Flower buds and root tips were collected from a range of population in Australia, Argentina and France, fixed, preserved and assessed for the regularity of meiosis and fertility of pollen grains to determine if hybridisation occurred and potential sexual fertility.

A study to determine if there are phenotypic differences in growth of lippia between native and invaded regions was carried out in a greenhouse in France using between six and ten clones from five populations of lippia from each of Argentina (native range), Australia and France (invaded regions). Plant material from each country was grown under the same conditions, first to eliminate maternal effects and then to compare growth parameters. The genetics of all clones were analysed.

A study assessed the movement of resources within plants to assess the effect of maternal subsidies of resources on the establishment of ramets in light-limiting environments. Four branches of a large mother plant were selected, stimulated to take root in an adjacent pot. Then two daughter ramets were severed from the mother, so each experimental unit consisted of one mother plant, two connected ramets and two severed ramets. The connected ramets and the severed ramets were subjected to two light treatments (full sun and 85% shade) while the mother plant was exposed to full sun. Replicated units were grown for eight weeks in a greenhouse. Growth, morphological, and physiological properties were observed.

The calcium content of leaf tissue samples was analysed by optical spectrometry. Crystals were observed on leaf sections under a polarized light microscope and the solubility of the crystals were examined by sequentially treating leaf section with acids. To examine the composition of the crystals, leaf sections were stained to highlight calcium salts and raman spectrum of these crystals was examined. To quantify the distribution of calcium within the crystals, different fractions of acid extractions were analysed.

A field and glasshouse study of breeding systems was undertaken to determine the obligate requirements for seed production – can flowers set seed automatically or is a vector required?

RESULTS AND DISCUSSION

Conventional and molecular taxonomy are helping the delineation of populations that have similar morphology. This work is in the early stages and so results presented here are preliminary. In Argentina, *Phyla canescens* was found east of 66°W and north of 40°S, from sea level (Buenos Aires Province) to 2100 m (Jujuy Province) (Figure 1).

In the northern half of this region pure and mixed populations of *P. canescens*, *P. fruticosa* and *P. nodiflora* occur along with hybrid forms. High phenotypic variation and poor distinguishing characters make it difficult to identify these species in the field. Genetic studies will assist in making the distinctions. Fortunately lippia is fairly well characterised and we are sure of its limits in all but the northern area of Argentina where hybrid forms occur. Over the southern range of lippia in Argentina, it is the only *Phyla* species present.

Lippia and *P. nodiflora* occur along the coastal plain of Chile at similar latitudes as Argentina. There lippia appears to have a different form with grey colour, more surface hairs, tougher more fleshy leaves and elongation of the inflorescences. All other samples from South America are thought to be species other than lippia. Current studies will help differentiate the different species and their distributions. In most places in Argentina and Chile lippia is associated with disturbed areas such as, along roadsides, railway lines, urban verges and water courses, and in lawns. It usually occurs in small clumps less than 2 m diameter or in linear clumps of several metres along road edges, rather than monocultures, and often with numerous clumps in the same general location. It often occurs as an under-story plant in the wetter areas of its distribution. However, in the drier areas it may be the only plant growing on exposed sandy dry beds or roadways.

In Australia just two *Phyla* species are present and lippia generally occurs south of *P. nodiflora* but with some overlap especially on the east coast of southern Queensland and northern NSW (Munir 1993; Mcdonald 2008). Collections of *P. nodiflora* have been made throughout Australia and worldwide and phylogenetic analysis of ITS data confirmed that *Phyla canescens* and *P. nodiflora* are genetically different taxa. The specific status of these taxa is currently under consideration (N O'Leary personal communication 2009). Phylogeographic analysis of *Phyla nodiflora* confirmed that most of the populations sampled in Australia are native to Australia but a few are of alien origin and may indicate cryptic invasion. Invasion by exotic genotypes into native genotype habitats may have implications for continued existence of the native genotype (Miura 2007). However, the importance of this is that biological control agents for lippia that cause significant damage to populations of native genotypes of *P. nodiflora* may not be permitted to be released. Such restrictions may seriously limit biological control of lippia.

Analysis of molecular variance of lippia populations revealed that most, 69%, of the genetic variance is distributed within populations regardless of location indicating that all populations share the same gene pool. This also suggests that for Australia the populations were derived from a limited number of founder events (introductions). The analyses for the combined Argentina, Australia and France populations show that the remainder of the variation is distributed 23% between populations within countries and just 8% among countries. Principle Component Analysis shows two distinct genetic groups of lippia in Argentina and similar groupings occur in Australian populations confirming that multiple introductions to Australia have occurred (Fatemi et al. 2008). The phylogeographic analysis of ITS sequence data also confirmed that lippia has originated from a number of founder events.

Little was known about lippia in its native range prior to this project. We have found about 20 arthropod natural enemies comprising four flea beetles [*Kuschelina bergi* Harold, two *Longitarsus* spp. and *Disonycha glabrata* (Fabricius) (Chrysomelidae)], a leaf mining fly (Agromyzidae?), two thrips (Thysanoptera), four species of Lepidoptera (two micro moths and two caterpillars), eriophyid mites, unidentified stem gallers, four species of leafhoppers (Cicadellidae) and two Cercopidae. The Cicadellidae and Cercopidae are not suitable but, at this stage, we consider the rest as potential biological control agents. Our work currently aims to eliminate those that are not suitable because they have a wide host range and to identify those that should be considered for introduction into quarantine in Australia for detailed host specificity testing.

The flea beetle *K. bergii* is the first insect considered for detailed studies because field surveys suggest it may be restricted to lippia. It has been found at five sites, throughout the year, and was most abundant in late winter in southern Buenos Aires Province. It has been found only on *P. canescens* in the southern Pampas (Figure 2).The adults are 5 mm long, have black and yellow stripes on the wing covers and feed on leaves leaving circular holes. Eggs are laid in batches in the substrate under lippia. Larvae are light brown and also feed on leaves: the first instar larvae just scratching the epidermis, and the larger larvae feeding from the edge of the leaves to the centre consuming all tissue. There are five larval instars. Pupation occurs in the substrate, and the whole life cycle takes about 2 months to complete. In preliminary host specificity test adults fed only on *Phyla canescens* and larval development was only recorded on *P. canescens*, *P. nodiflora* and *P. fruticosa*, in no-choice trials that also tested *Duranta* sp., *Lippia alba*, *Glandularia* sp., and *Lantanna montevidensis*, all Verbenaceae that occur in Australia. Nevertheless, the highest survivorship was recorded in *P. canescens*.

Longitarsus spp. are small flea beetles less than 2 mm long that has only been found as adults feeding on leaves. They have a wider range than *K. bergii* (Figure 2), however, based on populations having different colours, dark brown or amber we think that there may be two species. *Longitarsus* are abundant in summer, probably coinciding with the rainy season of the region. They have the typically developed metafemur of their group (Alticinae) that is used for jumping, making them difficult to catch in the field. In the field their damage is easily recognized as small circular feeding holes on leaves. We suspect that the larvae feed in roots as other closely related species do, e.g., a *Longitarsus* used for biological control of *Lantana camara* (Simelane 2005). Attempts to lab rear these insects have not yet been successful. In preliminary host specificity testing adults of the southern *Longitarsus* (dark brown) species fed on *P. canescens*, *P. nodiflora*, *P. fruticosa*, *Glandularia* sp., and *Lantanna montevidensis*. Tests with larvae or with the northern, lighter coloured species have not yet been initiated.

Interestingly, during surveys in Bolivia (on *P. fruticosa*) and Chile (lippia and *P. nodiflora*) we found no arthropod natural enemies or damage other than some feeding marks in Bolivia that were similar to *Longitarsus* feeding.

Two pathogenic fungi have been found infecting *P. canescens* in Argentina: *Cercospora lippiae* and *Colletotrichum* cf. *orbiculare*; both are necrotrophic fungi. On the related species *P. fruticosa* and *P. nodiflora*, the rust *Puccinia lantanae* and two, or three, *Colletotrichum* spp. have been detected. Some other potentially pathogenic fungi have been found associated with lippia but there is no evidence that they cause damage to their hosts.

For the rust, *Puccinina lantanae*, specific field surveys have been conducted seeking a form that might occur on lippia. Initial records indicate that *P. lantanae* Farl. (as *Uromyces lippiae* Speg.) was collected from *Lippia canescens* (a synonym for *P. canescens*) in the province of Salta (Spegazzini 1909), and on *Phyla* sp. in the province of Tucumán and in Paraguay (Viégas 1961; Lindquist 1982). However, we have not been able to find it on lippia, only on *P. fruticosa* and *P. nodiflora*, even when lippia cohabits with these other species. In the lab we have shown that isolates of *P. lantanae* obtained from *P. fruticosa* are able to infect both *P. fruticosa* and *P. canescens*. This form of the rust causes significant local and semi-systemic damage to *P. fruticosa*~~,~~ however, only mild localised symptoms occurred on lippia. During these inoculation tests the microcyclic and autoecious condition of the *forma* infecting *Phyla* were confirmed, an important issue for consideration of this rust as an agent for classical biological control. We will continue to look for this rust on lippia as part of other surveys but, since specific surveys over several years, have not been successful it seems likely that it has not evolved a specialised form on lippia.

Cercospora lippiae causes necrotic leaf spots on lippia plants which seem to inflict some damage to the host. This is the most widespread of the plant pathogens found on lippia covering the north-south range of lippia from the southern provinces of Río Negro and Buenos Aires up to the northern provinces of Salta and Jujuy. This suggests that *C. lippiae* thrives in a wide range of climatic and edaphic conditions and that it should disperse easily. Thus, its use as a classical biological control agent should be taken into consideration, although so far *Cercospora* spp. apparently have not been used in classical biological control of weed (Julien and Griffiths 1999). *C. lippiae* has been isolated and inoculation trials and host range tests have been initiated.

There are also records of *Prospodium* spp. on *Lippia* (including *Phyla*) in South America (Viégas, 1961) but none have been observed or isolated during our work.

Principal Component Analysis on phenotypic traits illustrated obvious phenotypic differentiation of lippia populations from three regions (Argentina, Australia, France). Compared to native populations, Australian populations displayed more investment in sexual reproduction, whereas French populations possessed enhanced clonal propagation. In addition, within invaded regions, Australian populations displayed significant divergence, while French populations were phenotypically uniform, probably due to the limited distribution range and high gene flow rate. We partitioned evolutionary forces (selection *vs*. stochastic events) using two independent methods (respectively termed ancestor-descendent comparison and Q_{st} vs F_{st} test). The results of both analyses suggest that the pattern of molecular and phenotypic variability among regions was consistent with selection-driven evolution, rather than stochastic events. These findings suggest that natural selection has shaped the evolution of *P. canescens* following it introductions into France and Australia.

Lippia ramets connected with mother plants obtained a subsidy of resources from the mother plant and had higher survival rates and faster growth than ramets separated from the mother plant. The subsidy facilitated the establishment of ramets in the light-limiting environment. Clonality did not have direct influence on the photosynthetic and respiratory properties of lippia, it affected the leaf nitrogen content. Connected and severed ramets grown in full sun had similar leaf nitrogen concentration, but when shaded, ramets connected with the mother stored more nitrogen in leaf tissue than severed ramets were able to. Thus, shaded, connected ramets seemed prepared to use this nitrogen storage to construct photosynthetic apparatus once highlight became available. The carbohydrate storage in lippia was mainly soluble sugar, which may facilitate translocation. These results indicate that subsidy from ramets that are growing in favourable habitats, e.g., on river banks or flood plains, may facilitate the colonization and opportunistic expansion of lippia ramets into native communities.

Glasshouse and field studies showed that *P. canescens* is self-compatible but cannot set seed automatically. Flowers require a floral vector to effect seed-set. In the study populations of northern NSW seed set was increased by introduced honeybees (C Gross and L Gorrell, unpublished data).

The plant tissue of lippia had high calcium concentration (up to 4% w/w) regardless of the concentration of soil exchangeable Calcium. Calcium crystals were observed in lithocysts on the surface of leaves. Analyses determined that these crystals are made of calcium carbonate. The calcium carbonate crystal in the lithocyst on the leaf surface may be a defensive mechanism against herbivores, and could decrease the palatability of lippia.

Our results show that lippia is clearly a highly robust species that has the ability to rapidly adapt genetically to new environments, to assist invasion into sub-optimal micro-climates by moving resources from older to younger invading ramets, and has adaptations that minimise herbivory. Biological control remains as one of a very few management tools that has the potential to work at large scales and in diverse environmental situations and land uses. We have identified several potential biological control agents in South America. However, work is ongoing to determine whether they are sufficiently safe to release in Australia (including that they won't significantly impact native *P. nodiflora* populations) and will cause the desired impact.

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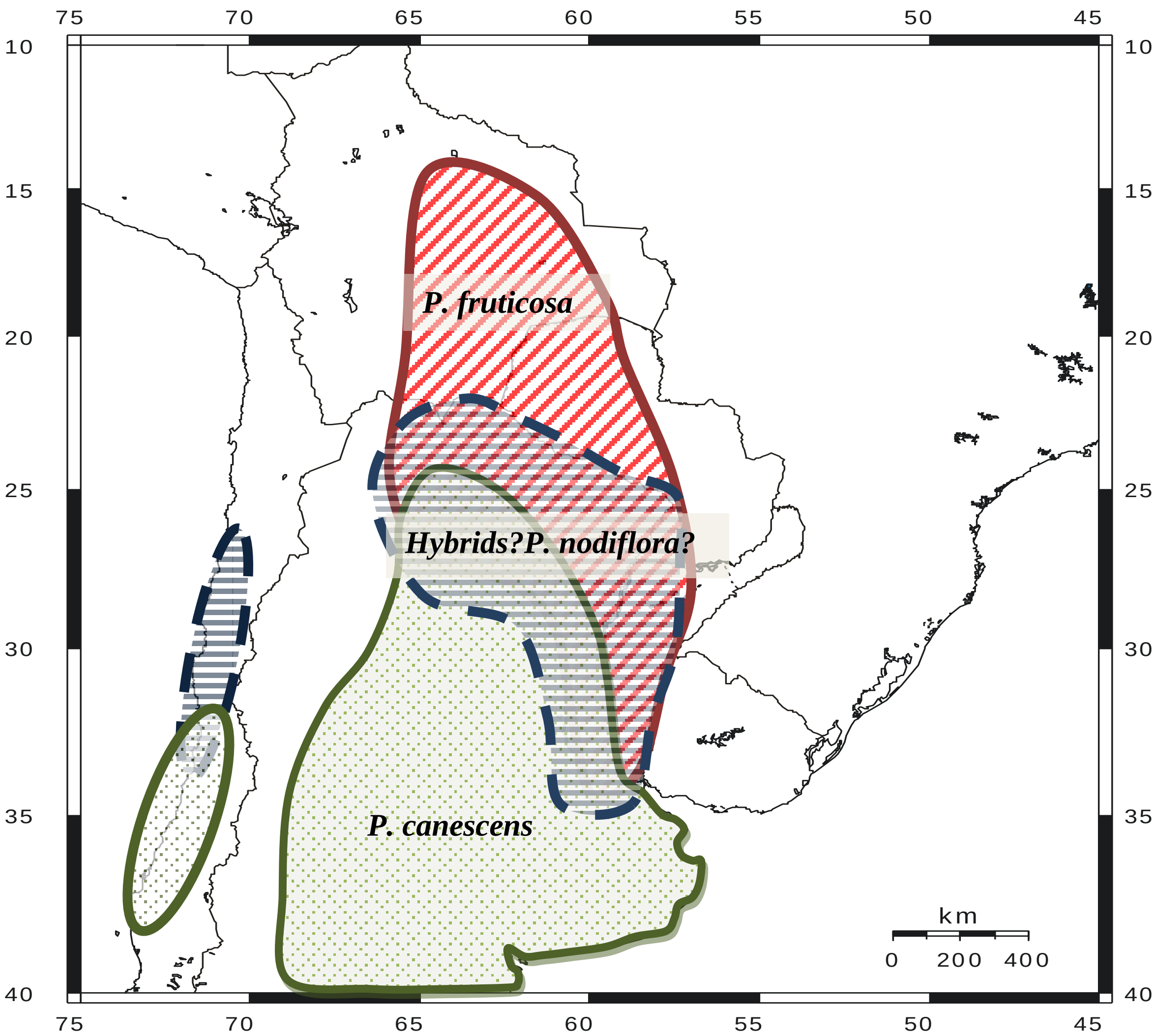

Figure 1. The general distributions of *Phyla* in Argentina, Paraguay, Bolivia and Chile: *Phyla canescens* (hatched), *P. fruticosa* (diagonal stripes), *Phyla nodiflora* (horizontal stripes) and the area where hybrids occur (within the broken line).

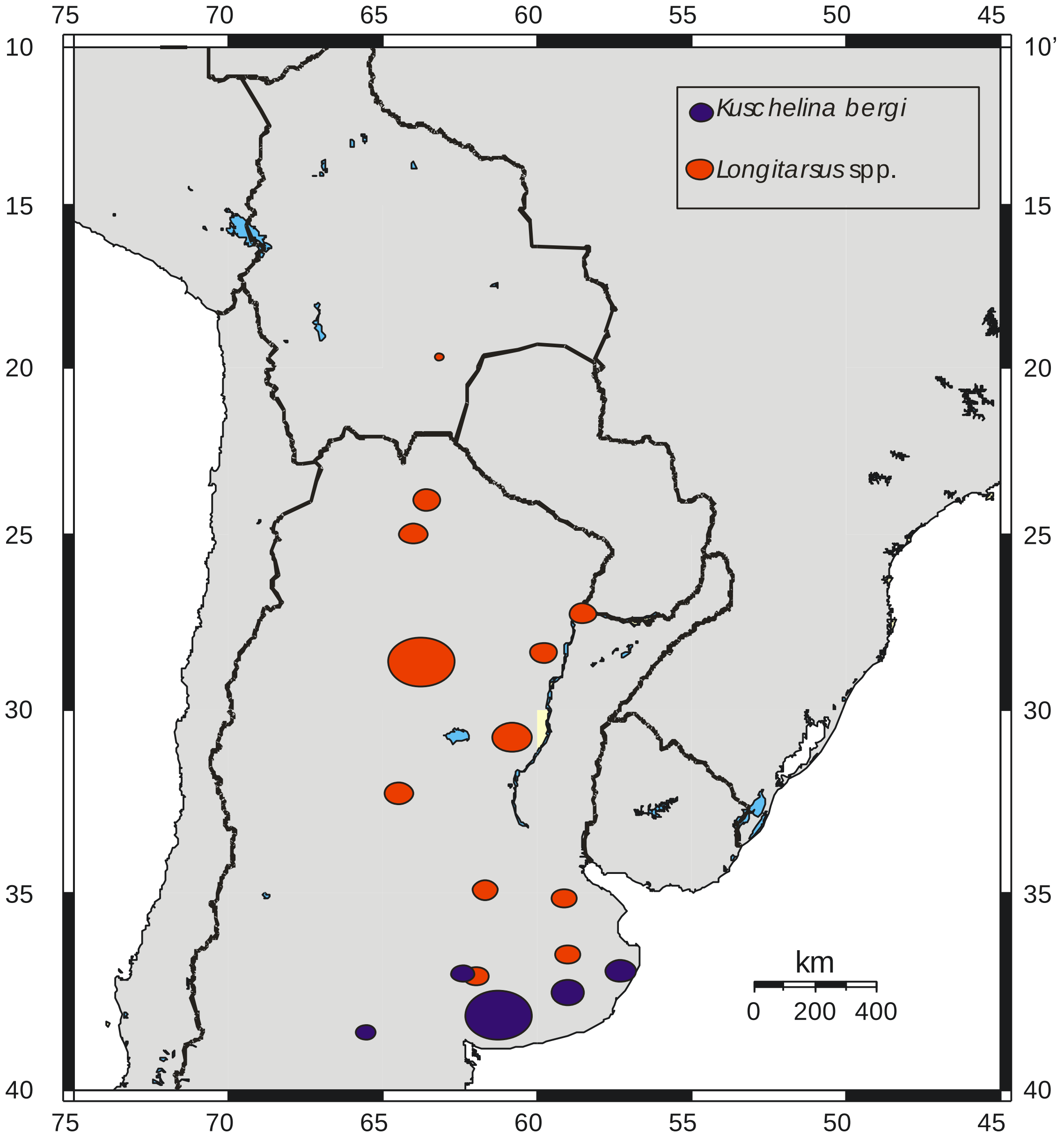

Figure 2. Natural distribution of two natural enemies: *Kuschelina bergi* and *Longitarsus* spp. found on *Phyla* spp. in northern Argentina. The size of the circles indicates the relative abundance of each species.

PROGRESS ON THE BIOLOGICAL CONTROL OF AQUATIC WEEDS: ALLIGATOR WEED AND CABOMBA

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Abstract

Similar to invasive terrestrial plants, invasive aquatic plants have negative environmental, economic, and social impacts. However, controlling aquatic weeds can be particularly challenging due to difficulties in physical removal and restrictions on applying herbicides in and around water bodies. In many cases, biological control is the only effective and sustainable alternative. This presentation will explore the current research on the biological control of alligator weed (*Alternanthera philoxeroides*) and cabomba (*Cabomba caroliniana*). We have completed surveys in the native range, prioritized potential biological control agents, and conducted host specificity testing in our quarantine. We will present the results of these surveys and tests. We will end with a discussion of the future potential of biological control for other currently intractable aquatic weed problems.

Keywords: Alien plants; aquatic weeds; introduced plants; landscape management; wetlands

INTRODUCTION

Challenges in controlling invasive aquatic and riparian weeds

We have many tools for managing weed populations including; physical removal, chemical application, biological control, and cultural practices. Some weeds are effectively controlled through mechanical damage or herbicide application. However, most invasive weeds are difficult to control using any single method and integrating multiple methods may be necessary to achieve the desired level of control (Paynter and Flanagan, 2004). Populations of invasive aquatic weeds are particularly challenging to manage because; (1) aquatic plants often spread by asexual reproduction (plant fragments) and mechanically damaging the plant will not kill the plant, and may even increase its rate of spread, (2) the use of herbicides is greatly restricted in aquatic habitats, particularly near potable water supplies.

Biological control is often the last recourse for management of weeds that are causing large negative impacts and can’t be controlled through other methods (Myers and Bazely, 2003). The ecological theory behind the mechanism of weed biological control is that when species move into new environments they are often introduced without the specialized herbivores that are present in their native range (Keane and Crawley, 2002). The absence of damage from these herbivores gives the introduced plant a competitive advantage over native plants that are being damaged by their natural complement of native herbivores. This competitive advantage allows the introduced plants to form dense stands and displace native plants. Biological control re-introduces these natural enemies to their host plants in the new range. Biological control programs are initially expensive, but are often the only effective means of providing safe and sustained control of aquatic weed infestations.

Cabomba

Cabomba (*Cabomba caroliniana*), or water fanwort, is a fast-growing submerged aquatic weed that has the potential to spread throughout the aquatic habitats of Australia (Mackey and Swarbrick, 1997). Originating from South America and SE USA (Orgaard, 1991), it is also considered a problem weed in the northern United States, Canada, Greece, Japan, and China. It grows well in slow-moving water bodies, particularly where nutrient concentrations are high. Cabomba prefers areas of permanent standing water less than 3 m in depth, however it can grow at depths to 5 m (Schooler and Julien 2006). The weed is easily recognised by its opposing pairs of finely dissected underwater leaves that are feathery or fan-like in appearance. The small white flowers extend above the water's surface, making weed infestations more visible during the summer months. Reproduction is almost entirely vegetative and any small fragments that include the leaf nodes can grow into a new plant.

Currently, there is little that can be done to control cabomba once it is established (Anderson and Diatloff, 1999). Herbicides are largely ineffective and herbicide use is severely restricted in or around public water supplies. Some managers are using floating mechanical harvesters to remove cabomba, but these machines are expensive to purchase and operate and are restricted to areas of deep water and wide channels. In addition, they only remove the tops of the plants and the remaining stems soon grow back to the surface. Shade is an effective strategy for reducing cabomba biomass (Schooler 2008), however, experiments have found that it is not a feasible method of eradicating cabomba, even from small dams (Moran and Schooler unpublished data). It is likely that the only method that will be effective in managing cabomba is biological control. In 2003, CSIRO Entomology began a project to discover and test biological control agents from cabomba's native range in an effort to find a long-term sustainable solution to this problem (Schooler et al., 2006; Schooler and Julien, 2008). We have identified several potential biological control agents in the native range (Schooler et al. 2009) and are currently testing the host specificity of the weevil, *Hydrotimetes natans*, in our quarantine facilities in Brisbane.

Alligator weed

Alligator weed (*Alternanthera philoxeroides*) is an invasive plant that originates from South America and is currently spreading in many countries throughout the world including the United States, China, India, Thailand, Burma, New Zealand, and Australia (Julien et al., 1995). It is primarily associated with aquatic habitats, but can spread into moist terrestrial environments. Alligator weed is a perennial plant that does not produce viable seeds in its introduced range and reproduces and spreads by adventitious rooting, primarily from stem nodes (Julien et al., 1992). Although herbicides destroy leaves and shoots, they do not cause direct mortality of roots (Tucker, 1994; Schooler et al. 2007). Physical control methods often increase the spread of the plant. Experimental trials have found that the use of dicot selective herbicides (i.e. metsulfuron), serve to increase the competitive ability of grass species and this results in a greater decrease in above and below ground alligator weed biomass (Schooler et al. 2008). However, even six treatments repeated over a two-year period (3 per year) were not sufficient to eliminate alligator weed from the study plots.

The difficulty of controlling the abundance and spread of alligator weed instigated a program to investigate the potential for biological control methods. The alligator weed flea beetle, *Agasicles hygrophila* (Coleoptera: Chrysomelidae), has been successful in controlling the aquatic form of alligator weed in the warm temperate climates of Australia. However the beetle has been unsuccessful in controlling the terrestrial form and does not control the weed in cooler temperate climates (Julien et al., 1995; Julien and Bourne, 1988). CSIRO Entomology is currently studying the prospects for safe and effective biological control of alligator weed in terrestrial habitats and cool temperate climates. We have conducted surveys in the native range and have assembled a prioritized list of nine potential biological control agents. We have tested the host range of three of these insects (*Amynothrips andersonii*, *Disonycha argentinensis*, and *Clinodiplosis althernantherae*), however, they were able to complete their life-cycle on one or more native *Alternanthera* plant species, so are not considered safe for release in Australia (Schooler and Julien, 2008). We are currently testing the fourth insect, the beetle *Systena nitentula*, in our Brisbane quarantine.

CONCLUSIONS

Invasive aquatic weeds can negatively affect our economy, environment, and quality of life. Physical damage and herbicide application are rarely effective in managing invasive aquatic weeds due to concerns of polluting water supplies, re-treatment frequency, and increasing weed spread. Although biological control has proven to be a safe and effective management method, it is initially expensive and there is no guarantee of finding a safe and effective agent. In addition, a single agent may not provide the desired level of control across the distribution of the weed. However, it is also the only self-sustaining method of controlling aquatic weeds, as evidenced by its large benefit to cost ratio of 27:1 (data from salvinia, water hyacinth, and water lettuce)(Page and Lacey, 2006). Therefore, biological control is a key element in the long-term and sustained control of aquatic weeds.

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INTEGRATION OF ENVIRONMENTAL WEED CONTROL WITHIN A NATURAL RESOURCE MANAGEMENT FRAMEWORK

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Summary

The integration of environmental weed control in a broader natural resource management framework is an important component of a whole-of-systems approach to conservation and management of our ecological assets. This approach is driven by increased awareness of the dynamic, interactive properties of ecosystems, and of the inter-connectedness of biodiversity, the delivery of ecosystem functions and services, and of threatening processes. Invasive plants represent one of the most significant threats to Australian ecosystems, and it is logical, timely and practical to take a unified approach to their management. Adopting a whole-of-system approach allows the development of synergistic, co-operative, complementary interactions between biophysical, social and institutional frameworks, resulting in sets of management actions that have multiple ecological benefits across different parts of ecosystems. The realisation of multiple benefits is more likely if ecosystems are managed holistically than if their component parts (water, vegetation health, biodiversity, invasive species and soils) represent separate targets for management intervention. This document outlines a conceptual framework for integration of environmental weeds management within a broader context of management for biodiversity outcomes and ecosystem functions and services. Its primary audience is natural resource management practitioners, scientists, and policy makers.

Introduction

Environmental weeds are invasive native or exotic plant species that often have detrimental effects on natural ecosystems. Their adverse impact may be on plant communities, invertebrate and vertebrate species, entire biotic assemblages and their food webs, or on ecosystem processes like nutrient cycling, hydrology, fire and flood regimes. Collectively, these effects can lead to a loss of ecosystem character and resilience, and a change to an undesirable ecological state which requires restoration. For these reasons, substantial resources are allocated for the control of environmental weeds.

A common belief is that weed control is all that is required to hasten the recovery of an invaded ecosystem. However, the responses of native plant and animal communities and ecosystem processes following weed control are often not monitored, which means there is no clear assessment of recovery. There are several examples indicating weed removal was followed not by a resurgence of native plants but by invasion of another weed, or by the original weed growing back. Re-establishment of native plants may also be hindered by the damaging effects of the weed control method (be it mechanical or chemical) or by a lack of natural regeneration due to depletion of the seedbank, or lack of other propagules. Such outcomes can have a devastating impact upon morale and sense of purpose of practitioners, especially members of volunteer natural resource management groups.

Whilst managers implement control programs for environmental weeds, considerable time and money is also devoted to managing and restoring native biodiversity, soils and water resources. A whole-of-system approach, integrating weed management with other actions to assist the recovery of native communities is generally the best way to restore structure and function of ecosystems and protect against future weed invasion. The challenge is to develop cost-effective, integrated approaches to manage all key components in a way that builds on the inherent connectivity within natural ecosystems. Long-term monitoring becomes a vital component for evaluation of the effectiveness of these restoration approaches. The key to this ecosystem-focussed management approach is the identification, at the outset, of the desired ecological objectives and outcomes. Appropriate interventions can then be designed. At site scale, they may or may not include weed management, depending on the characteristics of the site.

The options available to managers for addressing ecosystem change are: 1) to passively accept these phenomena and try and adapt accordingly; 2) to actively attempt to stabilise, control and restore ecosystems to a pre-disturbance equilibrium, or 3) to anticipate that disturbance and change are inevitable, and to manipulate the system to minimise harmful effects. An integrated, adaptive framework is about adopting the latter option and recognising that command-and-control approaches aimed at maintaining or restoring stability will almost always fail. Such an integrated framework helps managers identify cause-and-effect processes, understand that ecosystems are dynamic, and prioritise for interventions based on the likelihood of achieving the objectives. Resources are saved by avoiding activities with a low chance of success. Where weed invasion is a symptom of an underlying driver of ecosystem degradation, the appropriate strategy is to address the cause of the degradation, not just the weeds. These ideas are at the core of resilience-based approaches to adaptive natural resource management.

The aim of this paper is to outline a conceptual approach for integration of environmental weeds management within a broader context of management for delivery of ecosystem processes and services. Its primary audience is natural resource management practitioners, scientists, and policy makers.

Why do we have weed problems in natural ecosystems?

The Role of Disturbance and Renewal

One view of ecosystems, evoked by tropical rainforests and coral reefs, for example, is that of complexity and stability due to high biodiversity and many intricate species-interactions. The resilience of biodiverse systems, i.e. their capacity to absorb disturbance, renew themselves and remain in the same state, is thought to be a function of the buffering capacity, or insurance value, of many species doing similar functional jobs. When disturbance events eliminate some species, others take their place. Another view is of ecosystems typified by relatively few keystone species, with little functional redundancy, and where heterogeneity and change are driven by strong, episodic, abiotic disturbance events like floods, fires and drought. Such systems include those of floodplains, rangelands, estuaries, temperate forests in medium rainfall zones and grassy woodlands.

Ecosystem disturbance is a complex restructuring mechanism. It expedites the maintenance of biodiversity by creating biotic and abiotic variation that emerge from ecosystem recovery and renewal. Heterogeneity of resources and habitats across ecosystems provides niche space, and opportunities for animals and plants, including weeds, to colonise and establish. Disturbance is critical for the very existence of particular ecosystems. One approach to restoration is based on attempts to re-establish the natural patterns of flood and fire events, where these have been altered by human intervention. There are several examples where decreased fire frequency has changed plant community composition. One of these is the increase in range of sweet pittosporum (*Pittosporum undulatum*), from the rainforests of eastern Victoria into bushland much further west, as fire frequencies in these latter areas have decreased. This species dominates bushland and the dense shade it creates makes it difficult for native species to recruit.

But disturbance can also initiate conditions that favour the dominance of one species, and the effects of disturbance vary according to frequency, intensity, duration, timing and scale, and on the prior condition of the ecosystem. The impact of disturbance can be difficult to predict, especially so where the disturbance regime or the ecosystem has undergone human modification. Predicting and managing the effects of such changes on our native ecosystems represents the main objective and the greatest challenge facing natural resource managers, scientists, and policy makers in Australia today.

Weeds as Symptoms or Causes of Ecosystem Change

One reason that environmental weed control alone may not lead to desirable ecological outcomes is because weeds may not be the primary driver of ecosystem change. Instead, weed invasion often represents a symptom of underlying ecosystem degradation, due to nutrient enrichment, overgrazing, changed flood or fire regimes; habitat fragmentation, or the combined, often synergistic effects of such processes.

An increase in plant-available soil nitrogen and phosphorous due to fertiliser drift, sediment deposition or nitrogen fixation by weedy legumes will have direct detrimental effects on native plant communities not adapted to high nutrient levels. Weeds may thrive under such conditions. Another example of how external drivers of ecosystem change relate to invasibility is stream flow, a strong determinant of riparian vegetation structure. Changes in stream flow, or alteration in flood regimes due to river regulation (dams, weirs and locks), affect both the recharge of groundwater and the water content of riparian and floodplain soils. Lowered soil moisture content due to decreased frequency of flood events may favour more terrestrially-adapted weeds over flood-dependent native vegetation.

These examples highlight a major challenge: the need to improve our understanding of how cause-and-effect relationships operate in natural ecosystems. A weed invasion may be a consequence of ecosystem disturbance, but once established, some species can be important causes of further ecosystem degradation, as witnessed by the damaging ecosystem engineering effects of Lippia and giant rush (see figures). Determining whether weeds are drivers of ecosystem change or ‘passengers’ - taking advantage of habitat modification - is an important issue for managers. It is likely that both situations occur depending on weed species, ecosystems and their degrading processes. With the ‘passenger’ scenario, management efforts need to address both the control of the weed and the underlying degrading process.

Why Control Environmental Weeds? Impacts on Biodiversity and Ecosystem Processes

Environmental weeds affect ecosystem processes by disrupting the functional roles that native biodiversity contributes to the maintenance of ecosystem character and integrity. Effects include those on native vegetation composition and structure; animal communities including habitat provision and maintenance of food webs; decomposition and nutrient cycling; disturbance regimes including fire; hydrological processes including water quality and availability, stream channel morphology and sediment dynamics; and changes in temperature and light levels. Knowing what effects weeds have on these processes better enables us to plan our management actions. There are few such studies, and more are needed. Some weeds may have little impact, while others like willows, legumes, pasture grasses and climbers may be transformer species, or ecosystem engineers, that simultaneously affect one or more processes or assets of interest.

Native Vegetation Community Composition and Habitat Provision

Weed invasion can result in reduced native plant cover, especially when the weed dominates large areas and occupies the same habitat. Plant and animal species may become locally extinct following invasion because weeds out-compete other plants for resources. The abundance of a weed is not necessarily an indicator of the decline in native species cover or community diversity, as the impact a weed has on native vegetation can vary according to the community it invades. The disturbance history of a site can strongly influence community response to invasion, and not all sites invaded by the same weed species should necessarily be managed in the same way.

Weed invasion can simplify native vegetation structure. This loss of structural diversity further decreases the diversity of plants and animals within a site. Managing weeds to restore spatial heterogeneity, and thus create niche opportunities for components of the original community, can also promote the coexistence of weeds and native vegetation. The damage of weed invasion to fauna may be significant if the weed has a different life cycle, phenology, or represents a substantially different set of food or habitat resources from the native plants it displaces; like where an invasive shrub replaces grasses and herbs, or an annual weed replaces perennial natives. Effects can be especially severe for animals that rely on native plants for food; where, for example, a plant bearing palatable, fleshy fruit is replaced by a weed with large hard seeds.

Environmental weed control can become a complex issue if the weed has been present for long enough to provide alternative resources for native animals. The shrubby weed lantana (*Lantana camara*) provides habitat and food for native birds and protection against the aggressive noisy miner (*Manorina melanocephala*) which is abundant in adjacent open areas. Lantana appears to be associated with higher native bird diversity. This is a good example of an ecological trade-off scenario, where our viewpoint is dependent on the conceptual boundaries we draw around the system. From one perspective, a Weed of National Significance may be providing a habitat benefit to native birds. But alternatively, at a pristine site, or one revegetated after lantana removal, a well-developed native understorey will provide benefits not only to native birds, but to other species and to natural ecosystem processes. The trade-off we make is whether to leave the lantana in place and impart a perceived biodiversity benefit, remove it and reduce bird diversity (with likely knock-on effects, such as avian control of pest insects), or remove it and revegetate with native plants. These sorts of decisions force us to re-think how we manage weeds in a whole-of-systems framework. In such circumstances weed control has to be linked to restoration and provision of alternative native habitat and resources. Weed control and restoration may have to be done in a mosaic fashion in several stages.

Soil Nutrient Cycling

The availability of essential nutrients affects the productivity, composition and interactions between populations of plants, animals and microbes. While some weed invasions are more successful on nutrient-enriched soil, other plants can directly or indirectly alter soil nutrient levels. Soil fertility is based on parent material and the processes of plant and animal matter decomposition and nutrient cycling. Weed invasion can change the cycling time of nutrients from soils to plants and back to soils. This can be via changes in the invertebrate and microbial community and the development of plant-soil-microbial feedbacks that can slow or hasten nutrient cycling.

Many post-invasion changes to the decomposer community are due to the leaves of the weed being of different quality or being added to the litter layer at a different rate to those of the native vegetation. A change in the amount of leaf litter can also affect the environment in which native plants germinate and establish. Alteration of soil nutrient concentrations and decomposer communities by weeds may facilitate weed persistence and inhibit re-establishment of native plants after weed eradication. Positive feedback loops such as these are very hard to manage because the underlying conditions (e.g. soil nutrients) must be modified before the original vegetation can compete effectively with the weed species. Australian native sclerophyll species are particularly sensitive to changes in soil nitrogen and phosphorus, and their symbiotic fungi and bacteria may be lost from the system after long term disturbance, hindering native plant reintroduction.

One example of how weeds can directly increase soil nutrients is through the fixation of atmospheric nitrogen. Many weeds do this, including Acacias, gorse (*Ulex europaeus*) and English broom (*Cytisus scoparius*). These plants produce nitrogen rich leaf litter which adds to the soil nitrogen pool as the litter decomposes.

Impacts on Aquatic Systems

Willows (*Salix* species) have major impacts on stream flow and water availability through altering the structure of banks and stream beds, as well as changing sediment deposition and channel direction. Differences in the seasonal timing of life cycle events between natives and exotics can have consequences for native communities. Willows and river red gum (*Eucalyptus camaldulensis*) both occur in riparian zones but deciduous willows shed all their leaves in the Autumn, whereas evergreen red gums shed far few leaves throughout the year. These events result in different levels of river shade and litter decomposition rates. This results in changes in abundance, diversity and composition of terrestrial and aquatic invertebrates, with potential consequences for associated riparian fauna and food webs.

In relation to water quality, the effect of certain aquatic weeds with emergent or floating leaves is likely to shade out submerged native species. Where floating-leaved plants have replaced submerged vegetation the result can be significant oxygen depletion in the water, because these plants vent oxygen to the atmosphere, not into the water. This has cascading effects on freshwater food webs, typically depletion of fish and invertebrate populations.

Loss of Genetic Diversity - Implications for Ecosystem Resilience

High genetic variability is important for development and maintenance of diverse community structure and resilience, as genetically variable populations of organisms are likely to better withstand and recover from perturbation. Weed invasions can decrease the genetic diversity of native plants by reducing their population size. This is measurable but may easily be overlooked if sites are assessed only on the basis of species diversity.

A second mechanism whereby weed infestations can narrow the genetic variability of native species relates to those weeds which reproduce primarily by vegetative means. For these weeds, their populations at a site are genetically homogeneous - they are all clones of the parent plant. There is some evidence that invertebrate diversity is strongly linked to the genetic diversity of their host plants. Were this phenomenon found to be significant and widespread, it follows that clonal populations of environmental weeds would be likely to host depauperate invertebrate communities, with detrimental consequences for food web structure and other ecosystem properties and processes.

A consequence of the need for awareness of threats to genetic diversity relates to our restoration activities. It may be better to mix genetic resources of species at restoration sites, rather than strictly using seeds of local provenance. This is particularly relevant if we are seeking to establish sites resilient to climate change, whereby broad genetic diversity of each species may give the best chance of the ecosystem persisting over the long term.

Managing Weed-invaded Natural Ecosystems - Protecting Our Natural Assets

Management of our natural resources requires articulation of clear, explicit outcomes. There is a need for managers to critically examine, on a case-by-case basis, exactly why they are embarking upon weed control and other management actions and what outcomes they are seeking to achieve. Weed management should be a means to an end of ecosystem management, not an end in itself. This requires definition of the assets that will be protected and enhanced by all management activities. These assets may be physical ones, such as water quality and availability, stabilisation and integrity of soils and river banks, soil nutrient status and structure. Or they may be biological ones, such as aquatic and terrestrial vegetation communities, threatened species, assemblages of vertebrates and invertebrates, or indeed the combination of habitat and community types that give a particular ecosystem its defining characteristics. Assets also incorporate biotic and abiotic interactions, which manifest as ecological functions and processes, and they include assets defined by society on the aesthetic, cultural, recreational and spiritual values of ecosystems.

An Integrated Framework for Restoration and Threat Abatement

Control programs set within the broader context of ecosystem management and restoration are likely to have better outcomes for ecological and operational reasons. In an integrated restoration plan, economies of scale can be achieved through bringing together the resources of a broader group of stakeholders than those interested only in weed control. Greater capacity to influence drivers of ecosystem degradation is also possible, especially where these relate to cross-jurisdictional land and water use policies and practices.

Integrated approaches to managing environmental weeds in natural ecosystems are not new. For example, re-establishment of native vegetation has been identified as a key component in the management guides of some Weeds of National Significance including lantana, willow, boneseed, mimosa, Chilean needle grass, pond apple, serrated tussock and blackberry. For others (bridal creeper, gorse, prickly acacia, parthenium weed, mesquite, tamarisk, and Parkinsonia), the emphasis on integrated approaches is not so strong, and there may be sound logistical reasons for this. Nevertheless, there is considerable scope to build on the promising beginnings of more integrated approaches.

Recovery, Restoration and Revegetation - Weed Management for Ecological Benefits

The identification of multiple ecological benefits from few highly-targeted actions is of immense value in natural resource management, but there are few examples that have been put into practice on a large scale. One of the more important is the restoration of native vegetation: either natural regeneration by encouraging natural recruitment processes, or revegetation with tubestock or direct seeding. Revegetation with trees and shrubs requires investment in weed control for site preparation and during the growth and establishment phase. The simple act of stock exclusion by fencing areas targeted for regeneration has the benefits of encouraging recruitment through eliminating grazing on young trees and shrubs, reducing soil compaction and erosion from trampling and stock camps, as well as halting the accumulation in soil of excess nutrients from dung and urine.

There is a need for follow-up activities such as stimulating seedbank germination (for example through judicious use of fire), adding local native seeds or transplanting seedlings combined with sustained removal of new weed recruits in order to assist the recovery of native communities following control of the dominant weed species. Nonetheless, any possible underlying causes of the initial weed invasion will need to be identified and addressed before native plant communities can successfully be restored over the long-term.

The adverse effects on remnant woodlands of grazing pressure, nutrient enrichment from wind drift and environmental weeds are inextricably linked and there may be conflicts of use for land managers, such as the value of remnants for stock shelter, but a desire to improve native plant diversity as part of a LandCare program. Short periods of so-called ‘strategic grazing’ is one possible method for removing weeds and the nutrients they have accumulated from the soil, thus creating conditions more conducive for native vegetation. Yet the deposition of dung and urine from grazing stock may add to nutrient levels. Thus at farm-scale, strictly controlling grazing access to remnants, combined with planting shelter belts to intercept windborne nutrients and adopting conservation tillage to retain nutrients in cropping areas goes some way to satisfying both production and conservation objectives. Novel restoration approaches, such as redressing soil carbon-nitrogen ratios are more likely to emerge from adopting whole-of-systems frameworks.

The Importance of Monitoring

Monitoring is an essential part of any natural resource management activity including weed control, yet there is a belief that it is un-necessary and diverts resources from what is seen as the main task. Without monitoring, there no proof that the desired outcome was achieved, and adaptive management approaches are compromised. Monitoring includes reduction of the weed populations and the subsequent responses of native species. This means there is a need for monitoring efforts over timeframes consistent with the rate of ecological recovery. Short-term programs represent a mis-match between monitoring needs for weed control as part of broader natural resource management outcomes.

Given the importance of differentiating whether weed invasion is a cause of ecosystem degradation or an effect of other degrading processes, there are significant knowledge gaps of how an effective monitoring program could be designed and implemented by on-ground land managers without significant input from researchers trained in sampling design and data analysis. Another concern is the collection of monitoring data without any framework for its assessment and use. Active monitoring of the response of weeds and native plant communities using quantitative methods should be an integral component of weed control programs in natural ecosystems, to underpin subsequent adaptive management actions and document outcomes of programs. Such methodologies can be integrated into broader evaluations, such as the Monitoring, Evaluation, Reporting and Improvement (MERI) framework. This is a modification of the widely-used principles of adaptive management and has been adopted as a generic basis for evaluation of natural resource management programs in Australia (http://www.nrm.gov.au/publications/frameworks)

The Importance of Environmental Stewardship

Environmental stewardship programs involve paying private landholders for managing environmental assets on their land. This is a particularly important issue because over 70% of land in Australian is under private management, either as leasehold or freehold. Such programs provide both an opportunity to manage ecological assets on private land in a holistic way using valuable local knowledge, but also represent a considerable challenge for stewards in terms of knowledge transfer of systems-based understanding, setting realistic goals and targets, and the monitoring and assessment of outcomes. Development of partnerships with agency-based natural resource managers and scientists can help overcome this challenge in part, but can be time-consuming and resource-intensive.

Possibly the most valuable aspect of environmental stewardship programs is they are designed to be long-term, providing the ideal opportunity for on-going monitoring. The recognition that ecosystems do not operate on 3-year funding cycles is a major step forward in natural resource management policy in Australia. A broadening of this recognition to allow for management and restoration of natural ecosystems within a realistic ecological timeframe can only improve the likelihood of successful outcomes.

A Planning Process for Management of Environmental Weeds

How does a manager select sites where the greatest ecological outcomes might be achieved? Priority setting includes consideration of both assets and threats amongst different sites, but also the weeds present within a site. Unless an environmental weed is the target of a feasible eradication or containment program, control should target multiple weed species and have the long-term aim of restoring native communities and ecosystem processes. So at some sites all weeds would be targeted, whereas at others some weeds might be managed and the rest left in place.

The stages and questions outlined below represent the weed management component of an integrated natural resource management program (see diagram). Consultation with key stakeholders is integral to planning, and development of partnerships will improve the likelihood of long-term success. Although the process outlined below is step-wise, an iterative, adaptive management approach will be most effective. Thus information gained during the development of one part of the program is fed back to refine the program. Adaptive feedback allows the data collected during the monitoring and evaluation phase to be used to inform feasibility of management objectives, threat control and the most appropriate control options.

Strategic Planning

1. Identify the assets in the system being managed. What key assets will management activities protect or enhance, and what are the physical, biological and cultural values of these assets? Are there off-site assets that require protection?

2. Identify and assess the threats posed to those assets (such as altered hydrology, soil nutrients, weeds). What factors pose a threat to the assets and their values and are they major or minor? Which threats require priority management?

3. Identify the feasibility of managing each threat. Is it possible to manage all the threats and are management strategies for different threats co-dependent or synergistic? Will managing all the threats result in an acceptable benefit for the required investment?

4. Assess the feasibility of weed management by determining the weed species currently present and those that could invade, and their impacts. What are the sources of the weeds and their means of reproduction and dispersal? What is the extent and condition of existing native vegetation, and are the factors that influence site invisibility known?

5. Determine the management objectives. Why is weed management being undertaken and what long-term outcomes are sought? Will data collected from monitoring previous management activities inform the development of future management objectives? Can we move the system from an undesirable state to a desired stable state?

Addressing these steps requires an assessment of the landscape context of the area for management. Where degradation has significantly changed communities and ecosystems it will be very difficult to restore original native vegetation, and the main initial purpose of control might be to contain the spread of weeds and reduce their impact on sites of higher native diversity nearby. Undertaking the strategic plan will help determine if an environmental weed management program is appropriate. If so, these steps can be used to prioritise sites.

Future Directions

We are just beginning to understand the complexities of how natural ecosystems work. Ideally, we need a deeper understanding of ecosystem functions, processes and responses before we even attempt weed control. But, as in most cases in natural resource management, we are obliged to act with incomplete information. This does not preclude developing objectives based on current knowledge and the desired outcome. Improving our understanding of the overall ecological context of weed management and other management activities has two main implications. First, we are beginning to focus on understanding the impacts of environmental weeds on ecosystems. These include effects on the structure and composition of plant and animal communities, interactions between species and between biotic and abiotic components, and on ecosystem functions such as soil nutrient cycling. Knowing what effect weeds have on these processes better enables us to plan our management actions. Some weeds may have relatively little impact, whereas others like willows, legumes, pasture grasses or climbers may be transformer species, or ecosystem engineers, that significantly affect one or more processes or assets of interest. Second, we need better understanding of the outcomes of our management actions. This forces us to face whether our interventions are achieving the positive outcomes we are seeking. Adequate monitoring and evaluation, beyond the life of the intervention, will enhance not only the assessment of success, but aid the generation of knowledge that would lead to improved management capacity.

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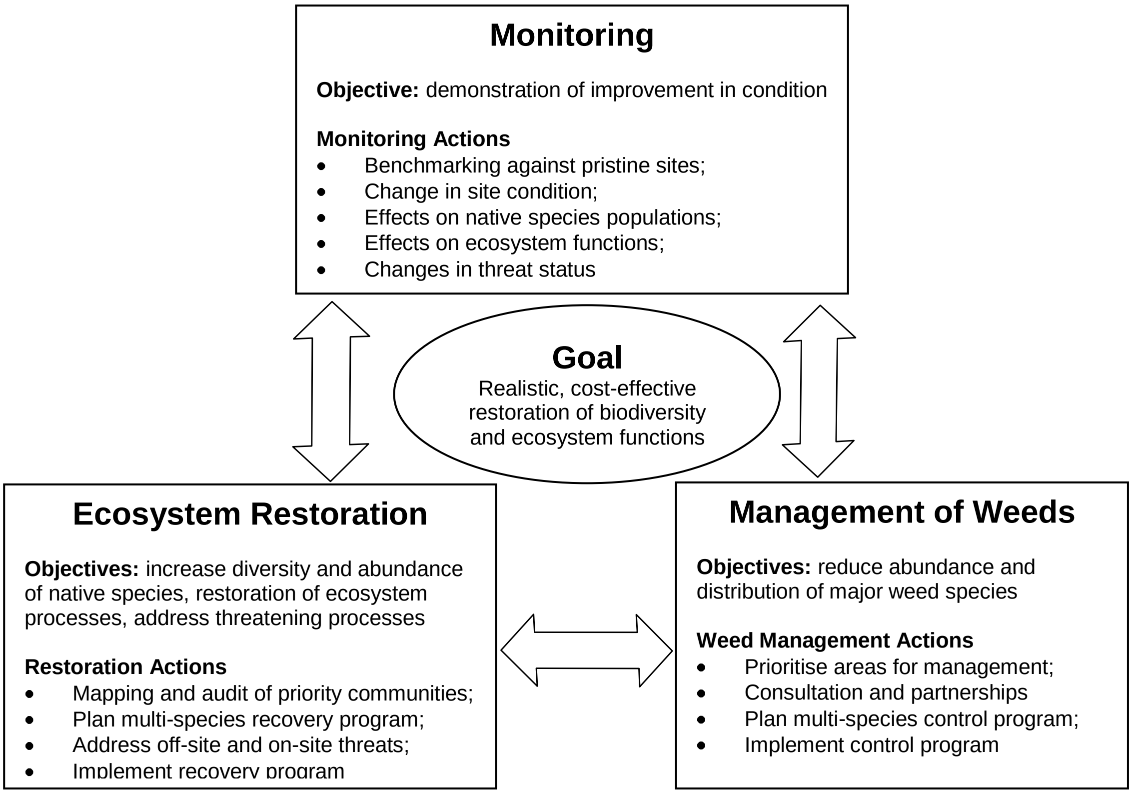

LONG TERM CONTROL OF MADEIRA VINE AND CAT'S CLAW CREEPER

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Abstract. Persistence of weed species is usually a consequence of underestimating strengths in the weeds life cycle. This theory holds true for the weeds Madeira Vine (*Anredera cordifolia*) and Cat's Claw Creeper (*Macfadyena unguis-cati*). Much effort on the past has been focused on the control of these established vines with lesser regard to the juvenile vines. This often resulted in established vines re-infesting treated areas within 6 months to 2 years. More effort needs to be targeted at the control of these younger vines, as the control of established vines is time consuming and therefore expensive. Until recently, there were few chemical control options available. Previous work from NSW DPI has investigated the use of herbicides to control these juvenile vines and subsequently, in January 2008, a Pesticide Permit was obtained that allows the use of products containing triclopyr 300g/L, picloram 100g/L and ± aminopyralid 8g/L.
Feedback from people in the industry suggest that this new treatment supersedes that of foliar applications of glyphosate, by providing better levels of control of tubers, keeping competitive grasses alive and having a residual effect.
This paper will discuss and report the findings of triclopyr/picloram based products and compare them to alternative herbicides for the control of seedling vines and tubers. Finally, suggested long-term management plans for both these weed species will be discussed.

INTRODUCTION

Madeira Vine and Cat's Claw Creeper are high priority environmental weeds because they are rated the most threatening and aggressive weeds for coastal riparian areas of northern NSW (Joseph 1999 and Turnbull 2006). Furthermore, a recent strategy developed by Oakwood (2009), identified these vine weeds as a threat in lowland forest and riparian landscapes in the northern rivers region. A priority species list was developed in this strategy document. These vine weeds were included in the top 20 of weed species of lowland riparian and forest landscapes. However, it must be stated that these weeds were placed lower on the priority list because they are not categorised as Class 1 or 2 noxious weeds, are widespread (less likely to achieve eradication) and are not on the on the National Alert List. Despite this, these vines are causing significant environmental damage along many river systems and should be given much consideration.

A new treatment

Research by Cook and Storrie (2007) has identified the use of a picloram/triclopyr treatment to be effective on both juvenile forms of Cat's Claw Creeper and Madeira vine. As a result, a Pesticide Permit (number 10200) allows the use of picloram/triclopyr ± aminopyralid related products for control of these juvenile vines. The treatment was selected due to superior levels of control, its selectivity and better residual control. However, the specific reasons why this treatment might be superior are unknown. Areas of investigation are therefore highlighted in this paper; namely

- translocation of active in aerial and subterranean tubers after foliar application (Madeira vine)
- level of control of tubers following foliar application to juvenile vines (both species)
- effect of repeated applications to juvenile Madeira vine on tuber persistence (demonstration)
- effect of tuber size on tuber survival following foliar treatment (Madeira vine)

The effects of repeated applications of herbicides to reduce Cat's Claw Creeper tubers was another experiment, but unfortunately the floods of February 2009 destroyed the experiment at a critical stage.

Juvenile vines

A critical point in the life cycle of these vines is when the juvenile vine attaches itself to the host. At this point the weed can climb above most of the competitive species and utilise more sunlight. Once these vines receive increased levels of sunlight, their growth rates and competitive abilities improve. Cat's claw creeper is not affected by light intensities as much as Madeira vine, as it can grow reasonably well under forest canopies whereas Madeira vine prefers open canopies with more direct light. Therefore Madeira vine is commonly seen above hosts and as ground based vines if ample sunlight is available (Stockard 1996).

Floyd (1989) states that Madeira vine grows approximately 1 metre per week under favourable conditions. Growth rates of Cat's claw creeper are less than that of Madeira vine, but it is still considered a fast growing vine.

Preservation of competitive groundcover species is essential, as these species will be light, moisture and nutrition competitive against seedling vines, reducing their growth rates. The foliar application of glyphosate is associated with death of other species and the reduction of these species has lead to increased emergence of vine weeds (Prior and Armstrong 2001, Cook and Storrie 2007).

Seed bank and dormant tuber persistence

If one is to undertake a persistent control program for juvenile vines, it is necessary to know how long seed banks or tubers survive in a dormant state. Once this is known, management plans can be written to accommodate the need for repeat applications until these survival tissues are exhausted.

Swarbrick (1999) reports that Madeira can produce seeds, however the longevity of this seed in the soil is unknown. This will ensure their persistence once the adult plants are killed. Seed production is considered the minor vector or spread and survival. The primary mechanism is the development of aerial tubers that may survive between 2 and 15 years (Vivian-Smith *et al.* 2007) and may be found at densities of at least 1,500 tubers m^{-2} (Floyd 1985). Larger, more persistent root (subterranean) tubers can be formed and may have a diameter of 20 cm (Vivian-Smith *et al.* 2007).

Both vines can also exist as ground runners. Often these runners form root tubers after stem nodes form roots in the process known as tip layering (Vivian-Smith and Panetta 2004).

Cat's Claw Creeper is a prolific seed producer. Its papery flat seeds have been reported to be deposited at an average density of 167 seeds m^{-2} $year^{-1}$ (Downey and Turnbull, 2007). However, low dormancy rates (Panetta 2003) and high germination rates have resulted in no emergence of seedlings 300 days after sowing (Vivian-Smith and Panetta 2004). The survival rates of these seedlings may be extended in inland regions as cooler weather and reduced rainfall patterns may reduce the number of favourable germination events.

Current registered control options

The following table summarises the current registered and Pesticide Permit treatments for both species in NSW. It is important to note that Permits 9907 and 10200 have only been issued since April 2007 and January 2008, respectively. Therefore prior to 2007, the range of available treatments was rather poor.

Table 1: Main chemical control options for use in NSW

Label or Permit	**Herbicide**(s)	**Rate**	**Type of application**
Permit 9158 **-expires March 31st 2010, general use in NSW**	**glyphosate 360g/L**	**1 part product to 100 parts water (CCC) or 1 part to 50 parts water (MV) and/or** **1 part product to 1.5 parts water**	**Foliar spray** **Cut stump/stem scrape**
Permit 9907 **-expires March 31st 2012, general use in NSW**	**Starane®**	**500mL to 1L per 100L water** **35mL per 1L diesel**	**Foliar spray** **Basal Bark**
Permit 10200 **-expires January 31st 2013, general use in NSW**	**Grazon® DS or Grazon® Extra**	**400mL per 100L water**	**Foliar spray**
Label	**picloram 43g/kg** **eg. Vigilant® gel**	**Undiluted**	**Cut stump/stem scrape**
Label **(Madeira vine only)**	**Starane® or** **Starane® advanced**	**500mL per 100L water or** **300mL per 100L water**	**Foliar spray**

There are other Pesticide Permits for the control of these vine weeds but are restricted to specific groups of people in NSW or for Queensland only. For more details on the current status of Pesticide Permits, access the website address, www.apvma.gov.au.

Therefore the current status for herbicide application is limited. The introduction Permit 10200 has added a great amount of flexibility.

EXPERIMENTAL RESULTS

The results of one Cat's claw creeper and four Madeira vine experiments are shown. A common aim of these experiments is to report the effects of various treatments on the survival of tubers. Particular reference will be made to the triclopyr/picloram treatments, as it represents the new Pesticide Permit treatment.

Results and Methodology

All experimental treatments were applied according to commercial standards, as stated on herbicide labels. In all instances, herbicide application was made to healthy, actively growing vines. The following table describes the basic aspects of each experiment.

Table 2. Experiments undertaken on vine weeds.

Exp. Code	Spray date(s)	Location	Investigating what?	Herbicides used	No. of treatments
CCC1	22.11.08	Tamworth – Glasshouse	Effect of foliar treatment on tuber survival	½ and ¼ dose rates of metsulfuron, glyphosate, dicamba, picloram/triclopyr/aminopyralid, and fluroxypyr ± aminopyralid	12
MV1	10.2.06	Ellenborough	Repeated application on tuber persistence	Initially a range of herbicides followed by 2 applications of Starane® ± Brush-off® followed by 3 applications of Grazon® DS or Extra	1
MV2	20.9.08	Tamworth – Glasshouse	Effect of ¼ & ⅛ dose rates of foliar sprays on tuber survival	Many combinations of metsulfuron, glyphosate, , picloram/triclopyr±aminopyralid, fluroxypyr ± aminopyralid	24
MV3	22.9.08	Tamworth – Glasshouse	Effect of foliar applied treatments on viability of aerial tubers	Full dose rates of metsulfuron, glyphosate, fluroxypyr ± aminopyralid and triclopyr/picloram/aminopyralid	5
MV4	15.9.08	Tamworth – Glasshouse	Effect of tuber size on survival	¼ dose rates of metsulfuron, glyphosate, fluroxypyr ± aminopyralid and triclopyr/picloram/aminopyralid	5

Where: CCC= Cat's claw creeper MV= Madeira vine
NOTE: Two experiments that were mid-way through their expected completion, were partly destroyed by multiple floods in the mid north coast region in February and May of 2009. These experiments were intended to study the seed bank longevity and effects of repeat treatment on Cat's claw creeper tuber survival. Therefore these results cannot be presented in this paper.

Experiment CCC1:
Five Cat's claw creeper plants per pot were cultivated and treated with herbicides once vine runner reached on average 50cm in length. Quarter and half-recommended dilution rates of herbicides were applied to plants so that spray solution was near the point of run-off. Lower than recommended dose rates were used because glasshouse-grown plants have softer leaves and are susceptible to lower rates of herbicides. Each treatment was replicated 6 times to ensure that results are not random effects. Table 3 details the rates used in this and other experiments.

Table 3: Treatment list for glasshouse based vine experiments

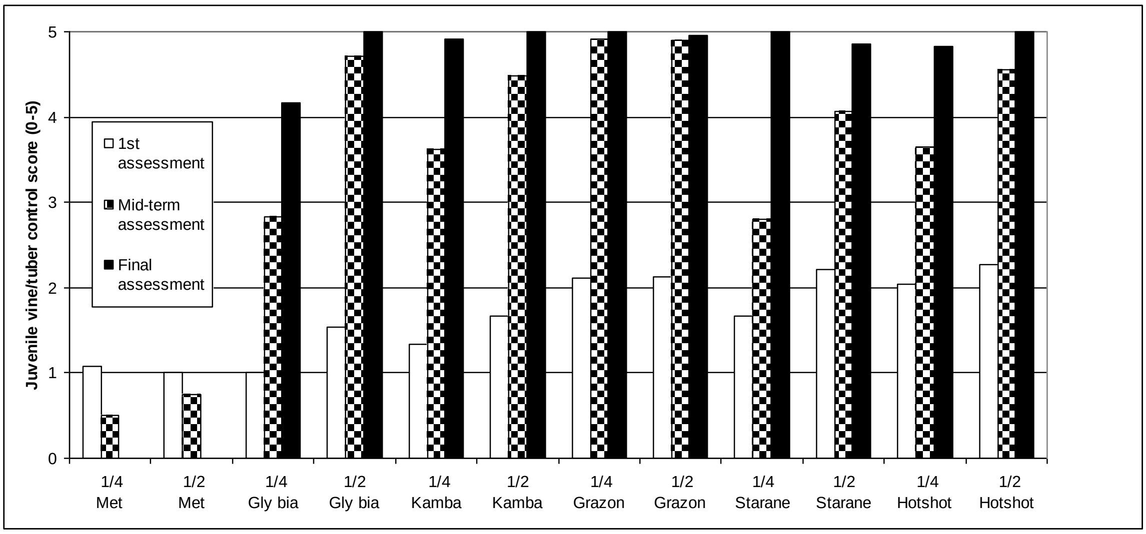
Product	**Active ingredients**	**Dilution rate**		
		⅛ rec. rate	**¼ rec. rate**	**½ rec. rate**
Roundup® biactive	Glyphosate	125mL/100L	250mL/100L	500mL/100L
Grazon® Extra or DS	Triclopyr + picloram + aminopyralid	37.5mL/100L	75mL/100L	150mL/100L
Brush-off®	Metsulfuron-methyl	1.25g/100L	2.5g/100L	5.0g/100L
Starane® Advanced	Fluroxypyr	37.5mL/100L	75mL/100L	150mL/100L
Hotshot®	Fluroxypyr + aminopyralid	90mL/100L	180mL/100L	360mL/100L
Kamba® 500	Dicamba	62.5mL/100L	125mL/100L	250mL/100L

Non-ionic surfactant added to metsulfuron-methyl treatments at 0.2% v/v. The rates of Hotshot® and Starane® Advanced were adjusted so that comparisons can be made using equivalent rates of fluroxypyr (to gauge the effects of aminopyralid).

The results presented in Figure 1 indicate that Cat's claw creeper is particularly tolerant to metsulfuron-methyl and has some degree of tolerance to lower rates of glyphosate. It appears that ½ and ¼ recommended dose rates of dicamba, Hotshot®, Starane® Advanced and Grazon® Extra achieved excellent control of juvenile vines on the last assessment. The Grazon® Extra treatments resulted in the best mid-term assessment of control. There was a slight advantage using Hotshot® over Starane® Advanced if comparing ratings at the mid-term period however little difference was evident at the last assessment.

All tubers were allowed to regenerate after the last assessment date. An inspection of pots from effective treatments recovered a very low percentage of viable tubers. Most tubers had died and rotted.

Figure 1. Effects of various herbicides and rates on the control of Cat's claw creeper tubers



Where: * Control scores; 0 = nil effect, 1 = 20% reduction, 2 = 50% control, 3 = commercially acceptable control or 80% kill, 4 = 95% kill and 5 = total kill.

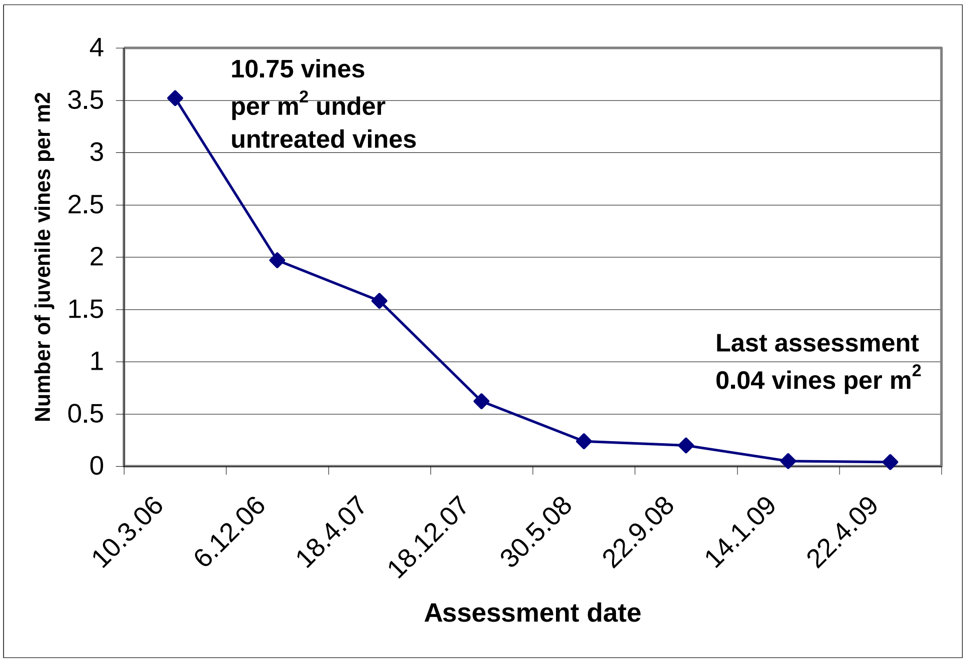
Experiment MV1:
A total of seven herbicide applications were made between May 2005 and April 2009. Refer to Table 4 for the specific dates and herbicides used. Madeira vine was growing naturally on a reserve with the initial control of larger vines successful; consequently the area was predominantly infested with juvenile vines after May 2005.

Table 4. Repeated herbicide application regime for experiment at Ellenborough

Application date	Herbicides applied
10.5.05	Predominantly Starane®, Grazon® and metsulfuron based treatments (previous experiment – mostly giving excellent control)
10.2.06	Starane® 500mL/100L
6.12.06	Starane® 500mL/100L
18.4.07	Starane® 500mL + metsulfuron 10g/100L
30.5.08	Grazon® DS 500mL/100L
18.12.08	Grazon® Extra 500mL/100L
22.4.09	Grazon® Extra 500mL/100L

After nearly 4 years and 7 applications of herbicide, it appears the Madeira vine infestation is nearing the point of eradication. This is best illustrated by Figure 2. It is important to note that there were a few small sections that had untreated established vines and the area under these vines represented the control plots (continual replenishment of aerial tubers). Under these established vines the density of juvenile vines was approaching 11 vines per m^2, compared to 0.04 vines per m^2 in the repeat application areas. This represents a 99.6% reduction in tuber emergence and upon inspection of surviving tubers/vines the majority of these were subterranean tubers (larger size). The annual rate of tuber depletion from the soil, assuming no replenishment, was calculated at 75% per annum.

Figure 2. Reduction in Madeira vine tubers following repeated spraying of juvenile vines



Experiment MV2: This experiment was designed to investigate the effects of very low dilutions of herbicides on juvenile Madeira vines. In this experiment three vines were grown in each pot and treatments replicated 6 times. Vines were sprayed when approximately 60 to 100cm long. Recommended dilution rates for each herbicide are shown in Table 1.

Table 5. Results from experiment MV2

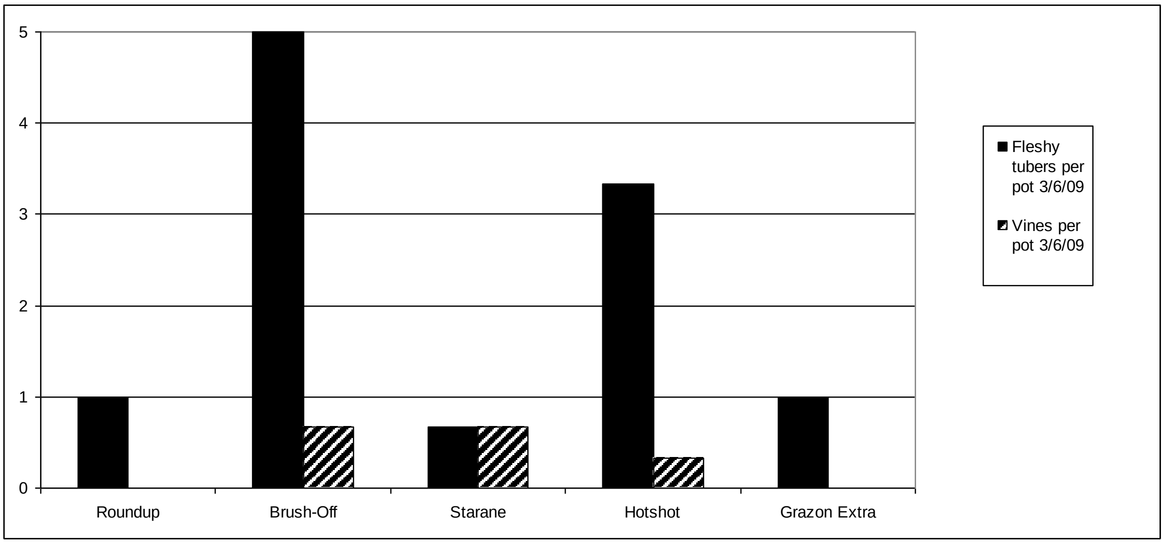
Herbicide 1	**Herbicide 2 (tank mix herbicide)**	**Rate of Herb 1**	**Control score (0-5)* Final assessment 42 days after treatment**
Roundup® biactive	Nil	¼	2.1
Roundup® biactive	Nil	⅛	1.0
Brush-off®	Nil	¼	3.3
Brush-off®	Nil	⅛	2.6
Grazon® Extra	Nil	¼	5.0
Grazon® Extra	Nil	⅛	5.0
Grazon® DS	Nil	¼	5.0
Grazon® DS	Nil	⅛	5.0
Starane® Advanced	Nil	¼	4.9
Starane® Advanced	Nil	⅛	5.0
Hotshot®	Nil	¼	4.9
Hotshot®	Nil	⅛	4.9
Starane® Advanced	Brush-off® - ¼ rate	¼	4.9
Starane® Advanced	Brush-off® - ⅛ rate	⅛	4.8
Grazon® Extra	Brush-off® - ¼ rate	¼	5.0
Grazon® Extra	Brush-off® - ⅛ rate	⅛	5.0
Hotshot®	Brush-off® - ¼ rate	¼	4.9
Hotshot®	Brush-off® - ⅛ rate	⅛	4.9
Starane® Advanced	Brush-off® - ½ rate	¼	4.9
Starane® Advanced	Brush-off® - ¼ rate	⅛	4.9
Grazon® Extra	Brush-off® - ½ rate	¼	5.0
Grazon® Extra	Brush-off® - ¼ rate	⅛	5.0
Hotshot®	Brush-off® - ½ rate	¼	4.8
Hotshot®	Brush-off® - ¼ rate	⅛	4.9

Where: * Control scores; 0 = nil effect, 1 = 20% reduction, 2 = 50% control, 3 = commercially acceptable control or 80% kill, 4 = 95% kill and 5 = total kill. Note: Shaded boxes indicate complete kill.

Grazon® Extra or DS, Hotshot®, or Starane® applied solely or in tank mix with Brush-Off®, resulted in excellent control of juvenile Madeira vines. This is a promising result since rates used in this experiment were ¼ and ⅛ the standard label dilution rates. This may leave some scope to reduce dilution rates for naturally grown infestations, reducing costs, herbicides entering the environment and minimising off-target damage. Grazon® Extra or DS treatments killed all vines. The addition of Brush-Off® did not improve efficacy as the hormonal herbicides seemed to do most of the weed control. Glyphosate was a poor performing treatment and Brush-Off® was moderately better at these lower dose rates.

Experiment MV3:
The aim of this experiment was test the viability of aerial tubers following foliar spraying. Low volume foliar applications of herbicides were made on 22.9.08 to naturally growing Madeira vines, north of Kempsey. Treatments applied were Roundup® biactive (100mL/L), Brush-Off® (1g/L), Starane® (50mL/L), Grazon® Extra (35mL/L) and Hotshot® (100mL/L) and tubers harvested from the vines 5 weeks later to allow sufficient time for translocation of herbicides into the tubers. Ten tubers were sown per pot and three replicates of each herbicide treatment used. Sufficient time (6 months) was allowed to either generate vines or decompose tubers. Results are presented in Figure 3 as fleshy tubers per pot and vines above ground, approximately 6 months after planting.

Figure 3. Effect of foliar herbicides on aerial tuber viability

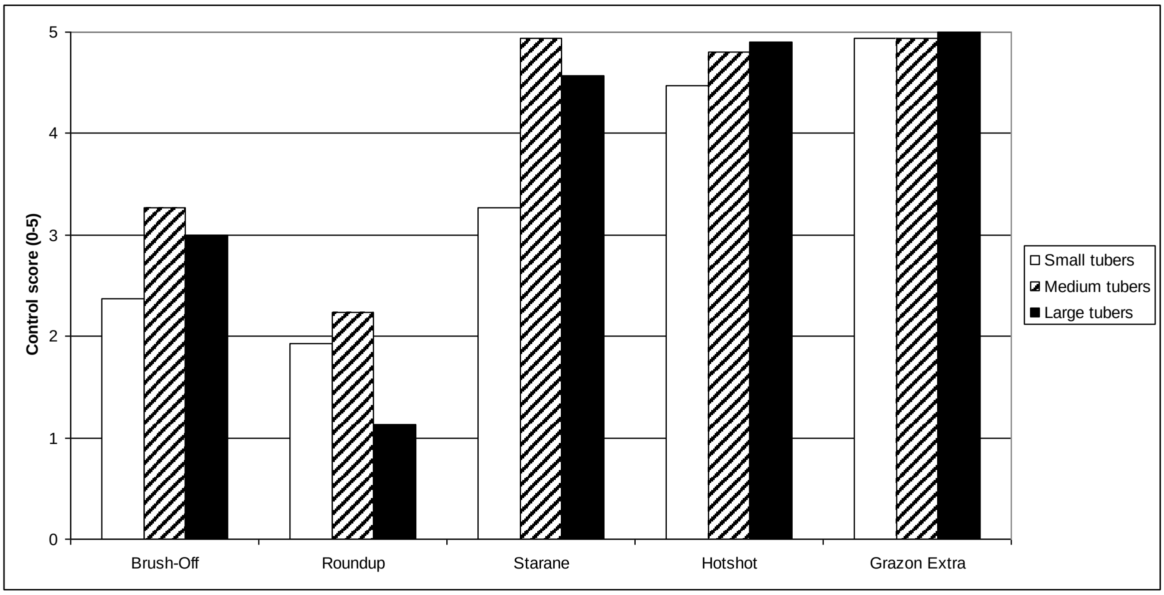


It was noted, approximately two months after planting, that most treatments had generated juvenile vines. However, most of these vines suffered and slowly died approximately 2 to 4 months after emergence. This effect was most likely due to residual herbicides in the tubers because different herbicide symptoms were expressed and were strongly linked to that foliar herbicide treatment (eg. distortion of new growth in Grazon® Extra treatments).

Half the tubers were viable 6 months after treatment; following a Brush-Off® application and a third of the Starane® treated tubers were fleshy after the same period of time. Of the remaining treatments, approximately 10% of the tubers were considered potentially viable (fleshy).

Experiment MV4:
Survival of Madeira vine tubers is related to size (larger tubers persist longer) and may cause greater survival following herbicide application. Therefore different tubers size categorises were planted in pots, allowed to grow juvenile vines and sprayed with five different herbicides. The three different size categorised are as follows; small (1 to 2cm diameter – aerial tubers, medium (2 to 4 cm diameter - subterranean tubers) and large (4 to 8 cm diameter - subterranean tubers). Due to space restrictions in pots, only one large, 3 medium and 5 small tubers could be planted per pot. The juvenile vines were allowed to grow approximately 1 metre tall prior to spraying. Quarter recommended dilution rates of herbicide were applied (refer to Table 3). Each treatment was replicated three times to ensure consistency of data.

Figure 4. Effect of tuber size on control of juvenile Madeira vine



From the data presented in Figure 4, there appears to be no consistent trend associated with tuber size. However, increased tuber size appears to result in better vine control for herbicides such as Starane®, Hotshot® and Brush-Off®. The effect is random for Roundup® biactive treatments and tuber size response is negligible for Grazon® Extra. Superior control was reported in the Grazon® Extra treatments, regardless of tuber size. The poor efficacy of Roundup® biactive and Brush-Off® treatments is consistent with results from experiment MV2.

Discussion

It appears that the use of picloram/triclopyr ± aminopyralid formulations is highly effective on both juvenile forms of Cat's claw creeper and Madeira vine. In summary its use has many advantages over other treatments, namely;

- It is selective and is safe to competitive monocots (grasses and rushes)
- Has superior efficacy on both species of juvenile vines at reduced dilution rates and kills the tubers attached to these vines
- Ability to kill all sizes of Madeira vine tubers, whereas other treatments resulted in less efficacy.
- Can be translocated to aerial Madeira vine tubers following foliar spraying and dramatically reduces their viability.
- Was used repeatedly to reduce juvenile Madeira vine density by 99.6% over 4 years
- Has residual active ingredients that may provide residual control
- Potential to reduce rates in the field (needs to be researched if adjusting current Pesticide Permit dilution rates lower)

Suggested management plan: The key to successful long-term control of Cat's claw creeper and Madeira vine hinges upon the persistent treatment of juvenile vines following effective killing of established vines. Control of established vines is generally completed successfully, using a modest range of options. Once this is achieved, the task of gradually depleting the soil of seeds and tubers can commence.

The management plans of both species will be generally similar, except for a few differences. Madeira vine tubers tend to persist 4 to 5 years in the study shown within whilst Cat's claw creeper may last a few years via tubers and seeds under repetitive spraying (T. Schmitzer pers. Comm.). More regular spraying is required when treating Madeira vine due to faster growth rates. It is estimated that two to three foliar applications of herbicide are required per year to prevent vines getting too large. However, Cat's claw creeper may need one treatment per year. Therefore Madeira vine is a weed that requires more effort due to the need to treat more frequently and for longer periods.

The preferred treatment is a foliar application of herbicide that contains picloram, triclopyr and possibly aminopyralid as their active ingredients. However, people may wish to select fluroxypyr or glyphosate as their herbicide, but are likely to get lower levels of control and will need to spray for more years. It would be prudent to have annual scans of riparian areas once vines density appears non-existent, as one established vine may develop into a significant infestation within a relatively short period of time. A small effort spent treating the occasional vine now is likely to prevent an enormous effort later.

Maintaining control programs to foliar treatment of small vines will be an efficient use of labour. It can be less demanding on staff compared to the physical exertion of cut stump or stem scrape applications. More infested ground can be covered and less herbicide is required each year as vine density reduces significantly with time.

It is recommended to treat upper catchment infestations first. These infestations are a source of seeds/tubers for riparian areas downstream. The main logistical problem is the range of difficult terrain that has to be traversed to access these weeds and the shortage of resources to cover large areas.

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CURRICULUM VITAE

The author has 20 years experience in weed research. His career began after graduating in 1988 with a Bachelor of Agricultural Science degree from Sydney University. Initially based in Glen Innes in 1989, his roles as a Technical Officer of NSW Agriculture, was to conduct applied research into cropping and pastures weeds in northern NSW. He undertook a Masters of Rural Science degree at UNE in 1992. As a consequence of this Masters thesis, he developed the technique for controlling wild oats, by preventing seed production in wheat crops.

In 1995 he was transferred to Tamworth and now his roles include developing effective integrated weed management of pasture, cropping and environmental weeds. He has been responsible for many technical aspects of projects. Some of the outcomes from these projects include the improved control of alligator weed, the prevention/management of herbicide resistant weeds and obtaining many Pesticide Permits for controlling various environmental weeds.

NRM SKILLS, KNOWLEDGE AND ENGAGEMENT FOR LOCAL COUNCILS IN RURAL NSW

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Local Government and Shires Association, Sydney

Background

All local councils in NSW, irrespective of their size or location, either make or are in a position to make, a significant contribution to the management and protection of natural resources. Local Government is responsible for the development and implementation of land use planning schemes, the management of public land, and the regulation of a wide range of activities that may impact upon natural resource management. Local Government also has a key role to play in translating the NRM policies of Commonwealth and State governments for local implementation.

The development and delivery of integrated NRM in NSW has evolved over the last ten years in response to developments in national and state policy and a shift to joint investment by the Australian and State Governments in the regional delivery of NRM.

The NSW Government has outlined 13 state-wide NRM targets within the NSW State Plan, and recognises that delivering on these targets will depend on an integrated approach across all spheres of government and the community. This approach includes appropriate land use planning decisions, as much as publicly funded conservation and improvement programs.

Local councils have a long history in this area, including integrating NRM into local land use planning schemes, and undertaking extensive land management activities. Recent reforms in the NSW planning system, and proposed reforms in Local Government planning and reporting requirements, have created some uncertainty and confusion around the issue of NRM and council operations.

It is vital that all councils address how their corporate planning and land use planning systems contribute to the delivery of local and regional NRM outcomes.

Building the Capacity of Local Government NRM

Although a number of local councils are advanced in the incorporation of NRM into their policies, procedures and processes many currently do not have the capacity to be effectively involved in local and regional NRM planning. Some of the key factors that influence the level of engagement of Local Government in the regional NRM framework include:

- Level of council awareness and understanding of NRM
- Staff NRM expertise
- Availability and continuity of resources
- Recognition of the need for Local Government to be involved in the regional NRM framework
- Recognition of NRM as part of core business (eg NRM incorporated into land use and corporate planning processes)

In early 2008 the LGSA received Australian Government funding for two projects aimed at building the capacity and engagement of local government in NRM. Specific focus was given to integrating NRM into council land use and corporate planning processes, and to build council capacity to deliver sustainable NRM outcomes for the catchment.

1. NRM Skills, Knowledge & Engagement for Local Councils in Rural NSW

A 12 month project, funded by the Australian Government (via Sydney Metro CMA), aimed to build the capacity of local councils in NRM across NSW with a particular focus on rural and regional areas.

2. Integration of NRM into Local Government Land Use Planning

A 12 month project, funded by the Australian Government (through Sydney Metro CMA), aimed to investigate and provide guidance on local planning for NRM, to ensure decision-making at both regional and local level strategic planning and development control take account of key issues in managing natural resources.

Prior to project commencement of both projects a survey was conducted to *review the current capacity of Local Government to undertake NRM activities*, and areas where the LGSA could invest resources to support councils in their ongoing effective delivery of NRM. This Survey built on a previous needs assessment conducted by the LGSA in 2004/2005.

Presentation
The LGSA intends to present a summary of the Survey findings and introduce the current range of resources now available to councils as a result of the project. In particular the LGSA will provide further information on the following resources:

Survey
- The capacity of NSW local government to engage and participate in NRM

Guidelines
- Integrating NRM into Local Government Operations
  - Volume 1 - Corporate Planning & Reporting
  - Volume 2 - Land Use Planning
- Regional Workshop Series

Education and Training
- NRM Training program for Councillors
- Fact Sheets **–** 6 fact sheets to build awareness and council capacity in NRM

Networking and Knowledge Sharing
- Community of Practice **-** an interactive web-based network for NRM professionals
- Case Studies **–** best practice council activities, procedures, projects and programs

Policy & Legislation
- Discussion Paper - Integration of the NSW Land Use Planning System and the Regional NRM Delivery (CMA) Model

- Local Government feedback – review of the Native Vegetation Act *and* Catchment Management Authorities Act (2003)

THE NSW INVASIVE SPECIES PLAN – INCURSION PLAN FOR INVASIVE PLANT SPECIES

"A brain-chilling tale of tomorrow happens in our world today"

Scott Charlton
Weed Strategy and Planning Officer
NSW Department of Primary Industries, Orange

Introduction

The year is 2011; large parts of Australia have been devastated by an extreme drought. The effects of Climate Change are even more devastating than the wildest predictions from the States best climate modellers (Brown 2006). Sydney residents have all but given up the idea of having a green lawn, and Victa lawnmower sales have dropped by 83%. In an attempt to take advantage of the extreme conditions one enterprising Sydneysider imports the evergreen groundcover *Polytroublsomia perplexa* into the Country under the trade name 'Aldous green'. Within 6 months the species has invaded 400 ha of the Hawkesbury Nepean River Catchment rendering the last of Sydney's horticultural - and even more valuable - turf industry un-productive. More troubling, is the widespread introduction of 'Aldous Green' to regional Australia through the landscape superstore Plant Depot - which has outlets across the Country.

Although fictitious, elements of the above scenario are very realistic and closer to reality than you may think. We currently enjoy unprecedented freedom of movement not available to previous generations; along with this freedom of movement both domestically and internationally, come the ability to transport items such plant materials large distances. Changing climatic conditions are impacting on the success of weeds in new environments, and new weather patterns present opportunities for new plant industries to be established, notably new food and the biofuel industries (Williamson 2001).

The NSW Invasive Species Plan

Over 1,350 exotic plant species –weeds- have naturalised in NSW with more than 100 of them having significant impacts on the environment. In agricultural areas, weeds can out-compete crops and pasture species resulting in lower economic returns and the need for expensive control measures. According to the Bureau of Statistics, herbicide, labour and other expenses cost NSW farmers $475 million in the 2006 -2007 period (Australian Government 2008).

Invasive species pose one of the greatest threats to biodiversity and primary production in NSW. To address this challenge the *NSW Invasive Species Plan*, an 8 year plan to improve the management of invasive species in NSW was launched last year (NSW Government 2008). Accordingly, NSW DPI has led the development of the *Incursion Plan for Invasive Plant Species in NSW* to address Goals 1 and 2 of the *NSW Invasive Species Plan* – to exclude and eradicate or contain weed species in this State.

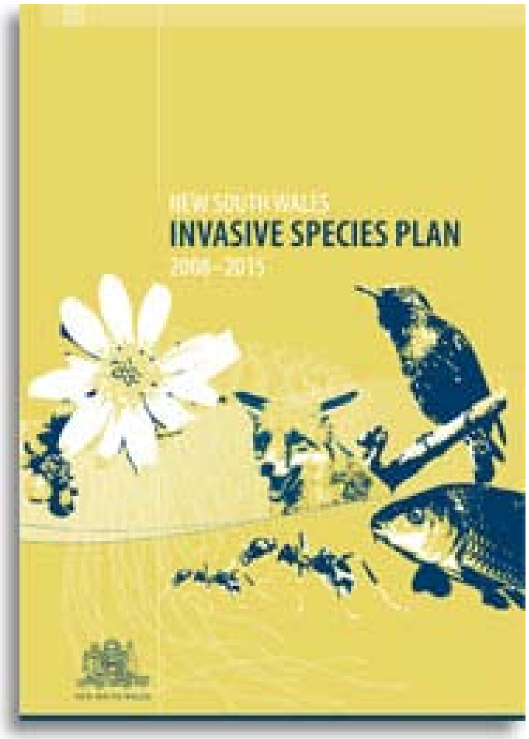

Figure 1 NSW Invasive Species Plan

The NSW Incursion Plan for Invasive Plant Species

The *NSW Incursion Plan for Invasive Plant Species* recognises that the most effective way to minimise the impacts of invasive species is to prevent their initial incursion. Once weeds get into a new area, they have the ability to establish rapidly, and successful control often depends directly on a quick and effective response.

The Plan is being used to coordinate the surveillance and identification of weeds and weed pathways, risk assessment of species and implementation of effective barriers to prevent their establishment. It -the Plan - also outlines how responses to weed incursions are coordinated, implemented, monitored and reported.

The Plan works on the premise that most new weeds are found in either of two ways, adhoc discoveries or deliberate searching. Once plants are detected, a systematic approach is used to process information quickly so that an effective response can be made. This system sets out to both take advantage of ‘accidental’ discoveries of new weeds and to also formalise a system of deliberate targeted surveillance through species searches and pathway analysis (Figure 2).

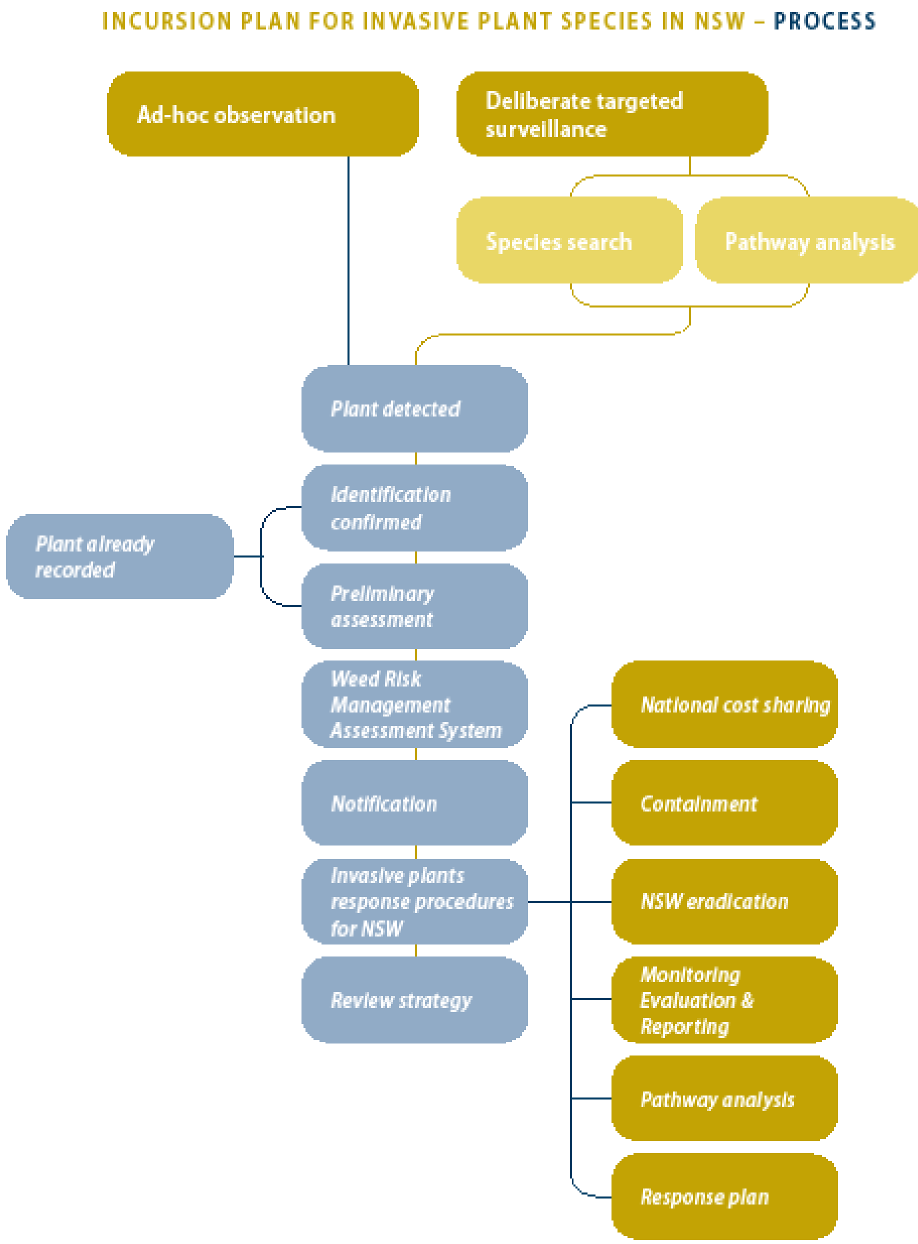

Figure 2 New Incursion response process

One of the key actions from the Plan is to establish a mechanism for deliberate and targeted surveillance to increase the likelihood of finding new weeds before they become established. To assist this process, a list of high risk targeted species has been established based on existing lists such as the WoNS, Alert list and Control Class 1 and 2 weeds. All species on the list have been subject to a Weed Risk Assessment (WRA), and the list will be regularly reviewed to assess feasibility for inclusion or removal of species. The Plan also formalises pathways analysis to determine target species pathways and areas. Existing knowledge will be assessed to indentify gaps and to establish a list of areas for surveillance. Priority incursion pathway /areas are being identified and search procedure and survey methodologies will be developed. Where practical, multiple target species based on similar pathways/areas will be targeted to increase efficiency. A State-wide protocol for surveillance and reporting will be developed.

An important part of the Plan is to build the capacity of stakeholders to detect and identify new invasive plant species. The NSW Government is reviewing the current capacity building activities for its effectiveness. Already several areas have been highlighted such as the need to form a cross agency working group, the need to establish a mechanism to quickly identify weeds, replenishment of herbarium specimens and review submission procedures. Training and extension material is being created in the form of a toolbox of materials and resources for which training will be provided, and the creation of weed networks will be encouraged. The Plan also identifies the need for greater emphasis on new and emerging species in the Noxious Weeds Grants projects, and the continuation of community engagement programs such as '*No space 4 weeds' and 'Grow me instead'*.

With such a diverse range of stakeholders managing weeds in NSW it is crucial that information about the incursion of weeds is communicated promptly. It is proposed that an auto notification system for new national, state and regional records in NSW & ACT is developed. This system will include a standardised procedure for all NSW weed managers, and a process to collate and register new information into central repository. This system could be integrated into a national database such as BioSirt. The use of BioSirt and other hardware allows the facility for mass auto-notification of new incursion information, and access to extensive special data. Notification will occur at different points throughout the process and is an important part of giving feedback to those involved.

If a plant is suspected of being a weed it is subjected to an initial or preliminary assessment. This assessment is important because it can eliminate easily identifiable species from further investigation while expediting the processing of species that are a high priority. A protocol has been developed for this initial assessment to ensure that assessments are consistent and objective.

Once a preliminary assessment has taken place the species will undergo a Weed Risk Assessment to determine the plants risk of spread and its feasibility of coordinated control (Australian Government 2009). The NSW Government uses a Weed Risk Management (WRM) system which considers the invasiveness, impacts and potential distribution of the plant, while feasibility is assessed by considering the control costs, persistence and current distribution of the plant (Johnson 2000). NSW DPI is currently implementing the WRM system and has commenced the training of stakeholders in its use so that WRM can be incorporated into declaration applications; regional planning and noxious weed grant applications.

The last stage of the Plan will put in place a Response process that will provide a framework for making response decisions. The framework will determine the most appropriate response from a range of options. These options may include establishing National cost-sharing arrangements and implementing containment, eradication or asset protection strategies.

The Incursion Plan for Invasive Plant Species provides a whole of Government approach to managing new and emerging weed species in NSW, and is consistent with the NSW Invasive Species Plan goal of fostering a cooperative culture to minimise the impacts of weeds in NSW.

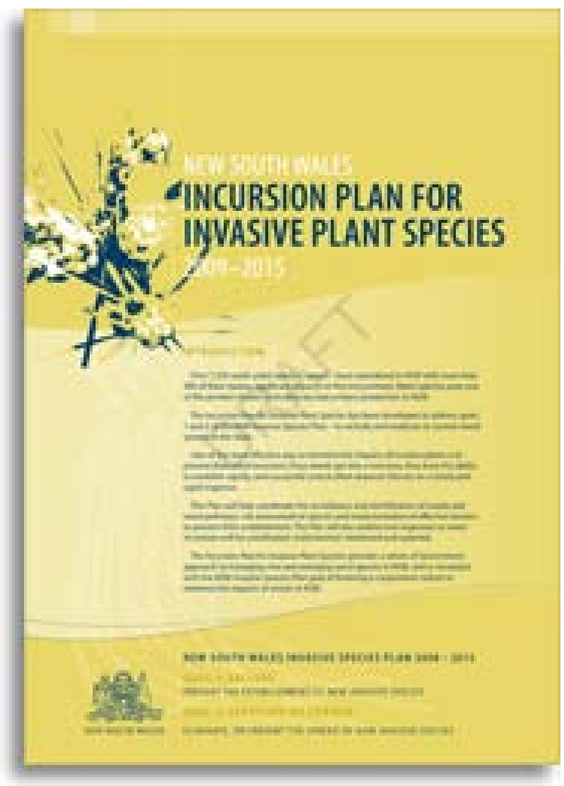

Figure 3 Incursion Plan for Invasive Plant Species

The Incursion Plan for Invasive Plant Species is available at:
http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/legislation/state/incursion-plan-invasive-plant-species

ACKNOWLEDGEMENTS

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AUTONOMOUS WEED SURVEILLANCE USING ROBOTIC AERIAL SYSTEMS & MACHINE LEARNING

Aerial imaging, autonomous classification and spatial estimation.

Alistair Reid, Fabio Ramos, Salah Sukkarieh
Australian Centre for Field Robotics, University of Sydney, NSW, 2006

ABSTRACT

In 2007 the Australian Centre for Field Robotics at the University of Sydney was funded under the Defeating the Weed Menace program to develop a robotic aerial platform for the detection and spraying of invasive aquatic weeds (Alligator and Salvinia). In 2008, this line of research was extended to terrestrial weeds (Parkinsonia, Mesquite and Prickly Acacia) as a new project funded by the MLA. This paper will review the development and testing of robotic aircraft for these projects, and present some initial findings on the use of machine learning techniques for autonomous classification of aerial imagery and mapping of weed spatial distributions.

INTRODUCTION

Unmanned aerial vehicles (UAVs) are essentially robotic aircraft equipped with sensors, computers and actuators. These platforms house payload sensors, in addition to sensors that measure flight control variables including position, airspeed and heading. Algorithms running on the UAV's computers will use this information to carry out control tasks such as waypoint traversal or target observation. The commands generated by these algorithms are executed by actuators that mechanically drive the UAV controls.

In the past, UAVs have usually been reserved for military projects, mainly due to high platform costs, safety concerns, and the need for specialised operating personnel. As the technology is maturing, UAVs are starting to appear in civilian applications such as agricultural and ecological research [Cox04, Dossier99, Herwitz02, Rango06]. The primary role of our UAV platforms is to collect remote imagery over large areas, and at locations that would otherwise be difficult to access. Compared to other data sources such as satellite imaging or manned aerial photography, UAVs offer a number of advantages: they can be quickly deployed to specific areas of interest, can operate at low altitudes to obtain very high spatial resolution images (superior to that of current satellites), and can operate with a high degree of autonomy. Although the current aviation safety rules in Australia require qualified UAV operators to attend any UAV experiments, we envision that in the future UAVs will be operated in the field without specialised personnel, providing a reliable and flexible source of information.

We are also pursuing an autonomous machine learning framework for data interpretation. This includes autonomous classification to identify weeds in images, and Gaussian Process modeling to produce probabilistic weed maps. Given the large quantity of data involved in this project, we expect that automated computer analysis will be an invaluable resource for experts to use when making assessments and management decisions.

AERIAL PLATFORM DEVELOPMENT

The aerospace research group at ACFR has been working on UAV projects for the aerospace industry for over a decade. Much of our experience has directly transferred to this project. However, the new application and operating environment have posed engineering problems to be solved in the design of the platform, the selection of sensors and the algorithms used to analyse the image data.

Platform Designs

Fixed wing aeroplane UAVs (FUAVs) are well suited to collecting aerial imagery over large areas by flying patterns such as grids. For this purpose, we are in the final stages of outfitting a FUAV with navigation and camera sensors to collect a high resolution, geo-referenced image dataset of Parkinsonia, Mesquite and Prickly Acacia at Julia Creek, QLD as part of the MLA Woody Weeds project. We have used a kit model J3 Cub as a base platform, installed flight sensors, actuators and GPS, and tuned an autopilot system to enable autonomous flight capabilities. The current system can fly for approximately two hours at about 30m/s.

We have also developed and tested a robotic helicopter (RUAV) for low altitude surveillance and spraying in inaccessible locations. This platform was built for the 2007/08 Defeating the Weed Menace program, where it was deployed to collect imagery of aquatic weeds and was subsequently directed to spray locations based on this imagery. It is depicted in Figure 1A during flight tests in Pitt Town, NSW in August 2008.

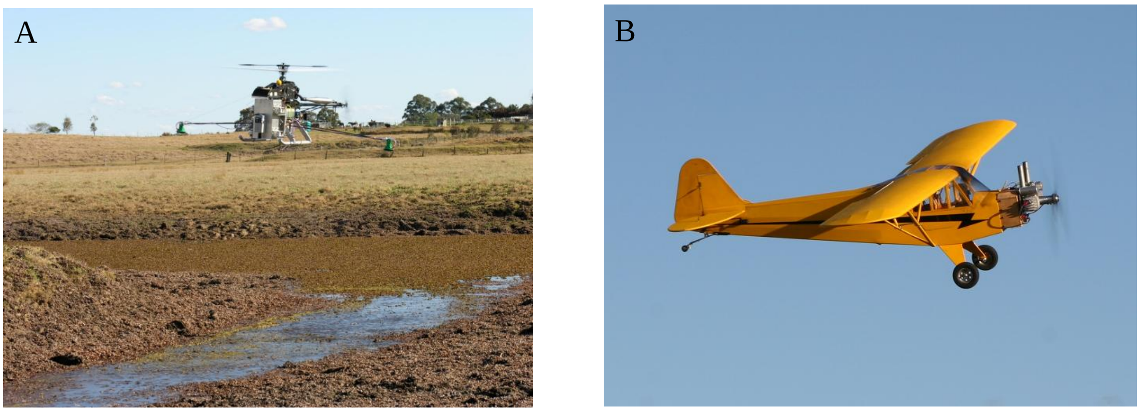

Figure 1. A. The G-18 RUAV hovering above sprayed Salvinia at Pitt Town, NSW
B. The J3 Cub FUAV during flight systems testing at Marulan, NSW.

The RUAV platform is a modified G-18 model helicopter. The rotary wing design was selected for its ability to stop and hover, which allowed the platform to operate in tight environments and also to target herbicide for spot spraying during the aquatic weed experiments. This helicopter will fulfill a similar mission role in the upcoming Julia Creek experiment, where it will collect low altitude, high resolution imagery. The RUAV system can fly for approximately two hours and carry 500 ml of herbicide

To improve the robustness and safety of our UAV platforms, they have been equipped with multiple modes of operation: manual control, semi-autonomous flight, and autonomous flight, so that in the event of a safety concern our trained operators can intervene and address the problem.

Payload Selection

The aerial platforms house camera sensors to record imagery of the environment, and provide information from navigation sensors including GPS and Inertial Measurement Units to a tuned navigation algorithm that logs the position and attitude of the platform so that the images can be geo-referenced on a map. Decisions about flight path, altitude, and sensor selection all have an impact on the quality of the final image data, so many experiments were conducted to evaluate the quality of images required for weed detection. These experiments were conducted early in the project, as the sensor selection directed the design of the platform itself. Vision systems including multispectral cameras with IR and NIR were analysed, but our final selection was a light-weight, high spatial resolution RGB-only camera.

AUTONOMOUS WEED MAPPING

Given that we must deal with large areas of the environment, it is critical that our system is as efficient and autonomous as possible with respect to both the collection and the processing of data. This is particularly true when dealing with terrestrial woody weeds, as they are distributed over a much larger scale than we have dealt with before.

The following examples are based on a preliminary terrestrial weed dataset. Although the Serrated Tussock depicted in the data is not the target of our work, it is abundant at Sydney University's research station at Marulan, NSW where we have clearance to operate UAVs and much of our development testing takes place. Figure 2 shows part of an RGB image dataset that covers 160m by 400m at approximately 10cm per pixel.

Figure 2. High spatial resolution, colour aerial images over a population of serrated tussock grass (obtained by the G-18 RUAV at Marulan Research Station).

Analysis of the geo-referenced images involves two main components: weeds are classified based on their appearance in the images, and then the weed spatial distribution is analysed. We are pursuing an autonomous solution to both of these tasks to ultimately generate a probabilistic weed distribution map.

APPEARANCE BASED CLASSIFICATION

To classify weeds in near real-time, we use a set of characteristic features to quantify their visual appearance in the collected imagery. We trained classification algorithms to learn the relationship between these features and the correct classification of a pixel. We have used a number of feature dimensions including texture (patterns in intensity) and colour measures at different scales from the images (Figure 3).

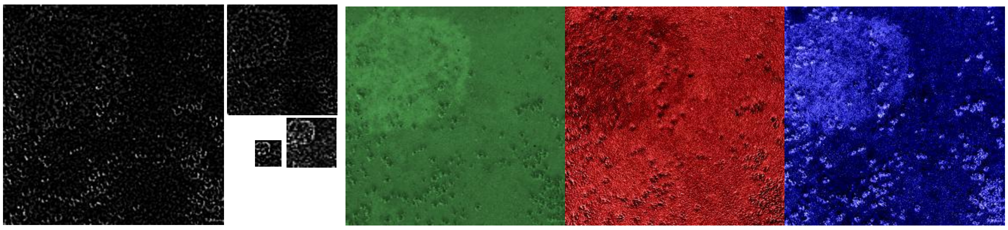

Figure 3. Decomposing an image into a feature set. Left: multi-scale texture decomposition based on Laplacian Pyramids (each block characterises the image gradients at a different resolution). Right: RGB colour space decomposition.

We have explored a number of supervised machine learning algorithms for classification, including Support Vector Machines [Suykens99], Adaptive Logistic Boosting with decision stubs [Friedman00], and Gaussian Process Classification [Rasmussen06]. Figure 4 demonstrates a classification made using a LogitBoost classifier.

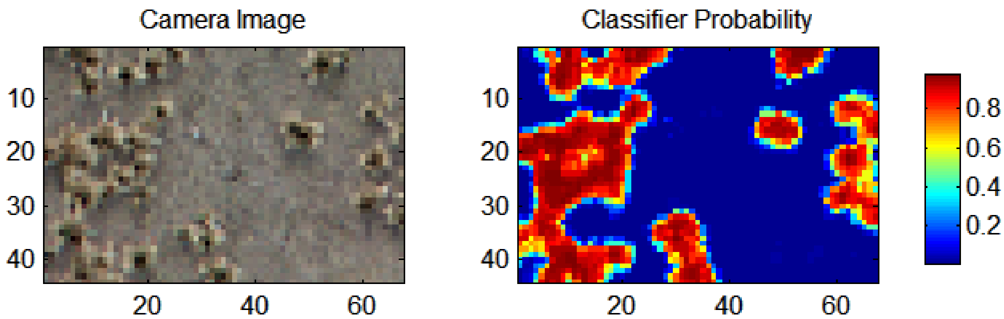

Figure 4. A per-pixel autonomous classification of a camera frame into an estimated probability of Serrated Tussock, produced by a Logitboost classifier trained with 30 decision stubs and using 4 texture based and 3 colour based features as input dimensions.

SPATIAL MODELLING & PROBABILITY MAPS

As we extend the classification work from aquatic to terrestrial weeds, there is an added need to determine how to handle large spaces effectively. We are currently looking at how Gaussian Process (GP) modeling can be used to effectively estimate a weed population map based on intermittent observations of features from different data sources, altitudes and resolutions.

Initially we have focused on the spatial structure of the weed distribution. We assume that weed density is not random but will vary according to a stochastic structure, a view supported by the literature (Holst07, Hartzler99). We quantify the distribution density by using the camera image classifications as a local measurement of weed area fraction. Figure 5 shows a simulated example of observing area fraction with incomplete coverage.

Gaussian Process are a type of stochastic estimator that makes predictions in a similar fashion to Kriging, itself an established tool for modeling geological and ecological distributions [Chiles99]. They are unbiased linear estimators that use hyper-parameters to control the shape of a spatial covariance function instead of using a parametric model to directly specify the modeled property. We have applied GPs to model the weed area fraction over the test data.

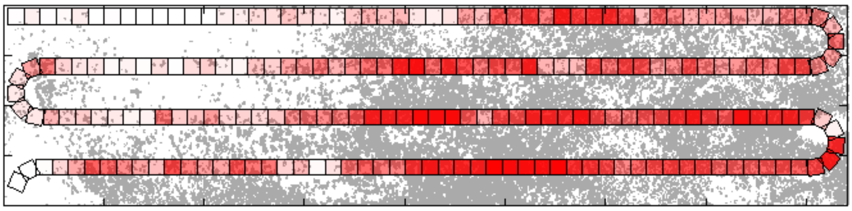

Figure 5. Observations with sparse sensor coverage. The background depicts the true weed distribution, while the high resolution images have been classified to estimate weed area fraction (superimposed in red on the black bordered image frames).

GP models offer some key benefits over other model types. They allow us to predict at any location with a mean and uncertainty, providing an automatic reliability indicator. Unlike grid based models, they naturally handle sparse inputs and outputs. And finally, they allow us to use machine learning to select a GP model autonomously, without having prior knowledge of the structure. This is achieved by numerically optimising the hyper-parameters to maximise the likelihood of the training inputs with respect to the model. This form of learning is resilient to over-fitting and will produce the simplest model that fits the data. It only leaves the equation of the covariance function as a modelling decision. Experiments on the Marulan dataset have indicated that the Matern and Neural Network classes are the most effective for modeling tussock spatial structure. The resulting model predictions in the Marulan dataset example are depicted in Figure 6.

Because the weed area fraction must lie between 0 and 1 (a property that a GP does not guarantee), we pass the output through a sigmoid function. This sigmoid is learnt with the model (to minimise error on the training cases).

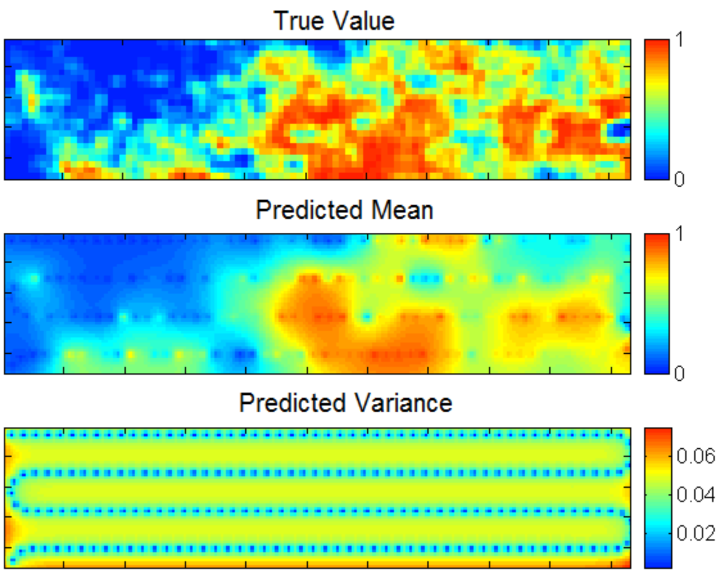

Figure 6. Spatial Estimation of Tussock Density based on sparse sampling. The GP model uses two isotropic Matern class covariance functions, and was selected based on predictive performance. Sigmoid, Length scale, covariance amplitude and noise hyperparameters were optimised.

CONCLUSION & FUTURE DEVELOPMENT

Our flight trials in 2008 demonstrated the potential of autonomous UAVs for observing and spraying aquatic weeds at inaccessible sites. To detect terrestrial woody weeds in the MLA trials, we will extend this approach to wider coverage areas, as well as look at how sparse image information from multiple robotic aerial platforms can be used to build a weed probability map.

We have outlined the development of two UAV platforms that will be deployed in these trials to collect high resolution, georeferenced image data. We have also presented findings on the autonomous, appearance based classification of weeds, and modeling of the weed distribution from sparse observations to form probability maps. The Gaussian Process models used can handle sparse inputs and outputs, provide uncertainty in estimation, and can be learnt from the data without prior analysis, while avoiding over-fitting. Further research will focus on the fusion of data across different feature sets, with the aim of unifying the classification framework across sparse data from different sensors, platforms and altitudes, thereby enabling the use of more efficient sampling strategies.

ACKNOWLEDGMENTS

We would like to thank both Land and Water Australia and Meat & Livestock Australia for funding our UAV projects and recognising their potential. We would also like to thank Andrew Petroeschevsky from NSW DPI, Luke Joseph from Farm and Dam Control, and Sunwater for their valuable contribution. Finally, we thank the Australian Research Council for their support.

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The Need For Weeds Tracer®

Mike Whitney
Weed Officer
Liverpool Plains Shire Council

Property inspections previously involved a cumbersome paper trail based system. This involved a book of maps, Lists of Land Owners and an Inspection Report book to adequately record the information that was then later manually transferred and entered into the computer data base back at the office. Limitations were obvious with many frustrations. The biggest was, not knowing boundaries of properties or even ownership of land being inspected and it relied heavily on local knowledge of the area. This made it difficult for a new inspector to confidently know what property they were on as property ownership detailed lists were not always updated regularly.

When the Central Northern County Council Weed Authority was disbanded in June 2004 it allowed us to consider finding and installing a suitable software program that would allow the capture of all the data required. It would need to be able to effectively identify, Land tenure, Owners/ operators, allow the recording of weed type, area infested, GPS location and control history (That is, work done in the past or currently being undertaken.) Previous attempts to get a program up and running were hindered as some of the council's data and information was not available in a form compatible with a GPS mapping based system.

After assessing several of the software programs available it was decided to adapt our "Paper Trail" system into a user friendly computer program that could easily be operated in the field. The ability to undertake an inspection from anywhere in the LCA was to be an essential feature. Also we required that it could be edited in all "text fields" easily and simply. Council's IT Manager Mark Daly was able to write the flexible software needed allowing us to fine tune it locally, to our needs.

A feature added to the Weeds Tracer® program is Google Earth® interface. This has made it possible to be in a paddock and view a satellite image of the land features right where you sit. The limitation is that an Internet data card is required with mobile phone coverage to view it. Or it can be used back at your office desk and is a useful tool in locating points of interest.

Another feature is the "point capture" option that can be used during aerial surveys/ inspections. You can plot GPS points of weed locations and on return to the office, overlay the points on the mapper and click "select" on each mark to produce a report for the property in question. This information can then be sent to the landowner nominating a re-inspection date.

The Program provides additional benefits for Council, such as:

- Helping to maintain accuracy and integrity as a check and balance of the rating data base system for property ownership.
- The locating and identifying Crown Land and Reserves.
- For Council to locate (plot) and identify the various managed assets.

eg. water meters sewerage, roads, culverts and bridges.

This software has more than halved our time to record and save data, compared to the old paper system. We are able to print out a report on site for the landowner and discuss any questions they may have.

Having local technical support for “problem solving” is a major asset.

An Inspector only requires average computer skills to operate the program. It is easy to use for collecting /collating data to compile reports for Council (the LCA) or to simply meet Department Primary Industries reporting requirements or for a report on a Catchment Management Authority project and other as may be required.

Acknowledgements:
Peter Scott: Liverpool Plains Shire Council
Mark Daly: Liverpool Plains Shire Council

CREATING A CATCHMENT WIDE 'WEEDS' MAP FOR IMPROVED INVESTMENT DECISION MAKING

Andrew Schweitzer
Invasive Species Coordinator
Namoi Catchment Management Authority

Within the Namoi Catchment area, a vast amount of information on weed infestations already exists and is available. This has primarily been generated and compiled by the Local Control Authorities (LCA) from Inspection Reports. This valuable information needed to be collated for assessment and consideration for Namoi CMA to make informed environmental decisions, in order to effectively allocate and invest public money.

Further investigation revealed that each LCA had their individual way of compiling this data. It ranged from paper files to advanced digital collection devices.

A Namoi CMA goal was to make it possible for LCA's to use a uniform data collection procedure and to provide information to both the NSW and Australian Standard. This would allow Namoi CMA to produce accurate catchment wide maps of known weed infestations. In turn, this would facilitate improved investment decisions in an endeavour to attract further funding from external sources.

Following thorough assessments and the hands-on demonstrations of WeedTr@cer® program's capabilities, it was soon apparent that this was the appropriate choice, from the technology available, to capture the necessary weed information. WeedTr@cer® development was initiated, supported and heavily influenced by local weed officers. The IT was also locally developed and it remains so today, as is the support base. There were several very good programs on the market, but the IT support offered by these programs was often time-consuming or missing all together.

The process of getting all LCA's onboard has not been without its problems, but there has always been a common belief by stakeholders that this project would greatly benefit the region.

In May 2009 the first data transfer took place and the region's weed base layer was born. Since then, thousands of individual weed data points have been added.
Once the completed weeds dataset has been finalised, additional information layers can be added to build an appropriate and useful decision-making tool.

Thre Namoi CMA can now create several maps using many digital layers:
For example:

1. Weeds base layer map, and overlay it with a-
2. Namoi CMA Vegetation layer - highlighting the Endangered Ecological Communities (EEC's).

From this, weed incursions are identified and accurately mapped, recording: the type of infestation, its class, size and the general land tenure, (crown, private or public land) with a date of entry plus any relevant, specific or additional notes on the EEC's.

The Namoi CMA weed base layer is a desktop exercise to prioritise sites, saving time, money and resources. All infestations sites will then be visited and verified so that the appropriate decisions can then be made.

ACKNOWLEDGMENTS

- Peter Scott and Mike Whitney - Liverpool Plains Shire Council

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<u>THE USE OF A “SPLATTER GUN” FOR THE CONTROL OF WEEDS</u>

Ken England
Pest Management Officer
National Parks and Wildlife Service, Scone

The first time I was acquainted with a splatter gun was some 25 years ago when an aged farmer in the Aberdeen (Hunter Valley NSW) was using an old cattle vaccination hand gun with a high concentration “brew” from the back of a horse to treat blackberry.

With the advent of new equipment, new chemicals and their associated registrations, “splatter” guns can be used on a larger variety of weed species, without the risk of spray drift, overspray, non target damage and in remote areas. A good result has always been achieved, comparatively often better than conventional foliar methods.

The use of a splatter gun is a very simple method that has been used widely throughout NSW in DECC (NPWS) managed lands. The splatter gun method allows access to weed infestations where vehicle access in not a viable option.

The concentrated chemical mixture is placed in a five litre backpack that is easily carried on foot, or can be used on horseback. It is also a suitable piece of equipment that can be used for minor weed infestations from a vehicle and is something that can be carried at all times within a vehicle when other tasks are being undertaken, other than specifically weed spraying, “just in case” weeds are found.

The splatter gun is a very low technology, cheap and effective method of treating weeds, without the need to purchase expensive equipment. Many chemicals have a registration for low volume, high concentration rates, for a number of weed species. The splatter gun mixtures are the same as for those registered for gas gun operations. Essentially the equipment is a hand operated gas gun, without the need to carry a bottle of gas and the complicated arrangement of gas pipes and valves that go with a gas gun.

Splatter guns have been used on blackberry, lantana, bitou bush, thistles, boxthorn, sweet briar, and pear species to name just a few. The guns are also an excellent application tool for basal bark treatment of woody weeds such as African olive, willows, tree of heaven and privet and are ideal to use for a stem injection applicator.

The splatter gun is a “must have” piece of equipment for those in the weed control business.

A WEEK IN THE LIFE OF A WEEDS OFFICER

Roger Smith

Vegetation Coordinator

Orange City Council, Orange

Gone are the days where weeds officers would be out in the paddock all day inspecting properties. Gone are the days where weeds officers would carry around a hoe on the back of the ute to chip out any burrs they encountered during their inspections. Gone also are the days where weeds officers would camp under a proud gum tree to enjoy their lunch. Bring back those days, I say, bring them back.

Today we have mobile phones, mapping systems, GPS, lap top computers, CMAs, Project Officers, C4 Management Plans, Quiksprays, group projects, noxious weeds AND environmental weeds, TV campaigns, other stake holders, electronic display boards, weather meters and 4 wheel motorbikes. Need I say more? All these effects are designed to make our roles easier and might I say busier. You see we are so efficient at doing our jobs these days that we appear to have idol time on our hands and are therefore assigned more tasks or we even volunteer our time to carry out other roles.

Whilst filling out a timesheet late last year I was amazed at the amount of activities I had actually carried out through the week. The time sheet went something like this.

Monday:

Promotions

- coordinating the production of 3 new noxious weed ads for the local television station.
- distributing Landholder Calendars to various agencies
- setting up the electronic display boards along regional roads, (daily)
- addressing a group of high school students on revegetation techniques once weeds have been eradicated
- doing a story in the local paper regarding noxious weeds

Tuesday:
Inspections

- urban privet inspections
- rural properties for St John's Wort and Blackberry
- meeting with Greater Western Area Health Services and other stake holders to discuss the best approach to controlling weeds in a bushland reserve adjoining their hospital

Administration

- sending out property reports
- issuing notices
- preparing for DPI audit

Wednesday:

- Attend a combined regional meeting with the Macquarie and Lachlan Valleys Weeds Advisory Committees

Thursday:
Administration and Inspections

- DPI audit
- inspect local property with landholder re bio-control agents on True Scotch Thistles, distribute bio-control agents at various sites
- check goats, (used as control agents on Council Land)

Friday:
Weed control work

- Spot spray blackberries and willow regrowth along TSR walking track easement
- Boom spray walking track for nuisance weeds

Administration

- Commence abstract for 15th Biennial NSW Weeds Conference
- Attend local CMA meeting

Talk about multi-skilling. The question comes to mind if Weed Officers are appreciated for the work activities they carry out on a weekly basis. I have only been in the industry since 1995 and am sure those who have been in the industry longer sometimes struggle with the work changes they endure. A long way from chipping burrs.

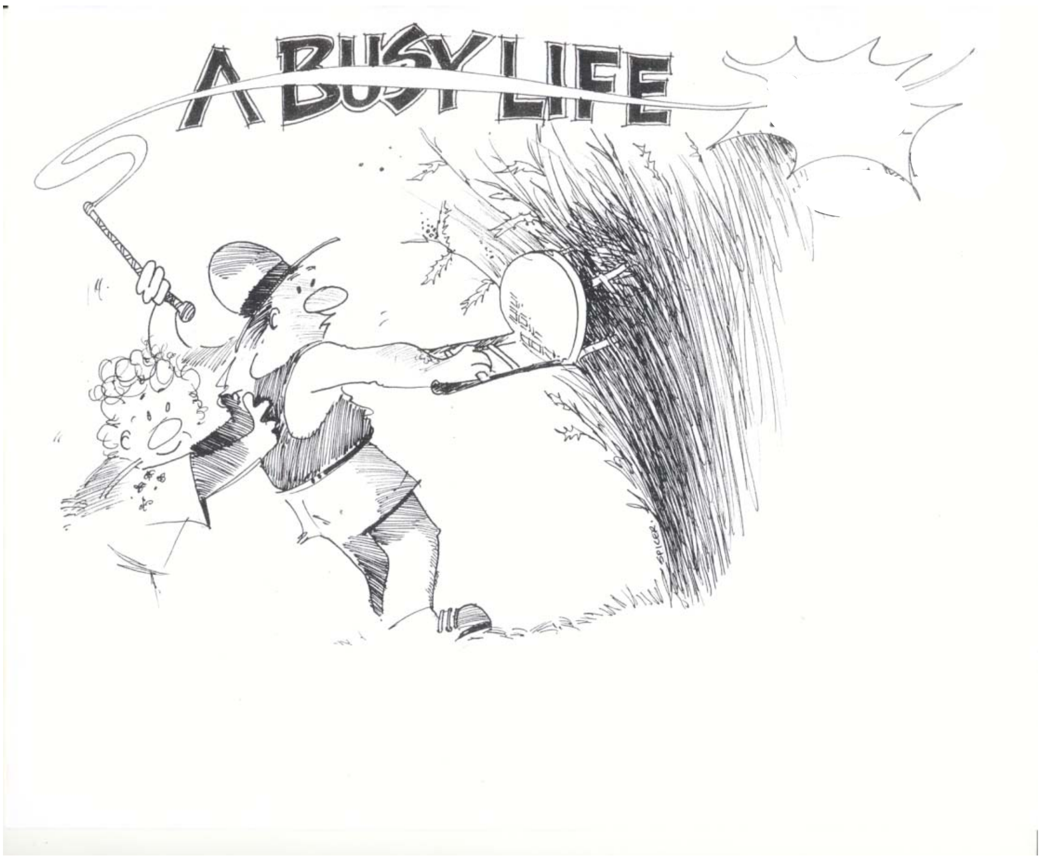
These days the emphasis is on awareness and education. Raising awareness can be very cost effective giving us more bang for our bucks. Orange City Council spends a lot of time involving schools in unground activities as well as educating the general public about weeds and their detrimental affect on agriculture and the environment and how to repair the environment once the weeds have been removed. Several local schools have included the activities as part of their curriculum and visit the sites on a regular basis. Awareness activities include television campaigns, newspaper articles, landholder calendars, various brochures and handouts, roadside signs and field days.

Catchment Management Authorities, (CMAs) play an ever increasing role in weed management throughout the State. Not so much in the way of noxious weed control but remediation works after weeds have been removed. A solid relationship with CMAs is crucial to one’s holistic approach to weed management.

Weeds Officers are now very accountable for their actions, not only from the DPI and local CMAs but from their own Council and local community. My presentation at the 15th Biennial NSW Weeds Conference is intended to illustrate the activities Weeds Officers undertake.

WEED MANAGEMENT

A Busy Life



Mr Terry Schmitzer
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BACKGROUND

In 2007 I was privileged to be nominated for the Inaugural NSW Beuckner and Stephenson Weeds Officers Award as part of the 14th NSW Weeds Conference at Wollongong.

This award was won by a very worthy, Don McKenzie from Bourke Shire Council

Along with Terry Inkson of Great Lakes Council I was selected as one of six finalists and as such was called up on stage at the conference dinner where each of the finalists were asked some interesting questions by the evenings entertainer.

My question was “Who is your favourite Weeds Officer?”

My reply was, “Could I ask the people a question?”, which was, How many Police Officers are there in your local Council area?” No answer. “Or NSW?” No answer. My next question was, “How many Doctors are there in your Council area?”, again, no answer.

I then said, “Ok, how many Weeds Officers are there in your Council area?” (which in most cases is only one)

And my answer to the original question ‘Who is my favourite Weeds Officer’, is all of them.

They are all champions, each trying to effectively implement weeds programs for their area.

The following information will try to demonstrate the scale of the tasks required to be performed by Weeds Officers and the paradigm shift or the change that has resulted in the way that we in the Mid North Coast region are now operating, and which results in Weeds Officers having “**A Very Busy Life”.**

Traditionally the Weeds Officer’s role has been regulatory.

That being to **‘POLICE’** the function imposed by the ***‘Noxious Weeds Act 1993’***in local Council/Authorities areas.

RUNNING INTERFERENCE

What are the Local Control Authorities (from Noxious Weeds Act 1992)

1. The Local Control Authority for land within a local government area is the Council of the local government area or, if noxious weed control functions for that area have been conferred on a County Council under any other Act, the County Council having those functions.

2. The Local Control Authority for land within the Western Division that is not within a local government area is the Western Lands Commissioner.

3. The Local Control Authority for land within Lord Howe Island is the Lord Howe Island Board.

What are the Noxious Weed Control Functions of Local Control Authorities?

A Local Control Authority has the following noxious weed control functions in relation to the area for which it is the Local Control Authority (the **LOCAL AREA**).

1. Responsibility for the control of noxious weeds by occupiers of the land (other than Public Authorities or Local Control Authorities).

2. Control of noxious weeds on land owned or occupied by the Local Control Authority and on certain roads and watercourses, rivers or inland waters as provided by this Act.

3. To ensure, so far as practicable, that the owners and occupiers of land (other than Public Authorities or other Local Control Authorities) carry out obligations to control noxious weeds imposed under this Act.

4. To develop, implement, coordinate and review noxious weed control policies and noxious weed control programs.

5. Inspection of land within the local area in connection with it's noxious weed control functions.

6. To report, at the request of the Minister, on the carrying out of the Local Control Authority's functions under this Act.

7. To cooperate with the Local Control Authorities of adjoining areas to control noxious weeds where appropriate.

8. Any other functions that are conferred or imposed on the Local Control Authority by or under this Act.

Some statistics
Mid North Coast Weeds Advisory Committee

Council	Area (sq km)	Population	Weed Coordination Benchmark	Ratio w/o population
Great Lakes	3,339	34,200	1.2	1 : 28,500
Gloucester	3,000	5,000	1.0	1 : 5,000
Greater Taree City	3,752	45,000	1.46	1 : 30,822
Port Macquarie/ Hastings	3,700	72,000	1.45	1 : 49,655
Kempsey	3,381	28,000	1.0	1 : 28,000
Average	3,434	36,840	1.222	1 : 30,147

Police Numbers Comparison

Council	Population	Police Numbers	Ratio of Police to Population
Great Lakes	34,200	43	1 : 795
Gloucester	5,000	3	1 : 1,667
Greater Taree City	45,000	60	1 : 750
Port Macquarie/ Hastings	72,000	93	1 : 774
Kempsey	28,000	90	1 : 311
Total	184,200	289	1 : 637

As you can see if the average ratio of Police to population is 1: 637 compared to 1: 30,147 for Weeds Officers.

Then we have little chance of success in controlling weeds given current resources while utilising a policing approach.

This is also demonstrated by the fact that once a weed is declared noxious it is rarely removed from the list due to eradication.

In fact most remain on the list, such as the case for blackberry, which has been a noxious weed for over 100 years.

This has lead to a change to:

1. That of principally an advisor/education role utilising the fact that in most cases the landholders property is their greatest asset and Weeds Officers are there to assist them in maintaining and improving their asset by using holistic and sustainable solutions, with the ***Noxious Weeds Act*** being utilised as a last resort to ensure control works compliance.
2. We have found that this approach has resulted in an ever improving percentage of compliant property owners, as well as making the Weeds Officer part of their community instead of being alienated from it.

Problem

With the increase in profile achieved by our Weeds Officers we now have increasing numbers of landholders/land managers coming to us requesting advice on weed identification, control options and planning issues. We are finding that we are unable to service this demand with current resources.

(you don't need a licence to own land, but from our experience you should!)

For comparison I will use the position of Doctors, whose patients come to them, are restricted to around 20 minutes and are charged for that privilege.

Weeds Officers visit the property, which may take from one hour to all day or more, and our service is free!.....

More Statistics – Ratio of Doctors to Population

Council	Population	Doctors	Ratio of Police to Population
Great Lakes	34,200	48	1 : 713
Gloucester	5,000	7	1 : 714
Greater Taree City	45,000	57	1 : 789
Port Macquarie/ Hastings	72,000	102	1 : 706
Kempsey	28,000	42	1 : 667
Total	184,200	256	1 : 719

In addition to inspection, education and compliance duties of Weeds Officers we:

1. Provide assistance, technical advice and coordination to an ever increasing army of volunteers who perform vital on grounds work on public lands in the war against weeds.
2. Maintain Weed Control Programs on roads, parks and reserves under Council's care and control.
3. Supervise externally funded projects utilising Aboriginal "Green Teams".

More Statistics – Weeds Officer Travel Distance

Council	Benchmark	Total km/annum	Av hrs per week travelled
Great Lakes	1.2	42,000	12.15
Gloucester	1.0	31,000	10.76
Greater Taree City	1.46	51,000	12.13
Port Macquarie/ Hastings	1.45	57,000	13.65
Kempsey	1.0	38,000	13.19

Government Authority Land Holdings

Council	Council Control (ha)	Stat Forrest (ha)	NPWS Estate (ha)	Vacant Crown Land (ha)
Great Lakes	7,137	58,709	67,920	2,676
Gloucester	1,562	7,790	52,815	17,626
Greater Taree City	4,190	43,600	43,600	7,000
Port Macquarie/ Hastings	5,547	73,164	86,529	7,105
Kempsey	2,495	24,843	93,000	?

Councils are one of the largest land managers in their area with their **'farm'** being subject to daily, constant abuse by not only the local population but also travelling public.

Council Land Holdings

Council	Area of Road Reserves (ha)	Area of Parks & Reserves (ha)	Total ha	Total Acres
Great Lakes	4,852	2,285	7,137	17,635
Gloucester	1,494	68	1,562	3,860
Greater Taree City	3,190	1,000	4,190	10,353
Port Macquarie/ Hastings	2,540	3,007	5,547	13,707
2,365	2,364	131	2,495	6,165

And finally

Are we addressing the cause/source of our weed problems or simply treating the symptoms?? My question is prompted by this:

About 65% or weeds invading reserves and bushland areas have originated from urban gardens!!

Dr R.H. Groves: 1998 – Recent Incursions of Weeds to Australia – Technical Series 111 – CRC For Weed Management.

Statistics (last for today) Percentage of Rural to Urban Properties

Council	**Rural Properties**	**Urban Properties**	**% Rural**	**% Urban**
Great Lakes	3,396	22,687	13%	87%
Gloucester	1,324	1,448	48%	52%
Greater Taree City	4,800	15,500	24%	76%
Port Macquarie/ Hastings	4,784	22,980	17%	83%
Kempsey	5,400	8,400	40%	60%
Average			28%	72%

Given that 65% or our weeds originate from garden situations, …

Do you spend 65% of your time targeting the cause??

Responsible gardening STOP 'garden escapees'!

About 65% of weeds invading reserves and bushland areas have originated from urban gardens, often termed 'garden escapees'.

Once established, these weeds become difficult and expensive to control (let alone eradicate), and compromise the health of the ecosystem.

The Problem

Plants escape from gardens in a variety of ways, but the main cause of spread from gardens is by green waste dumping in bushland and road reserves. This practice is harmful to the bush for many reasons, such as:

• Introducing weeds (plant fragments, roots, tubers, seeds, spores).

• Smothering native plants.

• Increasing nutrient loads.

• Increasing fire risk by increasing fuel loads.

Dumping in bushland reserves is illegal and can attract considerable fines.

Garden plants may also spread into bushland reserves directly from gardens where they are planted. "Weedy" garden plants may be indentified by:

• The ability to spread by vegetative means (e.g. bulbs, corms, tubers, root parts, stem fragments) (e.g. Glory Lily, Coral Tree, Trad).

• Berries that can be eaten by birds (e.g. Asparagus Fern, Cotoneasters, Olives, Camphor Laurel).

• Production of large amounts of seed that is easily distributed by wind, animals, water etc.) (e.g. Formosa Lily, Longleaf Willow Primrose, Balloon Vine, Moth Vine, Narrow Leaf Cotton Bush).

• High viability of seed.

• A general ability to survive under extreme conditions.

• A history of weediness in similar climates

You can make a difference by what you do in your garden. We suggest that you:

• Replace invasive plants in your garden with safe and preferably native alternatives

• Regularly prune your garden plants after flowering. Not only will this prevent seed set, it will also promote healthy and vigorous growth.

• Dispose of garden waste responsibly, ***NEVER*** dump it over the back fence, on roadsides or in bushland. Green waste is accepted at all Landfill operations

• Dispose of plant bulbs, tubers and seed heads in general waste for deep burial at a waste management centre.

• Cover your trailer when taking garden waste to landfill to stop weeds and seeds from blowing off and invading roadside and bushland areas.

• Buy a mulcher and mulch appropriate garden waste on site, then use it in the garden or compost it!

• Actively report any illegal dumping in your neighbourhood.

• Join your local bushcare group and help clean up the public reserves and bushland areas in your neighbourhood.

1

2

3

4

5

6


1. Formosa Lily. 2. Asparagus Fern 3. Glory Lily 4. Moth Vine 5. Coral Tree 6. Balloon Vine

WEEDS TO BE CONTROLLED – AUGUST	HERBICIDE INFORMATION
• GIANT PARRAMATTA GRASS & GIANT RATS TAIL GRASS	* FLUPROPANATE (VARIOUS TRADE NAMES) (PERMIT 3567)
• PATERSON'S CURSE	* 2, 4-D AMINE, MCPA, METSULFURON METHYL
• PRIVET	* METSULFURON METHYL, (FOLIAR), * GLYPHOSATE (STEM INJECTION / CUT STUMP)
• MOTHER OF MILLIONS	GRAZON DS®, STARANE®, 2,4-D AMINE

CONSULT THE LABEL PRIOR TO USING PESTICIDES

NOTE: Not all herbicides registered for these purposes may be listed.
* = Suggested, Registered Herbicide, indicated by local experience.

Mid North Coast Weeds Advisory Committee. On hand to assist your noxious weed enquiry

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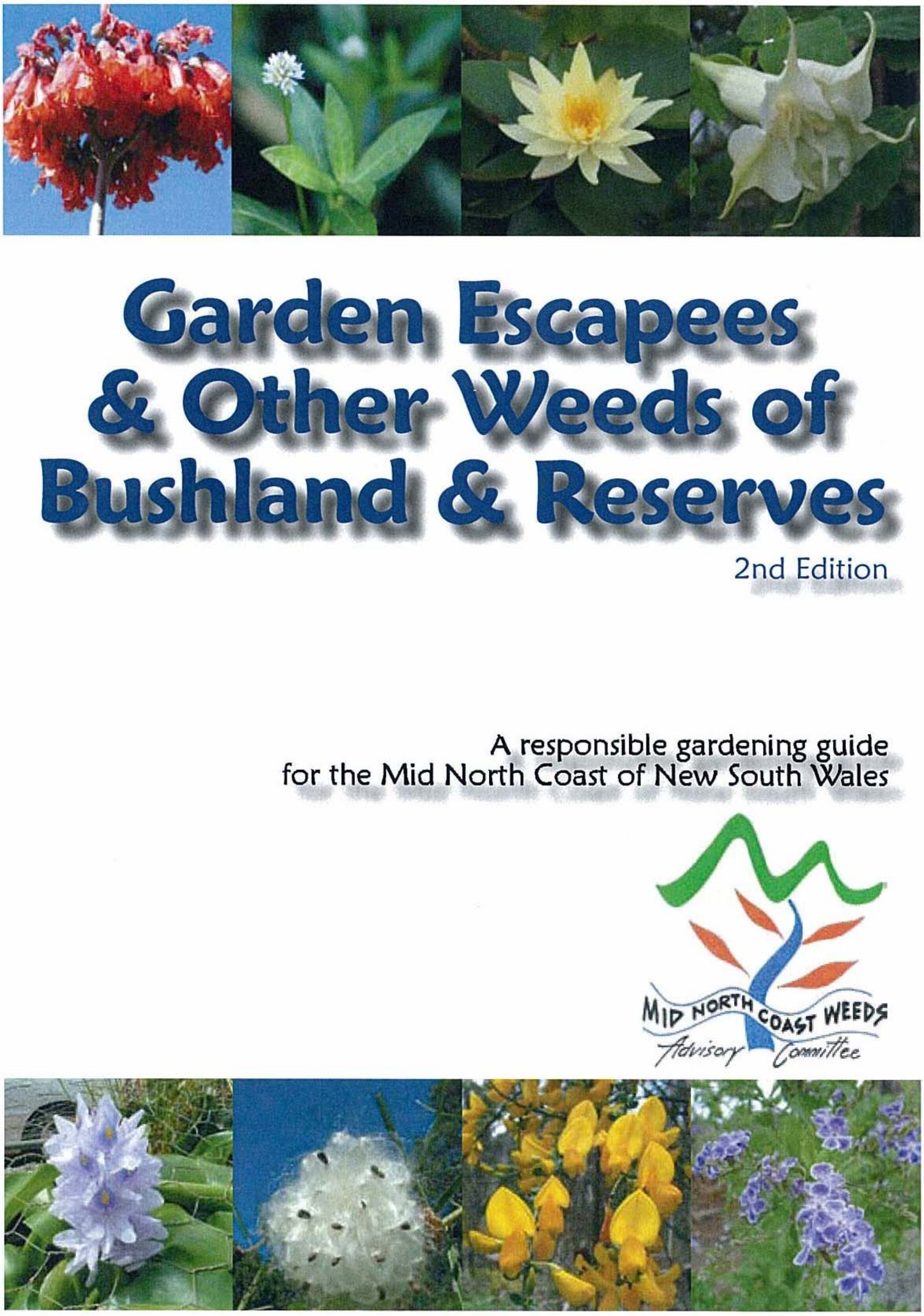

YOU HAVE THE BEST 'OFFICE' IN THE WORLD', EACH DAY HELP TO MAKE IT BETTER THAN WE FOUND IT

REFLECTIONS, CONNECTIONS AND AS I SEE IT

Peter Scott
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ABSTRACT
This paper is presented in terms of my reflections as a weed manager, within the 2009 Conference theme, "The Old and the New in Weed Control." It considers what our forbearers didn't have at their disposal to meet challenges that "Noxious Weeds" originally presented and compares it to where our industry is positioned today.

Our combined knowledge of hindsight and research is backed by an unprecedented range of information and technology. The mechanical equipment, numerous chemical options and Best Management Practices underpin strategies and plans implemented by professional Weeds Officers. Our forbearers would be envious. I do consider however, that they would be critical of the lack of commitment and cohesive coordination. Their vision is not matched today with leadership that keeps pace with our ability to achieve effective control.

The weeds removed from the Declared Noxious Weeds List have not been defeated with a new Strategy a Plan or by new technology. The time and procedure to have a weed declared or a control class reviewed is unrealistic. The process was developed because of the need and to also reflect local expectations.

A Weeds Officer's core business was to conduct property inspections, locate Noxious Weeds and to provide reliable control information. Increasingly, now the expectation is for us to be de-facto Environmental and Biodiversity Game Keepers, as distinct from just being Weeds Nazis.

Risk Management was not a consideration when Mysore thorn and lantana were introduced and Lake Innes, near Port Macquarie was opened to the sea. Now, thankfully it is! Consider the choices and options available to the community and the mutual benefits of mandatory standards today!

INTRODUCTION
The theme of this conference challenged me to reflect on the weed problems our forefathers faced and the circumstances that led them to declare "Noxious Weeds."

With gratitude I now acknowledge the agriculturists and botanists who were, in all probability, also our first environmentalists. They identified future problems.

Imagine what they did not have at their disposal then to deal with not only agricultural problems but future environmental degradation a lack of decisive action would cause! Compare their predicament, their limited knowledge and resources with ours today!

Undoubtedly for me, they had a forthright intent and an uncomplicated approach. Despite the limitations, they chose to confront rather than deny the challenges they faced and called it as they saw it. Today I consider they would be critical of**:**

- The national approach to Noxious Weeds that lacks uniformity, despite the fact that here in NSW the *Noxious Weeds Act* (the Act) is regarded as important Environmental Legislation.
- The complications caused by some conflicting legislation and regulations.
- The lack of willingness and commitment of some industry leaders to resolve problems that exist.
- The outcome of strategic cost and goal shifting, from roadside control to a property inspections focus, condoned for political convenience.

Regrettably the wisdom of our forefathers is not matched today with commitment and leadership from all levels that keeps pace with our ability to achieve more outcomes, by using readily available technology. History highlights the shame that results from inaction, particularly when early and continued intervention could have changed outcomes, for example mimosa and olives or the contentious issue of maps and boundaries to adjoining Local Control Authority **(**LCA) or the variations of their weed control status.
With evolving scientific knowledge and the understanding of new, exotic and invasive weeds, current logic dictates we need a less complex process to include them as Noxious Weeds, and a more comprehensive reassessment procedure to justify their removal or for a status variation.

Significantly, some of the thrust of the Gledhill Report has not yet been embraced.

Where are we positioned with weed control today?
Consider the evolution of our industry's vast range of weed control resources. Nowadays we have accumulated knowledge from research findings and experience, all backed by a huge range of educational and Information & Technology (IT) services, mechanical equipment and chemical options. The advantages of and accessibility to scientific and educational material alone would exceed our forefathers' comprehension and leave them awestruck.

And what of bulldozers, backhoes, boom-sprays and the retractable "Quick Spray" hose systems with the plethora of selective/non selective, residual/non residual and environmentally friendly herbicides, deliverable by aircraft?
All these, plus elements and options of "Integrated Control", used in conjunction with live GPS plotting, remote tracking and mapping plus the electronic eye "Weedseeker" technology systems, are hardly comparable to a knapsack with the early generation herbicides, a fire, chipping hoe or mattocks and shovels.

Considering this evolution our team is now in an enviable and unprecedented position to deliver effective weed control. To demonstrate this**,** papers from Roger Smith plus Reece Luxton and Rod Ensbey at a previous conference discuss successful control projects. Two points (among others) highlight good reasons for their success:

(1) The targeted weeds were declared and recognised as Noxious Weeds.
(2) The work required was well planned and actually completed effectively.

So let's reflect and consider why then in general haven't we been more successful with Noxious Weed control and why are so many weeds widespread? What has been missing? Clearly not enough effective, well coordinated, adequately resourced on ground control work has been undertaken with true resolve and the higher level of support needed, has been missing from the equation.

The excuse, "It can't be done, it's too wide spread" is a politically orchestrated stunt that has no validity. It's a distraction, "to go look for other weeds". The statement is more about abandoning our responsibilities. (Like the defeated fox in Aesop's fable, "The fox and the grapes"). When we ignore them, infestations will expand and find their "natural range". These "weeds are killing us softly". The impact on industry is an enormous contribution to costs that exceed $3.4 billion a year and this is not a desirable outcome.

I support the sentiment expressed in the advertised and open invitation to attend a Noxious Weed Control Site, Field Day that said: - "*Come to see the results and discuss the process*." YES, it can be done!

The system in use today

What justification is being used when processing an application for a weed to be included on, or removed from, the Declared Noxious Weeds List? The process and criteria for either proposal are officially; equitable, transparent and scientifically measurable. In reality, this is not so. The criteria are not being observed. Despite an assurance that the Declared Noxious Weed List would not be dismantled, with the stroke of a pen many weeds have been removed. Regrettably, this is not because "The Weed Menace" was defeated with the assistance of a supporting new strategy, a plan or even new technology. On the contrary, they were nominated and just removed.

For example, the procedure involved to review, on appeal, the allocated Control Class of St Johns wort in Liverpool Plains Shire Council (LPSC) for reinstatement back to a Class 3 (previously a W2, now a Class 4) revealed an inequitable, unrealistic and protracted process. It's not as if the information needed for consideration, or any further information that may have been required, was unavailable or "classified" new science. The lack of communication, acknowledgement or even an exchange of information, for 18 months, was a deliberate and ignorant silence. The adjudication was unsubstantiated with no supporting factual evidence provided for the verdict. It is clear to me, the bureaucratic process, initially designed to also reflect highly valued local contributions and expectations, has been hijacked by autocrats.

LPSC now have 97 plants and species of Noxious Weeds, whereas previously there were 45 declared. This includes 26 Class 4 Weeds, supported by LCA sponsored Individual Management Plans. "Having said this, [as a NSW Department of Primary Industry (NSW DPI) instruction explains] it is possible that an LCA may not wish to prosecute land holders for the presence of every Class 4 weed listed in their areas. In these cases, a more generic wording may be possible." (NSW DPI 2006). This suggestion or instruction is a contradiction of Legislated Class Control requirements and does not initiate confidences for a go-forward position. I feel it is neither constructive nor helpful, especially as NSW DPI is now the state's largest provider of science (NSW DPI 2005), and is in a great position to provide primary industries with technology and partnerships needed for profitable and sustainable production.

For seventeen of these Class 4 Weeds, there is no provision to stop the sale, propagation or their knowing distribution. Also the 35 Class 5, *notifiable* Noxious Weeds, are without a control obligation provision or expectation and is why I call them “Claytons” Noxious Weeds

The review initiative and changes were a scheduled requirement of the Act, albeit without effective consultation. Unintentionally, legislative mistakes were made, some were acknowledged and some not. For example Don Bourke has pointed out the Gaura species *lindheimer*; as one and that episode got everyone’s attention!

Some other mistakes I have noticed:

- Incorrectly a Mexican poppy variety was nominated.
- St John’s wort was inappropriately dropped from a W2, to a Class 4 without provision to prevent its sale and on what has since been acknowledged as unsubstantiated justification. This has yet to be rectified.
- Star thistle was allocated as a Class 4 to the LPSC on a false premise. (not conceded)
- Golden dodder in the LPSC was relegated from a W2 to a Class 5, without a Control expectation. This defies logic.
- Espartillo, formerly a “Sleeper Weed” was previously unable to be classified as a Noxious Weed because there are “No reasonable means of control,” but is now a Class 5 *notifiable* Noxious Weed, without control provision.

A rhetorical question for consideration, should we include Lippia or Mimosa (and there are others) in the discussion or just sweep them under the carpet? Is the problem too big and widespread, so forget it as a Noxious Weed? No, I do not agree. Delegates may know of others.

Why all this is important to me?

As a farmer, in the early 1980’s I was an active but I must say not a willing participant in the “Recession we had to have”. During my “Exit Interview” from the industry to which I remain fully committed, unashamedly passionate but rational about, the State Manager (Rural Business) of a major Bank asked, “What do you think we (the Bank) can learn from the process?” (*ie*. Winding up a farming and grazing operation). In the main my answer was, “Always provide and budget for sufficient funds to control and manage (all) weeds.”
He asked, “Why is this so important?”
My answer: “It’s not only an obvious prerequisite in the short term but for the future as well. It will help maximise production potential and is a positive contribution to the framework of a sustainable enterprise that protects the environment too. It helps immediately to showcase the asset in its best light to prospective owners.”
“Yes” he said. This was instantly understood and given endorsement with an undertaking it would in future, be given favourable consideration with a higher priority.
I do appreciate legal obligations and frankly, I take no pride in failure, nor should anyone. Whilst farming and long before becoming a Weeds Officer, I was summoned to court and appropriately fined for non-compliance with the *Noxious Weeds Act.*

Connections, with hindsight but looking forward
Major Innes's family were the early settlers of the Port Macquarie area and historically they are credited with introducing Mysore thorn and lantana in the 1830's. Coincidentally I just happen to be a direct, family descendent. Mike Dodkin, an esteemed long term friend and more recently for me, a colleague in conservation with National Parks & Wildlife Service, (NSW NP&WS) will never forgive me for that, nor for the fact the Innes family also opened Lake Innes, near Port Macquarie, originally a fresh water lake, to the sea. Just imagine the scope of the "Environmental Impact Statement" needed to get that project over the line today.

What have we learnt from the past and what risk assessment procedures are now in place to minimise making similar mistakes?

Do we just wait to see the impact of new introductions?

No. The Australian Government and Biodiversity Australia are to be applauded. They took the initiative and banned 3335 species of known weed plants from entering Australia. Hopefully, this action can be a base on which to build a comprehensive National Standard. Also a rigorous assessment process has been implemented, aimed at removing genera (groups of species) from the permitted list, some formerly allowed entry without assessment.

Are the goal posts shifting?
The valued resources of motivated, volunteer, community-based groups have emerged and been recognised. They have energetically embraced weeds and the broader environmental issue of their negative impact, particularly those threatening a balanced biodiversity. Adequate resources are not always available to maximise the opportunities to grow and harness these partnerships. Regrettably they are not always appreciated, are underutilised and improved coordination would be mutually beneficial.

The obvious strategic cost and goal shifting (from road side control to a property inspection focus) condoned for political expediency, has regrettably, had a negative impact too. With very limited funding available some roadside control programs have progressively been neglected. This sends a wrong and corrupted message to the broader community. Successfully the Great Lakes Council and others now set environmental levies to fill the funding void and locally, prioritise the control work needed. This also helps to justify the shift in goal as both of these elements are essential to achieve a sustainable and balanced environmental outcome.

Traditionally, a Weeds Officer's core business has been property inspections, to locate Noxious Weeds, provide educational material and the current information about controlling them. Now, increasingly there is an even greater, green, warm and fuzzy expectation for us to be Environmental and Biodiversity Game Keepers, essentially without official sanction, recognition or specific training. This de-facto expectation is additional but simultaneous and is quite different to just being a "Weeds Nazi.".

As a Weeds Officer, one of the positive highlights is to visit an operator who is on top of their weeds problem and can only see the advantages of the exercise. This type of exchange sours dramatically when they direct discussion to "noncompliant neighbours" or to those who have obtained outside funding. Attitudes change to that of vigilante and disbelief that as a Weeds

Officer, neither I nor the LCA, “can make them undertake Weed Control”. Some groups of neighbours have organised meetings with private legal representation in absolute frustration and in an attempt to resolve the impasse.

The CMA’s have arrived to fill, among a growing list of functions, a pivotal role between the community and some environmental issues. Originally we heard that they would not be a source of funding for Noxious Weed control. Now they are. This will remain a divisive reality, both within the community and between neighbours. The situation will fester until resolved, even though historically and it is generally agreed, that insufficient resources are provided for Noxious Weed control.
This is all the more reason to embrace the underlying sentiment of the eleventh (11^{th}) recommendation in the Gledhill Report: “The use of the words NOXIOUS and ENVIRONMENTAL in describing weeds should be discontinued and should be referred to as WEEDS.”

As I see it and it is with out doubt, achievable!
Clearly and significantly, the broader community expectations have not been met.

- **Just do it.** Avoid the confusion, and formally qualify the problem scientifically, as one (be they Noxious, Invasive or Environmental weeds, by degree or class)

<u>and get on with adequately resourced management.</u>

- Not recognising the problem places us in a position of contradiction with our Regional Strategy.
- If a weed (other than Noxious) meets criteria, under scientific examination, qualifies to be a project target, is eligible for funding from public financial reserves through an equitable and competitive process, then, under any reasonable definition, surely it must be “Noxious!” So, realistically, in the world of weeds, why do we continue to procrastinate?
- A more forthright approach, with intent, is needed.
- Without question, you can not control something you can’t measure. You need three things to control (Noxious) weeds:
  1. The Method or Means.
  2. The Money.
  3. The Intent to do the program.
- If you do have INTENT you don’t need as much of the other two.

How has making a choice, changed for the community in general? Options available today are far more complex and sophisticated than those faced when selecting a car in the mid sixties. Many items formerly regarded as “optional extras” are now mandatory inclusions. Consider our expectations today and the vast range of mutual benefits offered by the National Safety Standards now in place. Mandatory is not all bad, is it?

Voluntary building codes originally introduced idealistically and hopefully to achieve savings of net energy consumption in buildings for basic heating and cooling, failed to deliver targeted expectations. Now these same codes and more are mandatory. The energy savings are measurable. Both the community and environment are beneficiaries. This really is progress!

Solar energy capture
Who can remember, setting dry grass or paper alight with a magnifying glass?
I do, my big brother made me do it! Yes we have come a long way with a long way to go!
Who here at Conference has, or planned to, or knows someone who has installed a Solar Hot Water system or the Insulation, in line with the "National Strategy" to take advantage of the cash rebate and to reduce our carbon foot print?

Well, let us all be very clear about this and under no illusion. There is nothing in it for the environment and certainly nothing in it for you, the individual, no dollars, nothing, **until the (**installation**) work is actually done.**

<u>The same applies to Weed Control!</u>

ACKNOWLEDGMENTS

- To my darling wife who tried for the first time at midnight to make sense of all this.
- Robyn Singleton for "Presentation Skills" training. A commendable initiative of NSW DPI.
- I also extend heartfelt thanks to my colleagues and fellow Weeds Officers for their help and encouragement, especially Mike Whitney and Lee Amidy.

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OTHER INFORMATION

- Key Threatening Process List.
- Environment Australia Alert List.
- CSIRO Report: Jumping the Garden Fence.
- Invasive Species List.
- Threatened Species Process
- Australian Weeds Strategy
- The Slim Dusty song "Looking Forward Looking Back"
- www.bpinsw.gov.au
- Examples of some complications that conflicting legislation and regulations may be found: (Native Veg. / the Noxious Weeds / Local Gov. / and the RTA Act's).

GLOSSARY

The Macquarie Concise Dictionary.

- Excuse:- defensive apology, a pretext, asking for forgiveness.
- Reason:- a reasonable explanation, the basis is fact, a cause, the grounds or rational.
- Sympathy:- perceptive understanding, compassion, consideration, pity.
- Empathy:- perceptive understanding, compassion.
- Bureaucrat:- public servant
- Autocrat:- authoritarian despot

DISCLAIMER: The views expressed in the above paper are those of the writer and do not necessarily convey those of the organization represented by the writer.

BIOGRAPHY: (in part)

- Has worked closely with, hosted and been encouraged by respected NSW Ag, agronomists and CSIRO researchers. Successfully participated in numerous crop competitions and trials locally and at state level, for highest yield, baking quality and Pure Seed production crops.
- Registered as No 3 customer/client of the former Soil Conservation Service.
- Among other past experiences, involved with experimentally and successfully feeding 1st Cross ewes to join during the extended drought 1964/65, watched closely and assisted by CSIRO Scientists from Chiswick, Armidale.
- Funded a trip to USA in 1971 to study the Beef Cattle Feed Lot industry, with a leading NSW Ag Beef Officer and another private beef producer. Later became a foundation member of the Australian Lot Feeders Association (ALFA). Then, twelve years on, spent a further ten year period at a major commercial and innovative feedlot facility.

An observation-

- There is good reason to raise a flag of caution.
- What of the potential for seed and grain contamination or introduced diseases if bulk feed grains are allowed to be imported for stock feed, despite any amount of protocol that may be in place?
- From within NSW we look at the Parthenium Weed situation interstate, while the Nation looks back at the Equine Influenza episode.

In Summary and also found in the Slim Dusty song, “Looking Forward Looking Back”
“There are strange days
Full of change on the way
But we’ll be fine, unlike some
I’ll be leaning forward, to see what’s coming”

And we can all make a difference.

LOCAL GOVERNMENT WEEDS SURVEY

Sean Brindle
Project Officer
NSW Department of Primary Industries, Orange

The NSW Noxious Weeds Act (section 37) requires local control authorities to supply the NSW Department of Primary Industries (DPI) with distribution information on noxious weeds (on request). The NSW DPI currently collects information, via local control authorities, on new incursions of notifiable noxious weeds. Notifiable noxious weeds relate to weed control classes 1, 2 and 5.

In the summer of 2007-08 the NSW DPI Weeds Management Unit undertook a local government survey of 134 priority weeds to map their distribution and abundance. The 134 weed species included in the local government survey were from the following categories:

1. Noxious weed control classes 1,2,3,5.
2. Weeds of National Significance (WoNS), Alert WoNS.
3. Emerging weed species suggested by regions i.e., CMA's weed strategies and local government regional weed committees.

The collection of such a comprehensive amount of weed distribution data had not been attempted before in NSW. Over 16000 individual datasets were collected, processed and mapped thanks to the cooperation of well over 90% of the 125 local control authorities in NSW.

The survey produced a publication of distribution and abundance maps of NSW for the 134 priority species. The survey mapped weeds to a grid cell size of approximately 25 square kilometres for NSW and approximately 10 square kilometres for the Sydney Catchment Area.

Project Team Leader	Rob Williamson
Project Officer	Sean Brindle

THE STRUCTURE OF WEED MANAGEMENT IN NSW

Position Vacant – NSW Weed Authority (Part-Time)

Ian Turnbull
Manager Vegetation & Environment
Bellingen Shire Council

ABSTRACT
Following the Gledhill report of 2006 and recommendations from that paper the Minister for Agriculture has reinvigorated action towards the exploration of "…options for structural and operational alignment to deliver more effective weed control in NSW". This reinvigoration has started with a "weeds summit" held in Sydney on the 26^{th} of June 2009. This paper aims to identify the key elements of current weed legislation and strategies in NSW which require a deliverable outcome. In order to achieve structural and operational efficiency in delivering these outcomes a capability assessment of current organisations who have the ability or current responsibility for weed management will be made. This process will provide a clear indication of the style of organisational arrangement required for the effective delivery of weed management in NSW.

BACKGROUND

Local Government has been tasked with responsibilities by the Minister for Primary Industries (Agriculture) for the management and enforcement of the primary piece of invasive plant legislation in NSW, the Noxious Weeds Act 1993. Local Government, by default, has become a part-time employee of the Minister to undertake this role, delivering specified actions with financial assistance; however the position has never been fully funded. The Minister in 1996 engaged Mr Robert Gledhill to review the delivery of these roles and more recently has hosted a "summit" to explore "…options for structural and operational alignment to deliver more effective weed control in NSW".

While a definition of effective weed management has not been given it is assumed that the Minister is reviewing the position of "NSW Weed Management Authority (Part Time)" to ascertain the following;
a) does the position description fulfil all of the strategic requirements required for weed management across the state?;
b) is the incumbent the most suitable to best perform the duties required?

INTRODUCTION
The position of "NSW Weed Management Authority (Part Time)" is currently held by Local Government (including Council's, Shires and County Councils), this paper will review the position description, determine essential and desirable criteria for delivery of the duties and review some potential candidates for the position.

The strategic or legislative direction for this position is drawn from two specific documents. The first is the Noxious Weeds Act 1993 (the Act) and the second is the NSW

Invasive Species Plan 2008 (NSW ISP). The Act gives specific requirements required by law for performance by the position and the NSW ISP identifies some goals for the Weed Management Authority (Part Time) to aim for to assist in a coordinated response to the threat of invasive species (including weeds) in NSW.

Noxious Weeds Act 1993
Under Section 36 of the Act a weed authority is required to undertake a number of tasks including

- control of noxious weeds on its own land,
- ensuring that owners and occupiers of land carry out obligations to control noxious weeds,
- to develop, implement, co-ordinate and review noxious weed control policies and noxious weed control programs,
- inspection of land within the local area,
- to report on the carrying out of the local control authority's functions
- to co-operate with local control authorities of adjoining areas,

NSW Invasive Species Plan
There are 4 Goals of the NSW ISP - the role of the NSW Weed Management Authority (Part Time) in relation to these goals is as follows;

1. Preventing the establishment of new invasive species – primarily by early detection and management of new incursions.
2. Eliminating or preventing the spread of new invasive species – by the effective management of new incursions.
3. Reducing the impacts of widespread species – through maximum benefit management programs
4. Identifying its capability to deliver the above three items.

The above elements identify the key areas and accountabilities for the position. Drawing on these elements the development of some essential and desirable selection criteria can be identified.

Essential Criteria

- *Ability to plan and implement Noxious Weeds Inspections.*
  The successful applicant must be able to inspect and enforce weed control across all private land in NSW (over an undefined period). In order to successfully enforce the legislation access to land ownership details are required.

- *Ability to inspect all high risk sites for new incursions*
  The successful applicant must be able to inspect all nurseries, pet shops, waterways, roadsides, saleyards and markets in NSW for new incursions.

- *Propensity to part fund position*
  As the position is only part funded (ie via matched grants up to dollar for dollar) the applicant must be able to invest at least $7 million to undertake the role.

Desirable Criteria

- *Community Capacity Building*
  The position is required to undertake extensive community capacity building in the areas of weed identification, land management and integrating weed control into management activities, additionally negotiating with retailers on the invasive properties of popular garden species.

- *Experience in Grant Processes*
  The position requires a substantial investment in grant application and reporting processes, additionally the position may require extensive negotiation with other organisations to fulfil some grant requirements.

While the above list is clearly not an exhaustive list of criteria it will provide the selection panel a baseline for which to cull potential applicants.

Potential Applicants

Realistically there are only two other potential applicants who could be shortlisted for the position, these are Catchment Management Authorities (CMA's) and Livestock Health & Pest Authorities (LHPA's). While there are arguments for both organisations undertaking the role the broad nature of the position (ie both urban and rural focus areas) steps outside the core business areas of both organisations.

Catchment Management Authorities
CMA's specifically are charged with delivering on natural resource targets as defined initially within the NSW State Plan and then through the Natural Resources Commission. CMA's can certainly deliver on weed targets with respect to protection or improvement of natural resources within the state (and they do) the move from incentive programs to enforcement and additionally enforcement within urban areas (eg nurseries) would require a significant change of focus within their organisations.

CMA's have the potential, under the Catchment Management Authorities Act 2003, to collect a catchment contribution from landholders within the authority area, additionally they can enter into an agreement with Local Government as a "collection agency" to collect these funds.

CMA's could certainly become the Weed Management Authority (Part-Time) however the shift in focus to address the broader range of primary producer weed management issues would need further exploration prior to consideration.

Livestock Health & Pest Authorities
LHPA's (once Rural Land Protection Boards) currently state core business as animal health, pest animal and insect pest control (and Travelling Stock Reserves) and concentrate on the rural sector with a delineation (at least in rating its constituents) of 10Ha or more. While small landholders are not levied enforcement and awareness for small farms is still included in the provision of advice and enforcement of the Rural Lands Protection Act by LHPA's.

In a review of LHPA's in 1993 by Integrated Marketing Communications Pty Ltd it was stated " Given that RLPB Rangers have unsurpassed local knowledge of landholdings in their areas of responsibilities…the regulation of noxious weeds on a fee-for-service basis could be a reasonable option to consider” (IMC Pty Ltd, 1993 p 30).

While the move to fee for service inspections by LHPA rangers may be feasible the integration of inspection of high risk areas (such as garden escapees in peri-urban areas) is currently outside the core business of these organisations. The ability of LHPA’s to match the $7.5 million required to fulfil the position from properties greater than 10ha is also an issue that would need resolution should LHPA’s wish to undertake the role of Weed Management Authority (Part-Time).

Conclusion

While there are a number of organisations who have the capability to undertake the position of Weed Management Authority (Part–Time) it is clear that in order to increase efficiencies a direct measure of current expenditure and return on expenditure is warranted. If a cost benefit analysis of the current situation is not undertaken how can any alternative model be compared?

Local Government who currently holds the position of Weed Management Authority (Part-Time) has, over many years, moulded itself into a collective of organisations which deliver (to varying degrees) both the essential and desirable elements of the position. While looking externally for an increase in efficiency it is most likely that a diversion to increasing efficiencies within the current arrangements may be more fruitful.

REFERENCES AND FURTHER INFORMATION

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Livestock Health & Pest Authorities website - http://www.lhpa.org.au/

RIVERINA EASTERN NOXIOUS WEEDS AUTHORITY
Formed April 1st 2006

Why form it, how and is it working?

Robert Ferguson
Manager
Riverina Eastern Noxious Weeds Authority
Encompassing Temora, Coolamon and Junee Shires

The Situation

Junee and Coolamon Shires have difficulties in obtaining and retaining suitably qualified staff over recent reporting periods.
Junee and Coolamon Shires acknowledge their noxious weeds coordination systems must be improved.
Temora Shire has a successful well established contract arrangement in place meeting all requirements.
Meetings were held between Regional Weeds Coordinator and Junee and Coolamon Shire Councils to propose and discuss options to improve Noxious Weed Coordination management.
Further meetings were held with and Temora, Junee and Coolamon Shires.

The Process

Junee and Coolamon agree that a contract operation may be an option
Temora Shire is approached and agrees in principle to a cooperative arrangement providing Temora Shire suffers no loss of service.
Temora Shire approached their contractor, Robert Ferguson and sought a business proposal that would meet the three Shires requirements.
That proposal was provided in December 2005.
Discussions in early 2006 lead to an acceptance of the structure and basic requirements of the contract being approved
A formal budgeted proposal was submitted and approved for contract commencement on 1/04/06.
The budget showed all areas considered but quoted a final figure only.

The Noxious Weeds Management System Established

Two full time weeds inspectors tasked with all inspection/coordination duties across the three Shires.
The contractor and senior officer based in Temora.
The second officer based in Junee.
The contractor, Robert Ferguson as the senior officer assumes all management and administrative duties as well as approx one third of the scheduled inspections.
The weeds officer performs approximately two thirds of the scheduled inspections.
Community contact and education events will be shared according to work in progress at the time.

The Weed Control Coordination Assistance applications for 2006 / 2007 were entirely rewritten to conform with the cooperative approach to noxious weeds management within the three Shires.
The contractor accepts responsibility for the performance of the noxious weeds system

Benefits achieved by a Cooperative Arrangement

For the first time in any of the three Shires, there is a unit whose sole focus is weeds.
The three Shire Council areas have a consistent, common approach to all weeds matters.
Weeds matters are under professional full time management.
One contact point for all weeds matters over the three Shires.
The ability to instigate and manage projects across Shire borders with single point management will allow for greater success with less organisational problems
Tasking is not interrupted or deflected by any duties other than weeds matters.
Skills and training and their associated costs can be focused in one area.
Weeds inspectors can have an area assigned to them and build contacts within that area.
A complete change of system brings an invigorated, fresh approach to weeds matters.
There is an opportunity to change public perception of weeds officers and their role in the community.

Alternatives

Consideration and a short lived attempt at sharing a weeds officer between Coolamon and Junee proved unsuccessful due to workload and time constraints. The decision to move to an external contractor was based around the fact that the knowledge and expertise necessary to make a cooperative weeds management unit successful was not available within the Shire's workforce. In addition the contractor chosen has proven experience and is known throughout the area.

Benefits and Advantages in Forming a Weeds Authority

Becoming a separate entity as distinct from being part of local Councils:

Weeds are regarded as an 'add on' to either Engineering or Environmental Services and as such have a low priority in comparison to those departments core business. Creating a Weeds Authority means we have a focused operation with only one priority. It employs staff and deals with the public for only one purpose, successful weed management. There will be no dilution of service through multi tasking.

Creating a new, separate identity lets us show a significant change in commitment to weeds matters. It can give impetus to promotional activities and allow separation from general Council activities.
Being able to brand our activities under one name and logo gives us better publicity and recognition opportunities in the public arena.

Community support for the raising of public awareness and education will be enhanced if we show we are a new, committed organisation dedicated to assisting the public with weed related matters and not just a Weeds Inspector with a fines book.

Contracting the service under an Authority allows the employment of a professional, self contained workforce whilst the Shires retain ownership of direction, policy and control of public moneys.

Authority status will further meld the three Shires into a cohesive unit by removing internal boundaries and allowing the concentration of more management assets on a single problem or area.

Making the three shires into one LCA allows uniformity of management over a large area. This fits well with the regionalisation of noxious weeds management.

Authority status will allow the manager to supply comprehensive reporting across the three Shire area rather than three individual reports that will duplicate a lot of information without giving the larger picture. Information is always more reliable if collected by one body over a large area.

With a single point of contact for the three Shires, a considerable saving in administration time and costs will be made if there is one reply to all correspondence from an Authority instead of three from individual Shires.
Having a management committee involving all Shires will give each Shire excellent oversight over Noxious weeds related matters within their area whilst allowing weed management professionals to make day to day decisions.

Contacts established by the Weeds Manager over eight years in the industry are immediately shared across the three Shires and strengthened by the "Weeds Authority" professionalism.

Three years on

Out of this restructure, the Temora , Coolamon and Junee Shires have gained a professional, weeds focused management unit, with a clear chain of command and responsibility.
This unit can be and is held accountable for its actions and performance and has given a marked improvement in weed management performance across Coolamon and Junee Shires and assisted in gaining management efficiencies through scale of operations in Temora Shire. The use of a contractor instead of shire staff has no impact on the Authority status as all relevant Local Government and Noxious Weeds legislation and regulation has been investigated and where necessary complied with.
At this time, Temora, Coolamon and Junee Shire Councils remain committed to the Weeds Authority.

Why does it work?

Quite simply, for four reasons:

1. The three councils chose to enter this arrangement.
2. The three councils support the Weeds Authority.
3. The Weeds Authority is someone's business and there fore its success has considerable personal investment to the contractor involved.
4. Weeds people do weeds work, there is no non weeds middle management.

Reference

Noxious Weeds Act 1993 No 11
Amended 2005
Section 68 Delegation by local control authorities.
Section 69 Arrangements by local control authorities.

Contact details

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RIVERINA EASTERN NOXIOUS WEEDS AUTHORITY

BACKGROUND STATISTICS

Consists of three adjoining Local Control Authorities:

Temora, Coolamon and Junee Shires

Total area: 7,327 square kilometers (732,700 hectares)

Population: 16,000

Towns & Villages: 9

LCA controlled roads: 3,557 km

Murrumbidgee River frontage: 22 km

Nurseries, pet shops, aquariums etc: 8

Urban landholdings: 5,012

Village, semi urban landholdings: 694

Small rural landholdings: 805

Large rural landholdings: 2508

SILVERLEAF NIGHTSHADE – SILVERLEAF NIGHTMARE OR JUST A BAD MEMORY?

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Abstract

Control of silverleaf nightshade (SLN), a summer active deep-rooted perennial weed, has challenged land managers for decades. SLN infestations have been estimated to affect over 26 million hectares in NSW, or approximately one third of the state. SLN can reduce pasture production and subsequent winter crop production by as much as 20% and also reduce land values by a similar amount.

Land managers report SLN control as expensive or not effective. Traditional control approaches have centred upon herbicides, with recommended application timing targeting prevention of seed set. Control of seed production can be achieved with several herbicides, however these generally require several applications during summer and can result in land managers spending $30/ha or more in control costs. Importantly, SLN can regenerate from rootstock and the current herbicide practices do not significantly reduce the SLN rootbank from season to season.

To achieve long term control of SLN, it is suggested that both the seedbank and the rootbank need to be managed through implementation of an integrated management package. Pastures and active spring biomass production can significantly reduce SLN density and vigour, which will reduce seed production and also decrease the amount of resources being returned to the rootbank. Alternative timing of herbicide application may assist with targeting rootbank control, therefore decreasing the potential for SLN populations to regenerate the following season from existing roots.

Options for SLN control that can be used as part of an integrated management plan are proposed. It is further suggested that land managers can tailor a management plan to suit their particular situation.

Introduction

Silverleaf nightshade (SLN) arrived in Australia on multiple occasions in the early 1900s as a contaminant of grain and fodder (Stanton *et al.* 2009). It remained as a sleeper weed until the 1960s when it spread rapidly across south-eastern Australia, including much of NSW (Figure 1). It is currently rated as one of the worst weeds in New South Wales, with an infestation of more than 26 million hectares.

SLN is a deep-rooted, summer-growing perennial solanaceae weed that grows in the cropping/pasture zone of southern Australia and is very difficult to control once established. SLN in south-eastern Australia is estimated to cost $1730 per annum in control costs, with a further $7786 in production losses per annum (McLaren *et al.* 2004). Production losses result from reduction in stock carrying capacity by 20-50% and crop production losses estimated at 20%. The presence of SLN is also estimated to decrease land values by 20-25%.

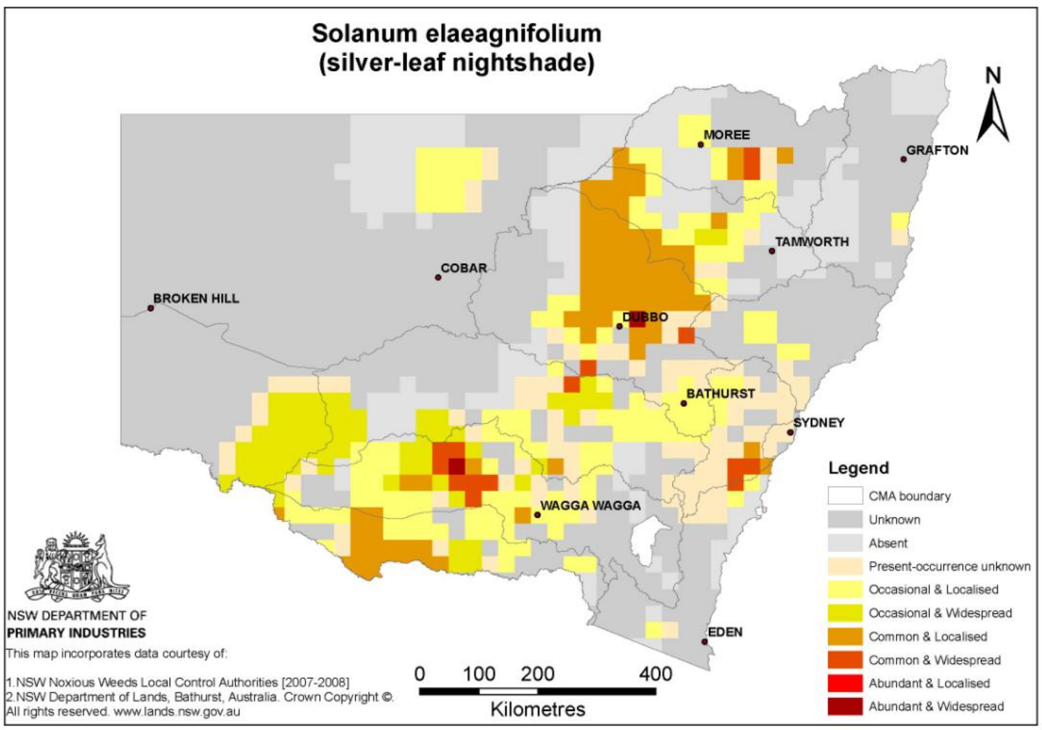


Figure 1. Current distribution of silverleaf nightshade in NSW.
(Courtesy Sean Brindle, NSW DPI**)**

As a perennial plant, SLN is capable of reproducing sexually through seed or asexually through root fragments. SLN can be spread through cultivation, animals and seed production and can establish on most soil types (Kidston *et al.* 2007). SLN competes directly with summer growing crops and pastures, and reduces production of winter crops such as cereals.

Improved management options will reduce control costs and lessen the direct impacts of the weed on agricultural production in the short-term. In the long-term, reducing the spread of SLN will reduce future weed costs.

Herbicides

The NSW DPI Noxious and Environmental Weed Control Handbook, 3rd edition lists several active ingredients as currently registered for control of SLN by spot spraying or boomspraying; namely fluroxypyr, glyphosate and 2,4-D amine + picloram. Current recommendations are for herbicides to be applied at flowering/early berry set.

Our research has shown that a range of Group I herbicides containing one or more of the active ingredients such as aminopyralid, fluroxypyr, picloram or triclopyr, provided 80-90% control of stems during the season. Stem numbers were reduced by 40-70% at the start of the next season compared to untreated controls.

Glyphosate (Group M), applied at 1080 g a.i./ha, was less effective for within-season SLN stem control, with only 10-20% control observed, due either to poor herbicide efficacy or new SLN stems emerging after the herbicide was applied. There was a 30-50% reduction in stem numbers at the start of the next season compared to untreated controls. Glyphosate efficacy may be reduced if the target plants are covered in dust. Research on two related nightshade species in the USA has shown that $1 g/m^2$ of silty clay dust can reduce glyphosate efficacy by over 30% (Zhou et al 2006). This effect was less significant at higher water rates.

The efficacy of a herbicide to control seedset can be greatly influenced by the growth stage of the target weed. When treated at flowering stage, all herbicides evaluated caused nearly all flowers to be aborted (Table 1). Those flowers survived produced 72-96% less seeds when compared to the untreated control. In addition only 5-17% of the produced seeds were viable. Consequently, the treated group I herbicides resulted in < one viable seed produced per berry, while the glyphosate treated < three viable seeds produced per berry. When treated at the green berry stage, although all the herbicides caused significant reduction in seed production and viability, considerable amount of viable seeds was produced, ranging from 12 to 48 per berry. Treatments containing picloram were the most effective in sterilising seeds. These results indicated that current recommendations to spray SLN at the early berry-set growth stage might be too late to completely prevent the seedset.

Herbicide application during flowering/early berry set is important to help stop seed set and reduce input into the soil seedbank, but might not be the best option for controlling SLN roots.

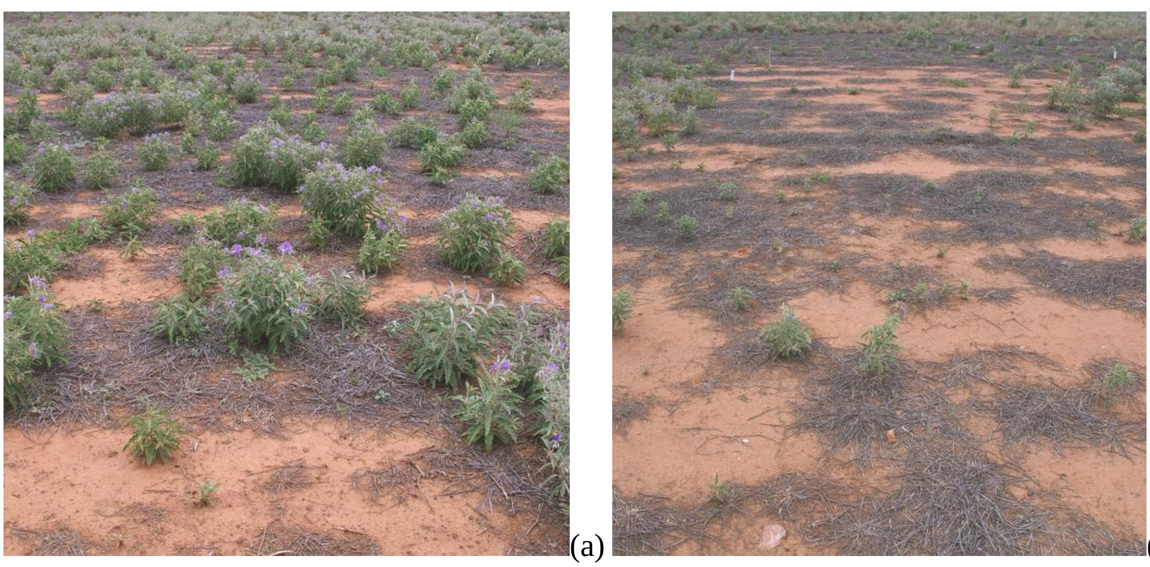
Research conducted at Adelaide University suggests that there is limited translocation to the root system while SLN is producing berries (Greenfield 2003). There is increased translocation to the roots after berries have matured, suggesting that a spray application late in the season will result in more herbicide being transported to the roots, potentially leading to better control of the rootbank.

This approach was included in research trials, with 225g a.i./ha picloram + 900g a.i./ha 2,4-D amine was applied in December 2007 during flowering/early berry set, and a second application of the same treatment was made at the start of April before the SLN started to naturally senesce. Where the late season application was used, SLN emergence and growth was greatly reduced in the following December (Figure 2). This suggests a late season application is a necessary step in providing effective control of SLN roots. Research is being repeated to verify these results, as well as investigate alternative herbicides when applied late in the season. The impact of the late season herbicide application on winter crop and pasture options is also being investigated.

Table 1. Influence of herbicide and application timing on SLN seed production per berry (averaged across two sites).

Flowering	Seeds	Viability (%)	Viable Seeds
control	57.2	77.3	44.3
2,4-D amine	9.3	5.0	0.5
glyphosate	16.3	15.7	2.6
fluroxypyr	2.3	16.7	0.4
picloram + 2,4-D amine	0.0	0.0	0.0
triclopyr + picloram + aminopyralid	0.0	0.0	0.0

Early Berry	Seeds	Viability (%)	Viable Seeds
control	84.2	99.0	83.4
2,4-D amine	55.1	75.6	41.7
glyphosate	63.8	66.0	42.1
fluroxypyr	73.5	65.7	48.3
picloram + 2,4-D amine	64.5	33.7	21.7
triclopyr + picloram + aminopyralid	34.0	36.0	12.2



(a) (b)

Figure 2. SLN emergence in December 2008 following (a) untreated control or (b) 225g a.i./ha picloram + 900g a.i./ha 2,4-D amine applied in December 2007 and April 2008.

Pastures

Competition for resources (e.g.., water, nutrients) can be used as part of an IWM strategy to manage weeds. This competition can be direct through use of summer-active species or indirect by using winter/spring-active species to deplete the resources available towards the end of spring when SLN begins emerging.

Field trials near Wellington, NSW evaluating a range of pastures indicated that SLN density in February was greatly reduced as pasture biomass increases (Figure 3). Katambora Rhodes grass (*Chloris gayana* cv. Katambora), Bambatsi panic (*Panicum coloratum* var. makarikariense), Strickland finger grass (*Digitaria milanjiana*) and digit grass (*D. eriantha*) provided the highest level of competition. Lucerne and phalaris are also reported as species capable of providing competition against SLN (Kidston *et al.* 2007).

The choice of pasture species will be dependent upon location and ability to irrigate if necessary for establishment. Maintaining biomass during early summer is the critical component to using pastures for SLN control.

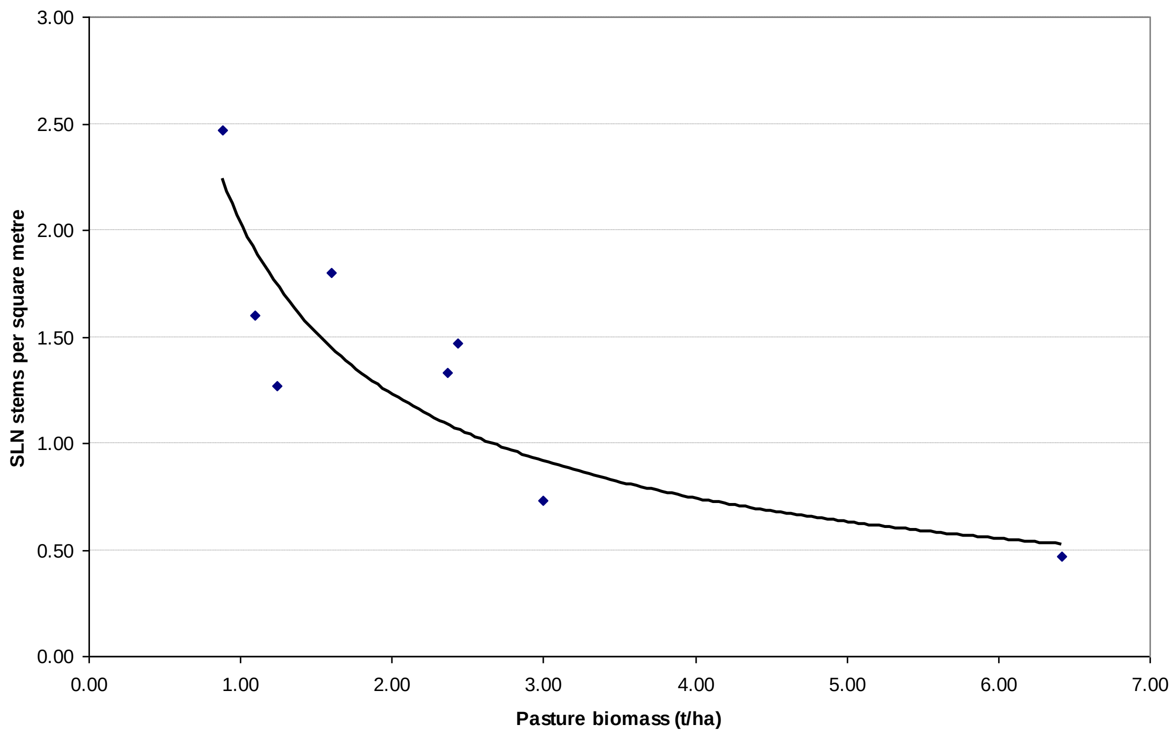


Figure 3. Effect of pasture biomass on SLN stem density in pastures near Wellington, NSW.

Cover crops and mulches

Winter cereals can reduce early SLN emergence (Table 2), although this impact will lessen later in the season. Reducing early emergence helps manage silverleaf nightshade by shortening the time in which it is active. Importantly, it means there will be more uniform emergence and growth of SLN, so that the stage of maturity of the SLN population is more even. This will allow summer herbicide applications to be more targeted and be applied to a higher percentage of the SLN population at the same growth stage.

Table 2. Effect of winter crop residue on SLN stem numbers and berry production.

Treatment	Crop	SLN (stems/m^2)			
	Wt (t/ha)	November	March	wt (g)	Berries
Standing stubble					
Control	0.0	4.2	5.3	4.3	3.7
Annual ryegrass	0.3	1.3	5.0	4.0	2.3
Oats (cv. Saia)	1.3	0.3	7.1	1.8	0.3
Cereal rye	2.1	0.2	3.9	2.2	0.2
Wheat (cv. Diamondbird)	1.5	0.6	6.0	2.0	0.2
mown					
Control	0.0	4.9	6.2	2.9	2.5
Annual ryegrass	0.2	1.0	3.9	2.8	1.1
Oats (cv. Saia)	1.4	0.1	8.2	2.0	0.0
Cereal rye	1.9	0.2	7.9	2.0	0.6
Wheat (cv. Diamondbird)	1.7	0.9	5.1	2.7	0.7

Discussion

SLN is a persistent weed that can not be eradicated with a single operation. An effective control program needs to use multiple approaches to provide control of both the seedbank and the rootbank. Some techniques can reduce the overall vigour of the weed, while other techniques can be used to focus on reducing sexual or asexual reproduction. SLN is a perennial plant, and an effective management program should extend beyond the months in which SLN is visibly present in the field. Table 3 outlines a range of IWM options that can be implemented throughout the entire year. The techniques that are applicable and cost effective will vary with every situation and will also depend on the size and density of the SLN infestation. SLN is a long term problem and a management plan should extend for more than one season.

From current research knowledge, using a combination of techniques throughout the year will help reduce SLN plant vigour and seed production and ultimately lead to reductions in both the seedbank and the rootbank.

Current research has identified several new options that may be used for the control of SLN. Further research needs to be conducted to verify that these new approaches can be included in an integrated management program to successfully and economically control SLN.

Research has also been commenced to determine the longevity of the SLN seedbank, as this knowledge is critical in terms of implementing management programs over a sufficient period of time to exhaust the potential for a SLN population to re-establish. Similar information of the longevity of the rootbank needs to be determined, particularly in response to various control options.

Table 3. Silverleaf nightshade management options.

	Purpose	Options
Spring	Provide competition to emerging SLN stems and seedlings	• Maintain ground cover in areas where SLN occurs using crops, annual pastures, perennial pastures, mulches or cover crop
	Control SLN seedlings	• Spot spraying • Boom spraying • Chipping
	Management planning	• Monitor your land for new patches of SLN
Summer	Prevent viable seed set (seedbank control)	• Spot spraying at flowering/berry set • Boom spraying at flowering/berry set • Slashing • Chipping • Hand weeding
	Prevent seed spread	• Minimise grazing once berries have formed • Do not make hay or silage from pastures once berries have formed
	Provide competition	• Keep summer active crop or pasture biomass standing for as long as possible
Autumn	Control SLN root stock (rootbank control)	• Use residual herbicides as directed • A targeted autumn application of a Group I herbicide may assist with root control. Be aware of plant back periods if you use this technique • Dig out new, isolated plants before they become established
	Management planning	• Monitor your land and note where SLN is/was present for attention next season
	Reduce the soil seedbank	• Minimise cultivation to reduce the number of intact berries being buried • Remove and destroy as many berries as possible
Winter	Reduce SLN root spread	• Minimise cultivation in SLN areas • Clean down implements to minimise movement of root stock
	Competition	• Plan future land use to maximise potential competition to SLN during the next season(s)

Key messages:

- Be alert to new occurrences of SLN as new infestations are easier to control than established ones
- Maintain biomass of crops/pastures during winter/spring and into summer to provide competition to emerging SLN stems and seedlings
- Prevent seed set to reduce the seedbank by use of herbicidal, cultural or mechanical control at flowering/early berry set
- Prevent seed movement to new areas by cleaning equipment and managing livestock exposed to mature berries
- Control rootstock by using herbicides at the end of summer when there is increased translocation towards the roots

ACKNOWLEDGMENTS
This project gratefully acknowledges the input of Meat and Livestock Australia (MLA), the EH Graham Centre, Noxious Weeds Officers, farmers (particularly those who are hosting field sites), researchers, District Agronomists, advisors, consultants and members of the public with an interest in SLN control.

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HUDSON PEAR: A CO-ORDINATED WEED MANAGEMENT PROGRAM IN WESTERN NSW

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INTRODUCTION: THE HUDSON PEAR PROBLEM

Hudson pear (*Cylindropuntia rosea*) is an introduced cactus that has become an invasive weed problem threatening significant areas of Walgett Shire and potentially the greater Darling Riverine Plains Bioregion in western NSW, including the important Narran Lake area. This paper will describe the background to the Hudson pear problem in Walgett Shire, changes in weed management approach and future management directions. It is similar to a poster paper presented at the 15th Conference of the Australian Rangeland Society at Charters Towers in 2008.

Hudson pear is of Mexican origin and was first recorded in Walgett Shire in the late 1960s. The cactus was suppressed by herbicide spraying, however in recent years coinciding with significant drought conditions, Hudson pear rapidly increased in extent. The weed problem has included areas of thicker core infestations and scattered known and new infestations. Affected areas include red ridge country used for grazing and opal mining, which also supports tourism, and more recently, the surrounding floodplain and plains country principally supporting grazing and cropping. Hudson pear infestations can also impact on Aboriginal landscape values.

Hudson pear is a branched cactus that grows to a height of about 1.5 metres and produces cylindrical, rope-like segments growing from a cylindrical trunk (Holtkamp, R., 2006). The cactus has formidable spines encased in a detachable sheath (like a barb at the end), which become embedded upon contact and are difficult to remove. Infestations affect biodiversity and primary production as they can compete with other plants and injure native wildlife, humans, domestic stock and other animals. Hudson pear is thought to be a hybrid of a similar cactus, *Cylindropuntia tunicata*, and another species. It is known to reproduce vegetatively, with segments spread by livestock, wildlife, feral animals, vehicles, human traffic and water.

Control of Hudson pear has traditionally relied on herbicide application. Locally present biological control agents for other cactus species are not effective on Hudson pear and physical removal is difficult and practical for very small infestations only. The spread from red ridge country into surrounding floodplain country is of particular concern as a major flood event could result in a significant increase in the distribution of the pest cactus through the Barwon-Darling River system, including the nearby Narran Lake Nature Reserve Ramsar site. Hudson pear is a Control Class 4 noxious weed under the Noxious Weeds Act, 1993.

HUDSON PEAR MANAGEMENT IN WALGETT SHIRE – AN INTRODUCTION

The history of Hudson pear management in Walgett Shire has been documented in Castlereagh Macquarie County Council (CMCC) meeting minutes. Unfortunately, control efforts were not initiated in time to achieve complete eradication and early efforts were hampered by a lack of public awareness. Mr Stan Joyce, a Castlereagh Macquarie County Council Weeds Officer, was a champion for the recognition of the Hudson pear problem and subsequent control. In the 1970s, Hudson pear was a significant problem in the streets and backyards of Lightning Ridge and in the opal mining areas surrounding town. Spraying by Castlereagh Macquarie County Council from the 1970s and the Prickly Pear Destruction Commission until the 1980s, proved effective in suppressing the spread of Hudson pear. However, in recent years, especially from 2001, coinciding with drought conditions that reduced native pasture competition, the cactus problem was able to increase. While the extent of Hudson pear at Lightning Ridge did not reach 1970s proportions, the cactus became more prevalent in the Permissive Occupancy opal mining areas around Lightning Ridge. Also, infestations were recorded around the Grawin and Glengarry opal mining areas and the village of Cumborah. The infestations of Hudson pear included thicker core infestations and smaller scattered infestations along roadways and spreading out from the edges of core infestations into surrounding floodplain country.

In recent years, the increasing Hudson pear problem in Walgett Shire was faced by various stakeholders, such as the Lightning Ridge Miners Association (LRMA), Glengarry Grawin Sheepyard Miners Association (GGSMA), Walgett Shire Council and Castlereagh Macquarie County Council, NSW Agriculture, Department of Natural Resources (for Western Lands) and local primary producers. This work often had a local focus and at times was independent of other stakeholder groups and individuals. Some of this work was supported by Government funding. As might be expected, the results of control and mapping work varied in terms of available resources and known success. Six years ago, the extent of the entire Hudson pear problem across Walgett Shire was not accurately known and there was a lack of clarity regarding the identification of *Cylindropuntia* species. In late 2003, expert botanist identification of the problem Hudson pear species was *C. tunicata* (Hosking, J.R. *et al.*, 2003). However, subsequent collection of flowering material enabled identification as *C. rosea*, a plant also naturalized in Western Australia and at a number of known locations in South Australia (Hosking, J.R. *et al*., 2007).

With funding and improved data available, Castlereagh Macquarie County Council as Local Weeds Authority for Walgett Shire mapped the extent of Hudson pear core and scattered infestations, and had prepared a five-year Hudson Pear Control Plan for Lightning Ridge and surrounding areas for 2001-2006. Based on this mapping, Walgett Shire reported with more accuracy that for 2005-2006, there were five known medium-high density Hudson pear core infestations totaling around 111 km^2 and scattered infestations over 458 km^2 (Walgett Shire Council, 2006). By late 2005, the extent of core and scattered infestations was better understood and control work was becoming more organized and involved more stakeholders, including the relatively new Western Catchment Management Authority. However, the extent of the infestations in often rough terrain and thick vegetation; and the costly and labour-intensive nature of chemical control added to public perception that the Hudson pear problem was still too big to successfully control, especially around the Grawin opal mining area. Increasing awareness about Hudson pear amongst involved Government agencies led to an inter-agency meeting in Dubbo on 13 October 2005 regarding the control of *C. rosea* in the key Walgett Shire infestation locations. An outcome of this meeting was the action to ask the Lightning Ridge Mining Board to hold a public information meeting to discuss the issue, with relevant agencies such as Shire, Weeds Advisory Committee, Rural Lands Protection Board representatives invited.

THE HUDSON PEAR TASK FORCE: CHANGES TO A MORE CO-ORDINATED APPROACH

At this Lightning Ridge Mining Board meeting in late 2005, the Hudson Pear Task Force was established to co-ordinate existing and future Hudson pear control work. This collaborative group of stakeholders brought together representatives from Lightning Ridge Miners' Association and Glengarry Grawin Sheepyards Miners' Association; Castlereagh Macquarie County Council; NSW Department of Primary Industries (including DPI Weeds and Mineral Resources representatives); NSW Department of Natural Resources (later NSW Department of Lands); Walgett Shire Council; Walgett Rural Lands Protection Board; NSW Farmers Association and the Western Catchment Management Authority. A second group, the Hudson Pear Steering Committee was also established, with executive-level representatives from these stakeholder groups appointed with the charter of co-ordination and sourcing of funding for a future co-ordinated Hudson pear management program.

The Hudson Pear Task Force and Hudson Pear Steering Committee began regular three-monthly meetings early in 2006. The initial meetings were focused on developing a more detailed strategic management plan to co-ordinate control work and to assist with the funding application process; combining stakeholder spatial data to improve mapping the extent of Hudson known pear infestations and control work; and documenting the current involvement of the stakeholder groups to develop a more co-ordinated attack. The Hudson Pear Management Plan, a Weed Management Plan for 2006-2011 was developed and officially adopted by the Hudson Pear Task Force in August 2006. The Management Plan identified the aim and objectives, stakeholders, situation and case for funding, financial considerations, barriers and contingencies, objective actions, monitoring and review process and resources. As a result of more co-ordinated planning, further Weeds Control Authority funding, DPI and WCMA funding has been obtained. This plan was reviewed in early 2009.

Mapping

Spatial data collected by CMCC, LRMA and GGSMA were identified as key resources for updating mapping of Hudson pear infestations and key control areas (eg. determining the extent of infestations and strategic buffer zones to control the spread into surrounding floodplain country and along roadways and watercourses and the focus areas of active stakeholder groups). The intention was to continue to update with new infestation records, for the information of the Hudson Pear Task Force. Also around this time, NSW Department of Natural Resources (DNR) undertook a survey of Western Division Walgett landholders regarding Hudson pear on their properties. Due to the collaborative approach of the Hudson Pear Task Force, the group aimed to combine this data with CMCC inspection and reporting data. Some obstacles were encountered, such as privacy issues; software incompatibility issues, continuous discovery of new infestations and issues with different GPS settings. Despite some difficulties, the Hudson Pear Task Force co-ordinated mapping attempts resulted in some general CMCC data and specific LRMA and GGSMA data being collated by both DNR/ Department of Lands staff and CMCC staff to produce a series of useful map diagrams. The mapping assists with project reporting, strategic planning and improving understanding of the overall success of project work.

Co-ordination

Co-ordination of Hudson pear control work, funding application and project support work has been facilitated by situation updates at meetings by each stakeholder group. Co-ordination has also been facilitated by the mapping effort and the development of the detailed Hudson Pear Weed Management Plan. Improved awareness amongst stakeholder groups has helped to improve efficiency of on-ground control work by different stakeholders treating Hudson pear. There has been an increased awareness amongst stakeholders of available funding opportunities and the project applications prepared are consistent with overall Hudson Pear Task Force priorities such as strategic targeting of buffer zones, strategic regrowth treatment, and integration of public awareness efforts, monitoring programs, and other possible control methods such as physical removal of isolated and small regrowth plants. Co-ordination of stakeholder groups also provides feedback and improves understanding of various stakeholder perspectives regarding Hudson pear management. Pooling of financial resources, on-ground control efforts, specialist skills and knowledge, and principal client audiences are also benefits of the collaborative approach. Effective public awareness materials have included DPI Primefact and Weed Alert, identification posters and cards and the production of television advertising footage. In November 2006, the Hudson Pear Steering Committee merged with the Hudson Pear Task Force for reasons of efficiency. The new, strengthened Hudson Pear Task Force reflected the progress of the co-ordinated control program in management of on-ground works and strategic planning.

OUTLOOK: FUTURE MANAGEMENT DIRECTIONS

Substantial on-ground treatment efforts have produced encouraging results, with greater areas of the core infestations also able to be treated than was considered possible. Despite this success, continued strategic control (spraying, monitoring and mapping) of Hudson pear regrowth is still essential to maintain the program success. Since 2006, the investigation of biological control possibilities has been part of the Hudson Pear Task Force collaborative focus. Led by NSW DPI experts, successful funding applications have enabled work to be undertaken overseas and nursery sites of healthy Hudson pear plants have been fenced off around Lightning Ridge and the Grawin area in hopeful anticipation of the release of a suitable biological control agent. The accurate identification of the pest species was important in the identification of a specific biocontrol agent. As of 2008-2009, GGSMA, LRMA, CMCC and local primary producer on-ground control and suppression work continues, despite good ground cover following summer rains affecting visibility. There is also potential for pasture trials to investigate the use of pastures to compete with and suppress Hudson pear establishment and regrowth. The television awareness program has proved a success, and a collaborative approach with CMCC and Queensland Government agencies has led to the identification of Hudson pear in South-East Queensland and the initiation of a public awareness campaign in Queensland.

In December 2008, the proposed Hudson pear biological control agent was officially accepted as a biocontrol target, so an application to import the agent for testing could proceed. In April 2009, the Hudson Pear Task Force submitted an application through the Federal Government's Caring For Our Country program for further Hudson pear control work to protect Narran Lake Nature Reserve Ramsar site from Hudson pear infestation. There also seems to be increased national awareness about *Cylindropuntia* cactus species as a key weed threat in rangeland areas, such as discussion amongst the Rangeland Alliance group.

Key word description: Description of the background to the Hudson pear problem in Walgett Shire, changes in weed management approach and future management directions.

ACKNOWLEDGEMENTS: The members of the Hudson Pear Task Force and the stakeholder groups that they represent.

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EXPLORING MANAGEMENT OPTIONS TO MAKE MORE PRODUCTIVE USE OF AFRICAN LOVEGRASS (*Eragrostis curvula*)

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CONTEXT

Despite efforts to control its spread, African Lovegrass (ALG) has become a dominant perennial grass component of pasture swards along the Murrumbidgee corridor north of Cooma. In this geographical area ALG has severely compromised both the grazing value and the ecology of both native and improved pastures. Cooma-Monaro Shire Council weed section currently requires that landholder make a concerted effort to control the spread of ALG beyond its existing range however it is recognised that the successful economic removal of the weed across the landscape is unlikely and impossible in non arable parts of the landscape. This is especially true in rain-shadow areas such as Chakola / Bredbo (average annual rainfall < 475mm) where establishing new pastures carries a high probability of failure.

Accepting that ALG will continue as a significant component of pastures in this area it is important that we learn more about how to maximise its utilisation. Anecdotal evidence suggests that ALG can contribute to whole farm grazing resources and has helped a number of farmers better maintain stock numbers through the recent drought. Despite this, without active management, ALG is low quality forage suitable, at best, for maintaining dry stock on a year round basis. In better seasons when animals are able to exercise more selective grazing ALG often remains ungrazed in favour of more palatable species.

The trial on the Bredbo Travelling Stock Reserve tested a range of management treatments for their ability to improve the productivity, nutritive value and palatability of Lovegrass to livestock.

PROJECT DESIGN

Voluntary feed intake is largely related to the apparent digestibility of the diet. Increases in diet digestibility form a linear relationship with intake (SCA 1990). Every percentage point increase in digestibility will result in an extra 20 – 25g intake per day in sheep (Hodgson 1977). Both dry matter digestibility and protein are low in pastures dominated by ALG and severely limit voluntary intake of the grazing animal. Management to remove dead herbage and /or promote fresh new growth is likely to improve these measures of feed quality. Management such as burning and slashing serve to remove the overburden of dead grass while fertilising especially with nitrogen, is likely to improve the quality of the new season growth. Fertilising with Phosphorus and Sulphur (superphosphate) has also been shown to increase the intake and performance of animals fed herbage from senesced pastures (Rees et al 1974, Rees and Minson 1976, 1978 and Ozanne et al 1976). Ozanne et al 1976 also showed that sheep will chose feeds with a high P content in preference to feeds with a low P content (up to 0.4% DM as P).

This project measured small plots to determine whether treatments such as slashing, burning, fertilising and addition of legume seed (and combinations of these treatments) ccould serve to improve feed quality or palatability of ALG.

LOCATION

The trial was conducted on the Bredbo Travelling Stock Reserve on the Monaro NSW, which has a dense population of ALG with a large accumulation of dead grass and is typical of the district. Thanks must go to the Cooma RLPB, Ken Bowerman (lessee of the TSR) and Jim Darrant (formerly Cooma Monaro Shire Council weeds manager) in finding this site for our use.

TREATMENTS

8m x 10m plots of ALG were prepared with a combination of fertiliser and physical treatments as shown in Table 1. There were ten treatments including a Control (or Nil). Legume seed was only added to burned plots and with Mo Super since successful establishment was deemed unlikely where an overburden of dead Lovegrass remained. Three replicates sought to account for random or spatial effects and sampling error and the whole plot area was fenced to exclude uncontrolled grazing for the term of the experiment. The replicates were blocked across the slope to account for possible slope effects and proximity to a contour bank on the up hill side of the trial block. Superphosphate was applied at 125kg/ha. Urea was applied at 45 kg/ha to simulate the amount of Nitrogen fixed by clover growth of 1000 kgDM/ha/yr.

Table 1. Combination of Physical and Fertiliser Treatments

	Fertiliser Treatments		
Physical Treatments	Nil	Mo Super’	Mo Super’ + Urea
Nil	✓ (Control)	✓	✓
Burn	✓	✓	✓
Burn + Legume		✓	
Slash	✓	✓	✓

The length of the trial area runs between a fence line and a contour bank on the lower slope of a north facing hillside. Due to the potential effects of being adjacent to the contour bank the replicates were blocked across the slope and treatments randomly allocated within blocks.

MEASUREMENTS BETWEEN SPRING AND AUTUMN 2008-09

Feed quality of the ALG was tested in November 2008 and March 2009 (Dry Matter %, Dry Matter Digestibility %, Crude Protein %, and Metabolisable Energy) to determine whether the treatments altered the feed quality of the ALG pasture at different stages in the growing season.

Herbage mass was assessed using a modified botanal technique utilising three experienced assessors and calibrating visual assessments against a range of cut quadrants. It was done at the same time as feed quality to enable modelling of likely animal performance and to estimate whether treatments impacted on either the total growth or the periodicity of this growth.

Likely Animal performance was modelled using the GrazFeed ™ animal grazing model developed by CSIRO plant industry (Freer et al 1996). Small plot trials do not allow grazing with animals in order to collect real animal growth data so herbage quality characteristics and herbage mass will be used as inputs to the model and animal intakes and performance predicted.

Palatability of the modified pastures was tested by grazing the entire plot area with a small number of sheep. Narrow lanes separate the plots and these were slashed and sprayed with Glyphosate in order to eliminate these inter-plot areas from possible grazing. Palatability is derived from a complex interaction of physical and chemical characteristics of plants. Normally 80% of grazing choice can be described by herbage availability and quality aspects alone but in certain cases other factors can have overriding impact. Anecdotally ALG is low in palatability so any improvement will be of great significance. The plots were grazed twice, immediately following each herbage assessment. Ten merino wethers were individually numbered and their location recorded at five minute intervals by replicate and treatment and whether they were actively grazing at the time. By collecting a time series of data it is possible to analyse whether the animals show an emerging trend of grazing preference over the grazing day as compared to grazing from a random selection of the treatments.

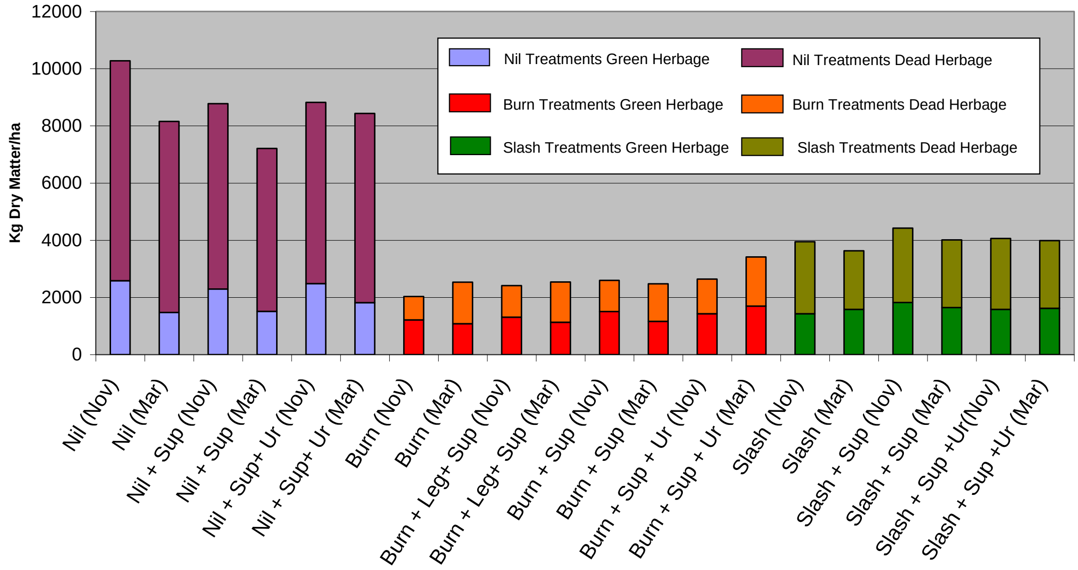
RESULTS

Reporting of results from this trial must be prefaced by the observation that they have almost certainly been affected by the drought conditions experienced for the duration of the trial period.

Herbage Mass

Figure 1. shows total herbage mass measured in November and March was dramatically reduced by burning in comparison with the Nil treatment. Slashed treatments were also substantially lower in total herbage mass. This impact is entirely expected as slashing and burning are done for the sole purpose of reducing or removing the dead standing herbage in order to promote fresh regrowth. Unfortunately during the poor growing season of 2008/09 these treatments also lead to lower green herbage mass than the Nil treatment. Comparing between early and late season the Nil and the burned treatments generally declined in green herbage while the slashed treatments maintained a similar amount of green herbage between the seasons. Nil treatments also generally declined in total herbage mass. Only the Burned treatment fertilised with both super and urea saw an increase in green herbage mass between November and March.

Figure 1. Herbage Comparison Between Seasons



Herbage Quality

Seasonal conditions lead to some perverse results in terms of herbage quality.

Figure 2. shows the digestibility of the green herbage harvested in November. On average Nil treatments had higher green digestibility than the burn treatments with the slashed treatments intermediate. This is the opposite to the response we might have anticipated due to burning and slashing. In this case we believe this is the result of the dry seasonal conditions and it's impact on plant phenology. At the time of sampling in November, lovegrass in the burned plots had already commenced flowering with at least 80% of plants with an open panicle. At the same time the slashed plots were around 40% with panicle open and the new seasons growth in the Nil plots was still largely vegetative. As such the differences in quality can be explained as a result of growth phase of the plant. These differences may be due to the effect of mulch in retaining soil moisture with the burned treatments having much greater bare ground.

Figure 2. Green Dry Matter Digestibility % by Treatment (24/11/08)

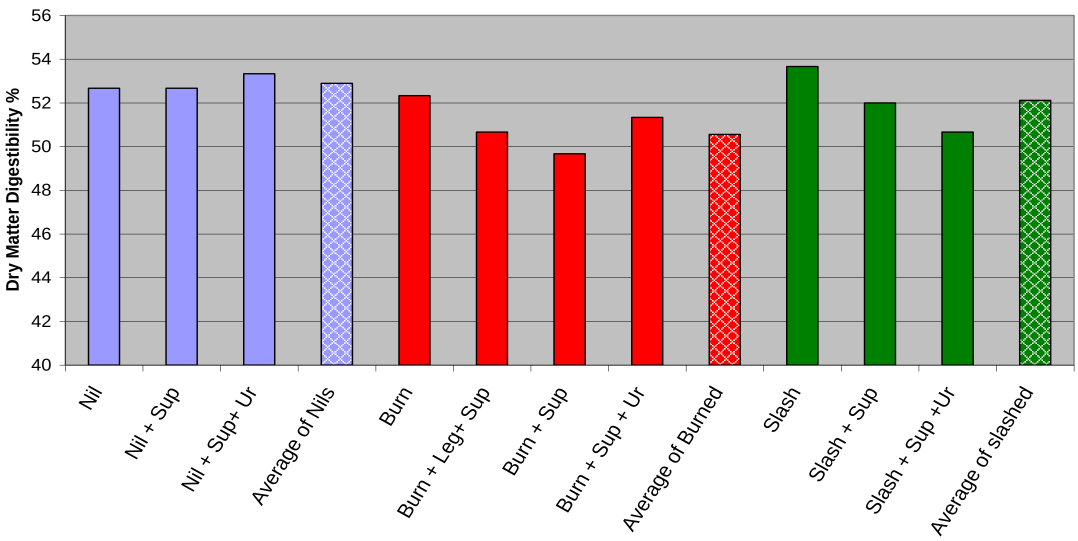
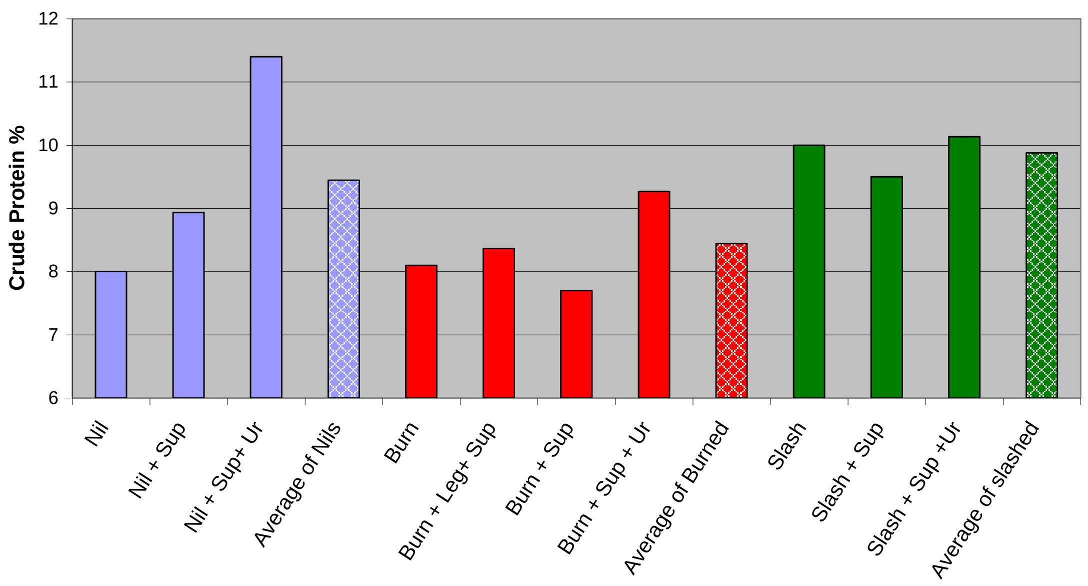


Figure 3. shows the crude protein content of the green Lovegrass and these correspond well with the trends for digestibility Except that there has been a tendency toward higher crude protein in treatments receiving Urea.

Figure 3. Green Crude Protein% by Treatment 24/11/08



Figures 4 and 5 show the digestibility and crude protein for the dead component of the herbage for each treatment. In this case the highest quality dead material was on the burned plots because all carry over material had been removed by fire. This meant that what little dead that was present came from the current seasons growth, perhaps as a result of late spring frosting.

Figure 4. Dead Dry matter Digestibility % (24/11/08)

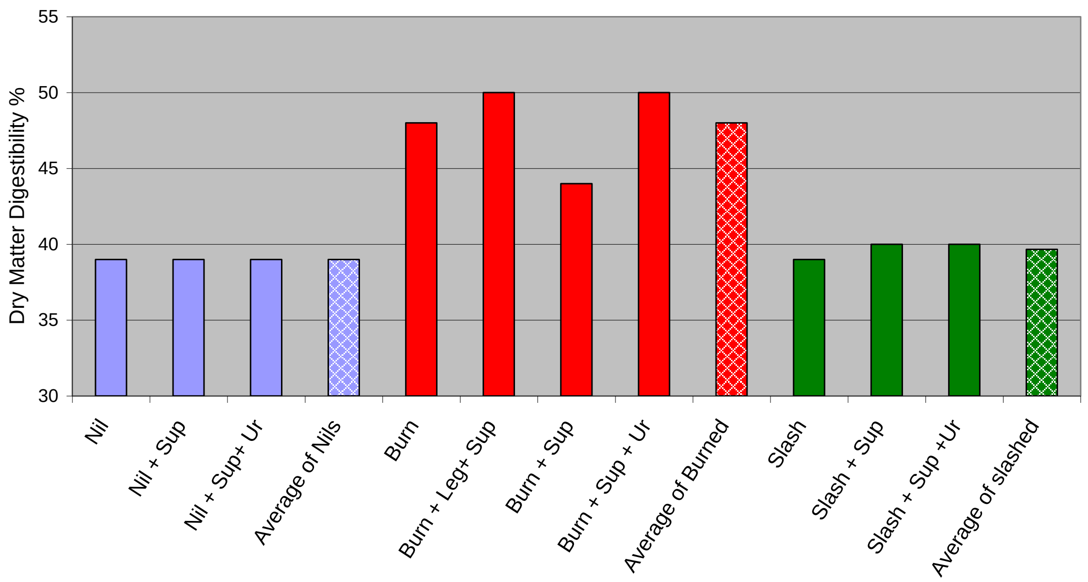


Figure 5. Dead Crude Protein % (24/11/08)

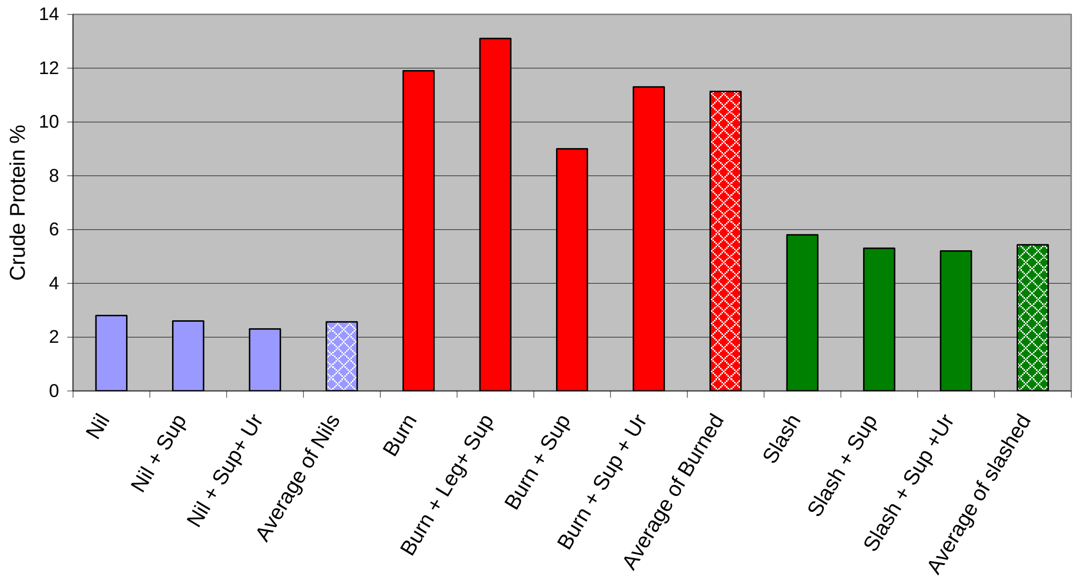
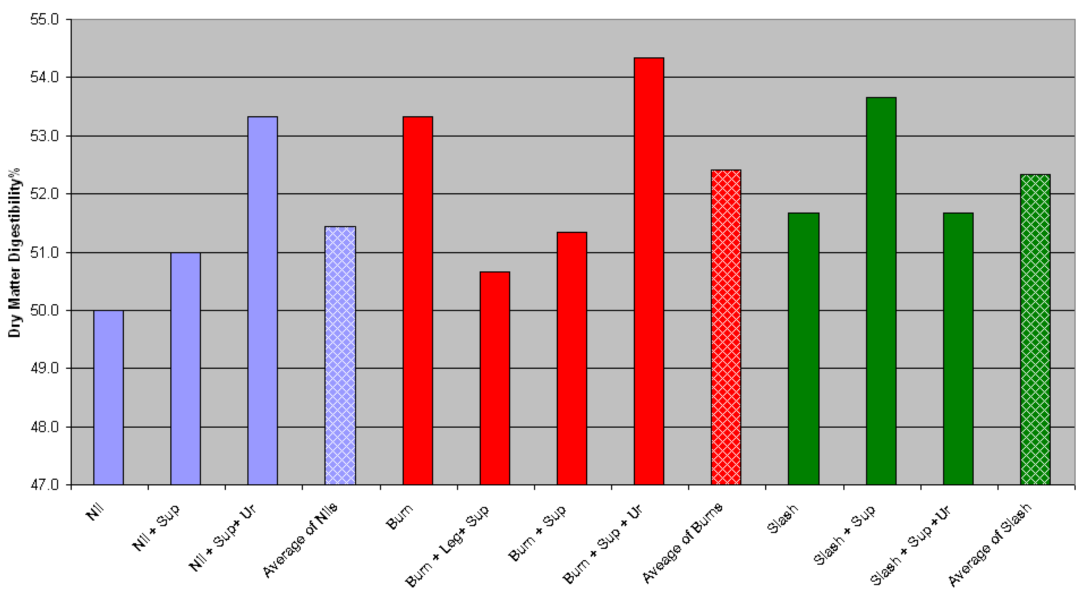


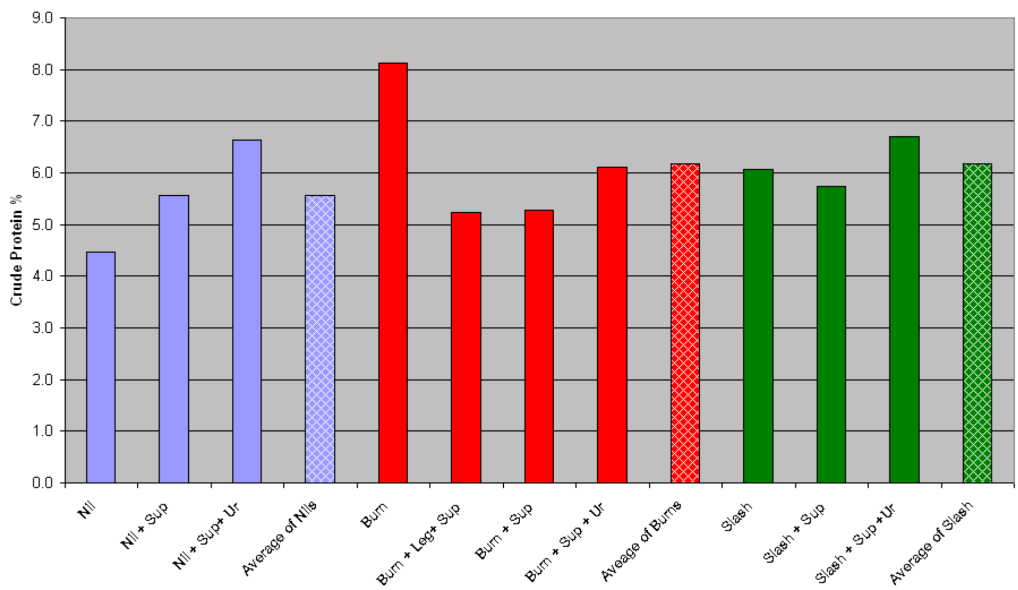
Figure 6 shows the digestibility of the green when it was cut in March. The most promising trend in feed quality at the late season cut was a tendancy toward higher digestibility in *Nil* and *Burned* plots treated with urea although this trend was not maintained in the slashed treatment. It should be noted that the differences are small and unlikely to be statistically significant.

Figure 6. Green Dry matter Digestibility % (18/3/09)



At the same sampling the crude protein of green ALG showed similar trends to digestibility (Figure 7.)

Figure 7. Green Crude Protein % (18/3/09)

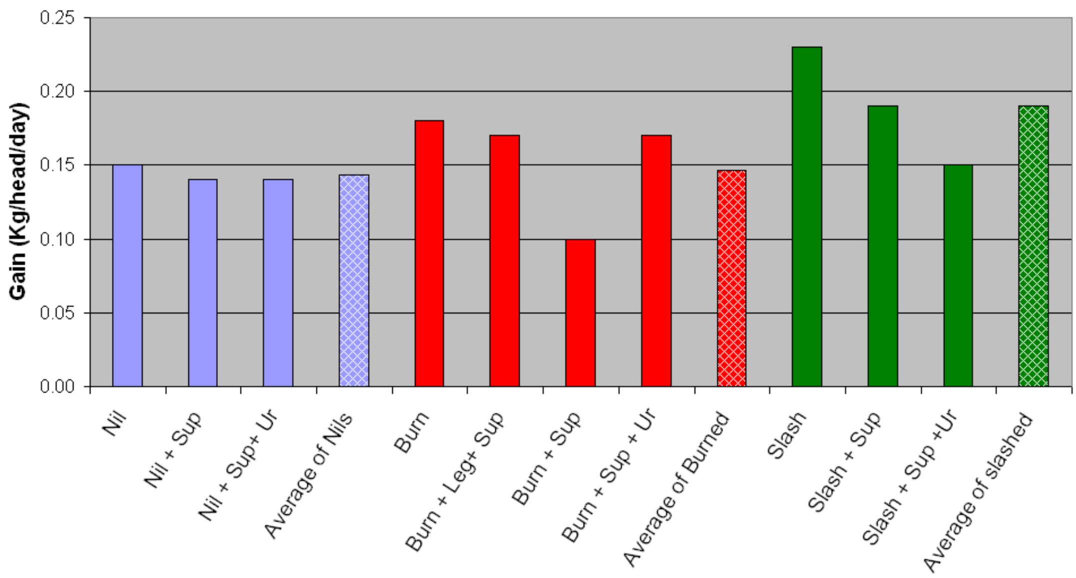


Likely Animal Performance

Digestibility and crude protein of each treatment from the spring assessment was entered into the GrazFeed decision support tool to determine the likely performance of 350kg yearling steers had they been grazing pasture uniformly the same description as the treatment plots. Figure 8. shows the predicted performance by treatment.

Predicted animal performance was generally improved by the application of a burn or slash treatment. The highest predicted performance came from the Slash only treatment and the highest average response also went to the slashed treatments compared to a very similar average result for Nil and Burned treatments. In general the predicted animal performance is in line with digestibility of the green herbage.

Figure 8. Predicted Average Daily Gain (350kg LW Yearling steer)



Palatability

Palatability has been expressed in terms of the observed grazing frequency of a treatment group vs the expected frequency based on the proportion of the trial area utilised by these treatments and assuming uniform grazing. Treatments have been grouped into Nil , Burned, Slashed, + Superphosphate and + Urea.

Figure 9 shows the grazing preference in November 2008. Animals actively selected against the Nil treatment with a grazing frequency 50% below the expected frequency. At the same time they have sought out the slashed treatments preferentially with a grazing frequency 50% higher than the expected value. Fertilised treatments and burned treatments had a grazing frequency slightly higher than the expected value.

Figure 9. Grazing Preference (Nov 08)

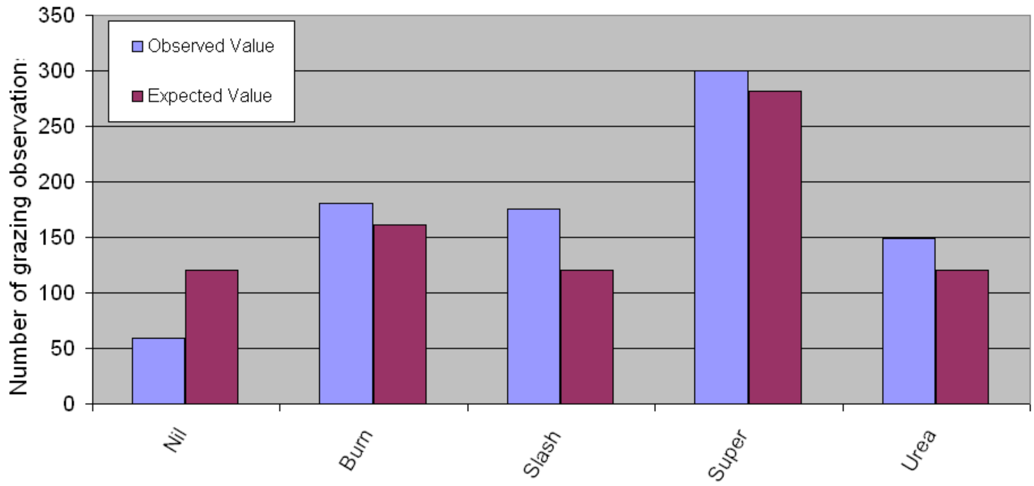
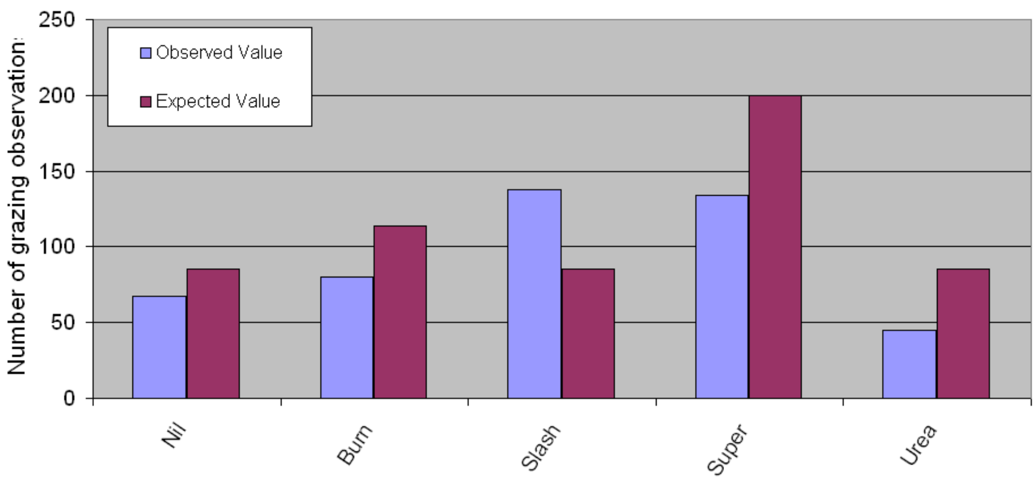


Figure 10 shows the grazing preference in March 2009 and maintained a similar relationship between observed and expected values for the Nil and the Slashed treatments while for the burned and fertilised treatments there was a reversal of the trend and a tendency for the animals to select against these plots. This appeared especially true for the fertilised treatments.

Figure 10. Grazing Preference (March 09)



DISCUSSION

While the results of this trial have clearly been influenced by the seasonal conditions there would appear to be only modest direct animal performance benefits from either the application of burning or slashing. Burning tended to accelerate the life cycle of the plant under these dry conditions leading to perverse results in terms of herbage digestibility and protein levels. Slashing lead to maintenance of better groundcover and potentially a mulching effect which maintained higher soil moisture than the burned treatments. In the dry conditions there was very little response to fertiliser and under these conditions it would be unlikely to be an economic option. Slashing did make the sward more accessible to the animal while maintaining the quality of the green herbage. As a result the animals exhibited a grazing preference toward the slashed treatments which would assist in helping them to utilise the slashed areas better. Slashing or burning followed by more intensive grazing may serve to open the sward to enable the establishment of other species which may serve to make the pasture more productive in the cool seasons. Ongoing monitoring would be needed in order to ascertain whether this will actually occur. An intensive rotational grazing system may also serve to provide a similar physical impact to slashing although the initial setup cost (fencing/water) may prove to be prohibitive.

ACKNOWLEDGMENTS

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SERRATED TUSSOCK: AN ON FARM APPROACH

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Overview

Serrated tussock (*Nassella trichotoma*) was identified in the Armidale area as far back as the 1960s and was possibly introduced into the region during the 1950s drought through hay imported by rail from outside of the region.

Two infestations were found east of Armidale in 1964 with council staff carrying out the control program for a three year period with responsibility then being handed over to the respective landowner and seedlings were treated when found.

The next major serrated tussock infestation in the region was formally identified on the property 'Kia Ora', in the Kellys Plains region on the outskirts of Armidale, in October 1990. Following this 'discovery', property inspections identified more scattered infestations in the area, mainly on smaller holdings. As most infestations were only small, (less than 100 plants) a program was implemented to raise landholder awareness, educate landholders in identification and control, and thereby reduce the spread of serrated tussock in the region.

With difficult seasonal conditions and the withdrawal of 'Frenock'® from the market (with the subsequent limited control options available) serrated tussock had the opportunity to establish itself in the region, and by the year 1999 it was found over a much wider area.

The Property Kia Ora

The property 'Kia Ora' is a 195ha holding situated on the outskirts of Armidale with the main production activities being wool and fat lamb production, as well as a 10ha orchard producing apples for the local markets.

The owner suspects that serrated tussock was introduced to the property in imported meadow hay purchased during the 1960s drought. The pastures then consisted of native species (principally Poa tussock) that enabled serrated tussock to remain undetected, and by November 1990 when it was identified, approximately 80 ha in the southern section of the property were infested.

When discovered, the infestation was actively flowering and a spray program using 'Frenock'® and Paraquat ® was recommended to treat the infestation. Control programs concentrated mainly on herbicide applications but following the withdrawal of 'Frenock'® from the market serrated tussock re-gained its foothold on the property and a new approach was required.

The Program

1. Management Plan.

After many years of unsatisfactory results with his serrated tussock control program, the landowner sat down with the New England Weeds Authority and developed a

mutually acceptable management plan to reduce this infestation to an acceptable level; i.e., requiring no more than the annual spot spraying of isolated serrated tussock plants.
This plan consisted of programmed pasture improvement, herbicide control, improvement of stock watering points, the establishment of 'wind-breaks' and the ongoing management to stop re-infestation of 'cleaned' areas.

2. Pasture Improvement

The continual use of herbicides had severely affected the pasture composition of the affected area with the native species all but non existent and the introduced species under pressure.
In 1995 a pasture improvement program was introduced to increase productivity and reduce serrated tussock levels. This involved a two year cropping phase (oats for grazing) to reduce the seed bank, followed by the establishment of improved pasture.
The first paddock undertaken was so heavily infested with serrated tussock it was boom-sprayed with Glyphosate and then burnt to remove the bio-mass that then enabled the paddock to be cultivated.
In the first year of the program good seasonal conditions enabled a good strike of oats, as well as serrated tussock. Serrated tussock germination levels were so massive that under the oats crop there was a lime green turf-like crop of serrated tussock seedlings.
By 2001 four paddocks had been improved, but then dry seasons returned, severely effecting crop/pasture establishment and putting extra pressure on the pastures that had been successfully established over the past years.
However, the program continued and to date 80% of the affected area has been sown down to improved pasture, with some of this sown area requiring further improvement in the future because of stocking and seasonal pressure. The fact that the property is only small in size, and the sole source of income for the owners, meant that only a certain percentage could be improved each year without seriously depleting 'income'.

3. Herbicides

Before the implementation of the pasture improvement program, the owner had used herbicide control extensively. As a result native pasture species were depleted and an invasion of unwanted weeds/grasses had occurred.
To reduce the continual use of high rates of flupropanate herbicides ('Taskforce®', 'Tussock®', etc.) as a means of control, arable areas that were waiting development were spray-topped with Glyphosate to prevent seeding and/or treated with minimal rates of flupropanate. Paddocks that had been improved were spot-sprayed to minimise seedling re-invasion and to control the tussocks in areas such as fence-lines and non-arable areas. Wick-wipers were trialed and were effective in some situations, but given the density in some areas handguns were a more effective tool.
The 115ha northern section of the property, that has only ever been lightly infested, continues to be spot-sprayed as required to prevent further invasion.
Herbicides are still an important tool in the agenda, but now only form part of the overall control program.

4. Watering Points / Grazing Management

One of the major obstacles to control in the early years of the program was the affected area only had three watering points servicing 12 paddocks. This made it nearly impossible to restrict stock access to some areas where pastures were recovering/developing. Therefore, existing dams were enlarged and new watering points are being created to allow better grazing management. A rotational grazing regime was implemented to maximise groundcover and minimise seedling survival. Also, some paddocks were subdivided to assist pasture management.

5. Windbreaks

Over the years the property had been severely affected by dieback, with very few mature trees remaining. Tree-lines were included in the 'management plan' to both reduce the potential of windborne seed dispersal and provide shelter-belts for livestock.
In 2007 the tree-line program was commenced with funding provided through the Landcare network, and planting carried out with the assistance of a local Greencorp team. A second tree-line was established in 2008 and this time the Weeds Officers called on their 'green thumbs' and assisted the landowner. More plantings are programmed for this year.

New England Weeds Authority's Role

The Authority has supported the landowner by providing annual advice/discussion on the control program taking into consideration the agreed 'management plan', seasonal conditions and the landowner's financial situation. This close interaction has seen the landowner and Weeds Officer work well together to achieve an agreed outcome that has benefits not only for this property but the surrounding district as well. The various trials put down and the direct involvement in the program has provided weeds officers with a practicable on farm control perspective that can be applied to other farms in the region, as well as getting a better understanding of serrated tussocks habits in the northern tablelands region. The Authority's plant has been utilized to spot-spray improved areas at cost.

The Future

Herbicide Resistance

Two paddocks in the infested area have relied heavily on herbicide control due to them being mostly non-arable. In 2006, rain events and prolonged windy conditions delayed the boom spray application of flupropanate. Then, after the treatment was carried out weather conditions became hot and dry. This resulted in extensive pasture damage and by January the serrated tussock was actively seeding. The landowner became concerned and seed was collected and sent away for testing. Results found a severe flupropanate resistance problem (up to 12L/ha, five times the recommended rate of application). One of these paddocks has since been direct-drilled with oats after being sprayed with glyphosate and the other is destined to be sown in the coming season. More resistant plants have been discovered further east that will require a different program to be implemented.

Long Term Control
Given that this is a heavy infestation for the New England region suppression of the infestation will require long term commitment to ensure that serrated tussock does not return to its previous levels.

Property Subdivision
As the landowner is over 70 years of age he has recently decided to subdivide the property into smaller holdings.
Where previously the Authority dealt with one landowner, in the future their may be five, adding another dimension to ensure the effective control program is continued.

The Regional Program

The New England Weeds Authority inspection program aims to have all rural properties inspected over a three year period. Inspectors inspect a division (approx. 1/3 of each shire) each year. This involves contacting the landowner, inspecting the property, discussing any weed issues found and raising awareness of ones that may occur. Priority is given to that division each year and complaints and problem properties are inspected in the other divisions only as required.
In 1999 it emerged that serrated tussock was continuing its expansion and had spread in a 50 km radius of Armidale. Most of the infestations found were concentrated on exposed hilltops where windborne seed had settled.

A different approach was required to prevent further expansion before the start of the next inspection round.

Factors that needed to be addressed included:

- The inspection program needed to focus on serrated tussock during periods that infestations could be easily identified.
- A strategy needed to be developed to ensure best management practices would be applied in the field.
- Landowners needed time and assistance to help them identify and control serrated tussock.
- The Armidale region has a 10 km radius that is principally small holding ranging from 10ha to 100ha. These smaller properties require a different approach to larger landowners.
- An education and awareness package for the overall region needed to be stepped up.
- Very little was known about the habits of serrated tussock in the New England (summer rainfall) region as available research and information packages concentrated mainly on southern infestations with their different climatic pattern.

Inspections – Large Holdings
The inspection program concentrated on inspecting properties during the winter period. By July heavy frosts and grazing pressure resulted in low grass levels and serrated tussock infestations are easier to identify.
Infestations were mapped, then either marked using flagging tape or the landowner was shown the site for future control. Weeds Officers assisted the landowner in some cases with removal of the smaller infestations and they were treated or chipped and bagged as part of the inspection. Advice was given on identification and control, and handouts distributed.
Infested sites were revisited annually if infestations where significant or more often at the request of the landowner.

Inspections – Small Holdings
Again initial inspections concentrated in the winter period when infestations were most visible with a focus on serrated tussock.
A 'door knock' approach was carried out and if somebody was home an inspection was undertaken and access to the property provided the opportunity to look over the boundary fences at the neighbours. Some infestations were discovered from the road or as inspectors drove to the front door.
Sites were then marked with flagging tape; small infestations (less than 20 plants) were dug out and left on doorsteps with a card to contact the Authority to make initial contact.

Inspections in areas that contained concentrated stands of serrated tussock were re-inspected annually to ensure adequate control was being carried out and to further assist landowners with identification at different times of the year. The 'good neighbour' approach was taken, with the Authority assuming an advisory role rather that a regulatory role. This approach enabled landowners to be comfortable in contacting weeds inspectors if they required assistance. As landowners became familiar with serrated tussock they began to identify infestations on neighbouring properties and the level of enquiries to our office again increased because the Authority was seen as an organization that could provide assistance.

On Ground Control

Assistance was also provided to small landowners with larger infestations using the Authority's Quikspray ® units to reduce the size of infestations to a level that they could be managed with hand held spray equipment. A private work minimum charge rate of $55 for 30min was also utilized to assist landowners that wanted further treatments. If work took longer, hourly rates were applied.

This approach has seen a dramatic decrease in serrated tussock levels with the vast majority of landowners now comfortable with contacting the Authority for information and/or assistance.

A regulatory approach has only been taken with landowners that failed to take their weed control obligations seriously and so far only a small number of Weed Control Notices have been issued.

Education and Awareness

Various methods to raise awareness in the area have been utilized.

- Where serrated tussock was found on major roadsides identification sites were set up and continue to be maintained. The grass on these sites is mown so that the tussocks are easily seen and, in season, all seed is removed manually. These sites have proved to be of enormous benefit as landholders can watch the seasonal changes in the tussocks.
- Media releases in the local newspapers were issued on a regular basis.
- The New England region has a very strong Landcare network, and inspectors regularly attended area meetings and field days, to give presentations on weeds in general but with a focus on serrated tussock. This association led to a successful NHT funding application for an Extension Officer (twelve months) and extension opportunities were further expanded. Field days, TV commercials, monthly media releases, school visits and the production of handouts all assisted in raising the profile of serrated tussock in particular, and noxious weeds in general.

- Field days for rural suppliers and other organizations were also undertaken. Weeds field days are still carried out each year with an ongoing association with NSW DPI.

Best Management Practices/Research

A Best Management Practice Guide was developed that covered various degrees of infestation and appropriate control measures for both large and small landowners. The development of the guide attracted interest from the University of New England and a PHD student, Tieneke Trotter (nee Cowan), was engaged to study growth patterns under different management practices. This association is ongoing with research on serrated tussock in the New England region continuing.

Conclusion

The New England Weeds Authority's Weeds Officers have learnt a lot from this highly intensive serrated tussock control program:

- Working so closely with the landholders has been a challenge for everyone involved; from the General Manager to the spray operators.
- Studying the mechanisms of spread and the growth habits of this weed has had positive implications for future incursions of other weeds.
- Working closely with other organisations such as CMA's, Landcare Groups and Greencorp teams.
- Methods of educating landholders on the identification of new weeds coming into the area.
- Methods of advertising new incursions through the use of the various media outlets and strategically placed roadside signs.
- The management of a core infestation area also benefits the surrounding region. The property program combined with increased inspections plus an increased extension program has seen a reduction in Serrated Tussock within the district.

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John Gordon: Senior Weeds Officer (Retired)
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1983-2008

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Abstract

A very heavy infestation of Serrated Tussock was first identified on a property on the outskirts of Armidale in October 1990. Of a total area of 195 hectares, approximately 80 hectares in the southern portion of the property was found to be heavily infested with the weed.
A control program using the herbicide 'Frenock' (Flupropanate) was initiated soon after and management practices were based solely on boom spray and spot spray applications to reduce Serrated Tussock levels.
Following the withdrawal of Frenock from the market, Serrated Tussock re-established itself to previous levels by 1999.

In 2000, as part of the Management Plan to reduce the infestation, a pasture renovation program was undertaken in arable areas. The program involved a cereal crop phase for a two year period, to reduce the seed bank, followed by the establishment of improved pastures to suppress seedling emergence. A change in grazing management was also implemented together with programs to subdivide some existing paddocks, add extra watering points, and plant tree lines to further assist in reducing the spread of Serrated Tussock on the property.

The New England Weeds Authority has been heavily involved with this program and has provided support to the landowner through both management advice and assisting in trials of various control options to reduce the Serrated Tussock infestation. This relationship has enabled the Weeds Officers to acquire a practical 'on farm perspective' for Serrated Tussock control that they can apply to other properties with similar problems.

Due to seasonal conditions, herbicide resistance issues and financial constraints, Serrated Tussock control on this property has been much slower than was expected, however, by December 2008 the management plan for the whole property had been completed and the immediate aim is to keep the infestation at a 'spot spray' level in the years to come, along with a steady reduction in the number of Serrated Tussock plants.

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Biography:

James Browning was appointed by the New England Weeds Authority to the position of Armidale Dumaresq Weeds Officer in 1999. He was given the task of leading the management of Serrated Tussock within the area and has raised the profile of Serrated

Tussock throughout the region through both his inspectorial duties and extension activities.

James holds a Diploma in Conservation and Land Management and is a member of the National Serrated Tussock Management Group.

CINERARIA *Cineraria lyratiformis*

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Cineraria is otherwise known as African marigold or wild parsley. This plant likes protected shady damp areas as well as open, sunny and exposed areas. Normally, Cineraria grows to 60cm, but will extend higher than competing foliage and makes its home on a wide range of soils.

Cineraria is currently thought to be an annual and reproduces by seed. It is a member of the daisy family. Its seed is easily dispersed by wind and water, but most seeds fall close to the parent plant. There is a common misconception held that Cineraria is a fireweed.

The best way to control this plant is to physically remove it prior to seeding, or graze the infestation with sheep. Chemical control options are currently under investigation. There is no registered chemical application current for the control of this Class 4 noxious weed.

Description:

Flowers

The flowers have the appearance of having eight petals which are separate and bright yellow. The flowers are in inverse conical heads, 3 to 5mm in diameter and about 7mm long.

Leaves

The leaves are alternate, glabrous, oblong 5 – 8 cm long, 2 – 3 cm wide, deeply divided into 2 or 3 pairs of obovate or oblong lateral lobes. The flower leaves are stalked with lobes at the base, upper leaves are relatively flat and clasping the stem.

Seeds

The seeds are 2 – 2.5 mm long, black, without hairs, spindle shaped with occasionally slightly hairy marginal wings.

Peak flowering time is usually between November and February

Distribution

Cineraria was first recognised as a problem in the Cox's Creek and Cudgegong area near Rylstone NSW in 1983-84. In 2008 it was found also at the Turon River, which is the border of Bathurst and Mudgee Council districts. Cineraria is found in altitudes between 750 and 2400 metres. It has been found across a broader range of the Mudgee district as far north as Turill and is heading west toward Burrendong Dam. Since its discovering it has become widely spread across the Mudgee district and threatens to invade neighbouring areas.

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NATURAL DISASTERS AND WEED DISPERSAL

Expect the Unexpected

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This paper will outline weeds officers experiences following a natural disaster – a freak wind storm and flash-flood event that struck the Hunter and Central Coast region of NSW on the June long-weekend of 2007. The Lower Hunter and Newcastle were declared a natural disaster area as a result of this event.

Background to the Region

The Hunter and Central Coast region of NSW covers an area of 23,500 km^2 with a population in excess of 720,000. The region has a diverse range of landscapes - coastal dunes, floodplains, alluvial grazing, woodlands, sub-alpine, to dryland grazing.

Significant agricultural activities include vineyards, turf farms, beef cattle and horse studs, whilst mining activities are also carried out on a large scale.

Australia's largest coastal saltwater lake, a Ramsar-declared wetland, and a number of State and National Parks are also located in the Hunter and Central Coast region.

Topographically, the region has a number of deep valleys producing several catchments. The rivers, creeks and tributaries in these valleys, in particular in the Lower Hunter, tend to serve as stormwater conduits for towns and cities. These conduits ultimately produced a funnelling of great volumes of water into low-lying farmlands and urban properties, contributing to the amount of destruction caused by the disastrous rains.

History of Weeds In The Hunter & Central Coast

Once again due to the wide range of landscapes, a variety of weed species – both aquatic and terrestrial - have been found or have established in the region. Aquatic weeds include Water Lettuce, Senegal Tea Plant, Hygrophila, Salvinia and Water Hyacinth. However, Alligator Weed is by far the most problematic aquatic and terrestrial weed in the region with great efforts being expended on containment in areas already affected.

Terrestrial weeds of the region include Chinese Violet, Green Cestrum (a plant extensively sold in the 1950's as a hedging plant in urban areas), Pampas Grass, Giant Parramatta Grass, Tiger Pear and Mother of Millions, with most of these being extensively moved by stormwaters during the event.

Events of the Days

An intense low pressure cell formed off the coast of Newcastle on Thursday 6th June 2007. By Friday the storm commenced, bringing extreme winds of up to 125 km/h and heavy rain causing massive seas with waves of up to 17m, ultimately causing a 40,000 tonne bulk carrier to run aground on Nobbys Beach. Although the storm/low persisted to varying degrees over the next three days, it was the initial 24 hours of high winds and record rainfalls that caused the catastrophe. Fallen trees blocked roads and drains, cars and machinery were washed into stormwater systems intensifying the problems of flash flooding, bridges were damaged or destroyed, homes flooded or washed away, and farmlands inundated with crops and livestock lost. Such was the intensity of the winds and rain that on Saturday the 8th June a natural disaster was declared for the local government areas of Liverpool Plains, Upper Hunter, Gloucester, Dungog, Singleton, Muswellbrook, Maitland, Cessnock, Lake Macquarie, Port Stephens, Newcastle, Gosford and Wyong.

In all, the storms caused 10 deaths due to flooding and destroyed roads and bridges. Many records were broken over the three days including total rainfall of almost 500mm (with falls of more than 340mm in 24 hours). This was deemed a 1-in-100 year flood event which led to more than 16,800 ha being inundated throughout the region. The estimated damage cost of the storms and subsequent flooding has been put at $1.35 billion, with more than 90,000 insurance claims being lodged.

Immediate Aftermath

Obviously the top priority for authorities was to make the region safe. The first works involved repairing and restoring infrastructure (electricity, roads, rail, bridges, drains, levees) and to enable this, enormous amounts of debris had to be moved. Due to this debris being scattered over such a wide area, and the urgency for its removal, it was necessary to bring in large numbers of heavy machinery from outside the region to assist local contractors.

Responsibility for a considerable portion of the emergency and clean-up works fell on local councils, and this meant that staff members were seconded from all divisions and teams to work in the field. Local Weeds Officers had normal duties suspended for four or more weeks in some cases whilst they were involved in sandbagging areas, clearing and chipping fallen trees, and general cleanup activities. Thus, some initial critical inspections of machinery and environmentally sensitive areas were unavoidably delayed.

The Expected

As predicted, a substantial amount of aquatic weed material was spread during the event. Water Hyacinth and Salvinia contaminated previously weed-free areas including agricultural dams, wetlands and recreational ponds. Senegal Tea Plant was scoured out of the creek and moved into a clean drain and tributary. Alligator Weed was not only moved into new creeks and wetlands but also moved onto grazing land, turf farms, and sporting fields.

Difficulties were experienced in both inspecting affected areas and implementing control measures due to restricted access and waterlogged land.

The Unexpected

In a natural disaster of this magnitude there are bound to be many unforeseen outcomes.

Foremost was the sheer extent of spread and the enormous amount of plant material moved. Contributing to this was the fact that 30 years of debris had built up in the river

catchment since the last major flood. This debris assisted fragments of Alligator Weed to establish by providing a favourable growing medium.
A major issue for cross-regional weed spread came from the number and types of machines brought into the area to clear creeks, drains and bushland areas of washed-away cars, trees, and general debris. Due to the number of agencies involved in the emergency, it was virtually impossible to obtain accurate records of where this machinery came from and where it went to after completing works in the region. Sufficient suitable machinery wash-down facilities could not be established across the region because of the damaged infrastructure and waterlogged conditions.

The weed material spread was not confined to aquatics. Indeed, a number of terrestrial weeds had been moved by stormwaters from areas previously inaccessible for treatment, for example, Mother of Millions scoured from rock walls and outcrops.

Other vectors for potential weed spread across the region and beyond were commercial products such as turf, hay, topsoil, etc where weed fragments and seeds are virtually undetectable. Quarries were also identified as sites of possible contamination with several located along the Hunter River.

The sheer size of the area needing to be inspected was unexpected. As time went by more and more areas were being found that had previously been thought not to have been affected by the flood and stormwaters. This put a strain on the inspection resources of most Local Control Authorities.

The outbreak of Equine Influenza and the subsequent quarantining of properties in August 2007 severely restricted property inspections in the majority of LCA's of the region and completely halting them in others. This long-term restriction allowed much of the dispersed weed material to establish wherever flood debris was deposited.

Another unusual source for potential weed dispersal came from storage yards set up by insurance companies to hold vehicles written-off as a result of the storm and floods. Vehicles were trucked to the yards in the condition they were found – full of silt, mud, debris and vegetation. The vehicles were then auctioned off "as-is" on site or sent to other areas for sale. The full extent of the potential of these yards to spread weed material can be difficult to appreciate. However, as an example, one insurance company alone wrote-off 3000 vehicles.

The disposal of demolition waste from buildings, bridges and similar structures was also of concern to Weeds Officers as a large proportion of this waste was not taken to recognised landfills but recycled or used as fill across the region.

Alligator Weed fragments were washed into Lake Macquarie and deposited around the foreshores. Inspections have revealed that the weed is now growing in mangroves and seaweed deposits within the salt water tidal zone. This situation is presenting new challenges for control and management.

The Lessons Learned

It has been stated frequently since this disaster "that it is not a matter of 'if" a catastrophe like this happens again, but 'when'…." therefore, planning is the key to minimising weed dispersal in an event of this nature. Foremost in this planning should be a basic principle of weed management – containment at the head of the catchment. Although this is an obvious measure to take, it cannot be stressed strongly enough that it is essential to prevent the movement of weeds from these areas.

The prioritisation of weed species, and locations for control, is another fundamental of planning that will help to lessen the impact of flood events. The 2007 experience has shown the value of treating isolated and marginal infestations of weeds, however these treatments must not be done at the expense of entirely neglecting core infestations. This event proved to us that more is needed to be done with the treatment core areas as they were the main source of weed material.

During emergency situations resources are channelled into the highest priorities – human life, shelter, and infrastructure. Understandably, the spread of weeds is considered by the general community to be one of the lowest priorities. Therefore, it should be understood that a number of containment activities are beyond a weeds officer's control. The tracking of machinery involved in cleanup will be difficult in the extreme as many authorities and organisations will be responsible for organising emergency equipment, and any records may not be available for months after the event.

It was learned that Weeds Officers must be prepared for "the long haul", as the extent of contamination is still unclear. Indeed, inspections and surveys are revealing new infestations to this day, more than two years after the event. Provision for changes in planning will be needed to adapt to the often constantly changing situation occurring in the field.

In conclusion, from our experience with weed dispersal by natural disaster, there have been both positives and negatives. The majority of the findings and lessons learned appear to be negative. However we believe that by taking these on board, and through sensible and flexible planning, the true positive outcome is that we will be in a better position to cope with the inevitable next event.

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Flood debris - including Alligator Weed


10·9
10·8
10·7
10·6


Salvinia
moved by floodwaters


Floodwater damage


Water Hyacinth embedded in silt

<u>CONTROL OF WATER LETTUCE IN THE DUMARESQ RIVER</u>

Cross Border Partnership and Control

John Conroy
Land Protection Officer
Biosecurity Queensland, Goondiwindi

Well I guess I can start with once a pond a time and finish with we lived happily ever after, but hey I'm talking about water lettuce control, or should I say for all you scientific intelligent people out there (*Pistia stratiotes*) anyway to make a short story longer I will give a brief overview of the water lettuce situation in the Dumaresq river system.

Initial infestation was brought to the attention of both Queensland Department of Primary Industries and Fisheries, and the Inglewood Shire Council field officers, during routine maintenance from Sun Water at their infrastructure at Cunningham's Weir, in late June 2007.

The first and immediate step was to ascertain the extent of the infestation both up stream and down. Containment barriers were put into place before investigation and control was undertaken. The area of concern, in the early stages, amounted to approximately 15km. The starting point was below Texas, at Whyalla feed lot, and no plants were sighted past Glenarbon Weir. Dealing with the situation of a regulated river system with unpredictable local run off, the water lettuce problem had just begun. In the first few days the infestation was found, the temporary containment zones were not able to hold back the volume of water that came through the system. Before we knew it we had infestation that covered 40km of the river system. A work plan was established but like all good work plans, it had to be radically modified to combat the variable flow - high flows, low flow, local flows, and the no flows, of the river system.

Ideally the winter period was not the time to do control, but you're damned if you do and damned if you don't. Work commenced at the site of the initial infestation to take out the mother plants and therefore reduce seeding. This gave us an opportunity to get a handle on who is responsible for what and where. Talks were established with our New South Wales counterparts, to define the classification, and responsibility of control and future management, of the water lettuce along the Dumaresq river system.

Water lettuce is a class one weed under the New South Wales Noxious weeds act 1993, while under the Queensland jurisdiction or should I say the Land Protection (Pest and Stock Route Management) Act 2002, it is a class two weed. Initially this discrepancy itself posed a small problem, different classifications for the same weed in the same area. Liaison between counterparts was vital to ascertain appropriate ownership and responsibility for this problem when dealing with a regulated river system.

A task force was formed in March 2008, made up of representatives from all stakeholders from both sides of the border. This group was formed to help with funding applications, implement control programs and strategies, and to consult with publicity to increase public awareness.

The first joint cross border partnership commenced in April 2008, to contain, control and eliminate the spread of the water lettuce for the 40km. Initial containment netting barriers broke and were unable to withstand the flow volume. Further, boom barriers were then used and remain in place to date. Control in the early stages was undertaken using a variety of equipment; including boats, bikes, spray rigs and the usual foot soldier patrol. During the early stages there were a few hiccups, the result of working in unfamiliar geography in particular access points in, and out of the river.

The river was not the only area that needed to be checked, all the creeks and gullies flowing in, from both sides of the river also needed to be included in this process. The costing for control was based at around $1000 per kilometre, covering labour, chemical (Roundup bi-active), equipment hire and maintenance. Teams of two people were able to cover a distance of approximately 250 meters per hour in the early stages of the project - that put a new spin on "Two Men in a Tinny". The heaviest infestation of water lettuce was within the first 8km and this was from Whyalla feed lot to the Cunningham's Weir. 2630 litres of Roundup bi-active was used to treat this section. The same section in April 2009 campaign only 540 litres was required.

A lot has been learned from the initial control program, resulting in a better understanding of both the river system and the growing period of the water lettuce. The equipment that was used during the project, also changed with the introduction of an amphibious base vehicle, an 8 wheeler Argo, fitted out with all the safety gear and a spray tank. This made life a lot easer; we could now go from a starting destination and continue down river in sections where we could not put a boat previously, due to the low river levels. Dragging boats is not a real profitable pastime; it's frustrating and tests the good will of mateship. The introduction of the Argo helped overcome the constant changes to the river, and the working environment we were in, as well as enhancing the camaraderie with work colleagues.

Access in and out of the river was no longer a major concern and allowed more time on the river. Obstructions in the river – due to the low levels and fallen timber were now the biggest concerns. Speed of travel on the water was not that quick, but it didn't need to be. With the introduction of the Argo the overall daily distances travelled had greatly improved, we were doing nearly 1km per hour average overall speed. You don't have to be Einstein to work out the cost effectiveness and overall savings.

Based on general experience, four control programs have been undertaken per year, with the main emphasis concentrating within the growing period from November to March, and a late winter run to take out any bigger plants. This was done to eliminate the chances of any seeding prior to the growing period. Most of the plants, if any, have been scattered and frost bitten at this time of the year, and are few and far between. I can only speak for the last couple of years, but experience shows that where the plants are sheltered from the frosts, and the elements, they are generally healthy

Cross border partnerships are well in place. Good working rapport with solid foundations among all stakeholders is imperative for the continuation of and the long term management, and control of this project. State of origin time adds a different dimension and a competitive nature to the overall scheme of things - state with state, and mate with mate, or something along those lines. Like a true Queenslander even with water lettuce control, we never give in, and it’s starting to brush off on our cross border blue based colleagues.

A collaborative approach has minimised the extent of this infestation, and has paved the way for the increased production, economical, social and environmental status of the Murray Darling system. The future support at all levels will help to contain, control and manage the water lettuce situation within the Dumaresq river system for the duration of this project and for many years to come.

The efforts of all parties are starting to show great dividends. Control resource management and funding were a few other obstacles that had to be dealt with. A lot has been learned from this project so far. This project like others before and those yet to be instigated, come complete with their own unique issues and experiences and are only as good as the dedicated, passionate people working on them. I couldn’t finish up without making mention of the help that has been received from all parties involved and especially Mr Cobby Hobbs from the Goondiwindi Regional Council, and Mr Les Tanner Inverell Shire Council, you don’t need too many blokes like this to drive a successful project. The help and commitment I have received has made my job a hell of a lot easier, thanks to all.

A DECADE OF ALLIGATOR WEED IN THE RICHMOND RIVER CATCHMENT

Successes, challenges and lessons learnt

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Ross Garsden, Coordinator-Weed Control Services, Far North Coast Weeds

ALLIGATOR WEED

Alligator weed is an aquatic plant that can grow in water and on land. It is a very aggressive, invasive species that can out-compete many native plants, choke waterways and wetlands, invade pasture, turf and crops, block irrigation channels, interfere with natural drainage systems and limit recreational activities. Native to South America, alligator weed was first recorded in Australia in 1946 near the Carrington shipyards in Newcastle, NSW. It is believed that alligator weed was introduced via cargo from ships during the Second World War. Alligator weed spreads very easily; small fragments can propagate and create new infestations. It has been found growing in freshwater creeks, in brackish water under mangroves and in drought stricken areas under saltbush. Alligator weed has demonstrated its capacity to spread rapidly throughout waterways and agricultural lands. It has the potential to affect much of southern and eastern Australia and consequently it has been declared a Weed of National Significance.

Alligator weed control is challenging due to the plant's demonstrated resilience to herbicide treatments. This is due to its capacity to partition off affected parts of the plant and then re-shoot from untreated fragments or unaffected roots. Other factors that make it difficult to control include:

- its capacity to grow on land and in water;
- a tendency to fragment after herbicide application; and
- its ability to regrow from fragments.

There are limitations on the use of herbicide in aquatic situations, and while herbicide treatments may reduce the above ground biomass of the plant they do not readily translocate into the root system. Removal of the entire plant including all root matter is an effective option in some situations, however physical removal is time consuming, expensive and in some situations difficult to achieve due to factors such as access, topography, soil type and surrounding vegetation.

RICHMOND RIVER CATCHMENT

The Richmond River Catchment is situated in the northern rivers region of NSW. The area has a subtropical climate with hot, wet and humid summers and mild, dry winters with high average annual rainfall, in some areas exceeding 2000mm. This frequently results in steady fresh water flushes and regular major flood events. The fertile soils and undulating topography result in steep creek and river banks often covered in thick vegetation and the subtropical environment provides ideal conditions for numerous invasive weed species, in particular camphor (*Cinnamomum camphora*) and privets (*Ligustrum sp.*). The northern rivers have one of the highest rates of regional population growth in Australia, and attract a diverse population including farmers, alternative lifestyles, organic hobby farmers and tree-change professionals.

ALLIGATOR WEED IN THE RICHMOND RIVER CATCHMENT

In December 1998 alligator weed was discovered in Byron Creek – in the head waters of the Wilson River, a major tributary of the Richmond catchment. The initial infestation was found under a bridge on the Pacific Highway, near Bangalow. It has been suggested that this infestation may have been deliberately planted by an individual known for propagating aquatic plants in local creeks and selling them to aquarium enthusiasts. No evidence was ever established to support this theory and the individual has since been closely monitored by Local Council Authorities. A sustained campaign targeting aquariums and other aquatic plant outlets has effectively eliminated the 'backyard trade' in aquatic plants.

1998 - 2008

The initial survey of the area in 1998 revealed that the infestation had spread approximately 30 kilometres downstream in Byron Creek and beyond the confluence with the Wilson River. Thirty sites of infestation were recorded. The survey was completed mostly on foot and was hampered by steep banks, thick vegetation (including many other weed species) and a rocky stream bed.

A rapid response involving a highly committed team resulted in the eradication of over 50% of these initial infestations; however the weed quickly spread to further sites downstream. Ongoing surveillance identified more new patches each year with a major finding in an adjacent wetland, Berrima swamp, near Eltham in 2007. This site is the first situation where an infestation has been found off the main stream and staff were faced with the challenges of controlling alligator weed in a wetland.

In November 2008 a further infestation of alligator weed was discovered in the lower reaches of the Richmond River, in Rocky Mouth Creek near Woodburn 30km upstream from the river mouth at Ballina. This new site is 40km downstream from the nearest known infestation site. Coincidentally, this site was also under a bridge on the Pacific Highway. There is some conjecture as to whether the alligator weed at this site had been washed downstream in a flood event or had been deliberately planted.

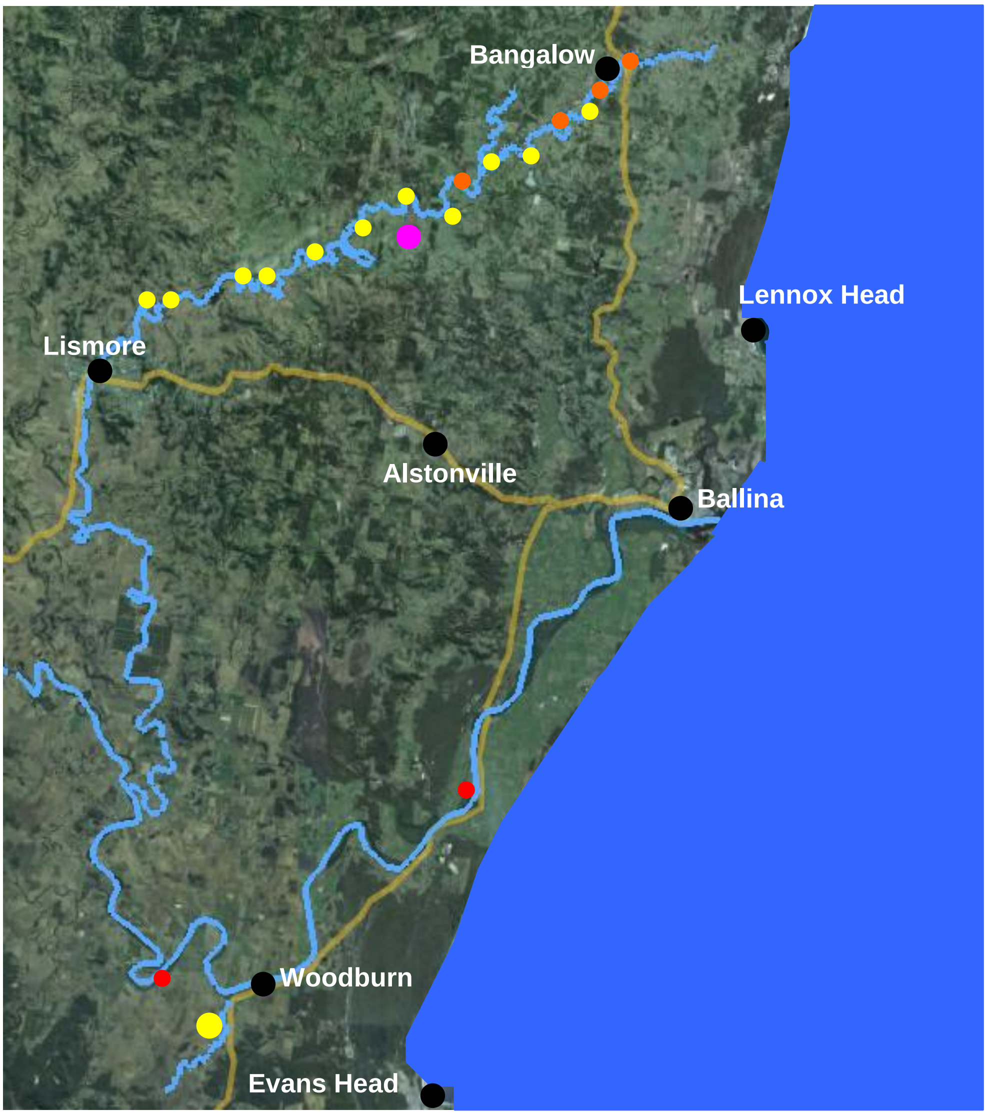
The major sites of infestation at present are Byron Creek and the Wilson River downstream of Bangalow to Boatharbour, the Berrima Swamp near Eltham and Rocky Mouth Creek near Woodburn. Other minor sites are at Byron Bay, Lismore Lake and the Casino Wetlands.

The current control program involves 2-3 surveys and treatments of the infested areas annually. Treatment programs involve the manual removal of floating fragments and mats and herbicide treatment and containment with shade cloth barriers of larger attached plants. In terrestrial situations plants that have had multiple herbicide treatments are then dug up manually to ensure the entire root system is removed. Staff also monitor and survey downstream waterways and wetlands and respond to numerous community inquiries about alligator weed.

The alligator weed control program absorbs the equivalent of 2 full-time members of staff for 6 months of the year, placing a considerable burden on Council's resources. Council has been successful in obtaining additional funds from the NSW Department of Primary Industries through the state priority weeds program.

It has been 10 years since alligator weed was identified in Byron Creek in the upper Richmond River Catchment. This was a significant finding as it was the first alligator weed infestation detected north of the Hunter and Great Lakes areas and the first infestation in the NSW Northern Rivers region. The past decade of alligator weed in the Richmond River Catchment has, despite the numerous challenges faced, celebrated some success. Reviewing and consolidating on the challenges faced and the success gained provides valuable insights into the lessons learnt and determines the direction for alligator weed management in the Richmond River Catchment over the next decade.

Map 1 - Alligator weed in the Richmond River Catchment



Current infestations
Berrima Swamp infestation
Initial infestations now eradicated
Eradicated infestations

CHALLENGES

The considerable and varied challenges encountered over the past decade can be divided into three categories: management challenges, environmental challenges and social challenges.

Management challenges

<u>Identification</u>

Alligator weed can be a difficult plant to identify as it can vary markedly in appearance depending on where it is growing and how it has been treated. Factors that affect the leaf morphology include whether it is growing on land or in water; the nutrient load in the soil or water and whether it has been treated by herbicide. Fragments of alligator weed are often transported with flood debris and can readily establish new infestations hidden amongst this debris. Thick surrounding vegetation, both native and introduced, deposits of flood debris and a dynamic environment result in difficulties in locating and identifying alligator weed.

<u>Underestimating the aggressive nature of the plant</u>

Alligator weed is a very aggressive plant that can survive in a variety of conditions and out-compete other species. Alligator weed has demonstrated its capacity to survive in different (and often hostile) environments; regrow after herbicide treatment or from broken fragments and re-establish after disturbance. Experience has proven that accurate mapping and record-keeping followed by routine monitoring are essential components of an effective containment and control program.

<u>Competing weed priorities</u>

The subtropical northern rivers region of NSW has experienced numerous invasive weed species, many of which are priorities for containment and control. The frequent identification of new weed incursions presents the local control authority with a continual challenge for the prioritisation of works, the allocation of staff time and resources. The high priority given to the survey and treatment of alligator weed is a time consuming program that rapidly absorbs resources from other programs.

<u>Limited weed funding</u>

The allocation of funds for weed control is limited by state and local government contributions. The considerable number of weed species in the region and the limited funding available presents a constant challenge when prioritising works and allocating resources. During the past 10 years the State Government has allocated approximately $300,000 of noxious weed grant funding to Far North Coast Weeds, the local control authority for the control of alligator weed and this amount has been matched by the community of the region through Council contributions.

<u>Management and staff changes</u>

Over the past decade, there have been five different managers overseeing the alligator weed control program. There have also been several changes in on-ground staff directly involved in the program. These changes have resulted in a loss of valuable experience and corporate knowledge. Alligator weed has proven to be a formidable foe and inexperienced officers can be easily surprised by its resilience and capacity to survive a sustained assault.

The local control authority has had to manage the alligator weed program alongside its routine work with other weeds across the County. At times, this has resulted in difficulties in providing the necessary resources to maintain the surveillance and control campaign. Introducing new staff to the team brings fresh ideas and renewed enthusiasm, and this has to be infused with the experience of staff who have been dealing with the weed for many years.

Environmental challenges

Topography

The Richmond River Catchment is typical of many coastal systems, characterised by a network of creeks and narrow tributaries, wide expanses of winding river flood plain, drainage channels, backwaters, permanent and ephemeral swamps, wetlands and channels. In many areas, these waterways are surrounded by thick, impenetrable vegetation, both native and introduced and the banks are often steep and littered with flood debris.

Rainfall and flood events

The high rainfall in the area of over 2000mm per annum results in regular minor flood events and periodic major flood events. There have been three such events in 2008. These events may alter the course of waterways and dislodge and transport vegetation and other flood debris great distances across the floodplain. Alligator weed fragments have been caught in flood debris and moved downstream where they readily establish new infestations. These fragments can be difficult to detect amongst the other flood debris. The changing nature of stream channels and banks presents challenges in re-locating known infestations for monitoring and conducting follow-up treatments. The introduction of GPS technology has largely overcome this difficulty.

Accessibility

Numerous small private properties, fences and gates, steep waterway banks with thick vegetation, steep landscape only accessible by foot have impeded the completion of survey and treatment of alligator weed infestations.

Social challenges

The popularity of the Richmond River region as a lifestyle destination has resulted in a varied and diverse demographic. The region attracts a diversity of people and industry. There are dairy, beef, sugar cane, macadamia and tropical fruit farms, small organic hobby farms, and alternative lifestyle communities. The landholders are diverse including conservationists, tree-change professionals and conservative farmers. These individuals hold a variety of attitudes; awareness and interest about weed-related issues ranging from disinterest and apathy to out-spoken anti-herbicide advocates. Many of the properties along the watercourse in the upper reaches are small to medium sized hobby farms with an average size of approximately 15 hectares and where the owners often work off-farm. Further downstream, the landscape is characterised by larger properties involved in cropping, grazing and cane growing where the landowners are actively involved in land management. The floodplain is dissected by a network of drainage canals to drain the sugar cane lands. Tidal flows in these areas are moderated by a system of flood gates. While alligator weed has not been found in the cane farms as yet, this part of the landscape is recognised as highly vulnerable to infestation.

SUCCESSES

The successes of alligator weed management within the Richmond River Catchment provide valuable insights into the context of such challenges.

Accumulated experience and knowledge

Despite the changes in management and staff over the past decade, the local control authority team has accumulated a considerable amount of knowledge, skills and experience. A number of techniques for surveillance, containment, treatment and removal have been trialled and developed by the team and in some cases the experiences of the team have pioneered best-practice techniques as part of the national response.

Pioneering of control techniques

A number of physical removal techniques were developed by weed control officers to the point where they provided the benchmark for national best practice. Deep manual digging of terrestrial infestations, manual removal of aquatic infestations and disposal of removed alligator weed plant material are techniques pioneered in this region. This valuable information is presented as Part 4 of the Alligator Weed Control Manual (2007).

Eradication of small infestations

Several small infestations have been removed and successfully eradicated using an integrated approach based on herbicide treatments and manual removal. These infestations mainly occur in the upper reaches near Bangalow where continued monitoring and repeat treatments have been carried out over many years.

Containment and suppression of broad scale large infestations

Containment fences have been installed in strategic locations to restrict fragment movement and prevent spread of alligator weed. Mapping the extent of the infestation, preventing disturbance to the infested area and regular monitoring activities have been conducted. The largest infestation in the catchment has been subjected to an annual treatment program using herbicide with the aim of ongoing suppression. This important information is presented as Part 2 of the Alligator Weed Control Manual (2007).

Recent early detection and eradication of down stream infestation

A weeds display at the Lismore Show in late 2008 led to the positive identification of alligator weed by a landholder from Woodburn, 30km downstream from Lismore. Rapid response involved containment measures including booms and fencing and herbicide treatment and the completion of a survey of both banks of the Richmond River downstream to the river mouth, approximately 30 km from this infestation. This survey resulted in the early detection of a small infestation at growing adjacent to the bank at Broadwater. Rapid response measures included the surrounding of the alligator weed with shade cloth, which was stitched closed and the alligator weed was dragged by boat to the bank and lifted onto vehicles, moved off site and dried out before disposal. If detected early when infestations are small, rapid response with site specific treatment offers the best chance of successful control and improves the likelihood for eradication at that site.

Containment across the catchment

Despite the challenges faced over the past 10 years, the actions taken have resulted in success in terms of the containment and limitation of spread of alligator weed across the catchment. Alligator weed has been contained to the waterways; there has been minimal impact on recreation and agriculture and no established infestations on the floodplain.

Waterway and land based survey techniques have been extensively trialled and developed enabling the employment of effective, site specific techniques.

There have been no alligator weed incursions in the catchments to the north, the Brunswick and the Tweed or to the South in the Clarence. This is mainly be due to the ongoing eradication and containment program underway in the Richmond Catchment, reducing the biomass of the infestation and thereby the risk of spread to nearby catchments.

Raising the profile

The establishment of the Richmond River Alligator Weed Taskforce in 2004 provides a focussed, multi-agency team to assist with the planning and direction of alligator weed management. The taskforce meets three times a year to oversee weed management programs, monitor progress and set and review targets and strategies for alligator weed management. The group is made up of representatives from NSW government agencies (DECC, DPI, Dept of Lands), local government, Northern Rivers CMA, Industry associations (Sugar industry and NSW Farmers Association), and Landcare organisations (Richmond Landcare and Wetland Care Australia).

Far North Coast Weeds and NSW DPI have run a number of field days, displays, radio interviews and newspaper articles over the years to help raise the public awareness of the problem.

THE LESSONS LEARNT

Collaboration, team work and fostering innovation

The importance of team collaboration, experience and knowledge sharing, skill development, colleague support and mentoring cannot be overstated. A cohesive, supportive work environment enables knowledge and experience to be shared and developed resulting in a more effective, team of skilled workers capable of undertaking a range of tasks in a variety of situations. This approach to collaborative engagement has proven a useful technique in fostering innovation and developing new, more effective surveillance and containment techniques. Great advances have been achieved where staff have been able to contribute ideas for improving the effectiveness of control methods. This approach is necessary when managing such a recalcitrant weed.

Importance of planning and monitoring

Prioritising sites, completing surveys, monitoring and recording treatments and utilising mapping software are important elements in alligator weed management. Recent advances have focused on rapid identification and containment of the sites that present the greatest immediate risk of spread. Water-based sites in the upper reaches of the catchment were identified as being the highest risk. A survey technique using two canoes, equipped with GPS units weer able to cover over 30km of river in several days, getting an accurate picture of the sites on the water’s edge. This was followed by a strategic containment exercise that effectively neutralised each site in term of eliminating the immediate threat of downstream spread. The advent of three subsequent floods will have tested the effectiveness of this approach.

Management techniques

Staff perseverance and trialling of techniques has resulted in considerable experience of best practice management for alligator weed. The importance of site-specific treatment and flexibility in control, willingness to trial methods, herbicide applications, hand removal, monitoring, and re-application cannot be overstated.

Maintaining priority

Future funding applications have focussed on the need to establish an aquatic weeds strike force which will have alligator weed as their main priority. If secured, this funding will enable the maintenance of alligator weed control as a high priority and enable staff to maintain knowledge, skills and experience in alligator weed management and ensure that early detection and rapid response measures can be utilised and improved.

Importance of community extension and engagement

The future for alligator weed management within the Richmond River Catchment requires community extension and engagement. The high number of stakeholders within the catchment and the extensive area for potential alligator weed infestation demands an awareness and extension campaign to utilise the community for early detection purposes.

Future direction

Eradication remains a realistic and achievable objective for Alligator weed within the Richmond River Catchment. This will involve an effective surveillance program, combined with the eradication and containment management options as shown in the weed management table.(see Figure 1 Weed Management programs in NSW after DSE 2007) (DPI, DECC 2007).

For the majority of sites within the Richmond River Catchment, eradication is an achievable goal within the next decade. In other areas, such as the Berrima Swamp, containment will be the initial objective. On-going suppression activities will be necessary to reduce the size of the infestation. however, while eradication is still considered possible , it is recognised that it is likely to take longer.

The longer term aim is to continue the current program of eradicating new, small infestations and the suppression and containment of the larger areas. It is hoped that with the combination of extra funding, support through the Alligator Weed Taskforce and community extension and engagement that the alligator weed infestation in the Richmond River Catchment will be at least contained and significantly reduced over the next 10 years.

CONCLUSION

The tenacity of alligator weed demands that it cannot be underestimated or ignored. This plant's ability to grow on land and in water, to quickly form new infestations and grow from fragments, to withstand herbicide treatment, and to establish infestations in brackish water insist that control and eradication of this plant remains a priority.

Early detection and rapid response are the key weapons in the fight against alligator weed. If detected early when infestations are small, rapid response with site specific treatment offers the best chance of control success and opportunity for eradication.

Utilisation of new technologies such as hand-held Global Positioning System (GPS) units and Personal Digital Assistants (PDAs) equipped with mapping software will improve efficiency of surveillance efforts. Encouragement of innovation and new ideas will lead to further improvements in knowledge and practice.

FNCW has submitted applications for Federal Government grants through the Caring for Our Country funding rounds. If secured this funding will enable the establishment of a dedicated team for whom the main priority will be the management and control of alligator weed with a focus on community engagement and extension.

NSW – *no space 4 weeds* NSW – *no space 4 weeds* NSW – *no space 4 weeds*

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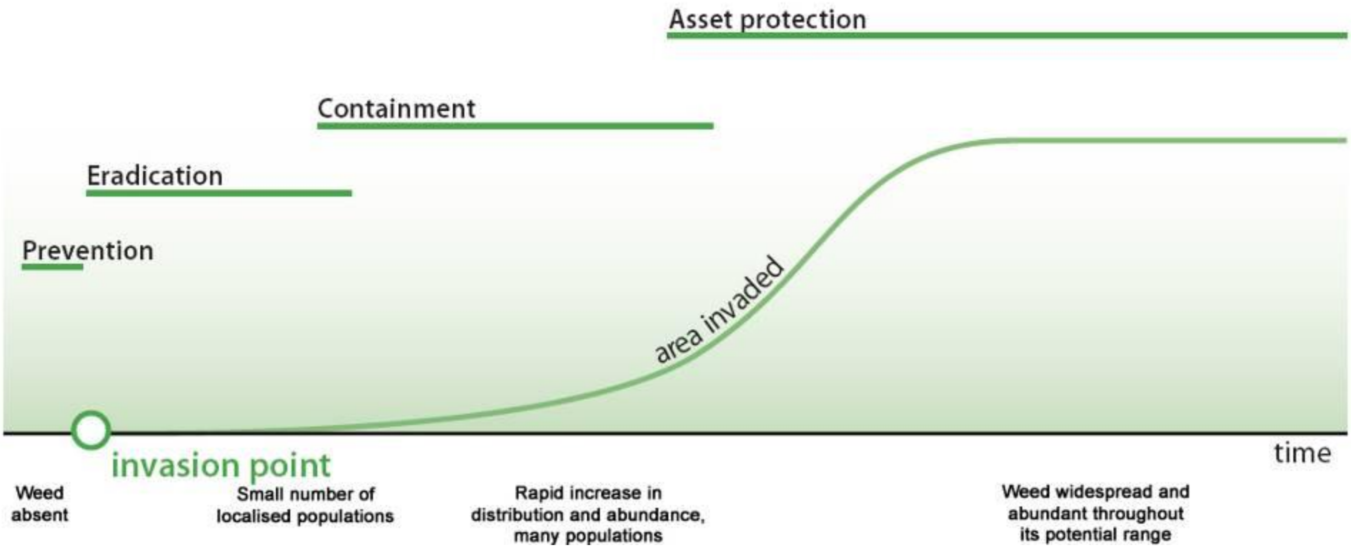
Figure 1 Weed Management programs in NSW (after DSE 2007).



DEVELOPMENT OF SUB-CATCHMENT MODEL FOR NOXIOUS WEEDS INSPECTIONS IN THE BLUE MOUNTAINS, NSW

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Abstract

The traditional approach to noxious weeds inspections in urban environments was highly reactive and often resulted with weed inspectors being dragged randomly across the landscape. Blue Mountains City Council has developed a model in which inspections are programmed in relation to drainage systems, weed dispersal patterns, protection of high value conservation sites and landscapes and previous public investment works. This has resulted in a system which has increased inspection rates and administrative efficiency. The public land maintenance cost has also reduced.

Background

The Blue Mountains City Council (BMCC) is a city within a World Heritage National Park. Settlement occurs predominately along a 45km ridgeline that runs the length of the city, and it also sits above 46 sub-catchments that all flow into the Blue Mountains National Park. This creates a peri-urban interface that covers a distance of 682km. The capacity to provide broad landscape level weed management has been traditionally limited due to lack of resources, and the lack of consistent integration of programs between public and private land owners. Council's role as a Local Control Authority has been predominately complaint driven. This resulted in a scatter gun approach to inspections, creating a high level of animosity towards Council from the public, and an antagonism to the concept of weed control.

The administration of this process was a large time commitment from inspectors and the overall level of compliance was still very low.

The early 1990's saw the establishment of programs in which the Blue Mountains City Council and other agencies such as DECC (formally National Parks and Wildlife Service, NPWS) began working alongside the community to tackle large scale weed issues. The emergence of community "Bushcare" and professional Bush Regeneration programs saw large scale works occurring in public reserves. These works were coordinated across public land tenure boundaries, and their success indicated its ongoing viability to fully achieve weed control aims in the areas it was applied. However, at this stage private land weed control was still the weak link in the system in achieving broad landscape wide weed control.

The private land holder in the Blue Mountains, as a result of a fairly unique zoning classification, is responsible for the management of portions of their lands that are zoned ENVIRONMENTAL PROTECTION (EP). These lands contain numerous conservation assets with some of the most significant vegetation types; in particular a number of Ecologically Endangered Communities (EEC's) such as Hanging Swamps are located on private lands. Additionally these lands were also regularly infested with Noxious Weeds such as Blackberry and Willow. Council, began a program to assist landowners wishing to voluntarily improve their standard of weed control on their own lands, and encouraged neighbouring properties to combine into official Landcare Groups. This program was set up outside of a regulatory framework to encourage positive community and Council relationships. To date the program has been successful in that 17 Landcare Groups are currently working on private lands, in addition to 50 Bushcare Groups on public land. The sub-catchment inspection model is to take weed control even more broadly into the urban context which surrounds these conservation assets.

Developing the Sub-Catchment Model

It was clear a different approach was needed towards our Noxious Weeds inspection system. The principal aims were to tie the process into a broader landscape level weed control strategy. Additionally it was felt Council could improve efficiencies, reduce the reactivity of the program and create a more positive relationship between residents and the community. After witnessing the success of Bushcare and Landcare activities in the Blue Mountains it was felt a system that both supports these works on-the-ground and also models their pattern of education and engagement could be utilised.

To select parameters for a “sub-catchment” Council staff firstly identified areas most in need of protection from the on-going seed source influx off private lands. A rating system was developed that gave value to factors such as the presence of listed EEC’s or Threatened Species; the presence and history of community investment via Bushcare Groups, and history of conservation funding from Council, State or Federal sources.

Each weed species listed as noxious was reviewed for it’s abundance near the areas of protection. The dispersal mechanism was considered, and the biophysical area of private land was selected to capture the best fit infestation range. This area was then further divided into “Inspection Sectors” based on available staff and resources. Figure 1 illustrates a sub-catchment area in South Lawson with inspections zoned into four inspection season periods.

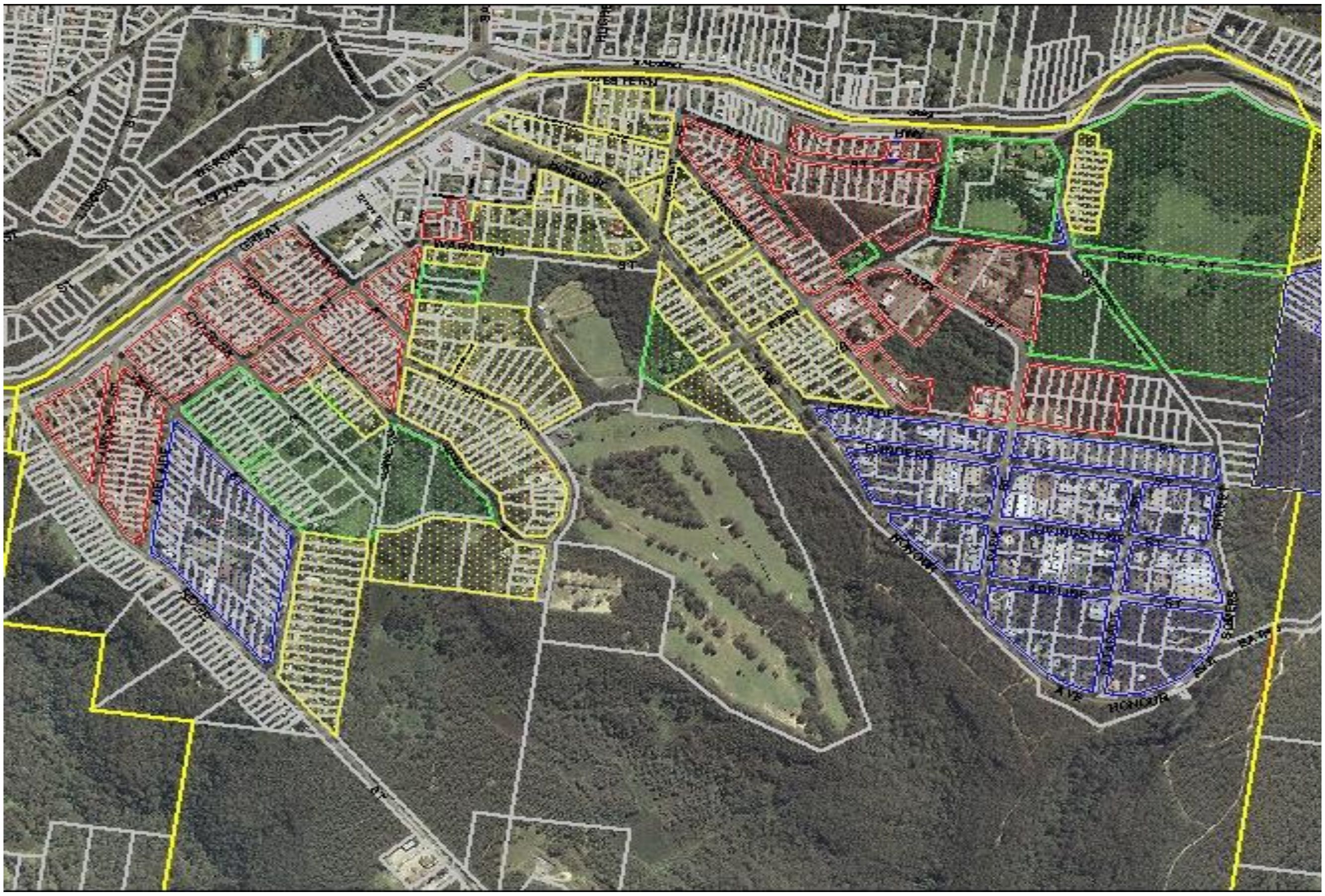


Figure 1: Inspection mapping over a 4 year period. Yellow = Year 1, Green = Year 2, Blue = Year 3, Red= Year 4

Refining the Enforcement Process

The aims of refining the Noxious Weeds enforcement process was to create a system that initially utilised an extension style approach focussing on educational material and technical support, but gradually backed itself more strongly against the legislation the longer non-compliance continued. If done successfully it should result in many people removing weeds being totally unaware of their applicable regulation. The key to developing a successful sub-catchment model is the ability for the Local Control Authority to undertake high levels of inspection as fast and efficiently as possible. The process must therefore be very consistent and easily repeated, but most importantly it must also follow the legislated guidelines (Noxious Weeds Act 1993). The organisation must also ask itself of its ability to follow the process all the way to the end, as sooner or later that end point will be tested. The various compliance processes of BMCC are shown in Attachment 1.

Blue Mountains City Council makes extensive use of Section 26 of the Act, which charges administration costs without actually being an official "personal infringement notice" or fine. This allows the option of fee reversal, and becomes a very useful bargaining tool to steer people in the direction of weed control and keeps resident's financial resources targeted at removing weeds.

Pulling it all Together

To ensure the proper function of weed management it is important to have good communication between operational staff across organisations. To this end Regional and Local Weeds Committee perform a very crucial role. Regional Weeds Committees strength is in the establishment of broad strategy, regional monitoring and reporting roles. Local committees can streamline operational logistics as projects roll out on the ground and integration across various land management agencies. This reporting, review, update and adaptation process is crucial to maximise resource effectiveness.

Positive Outcomes

The strongest positive outcome is that the noxious weeds inspection process is utilised as part of a coordinated complete landscape level weed management approach. The resources of inspections support the resources of the community, Local, State and Federal governments. This reduces the impact of weeds on public land and lowers the maintenance cost, reducing the burden on the tax payer. The selling of the overall weed control message becomes so much easier to facilitate, as an inspector can explain the decision to inspect a person's property against a whole background of big picture strategy. People feel less victimised and more willing to help the greater cause. This further helps to reduce adversarial attitudes against Council, and in Blue Mountains we saw this evidenced by a positive increase in compliance with all our notices.

There were also positive effects for Noxious Weed Officers, who broadened their role to "Catchment Managers" rather than isolated regulatory officers. This increased the morale of the team who became engaged in the overall challenge of conservation. Our administrative procedures were refined as we began to learn how to do more and more inspections. Currently the team of 5 inspectors and 1 administration officer complete around 2000 inspections per year, and issue well over 3000 notices. This would not be possible with traditional models, as an inspector normally has to drive between inspections. As our staff that are usually working in the urban context and inspecting entire streets can complete up to 30 inspections per day by walking from house to house.

Challenges

Involvement of other Public Authorities

Other public authorities often hold large areas of land within catchment areas, and can have varied levels of weed management occurring. Local control Authorities' have no power to issue Notices, so how do we gain their involvement? In the Blue Mountains we have developed effective weed control relationships with other major land owners such as DECC (formally National Parks and Wildlife Service), Railcorp and Sydney Water. A key feature is to find a person within the organisation that can work with the control authority on an operational level. An understanding needs to be developed about the best role for local Council to play. It may mean filling technical knowledge gaps, such as completing weed management plans, or providing correspondence to appropriate managers. Other cases may just involve a phone or email contact to indicate any issues as they arise. It's important to be flexible and useful to assist the public authority as much as possible. In time the Authority will hopefully come to understand its land management responsibility and develop a momentum within the organisation that is self sustaining towards weed control.

Ability to say "no"

It's very important to be able to keep the Local control Authority from being dragged into issues outside the central scope of the strategy. You must be able to offer a resident who is attempting to drive Council in different direction a rationale as to why a parcel of land may not be inspected, or have weed control undertaken. So a clear decision making process that prioritises non-strategic requests is important. Their must still be the flexibility to undertake some works outside of the main project scope, but it's important to be able to say "no" as appropriate and have staff backed up by a clear process and management.

Conclusion

BMCC has spent the past 15 years refining its approach to weed management for the aim of biodiversity conservation. The proximity to a World Heritage area and a community which continues to demand high quality environmental care has kept staff constantly thinking and adapting our toolkit of management. The success of community Bushcare, Landcare and large-scale professional weed control projects only further highlighted the limitations on private lands. The utilisation of a “sub-catchment” inspection process firmly re-enforces the role Noxious Weeds inspections can have in performing as effective conservation managers and is in turn having a positive effect on reducing maintenance costs of public land.

Attachment 1: Blue Mountains City Council Process for issue of Noxious Weeds Notices

SECTION 18A

Request /notification from Section 45

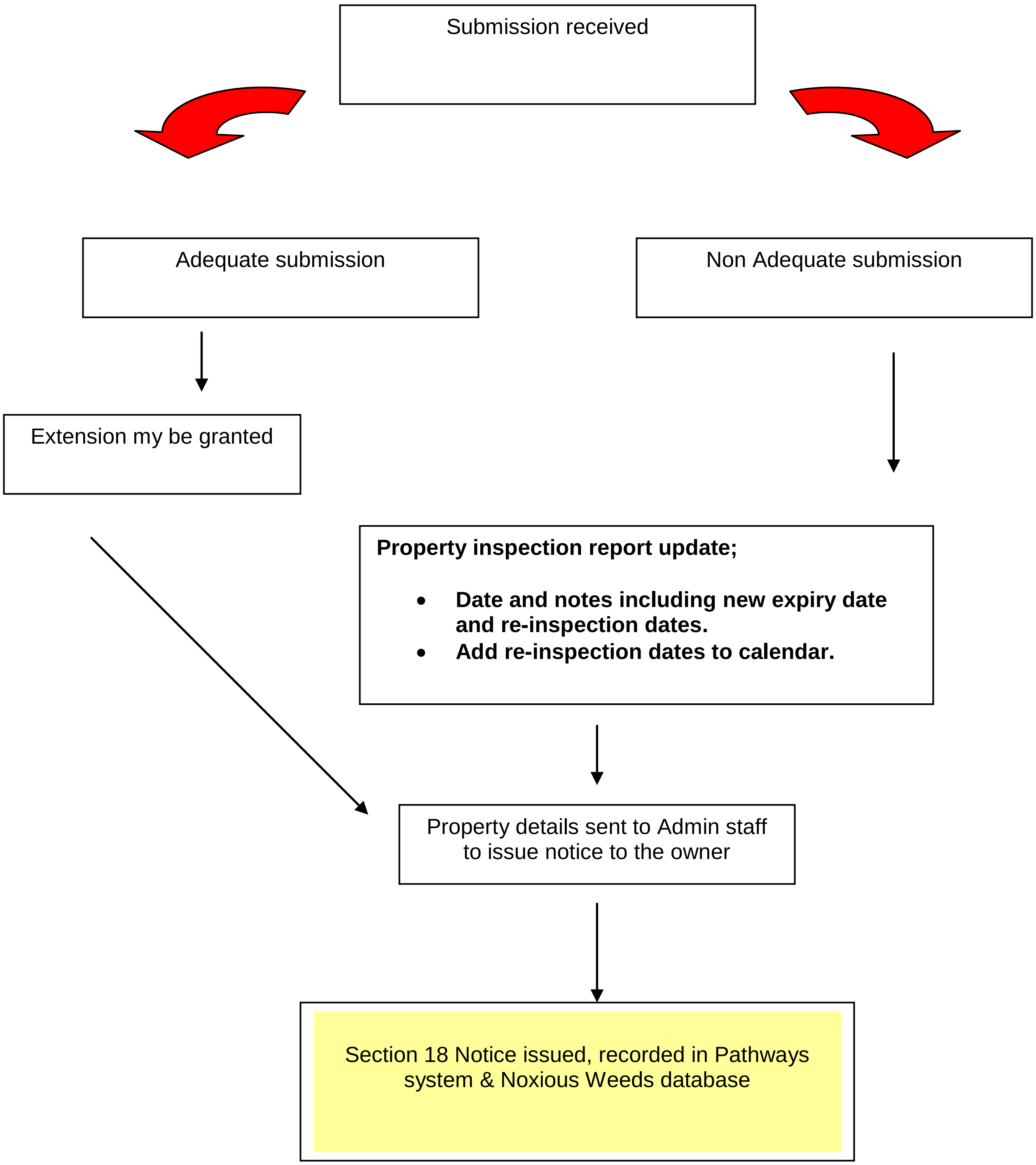
Property inspection report compiled including;

- **Weeds, density, method of control, location marked on the map, date and notes including new expiry date, re-inspection dates and notice recommendation.**
- **Add re-inspection dates to calendar**
- **Due date for inspection**
- **AS1 or AS2**
- **Section 18 issue date**
- **Inspection dates**

Property details sent to Admin staff to issue notice to the owner

Section 18A Notice issued, recorded in Pathway system & Noxious Weeds database

SECTION 18


Submission received
Adequate submission
Non Adequate submission
Extension my be granted
Property inspection report update;
Date and notes including new expiry date and re-inspection dates.
Add re-inspection dates to calendar.
Property details sent to Admin staff to issue notice to the owner
Section 18 Notice issued, recorded in Pathways system & Noxious Weeds database

SECTION 26 SHOW CAUSE

Re-inspection of property from Section 18 or Amended Section 18 Notice

Compliance Process ends

Non compliance

Property inspection report updated;

- Date and notes including new expiry date (three weeks should be given) and re-inspection dates.
- Add re-inspection dates to calendar
- Ensure photos have been taken and saved onto system and relevant paperwork has been filled in and attached to inspection file.
- Notify Weeds Coordinator

Property details sent to Admin staff to issue notice

Show Cause Notice issued, recorded in Pathways system & Noxious Weeds database. Recoverable Charges $147.40 issued.

SECTION 20

Re-inspection of property from Show Cause Notice

Compliance
Process ends

Admin fees still apply

Non compliance
Check records for response from owners

Admin fees still apply

Property inspection report compiled including;

- Date and notes including date to undertake work
- Before issuing a Section 20 Confer with Coordinator

Will Council be able to complete the work?

YES

- Report to Coordinator,
- Send notice including date work will commence.
- Complete work
- send invoice

NO

- Process for use of Contractors
- Estimate cost @approx 440.p/h
- Refer to Coordinator

Section 20 Notice issued, initialled by Manager, signed by Group Manager, recorded in Pathways system & Noxious Weeds database. Recoverable Charges $462.20 issued.

Under $1000

- Coordinator to directly appoint contractor to work as specified under $1000
- if work is going out to contract send Section 20 including the date work will commence
- Raise purchase order
- Contractor does work as specified and reports back to Coordinator with invoice
- Coordinator pays invoice

Over $1000

- Coordinator to request quotations
- Quotes received
- Coordinator appoints contractor
- Send Section 20 including the date work will commence
- Raise purchase order
- Contractor does work as specified and reports back to Coordinator with invoice
- Coordinator pays invoice

On arrival to complete work. If work completed charges remain

SECTION 13 (GOVERNMENT AUTHORITY)

Request /notification from CSR or other

Inspection of Property

No noxious weeds found

CSR signed off
Process ends

Noxious Weeds Found

If contact person known

Property inspection report compiled including;

- weeds / density, method of control, location marked on the map, date and notes
- Pass onto Coordinator to contact organisation
- Coordinator to make notes on agreement & dates
- On re-inspection if non compliant refer to Co-ordinator

In no contact for organisation send Section 13

Property details sent to Admin staff to issue notice

Section 13 Notice issued, recorded in Pathways system & Noxious Weeds database

If no response to Section 13 refer to Co-ordinator for GM to GM
If no response go to Section 21

Backyard Blitz in Brooms Head – garden escapes get the boot

Reece Luxton
Senior Environmental Officer (Weeds Management)
Clarence Valley Council, Grafton NSW

INTRODUCTION

This paper will identify the methods used and demonstrate the results of what was achieved through a novel approach to noxious and environmental weed control on private property which could be duplicated elsewhere on the coast.

Brooms Head is a unique beachfront village located 25 km south east of Maclean on the Clarence Coast (see map). It is a village of 166 properties surrounded by the heathland of Yuraygir National Park and the recreationally significant Council and crown land reserves – popular with tourist and day tripper alike.

Map 1. Brooms Head located on the Clarence Coast, NSW

As is common with many small coastal villages on the NSW North Coast, there are many vegetation management issues, particularly with garden escapees impacting on private and public land. Environmental weeds pose a significant risk to native vegetation and coastal ecosystems, and it is understood that many of these weeds originated from residential gardens.

Due to its significance environmentally and socially, the Council adopted the *Brooms Head Coastline Management Plan* in 2001 and included stabilisation planting along the foreshore to help protect the area from erosion. Further the *Brooms Head Vegetation Management Plan* was adopted in March 2007 to provide agreed priorities and recommendations for the many disputes occurring over various vegetation and weed issues on private and public land. Many landholders protested against the recommendations, including removal of backyard gardens encroaching into neighbouring Council and crown land.

Components of the Vegetation Management Plan were funded by the Northern Rivers Catchment Management Authority in August 2007 with the specific outcomes of reducing the biomass of weeds in Brooms Head, commonly thought to be spreading between private land, High Conservation Value ecosystems and neighbouring crown land and National Park estate.

A key task of the project was to '*Develop and distribute educational brochure on weeds of significance for Brooms Head to all households and caravan park permanents - education campaign to use Bushland Friendly Nursery Scheme or 'Grow me Instead' approach, but concentrate on Brooms Head issues*'.

With the financial resources secured it was decided to not only develop a specific weed brochure covering the main weeds of concern but provide a unique offer to the landholders of Brooms Head with a one-off removal of all noxious and environmental weeds from their backyards. Clarence Valley Council recognised that community education and engagement is essential to address this issue, and this opportunity would help the community reduce the impact of weeds and enhance biodiversity in close proximity to residential areas.

METHODS

The first key element of the program was to identify the priority species to be targeted in backyards. These included *Acacia saligna*, Asparagus fern, Cocos Palm, Umbrella Tree, Mother in Law Tongue, South Coast Tea Tree, Groundsel, Glory Lily, Bitou, Lantana, Easter Senna and other garden escapees. This provided the background for the development of the brochure, which included a key message and weed control advice.

Following this, a door knock on every private property was undertaken by Council staff (four staff – two Noxious Weeds, two Environmental Services) during January 2008 as it was deemed to be the best time to engage absentee property owners who came back to Brooms Head for holidays. Along with the specially developed brochure promoting the program, Council staff were able to door knock and assess the backyards of all 166 properties and 50 caravan park sites in the one day. From here the negotiations with each property owner accepting the free treatment was prepared through a simple two page agreement (see appendix 1), identifying the prioritised weeds to be controlled and the techniques to be used.

Administration of the project was minimal but effective – a free treatment agreement form (see appendix 1) was needed to be signed by the property owner before works could commence. For absentee property owners, they were given the opportunity to take up the offer via correspondance forwarded after the initial door knock.

On-ground works included use of Council's Bush Regeneration team to manually remove and treat the priority environmental weeds from the backyards, principally with a cut and paint method. Contractors were engaged to remove difficult trees such as Cocos palms and Umbrella trees. The removal of the weeds was an important step with disposal off site at the green waste transfer station near Maclean.

Property owners were also offered to have their weeds replaced with appropriate native species, sourced from the area and raised in the Bush Regeneration team's community nursery at Maclean.

DISCUSSION

Doorknocking and free assisted weed removal was a great way to get the community on side and educated on problems with garden escapees. Of the 166 properties inspected 57 or 34% had environmental weeds present and all but 2 agreed to removal of them. Council assisted 22 of the 57 properties to control or remove difficult weeds such as Cocos palms or Umbrella trees. The removal of seed trees from private properties will undoubtedly assist in control of weeds in the reserve system and reduce the level of resources needed into the future.

The take up for the program was unprecedented, and led to significant media coverage and filming of the project the Australian Government as part of their NRM video library project. An aerial inspection two months after the program allowed for identification of weeds missed during the ground control program, with detailed condition recorded using video footage.

The 'one on one' approach with property owners proved highly effective, and the cost of the program was minimised by using existing staff in the Noxious Weeds team, which proved to be complementary to normal inspectorial roles. The impact was immediate with the reduced bioload of weed seed from garden escapes no longer impacting the neighbouring reserves.

This project proved most suitable for villages or towns surrounded by areas of native vegetation, of a size where it is feasible to visit each household (perhaps up to 300 properties) and where environmental weeds are commonly present in residential gardens. The project could be delivered on ground by each local land manager, or by a suitable contractor if land manager resources were not available, or perhaps by a combination of both (Nicole Strehling, pers comm.)

It proved that people prefer to learn by doing (active education) and raised the community awareness of threat of environmental weeds in gardens.

The total cost of the program would have come in under $12,000, with in kind costs of the inspections, and development of the brochure not included. Costs incurred included production of the brochure $500, contractors for felling difficult trees amounted to $3000, transfer and disposal of weeds amounted to $2700 and the cost of the Bush Regen team for 2 weeks of backyard removal equated $5000.

The question could be raised as to whether this 'backyard blitz' potentially took the ownership of the problem away from the public and increased the expectation of the council dealing with weeds issues in Brooms Head on the whole. Conversely it could be argued that the increased presence of Council in the area has improved the rapport with property owners and identified weeds as everybody's problem and get everyone involved in the solution.

CONCLUSION

After implementing this innovative and highly successful coastal village weed control program in Brooms Head with the support of the NRCMA, Clarence Valley Council is now seeking to adopt the same approach with other coastal villages in the LGA. This project was deemed successful as it dealt with the old adage that 'weeds don't know boundaries' by complementing weed control in coastal reserves with community capacity building and weed control in the private properties of the village.

This project has demonstrated the benefits of choosing to use the funding set aside for educating the community by providing assisted removal of weeds verses a traditional approach of spending project funds only on extension material like brochures to obtain an outcome. At the same time Council has improved relationships with the property owners, increased native vegetation and decreased the weed bioload potentially eliminating larger problems in the future.

In the end, an important consideration is ensuring effective monitoring and evaluation is in place. The success of the program is only as good as the follow up over the next 3-5 years, which is crucial.

Future plans are now in place to adopt this model elsewhere along the NSW North Coast. NRCMA have applied for funding through the Environmental Trust's Restoration and Rehabilitation Program with the *Northern Rivers Coastal Village Weeds Attack proposal* for 2009/10. Based on the Brooms Head model, and following careful consideration of all nominations, the villages to be selected include Wooli, Valla Beach and Hat Head for inclusion in the proposal.

ACKNOWLEDGMENTS

I would like to thank Rodney Wright, Environmental Services Co-ordinator for promoting the idea of the assisted weed removal at Brooms Head, and Nicole Strehling from Northern Rivers Catchment Management Authority for being brave enough to let us have a crack at it. Bill Jordan and Marty Swain for the inspection work, and Victoria Bakker and Dave Purcell for the on-ground work.

Appendix 1 – sample – Free treatment forms provided to landholders during inspection

FREE TREATMENT OF ENVIRONMENTAL WEEDS

Dear Land holder

Clarence Valley Council would like to offer the service of free treatment of selected environmental weeds which are located on your property as part of the Brooms Head Weed Control Program.

Brooms Head Weed Control Program is available for a short time through funding available from the Northern Rivers Catchment Management Authority.

If you would like to participate in this offer please complete the application form provided as a record of agreeing to participate in the program and allowing free treatment on your property.

Clarence Valley Council staff will assist in removal of the following weeds:

____

____

____

____

____

For further information please contact Reece Luxton at the Clarence Valley Council Noxious Weeds Office on ph. 6643 3820 or reece.luxton@clarence.nsw.gov.au

Clarence Valley Council
Locked Bag 23 Grafton NSW 2460

Contact: Reece Luxton
Reference: Project 994642

FREE TREATMENT APPLICATION FORM

Owners Name: ______________________________

Property Address: ______________________________

____

Home Phone number: ______________________________

Mobile Number: ______________________________

Weeds to be removed ______________________________

____

I being the Owner would like to participate in the Brooms Head Weed Control Program by allowing Clarence Valley Council to treat selected environmental weeds that are located on the above property address.

I fully understand that any treatment carried out is free of any charge on condition that I accept any adverse effects which may occur as a result of this treatment.

I understand that this treatment is part of my responsibility to manage selected environmental weeds in accordance with priority weeds outlined in the Brooms Head Vegetation Management Plan and I will undertake any necessary follow up in the future.

Print Name: ______________________________

Signed: ______________________________ Date: ______________________________

Comments ______________________________

____

____

____

Sketch location of weed on property

Reference: Project 994642
Contact: Reece Luxton

WATER HYACINTH IN THE GINGHAM WATERCOURSE 1

The History of Water Hyacinth in the Gingham Watercourse

Philip Blackmore
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NSW Department of Primary Industries, Armidale

Paul Sullivan
Coordinator Biological Control
NSW Department of Primary Industries, Tamworth

Abstract
Water hyacinth was discovered in the Gingham Watercourse, a flood channel of the Gwydir River north west of Moree in 1955. A lack of timely action allowed the infestation to become established over a large area. A series of flood events in the early-mid 1970's created conditions ideally suited to water hyacinth and the infestation rapidly spread over 7000 hectares, threatening to escape into the Murray-Darling River System.

A major eradication campaign in the late 1970's was successful in destroying the infestation through a combination of drainage and herbicide application but failed to address the seedbank that remained. In the early 1980's drainage channels were extended and deepened form a stock and domestic water supply channel through to the lower Gingham Watercourse.

A series of wet seasons in the mid-late 1990's caused re-establishment of the infestation from the latent seedbank. Since 2000, combinations of natural flows and controlled flows for environmental and stock and domestic purposes have assisted the downstream movement of water hyacinth along the stock and domestic channel. Over the last 13 years water hyacinth has spread 15 km further west and the head of the infestation is now only 45 km from the Barwon River. This increases the threat to the Murray-Darling. A recent attempt to establish biological control agents in the infestation has been given reduced priority. Other control options are now being explored.

Introduction
Water hyacinth *Eichhornia crassipes* (Mart.) Solms is an erect free floating perennial aquatic plant. It has attractive purple flowers and reproduces from stolons and by seed (Parsons and Cuthbertson, 2001). It appears to be native to the Amazon region of Brazil (Wright and Purcell, 1995) and was probably introduced to Australia as an ornamental species that later escaped into rivers and streams (Wright and Purcell, 1995).

In 1955 water hyacinth was found in the Gingham Watercourse (the Watercourse) near Moree in New South Wales. The Watercourse is an ephemeral flood channel north west of Moree. It forms part of what has been termed an "inland delta" of the lower Gwydir valley (Curran, 1969). By 1976, 7000 hectares of the Watercourse were infested (Smith *et al.*, 1984). Strang *et al.* (1972) considered that water hyacinth from this infestation could have easily escaped into the Murray-Darling River system. Since 1976 there has been a boom and bust cycle of water hyacinth infestation and attempts at control. These have included chemical, mechanical, biological and drying out the infested area.

The Problem with Water Hyacinth
Water hyacinth forms dense impenetrable mats across water surfaces that leads to a huge decrease in biodiversity and limits access by humans, machinery, animals and birds (Wright and Purcell, 1995).

Under ideal conditions, water hyacinth grows at an exponential rate (Bock, 1969). Up to 3,000 seeds can be produced per inflorescence with each rosette being capable of producing several inflorescences per year (Barrett, 1980). Seeds can mature above or below the water surface (Manson and Manson, 1958). These seeds can remain viable for more than 20 years (Matthews et al., 1977). Water hyacinth also reproduces vegetatively. A single plant can produce a new infestation (Wright and Purcell, 1995). Eradication of water hyacinth is unlikely unless infested areas can be drained and any seedlings recruited from the seedbank can be destroyed prior to seed set.

The Gwydir Raft and Its Effect on the Watercourse
The Watercourse receives water from the Gwydir River, spilling at a point known as the Gwydir pool. The Gwydir pool was created by the Gwydir Raft, a silted logjam in the Gwydir River downstream from Moree (SPCC, 1978, Smith *et al*., 1984). The Raft began to be created around the turn of the 20th century but became a more permanent blockage during a flood in 1910. Its cause is unknown but its development was coincidental with upstream land clearing associated with the progress of closer settlement (BLWA, 1965; Curran, 1969). As more debris has accumulated it has continued to advance upstream and by 1976 was 17 km in length (SPCC, 1978).

Prior to the development of the Raft, freshes in the Gwydir River ran down the main channel and spilled into an anabranch of the Gwydir River known as the Big Leather Watercourse. These flows caused localised flooding and boosted growth of pastures. Not surprisingly, this country was highly favoured by selectors. Only larger rises in the Gwydir spilled into the Gingham Watercourse (BLWA, 1965; Curran, 1969). As the Raft extended in length, it effectively blocked the Gwydir channel above the efflux into the Big Leather Watercourse, denying flows to the Big Leather and instead directing Gwydir flows into the Gingham Watercourse.

The Raft has changed the hydrology of the Watercourse by causing a considerable increase of the frequency of flood events (Curran, 1969). Prior to development of the Raft a rise of 12'– 20' (3.5m - 6m) in the Gwydir was required to cause general flooding in the Watercourse but since the Raft formed, a rise of only 2' – 3' (0.6m to 1m) caused general flooding (BLWA, 1965). The effect of the Raft was to cause more regular flooding of the Watercourse. This in turn led to an abundance of feed but also caused an increase in semi-aquatic species such as cumbungi (*Typha* sp.) and later, water hyacinth (SPCC, 1978). Water hyacinth would not have thrived in the Watercourse without the Raft.

Flooding in the Watercourse caused by upstream rain events produced localised verdancy in stark contrast to the surrounding dry countryside. Over time, landholders in the Watercourse became used to increased water and did not want anything done that would stop the flood flows (BLWA, 1965; Curran, 1969; Strang *et al*., 1972).

A series of wet seasons in the early 1970's, combined with the obstruction to water flow caused by cumbungi and water hyacinth, lead to the creation of more permanent swamps on some Watercourse properties (SPCC, 1978). Water hyacinth flourished in these conditions and spread over a large area of the Watercourse.

Development of the Infestation

The following table is a chronology of the development of the water hyacinth infestation in the Gingham Watercourse.

1955	A single water hyacinth plant is believed to have washed into the Watercourse from a dam or pond during a major flood in the Gwydir Valley (Strang *et al*., 1972).
1956	Two significant floods in the Gwydir valley assisted the establishment of the infestation (Strang *et al*., 1972).
1958	The infestation became apparent (Strang *et al*., 1972).
1964	Department of Agriculture and Water Conservation & Irrigation Commission (WC&IC) staff urge Boomi Shire to enforce control of the emerging infestation in the Watercourse while it was still at a manageable level. However Boomi Shire Council took no action (Strang *et al*., 1972).
1965	Drought offered the perfect opportunity for Boomi Shire to act but again they did nothing (BLWA, 1965). The Watercourse remained largely dry until 1969 (Strang *et al*., 1972). The Gwydir Valley Water Users Association (President Wal. Murray) was concerned about the disruption to flow caused by water hyacinth along bore drains. They begin lobbying for a stock and domestic channel to be built through the watercourse (BLWA, 1965).
1969	Minor floods activated the water hyacinth seedbank (Smith *et al*., 1984)
1970	The size of the infestation started to cause local concern (Moree Champion, 1970).
1971	Major floods greatly increased the size of the infestation (SPCC, 1978).
1972	The infestation estimated by the Department of Agriculture Field Officer (Weeds) as covering 20 000 acres (8 000 ha). He observed that Curragundi bore on "Bunnor" was the western limit of infestation. WC&IC was concerned about water hyacinth encroaching on bore drains. A proposal was made by the Field Officer (Weeds) to aerially spray the whole infestation. However The Department of Agriculture Regional Supervisor recognised the Watercourse as a sanctuary for waterbirds and that aerial spraying could be controversial. Shell Chemicals discounted the potential for birds to be harmed by 2,4-D. The Department of Agriculture Regional Supervisor considered it probable that water hyacinth would escape into the Barwon. He considered that if this was not the case that it was doubtful that control of the infestation would be warranted. A meeting between the Department of Agriculture Regional Supervisor and Boomi Shire Council revealed that Boomi Shire had never served notices on landholders in the Watercourse for water hyacinth and according to the Shire

	Clerk was unlikely to do so. The Deputy Premier of NSW (Hon. Sir Charles Cutler MLA), in a letter to the Minister for Conservation, stated that the Premier of South Australia (Hon. Don Dunstan MP) had made representations to the Premier (Hon. Sir Robert Askin MLA) seeking eradication of the water hyacinth infestation. The water hyacinth infestation was discussed at the 9th meeting of the Australian Weeds Committee and was subsequently brought to the attention of the Standing Committee on Agriculture at its 88th meeting. The Committee recommended the formation of a tri-state (NSW, Victoria and South Australia) working panel to investigate the infestation and to make recommendations on how to proceed. The working panel reported in November 1972 and considered the threat to the Murray-Darling System to be both serious and imminent. The working panel made 8 recommendations; the main recommendation being that herbicides should not be regarded as the sole answer to the problem and that a combination of drainage and local use of herbicides offered the best prospects for control. It was further recommended that: any drainage scheme should cause minimal disturbance to flooding patterns, the water hyacinth be contained by spraying the western fringe of the infestation, Boomi Shire appoint a competent weeds officer, the limits of the existing infestation be determined and that regular downstream surveillance take place, and the state government make a special allocation of funds to support the control work on private property.
1973	In a letter to the Noxious Plants Advisory Committee, Boomi Shire Council accepted it had a role in the containment and control of water hyacinth in the Watercourse.
1974	The Standing Committee on Agriculture endorsed the recommendations of the working panel in January. Floods in January. In February, Boomi Shire appointed a part time Weeds Officer (Weeds and Bushfires). The Field Officer (Weeds) reported that the District Engineer from WC&IC continued to doubt that water hyacinth could move further west. The District Engineer considered that draining the Watercourse was impractical and unnecessary and that the status quo re flooding of the Watercourse was best maintained. The District Agronomist (Moree) suggested that normal water flows be diverted around the infested area of the Watercourse. However, this was contrary to the recommendations of the working panel.
1975	The Field Officer (Weeds) reported work on controlling the fringe of the infestation using herbicide. The objective of this work was to prevent further spread to the west. However, this was not successful.

	The District Agronomist (Moree) noted that cattle on one Watercourse property had not had a dry camp for more than 12 months. More than 40 cattle had been shot after becoming stuck in bogs and many more were so weak they would also need to be shot.
1976	Major flooding in the Gwydir Valley in February spreads water hyacinth 5km west to "Yarrol" and within 1.5km of the Gingham bridge (SPCC, 1978). The Premier of NSW approved the establishment of an inter-departmental project team. The team comprised officers from the Department of Agriculture, Local Government, the State Pollution Control Commission and the WR&IC (SPCC, 1978). The control program was to be financed by contribution from the state governments of NSW, Victoria, South Australia and the Commonwealth government (Smith *et al*., 1984). Copeton Dam and Tareelaroi Weir were completed. This was the starting point for the development of the lower Gwydir valley as a major irrigation district (SPCC, 1978).

The Gingham Water Hyacinth Eradication Campaign
The control program commenced in earnest soon after the creation of the inter-departmental project team in 1976 (Smith *et al*., 1984). The program was carried out in accordance with the recommendations of the working panel and was to be conducted in three phases.

The first phase was to destroy the existing infestation. This was implemented by:

- building earth dams at the Gwydir Pool to prevent inflow into the Watercourse during times of normal flow in the Gwydir
- clearing the main channel with a specialised bulldozer to drain the larger swamps,
- aerially spraying selected channels with herbicide and
- land based treatment of water hyacinth with herbicides initially from a specialised amphibious vehicle (the Tortoise) and later from four wheel drive trucks (SPCC, 1978, Smith *et al*., 1984).

Lastly, in an attempt to contain westward movement of floating water hyacinth plants, a netting fence was constructed at a narrow point above the Gingham Bridge.

The program was funded by equal grants from NSW, Victoria, South Australia and the Commonwealth (Smith *et al*., 1984). The grants made were:

1976-77	$200 000
1977-78	$200 000
1978-79	$60 000
Subtotal	**$460 000**

The Commonwealth withdrew from the project at the end of the 1978-79 financial year. Further grants were made by the three state governments in following years and by 1981-82 the total grant contributions (Smith *et al*., 1984) were:

Total	**$550 000**

The second phase of the program was to exhaust the seed bank by encouraging the recruitment of seedlings and destroyed those seedlings prior to flowering (Smith *et al*., 1984). This was attempted in 1980 and 1981 by a program of local flooding in the watercourse but was only partially successful due to limited water flows in the prevailing drought conditions (Smith *et al*., 1984). Severe drought conditions in eastern Australia in 1982-83 prevented the continuation of this program but reduced the density of water hyacinth in the Watercourse.

The third phase of the program was to trial biological control. This was conducted by CSIRO and involved the release of two agents, a water hyacinth weevil and a moth. However, as the Watercourse drained and water hyacinth was treated with herbicide during phase one of the control program, the population of the biocontrol organisms could not be maintained. The biocontrol program was then discontinued (Smith *et al*., 1984).

The ecology of water hyacinth in a warm temperate environment was not well known at the time. The University of New England under the leadership of Dr John Duggin from the School of Rural Science and Natural Resources was commissioned to study aspects of the water hyacinth seedbank, including the longevity of seed in the seedbank and methods of reducing viability of that seed (Smith *et al*., 1984).

Development of the Stock and Domestic Channel

During the series of dry years from 1978-1982, the Gingham Watercourse Association lobbied successfully for the construction of a stock and domestic water supply channel through the Watercourse and a stock and domestic water allocation (Shane Murphy, pers. comm.).

Apparent Success of the Eradication Scheme

In about 1983, the inter-departmental project team was disbanded. Responsibility for monitoring seedbank sites and water hyacinth control was passed to the newly formed Moree Plains Shire Council, which included the former Boomi Shire Council.

Water hyacinth in the Watercourse appears to have remained under control for the next 13 years. The demand for water by the cotton industry as irrigation expanded in the Gwydir valley in the 1980’s may have reduced flows into the Watercourse. Dry conditions in northern NSW during the first half of the 1990’s, including a drought year in 1994, may have also prevented germination of water hyacinth in the Watercourse.

This lack of water hyacinth may have encouraged Moree Plains Shire Council to believe that the Tortoise aquatic vehicle was redundant. The Tortoise was sold to Hawkesbury River County Council in 1994 with encouragement from the Department of Agriculture. In retrospect, this action was premature.

The Return of the Infestation

Floods in the Gwydir valley in late 1995 and early 1996 re-established the water hyacinth infestation in the Watercourse from the existing seedbank. More floods during the remainder of the 1990’s and the first half of the 2000’s expanded the infestation (Albertson, 2008). Outside periods of flooding, a combination of natural flows through the Watercourse as well as allocated flows for stock and domestic purposes and for environmental benefit have assisted in maintaining the water hyacinth population (John Duggin, pers. comm., Albertson, 2008).

Although responsibility for control of water hyacinth in the Watercourse rests with individual landholders, the logistics of controlling plants in inundated country are challenging. Farm quad-bikes are limited from operating in much flooded country by the depth of the water in channels and runnels. Recognising this restriction on access to water hyacinth infestations by landholders, Moree Plains Shire Council repurchased the Tortoise from Hawkesbury River County Council in 1999. However, by then it was in poor condition and subject to frequent and lengthy breakdowns. Aerial application of selective herbicides is problematic due to the risk of drift to sensitive crops. The consequent inadequate control of infestations has allowed additions to the seedbank.

In 1998 Dr John Duggin from the University of New England wrote to the Noxious Weeds Advisory Committee supporting a Gingham Water Users Association application for funding to control the re-established water hyacinth infestation. Duggin (1998) reiterated the need for a control program in the Watercourse based on a regime of alternate inundation to stimulate germination of the seedbank and drying to facilitate herbicide control of recruited seedlings.

The following year, Moree Plains Shire Council convened a workshop to develop a new management strategy for water hyacinth in the Watercourse. The strategy was developed but ultimately failed to be implemented. This was due to lack of support from the numerous stakeholders, who seemed to be more intent on pursuing their own sectional interests and the lack of a person or organisation from outside the stakeholder group to drive the implementation.

Westward Spread of the Infestation

Ad hoc control of water hyacinth continued until 2005 when it became apparent that rather than increasing in density at existing locations, water hyacinth was spreading westward along the stock and domestic channel. Water hyacinth has spread beyond the “hyacinth fence” and seed banks have been created downstream of this fence.

Today, water hyacinth infests about 6,000 hectares along 25 km of the channel. Water hyacinth infestations can now be found 15 km further downstream than at the recurrence of the infestation in 1996. Established populations of water hyacinth are less than 45km from the Barwon River. This spread greatly increases the probability that water hyacinth may escape into the Murray-Darling System during a significant flood event (Albertson, 2008). A flood in 1998 passed through the full length of the Watercourse and reached the Barwon River.

How did it come to this?

The presence of the Gwydir Raft created conditions in the Watercourse that were conducive to the establishment and growth of water hyacinth (Curran, 1969; SPCC, 1978). Nothing was done to rectify this problem.

Landholders in the Watercourse have always had responsibility for control of water hyacinth, initially under the noxious weed provisions of the *Local Government Act 1919* and after 1993 under the *Noxious Weeds Act 1993*. Prior to the creation of the inter-departmental project team, Boomi Shire Council was responsible for ensuring landholders in the Watercourse met their water hyacinth control responsibilities. Yet Boomi Shire Council failed to act despite the urging of the Department of Agriculture from as early as

1964 (Strang *et al*., 1972). Boomi Shire Council missed important opportunities during the early stages of the infestation to achieve control or to at least contain the infestation.

The reason for the early inaction of Boomi Shire is unknown but was possibly in the mistaken belief that water hyacinth would not persist west of the Great Dividing Range (Strang *et al*., 1972). Once the infestation had reached its maximum size, Boomi Shire Council baulked at the huge potential cost of control works (Anon., 1972).

In spite of the large area of water hyacinth infestation, The Department of Agriculture Regional Supervisor reported that the impact of the infestation on agricultural production in Boomi Shire was negligible. The real threat was to state and national assets of the Murray-Darling River System. By the time the infestation had reached its greatest size, Boomi Shire Council was reluctant to take responsibility for what was perceived by them to be a state and national issue (Anon., 1972). The development and implementation of the NSW Invasive Species Plan may help to avoid a repeat of this problem.

After the initial success of the 1970's eradication campaign, all parties were guilty of complacency. This was in spite of the ongoing threat posed by the latent water hyacinth seedbank in the Watercourse. The return of the infestation in 1996 and its subsequent westward spread is also the result of complacency, short term thinking, a failure to plan for contingencies and reluctance by some parties to accept the threat to the Murray-Darling River System.

Conclusion

The alarming discovery of the western spread of water hyacinth has given a new impetus to a strategic approach to water hyacinth control and containment in the Watercourse. This approach no longer includes a biological control program.

It is hoped that this new spirit of cooperation will contain and suppress water hyacinth at its present location. However, the threat to the Murray-Darling System remains and preventing the spread of water hyacinth to the Barwon River must be the main objective of the control program.

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WATER HYACINTH IN THE GINGHAM WATERCOURSE 2

The Future of Water Hyacinth, *Eichhornia Crassipes*, in the Gingham Watercourse

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Abstract
Water hyacinth, *Eichhornia crassipes* (Martius) Solms-Laub. is widely recognised as the world's worst aquatic weed. This highly invasive weed has degraded aquatic ecosystems in many tropical, subtropical and warm temperate regions of the world causing huge environmental and cultural problems. Water hyacinth grows and flowers very quickly and produces large numbers of long lived seeds. It forms dense impenetrable mats across water surfaces that lead to a huge decrease in biodiversity and limits access by humans, machinery, animals and birds. Water hyacinth also degrades water quality and has a massive evapo-transpiration rate.

In 1955 water Hyacinth was found in the Gingham Watercourse (the Watercourse) near Moree in New South Wales. Since then there has been a boom and bust cycle of infestation and management attempts that have included chemical, mechanical and biological control and drying out infested areas. During this time water hyacinth infestations have continued to move downstream and by 2009 water hyacinth was less than 45km from the Barwon River which flows directly into the Darling River.

The Watercourse is an ephemeral flood channel and wetland that has been termed an "inland delta" of the lower Gwydir valley. Local rain events and smaller floods usually stay within the wetland however a 1 in 20 year flood would be large enough for floodwater from the Gingham Channel to flow directly into the Barwon River. If water hyacinth plants were present, then there is a good possibility that water hyacinth would be carried with the floodwater into the Barwon River.

Unless there is serious, long term and concerted control and preventative measures taken by a multi agency task force, it is likely that water hyacinth will reach the Murray Darling River either in small discrete steps, or in one larger flood event. This would be disastrous. The decrease in biodiversity, loss of water through evapo-transpiration and costs to control this weed would be massive. The Murray Darling River system, lakes and wetlands would be seriously degraded.

The Problem
Water hyacinth is a perennial aquatic plant from South America and is widely recognised as the world's worst aquatic weed (Holm et al., 1977). It was exported from Brazil during the late 19th and early 20th centuries because it has attractive flowers. It rapidly spread throughout the tropical, subtropical and warm temperate regions of the world and has

caused huge environmental and cultural problems by degrading aquatic ecosystems (Wright and Purcell 1995, Centre et al., 2002).

Water hyacinth forms dense impenetrable mats across water surfaces that leads to a huge decrease in biodiversity and limits access by humans, machinery, animals and birds (Centre et al., 2002). Water hyacinth degrades water quality and has a massive evapo-transpiration rate, losing water into the atmosphere at up to 6 times that lost by open water (Pieterse, 1978).

Water hyacinth grows very quickly with its productivity rate being one of the highest for photosynthetic organisms (Pieterse, 1978). Plant doubling time vary from 5 days (Perkins, 1973) to 11-15 days (Penfound and Earle, 1948). Up to 3,000 seeds can be produced per inflorescence with each rosette being capable of producing several inflorescences per year (Barrett, 1980). These seeds can remain viable for up to 29 years (unpublished data).

Chemical and mechanical control measures have been used since the early 1900s, but they are expensive and ineffective on all but small infestations (Julien et al., 1999).

Eradication of the weed is rare because of its rapid growth rate and its ability to reinfest from long life seeds.

In 1955 water Hyacinth was found in the Gingham Watercourse near Moree in New South Wales. The Watercourse is an ephemeral flood channel and wetland that has been termed an "inland delta" of the lower Gwydir valley (Curran, 1969). By 1976 a 7000 hectare area of the Watercourse was infested. Since then there has been a boom and bust cycle of infestation and management attempts that have included chemical, mechanical and biological control and drying out the infested area.

Over this time water hyacinth has continued to move downstream and today water hyacinth infests about 6,000 hectares along 25 km of the Gingham Channel. Over the last 10 years water hyacinth infestations can be found 15 km further downstream and are now less than 45km from the Barwon River. Infestations have breached the "Hyacinth fence", the so called last bastion of defence, and seed beds have established downstream of this fence.

Environmental flows of water are released from Copeton Dam and diverted into the Upper Gingham wetlands for environmental purposes. Unfortunately these environmental flows also germinate large amounts of water hyacinth in mud and low lying areas of the upper Gingham wetlands.

The prospect of utilising biological control of water hyacinth in the Gingham watercourse as a long term strategy captures the imagination as easy, painless and a quick fix. However successful biological control is slow commonly taking 2 to 6 years in tropical and subtropical countries where water hyacinth cover was commonly reduced by 55 to 95 % (Julien et al, 1999).

A 1 in 20 year flood would be large enough for floodwater from the Gingham Channel to reach and flow directly into the Barwon River (pers. comm., A Falkenmire, Floodplain Management, Department of Environment and Climate Change, (DECC)).

The strategy of using biological control of water hyacinth in the Gingham water course increases the probability that water hyacinth infestations will reach the Barwon and Murray Darling Rivers with disastrous results.

Water Hyacinth Program since 2005

Concerted efforts brought the Gingham Watercourse infestation under control by 1983 however floods in the Gingham in 1996 re-established the infestation from the existing seedbank. Water hyacinth continued to increase and by the summer of 2005/2006, the infestation completely covered the Gingham water hole and much of the watercourse upstream of the Hyacinth fence. Several meetings were facilitated by NSW DPI and included representatives from NSW DPI, Moree Plains Shire Council (MPSC), Department of Natural Resources (DNR), Border Rivers-Gwydir Catchment Management Authority (BRGCMA), and landholders representing the Gingham Watercourse Association. A short term plan was developed to tackle the water hyacinth problem while a longer term action plan was developed that was subject to successful funding applications.

The short term plan involved destroying the bulk of the water hyacinth infestation with an aerial herbicide application by May 2006. This utilised the small window of opportunity that occurred after the cotton had defoliated but before the first frosts occurred.

The long term plan involved ongoing control of water hyacinth using biological control as part of an integrated strategy that included mechanical harvesting and chemical control.

Initial funding for the project was provided by the Border Rivers-Gwydir Catchment Management Authority, while longer term funding (3 years) was provided by the Australian Government Envirofund and the Wetland Recovery Program. This funding allowed the long term plan to commence.

Local landholders from the Gingham Landcare Group and staff from NSW DPI, DNR, Department of Environment and Climate Change (DECC) and MPSC were involved in this project.

Short term plan

The short term plan had some success at reducing the bulk of the infestation. However about one third of the sprayed plants were only damaged and not killed and grew back during the spring of 2006.

Integrated Control Program

The integrated control program began in mid 2006 and has continued until the present time in mid 2009. It consisted of using mechanical harvesting and herbicides to control water hyacinth while at the same time developing biological control nursery sites that were hoped would continue to increase in size and later be able to take over much of the water hyacinth control.

Two biological control nursery sites were established in the North West and South East parts of the Gingham water hole by containing water hyacinth plants inside two boomed areas. Six releases totalling 3800 water hyacinth weevils (*Neochetina eichhorniae* and *Neochetina bruchi*) were made into each nursery sites between September 06 and March 08. Both species of weevils survived two winters and continued to slowly increase in numbers. Presently they do not appear to have exerted any level of control other than perhaps reducing the amount of flowering. This is not unexpected as successful biological control is slow commonly taking up to 6 years in tropical and subtropical countries (Julien et al, 1999).

Chemical control continues to be the main weapon of control as it is much cheaper than mechanical harvesting. Mechanical harvesting has the added disadvantage that much of the infestation in the Gingham Watercourse is either too shallow or in constricted areas that are unsuitable for the harvesters.

Present Infestation

Today, water hyacinth infests about 6,000 hectares along 25 km of the channel. Water hyacinth infestations can now be found 15 km further downstream than at the recurrence of the infestation in 1996. Established populations of water hyacinth are less than 45km from the Barwon River. This spread greatly increases the probability that water hyacinth may escape into the Murray-Darling System during a significant flood event. A flood in 1998 passed through the full length of the Watercourse and reached the Barwon River.

Future Program

A meeting at Moree was facilitated by NSW DPI in October 2008. At this meeting the movement of water hyacinth 15km further downstream and the probability that water hyacinth would reach the Barwon River under the present control program were pointed out. The meeting identified that it was essential a plan be developed that would attempt to prevent the spread of water hyacinth into the Barwon and Darling Rivers. A Water Hyacinth Working Group was formed with representatives from NSW DPI, MPSC, BRGCMA, DECC, Murray Darling Basin Commission (MDBC) Gwydir Valley Irrigators Association (GVIA) and a landholder with the following Mission and Terms of Reference.

Mission:

- To manage water hyacinth in the Gingham, Gwydir and associated water courses to minimise the long term threat of the weed spreading to the Murray Darling system.

Terms of Reference:

1. To identify and document the history, spread, actions and outcomes of water hyacinth control in the Gingham, Gwydir and associated water courses.
2. To identify Best Practice Management for the management, containment, control, and education programs for water hyacinth.
3. To prepare a framework that identifies roles and responsibilities of stakeholders in the management and control of water hyacinth.
4. To promote a community engagement and awareness campaign of the threat water hyacinth poses to aquatic environments, particularly the Murray Darling system.
5. With the information from 1-4 above, prepare a Management Plan incorporating a funding submission for the post June, 2009 management, containment, control and education programs for water hyacinth.

Since then further meetings have developed more specific plans to contract the infestation. These include:

- mapping the infestations
- installing new physical structures needed to impede movement of water hyacinth
- improving farm to farm access through the Watercourse
- improve and acquire new equipment including major overhaul of the “tortoise”
- monitoring and evaluation
- identify the resources and people needed
- implement a spraying program
- education and awareness program

In addition to this new works are proposed for the Watercourse that should assist with water hyacinth control including:

- piped delivery of domestic water to the lower Watercourse,
- piped delivery of bore water for livestock, and
- environmental flows of water through the Watercourse to be timed to allow a flush and dry regime as recommended by Duggin (1998).

Discussion

Water hyacinth infestations and seed beds are now established well downstream of the Hyacinth fence, a fence that was supposed to be the furthest downstream that water hyacinth would be allowed to go. These infestations are 15km closer to the Barwon River from where they were prior to the 1996 reinfestation (Savage, pers. com.).

This movement of water hyacinth downstream towards the Barwon and ultimately Murray/Darling Rivers has four contributing factors:

- Regular mass germinations of water hyacinth from environmental flows and to a lesser extent from flooding.
- Reluctance by the few local landholders to diligently control water hyacinth due to the huge control costs and high labour input required.
- Poor vigilance and maintenance of the Hyacinth fence.
- Movement of small newly germinated water hyacinth plants through the water hyacinth fence and under containment booms. These plants are small enough to float through the mesh of the water hyacinth fence. They also barely float so in swirling water currents they become submerged and pass under and emerge on the lower side of the booms.

Environmental flows of water released for environmental purposes from Copeton Dam germinate large amounts of water hyacinth in the upper Gingham wetlands. Much of this water hyacinth finds its way into water channels and floats further down the Gingham watercourse. Biological control is a poor option for controlling this huge amount of newly germinated water hyacinth because it would be impossible to maintain a large enough population of biological control agents to control this large mass of water hyacinth. It would also take a number of years for populations of the agents to increase and control the water hyacinth. During this time water hyacinth is likely to continue its march towards the Barwon River and probably reach it in a 1 in 20 year flood.

The use of these environmental flows in the upper Gingham water course carries with it the threat of water hyacinth reaching and seriously degrading other wetlands in the Murray Darling River system. The questions needs to be asked “Should the water from the environmental flows be managed to suppress water hyacinth germination?” or “Should environmental flows be diverted away from the Upper Gingham wetlands and be used in other wetlands where the positives would greatly outweigh any negative effects?

Biological control of water hyacinth never leads to eradication but results in a reduction of weed populations to a lower level. Mature floating plants are always present. These mature floating plants present a real problem of establishing new infestations by being washed further down the water course during a flood. Thus the use of biological control of water hyacinth in the Gingham water course is likely to increase the probability of establishing new infestations further down the Gingham watercourse and sooner or later into the Barwon and Murray Darling Rivers. A 1 in 20 year flood is likely to achieve this in one event by pushing floodwaters from the Gingham watercourse directly into the Barwon River and quite likely take mature water hyacinth plants with it into the Barwon and Murray Darling Rivers.

All water hyacinth plants should be chemically treated to minimise the likelihood of new infestations spreading further downstream. If no plants were alive when a flood occurred, water hyacinth plants would first have to germinate and then float to the surface before they could spread further down stream. It is likely that the quickly moving flood waters would be long gone before this occurred. The biggest danger to water hyacinth spreading downstream would be if a second follow up flood occurred shortly after the first flood. For this reason a vigilant and timely monitoring and control program needs to be in place through out the year and especially needs to occur as soon as possible after each flood.

Another problem with using biological control of water hyacinth in the Gingham is the unreal expectations that are placed on biological control. Many people still see biological control as a “silver bullet” that will solve their problem and so they often decrease their monitoring and control programs.

Take Home Messages

The use of these environmental flows in the upper Gingham water course needs to be re evaluated in light of the water hyacinth problems that it creates.

In light of its quick growth rate, long lived seeds and floating habit where it is easily able to infest new areas; it is suggested that a long term zero tolerance policy of control for water hyacinth in the Gingham water course is the best option for preventing water hyacinth from infesting other parts of the Murray Darling Basin.

Unless there is serious, long term and concerted control and preventative measures taken by a multi agency task force, it is likely that water hyacinth will reach the Murray Darling

River system with disastrous results. The decrease in biodiversity, loss of water through evapo-transpiration and costs to control this weed will be massive. The Murray Darling River system, lakes and wetlands would be seriously degraded.

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THE NOXIOUS WEED DECLARATION PROCESS AND THE NSW WEED RISK MANAGEMENT SYSTEM

What does this mean for you?

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SUMMARY

This paper discusses the revised process used to determine the declaration of plant species as 'noxious' through the *Noxious Weeds Act 1993*. It briefly discusses the Noxious Weeds Advisory Committees (NWAC) policy on weed declaration and the procedures used by New South Wales Department of Primary Industries (NSW DPI) before examining the noxious weed declaration process.

There are three key components of this process which are: an **Operational assessment**, and **Regional plan** which largely include information previously supplied to support applications, and a **Technical assessment** using the NSW Weed Risk Management (WRM) system. Use of the WRM system enables an objective evaluation of the risk a plant species poses and how feasible the plant species may be to control. The outcomes of the WRM system also enable appropriate declaration decisions to be made. Three components of the process will be discussed in detail in this paper.

INTRODUCTION

The New South Wales Department of Primary Industries (NSW DPI) has revised the process it uses to determine the declaration of plant species as 'noxious' through the *Noxious Weeds Act 1993*. This process is informed by the Noxious Weeds Advisory Committee (NWAC) policy on declaration of weeds, Policy Paper 1 (NSW DPI 2006). A knowledge of the policy and process used is important to understanding to the procedures used by NSW DPI during declaration assessments.

This paper examines the *Noxious Weeds Act 1993*, the policy for the declaration of weeds and the procedures used by NSW DPI. It also examines the three key components of the process, the operational assessment, the regional plan and the technical assessment using the NSW WRM system. The roll out of the revised process is also discussed.

WHAT MAKES A PLANT NOXIOUS?

Many plants are classified as weeds, particularly when they grow in the wrong place at the wrong time. These are commonly and variously termed noxious weeds, environmental weeds, agricultural weeds, aquatic weeds (see Johnson and Charlton 2009, *these proceedings*, for a definition of some of these weed "labels"). For the purposes of clarity, the term "noxious weed" is used to describe those invasive plant species that have been declared to be noxious weeds under the *Noxious Weeds Act 1993*. This Act does not differentiate between weeds that impact on the environment, primary production or human and animal health.

A plant that causes a negative impact on the economy, community and/or environment of NSW may be considered a candidate for declaration as a noxious weed.

Potential weedy plant candidates must have a reasonable and enforceable means of control.

Declaration of a plant as noxious will result in enforced control. The benefits of this enforced control to all residents of NSW must be considered to see if these outweigh the costs and impacts of enforcing this control.

A plant is declared noxious by the Minister for Primary Industries by a Weed Control Order published in the Government Gazette

NOXIOUS WEEDS ACT 1993

One of the key objectives of the *Noxious Weeds Act 1993* is "to reduce the negative impact of weeds on the economy, community and environment" of NSW. It does this by establishing control mechanisms to:

- (i) prevent the establishment of significant new weeds
- (ii) restrict the spread of existing significant weeds, and
- (iii) reduce the area of existing significant weeds".

POLICY ON THE DECLARATION OF WEEDS

The *Noxious Weeds Act 1993* sets the framework in which NWAC Policy Paper 1, the "Policy on declaration of weeds" operates. The policy sets out the requirements for making submissions for noxious weed declaration and the conditions under which any submission will be processed. Some of these are expanded below but applicants should always refer to the internet for the latest copy of the policy at

http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/legislation

NWAC provides advice to the Minister on all aspects of noxious weed declaration. NWAC generally seek advice on weed declarations before providing a recommendation to the Minister.

Applications for declaration are normally submitted by Local Control Authorities (LCAs) or Regional Weeds Advisory Committees. The NSW Government, members of the community or community groups, or NWAC itself can initiate noxious weed declaration proposals. Consultation with affected LCAs is important.

The weed declaration application form can be found on the following webpage

http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/legislation

While applications can be received at any time of the year, only complete submissions received prior to 30 June will be considered in that year. Incomplete or inadequate applications will be returned for amendment and not considered until complete.

Applications are generally processed in order of Control Class, with Control Class 1 applications given the highest priority, and then in order of receipt. Urgent or Emergency declarations are possible however.

Control Class 1 noxious weed declarations apply to the whole state, while Control Class 2 and 3 declarations apply to a part/s of NSW, that is at least three adjoining LCAs. Only Control Class 4 weeds can be declared for single LCAs.

Any applications for a Control Class 4 noxious weed must be accompanied by a management plan for the species.

All proposed Weed Control Orders are subject to statutory public consultation before they are gazetted.

Approval of a new declaration does not imply the provision of additional funding. The proposing LCA must be prepared to fully resource the declaration.

DECLARATION PROCEDURES

Noxious weed declarations are not made lightly. Declaration imposes costs on the community of NSW and removes their individual freedom of choice in that they will be required to do things they would not normally do, or may be stopped from conducting part of their business. Once a declaration is made, neither the community nor the responsible authorities have any choice about implementing it, they are legally obliged to do so. For these reasons, there must be a net public benefit in the declaration and any proposal is subjected to close scrutiny.

All applications require evaluation of three key components, an operational assessment, a technical assessment (NSW WRM) and a regional plan for the species as discussed below. In addition, all applications must include evidence of consultation with affected stakeholders.

Operational assessment

An operational assessment is conducted by evaluating the following information. Further details can be found in Appendix 1 of NWAC Policy Paper 1. It is important to note that there are only two differences in the revised system when compared to the original system, these being the inclusion of potential distribution and key spread mechanism criteria. Applicants are encouraged to give succinct, factual answers to all criteria, and where appropriate, these should be referenced.

Minimum criteria on which an operational assessment is based include

- **LCA/Proponent name, address and contact details**.
- **Part of NSW** the proposal will affect.
- **Common and botanical names** of the weed (referenced).
- **Current distribution**.
- A valid estimate of **potential distribution**.
- **Key spread mechanisms -** the declaration application must address these.
- **Key problems caused**, that is the weed has, or could have, serious adverse effects on primary production, the environment or human health.

- **Benefits of control**. These must be clearly document and supported by factual evidence.
- **Regulatory need for control**, that is why the provisions of the *Noxious Weeds Act 1993* need to be invoked to bring this species under control. It is important to address why enforced control of the weed is necessary or desirable?
- **Means of control**. There must be a reasonable and enforceable means available to control the weed.
- **Intent of control**. There must be a clearly documented and costed intention by the LCA, or other proponent, to implement a planned program to control the weed, if declared, within their own resources.
- **Current Control Class** (if applicable).
- **Plans or strategies** the LCA participates in / will participate in for this weed.
- **Costs estimates** for Council, Private landowners and State agencies. Control costs need to be reported if the weed was not noxious (as if there was no compliance).
- Details of **stakeholders consulted** and the results of this consultation.

Regional plan
All declaration applications require a management plan provided with the proposal. The management plan has historically been a "stand alone" species-specific plan written for a single purpose. Over time this has changed and the emphasis is now on Regional Weed Management Strategies which provide an overarching strategic management document for a given region. The regional strategy must demonstrate that it was developed with wide consultation of relevant stakeholders.

A species-specific management plan developed to support a declaration proposal must sit under a Regional Strategy; it is actually an implementation plan for a species that implements parts, or all, of the Regional Strategy.

This management plan serves three purposes

- Its development requires consideration of all aspects and potential impacts of the declaration.
- It guides the proponent actions and resource use towards effective management of the weed over a defined period.
- It provides the assessors of the declaration proposal with a statement of intent and shows them that the proponents have fully considered the actions that need to be taken, that the proposal is sound and justifiable and that the proponents know what needs to be done.

What makes a "good" plan is difficult to describe in simple terms; what is "good" for one situation may not be for another. In almost all situations, it is the content that is important, not the format. Quality of information is more important than quantity; keep the information as short at practicable and succinct. However, the following points should be included in any plan supporting a declaration.

- **Background and general facts** – this part should describe the problem, the current distribution and extent of the weed, a brief summary of its biology and ecology and in particular any factors that are peculiar to the area and the plants method of spread including highlighting any spread mechanisms that can be managed under the plan. Note: any detailed information, such as research reports, should be given in Appendices, not in the body of the plan.

- **Considerations and opportunities** – the plan should consider any opportunities that may be exploited including the plants natural weaknesses, funding sources, use of integrated control programs, partnerships and collaboration, and education and extension opportunities.
- **Consultation** – as the proponent, you need to have identified and consulted with stakeholders and document where you have support from these stakeholders. In particular, community ownership of the plan is important so that implementation is as smooth as possible. Note: DPI must subject any proposal for declaration to mandatory consultation so it is important that you, as the proponent, have addressed as many community and industry issues as possible before this process begins.
- **Aim** – your plan must have a clear and concise aim, preferably, a single sentence. This statement does not include any measurable outcomes.
- **Objectives** – these are, measurable and achievable objectives specific to the plan and that can be met within the timeframe of the plan. The emphasis is on <u>measurable</u>, being able to collect information during implementation that clearly shows achievements. Be aware that to measure change, it is important to know what the situation is at the beginning, that is benchmark data.
- **Barriers** – these are issues and situations that must be overcome before the objectives can be met. Remember, you, as the proponent, must be prepared to meet the costs of implementing plan so things like "no noxious weed grant given" are not barriers.
- **Action plan** – describe what you are currently doing and what you will do the meet the objectives. Describe who will do what and what performance indicators will be used to measure success. Remember, you cannot commit anyone to an action unless they are party to the plan.
- **Declaration need** – describe why the declaration is needed, why effective control cannot be achieved without legislation, an agreed enforcement policy (as an Appendix) and how and when enforcement will be used.
- **Monitor and review** – describe how you will monitor success, who will do it, how progress will be reported and what process you will put in place to review the plan.
- **Justification, benefits and costs** – this part allows you to provide a justification for the declaration and the plan. Identify implementation costs and where funding will come from. The plan must demonstrate definite benefits and any cost savings resulting from implementation should be included, these should be measurable and reportable. This part should also provide information about any other weed program that will be reduced or impacted by this plan.

There are a few points that also need consideration when preparing the plan.

Firstly, the people reading it may not have detailed knowledge of the plant or the area the plan applies to. It is essential that the plan has enough information to inform the assessor.

Secondly the plan may become a public document, particularly if it is for a Class 4 declaration. You need to be happy to publish the document and it needs to be technically sound.

Thirdly, declaration by itself has never killed a weed. Declaration is simply a tool that provides an additional means of achieving weed control.

Be prepared to resource and enforce the declaration that you seek, rather than writing a plan to attract grant funds. Remember that this is your plan, and if the declaration is made, you and the community are legally required to meet its obligations

Technical assessment – NSW WRM system
One of the key components in the declaration process is the WRM assessment.

The NSW WRM system uses an objective set of criteria to assess which plants are of greatest concern and to implement action against these plants. This analysis is scientifically rigorous, repeatable and best-practice. For example, the NSW WRM system is consistent with the (Australian) National Post Border Weed Risk Management Protocol (Virtue *et al.* 2006). This protocol is the basis for the post-border WRM systems recommended internationally by the Food and Agricultural Organisation of the United Nations, and has been used to develop WRM systems throughout countries in Central and South America, South-East and Southern Asia, the Middle East and Northern Africa. Additionally, around 90% of all LCAs in NSW currently use some form of Weed Risk Assessment system as a means of prioritising management actions for weed species.

The key elements of the Weed Risk Management system are outlined in Figure 1. Although all stages of the system are important, this paper will focus on three stages, these being ‘Assess weed risks’, ‘Assess feasibility of coordinated control’ and ‘Determine weed management actions’.

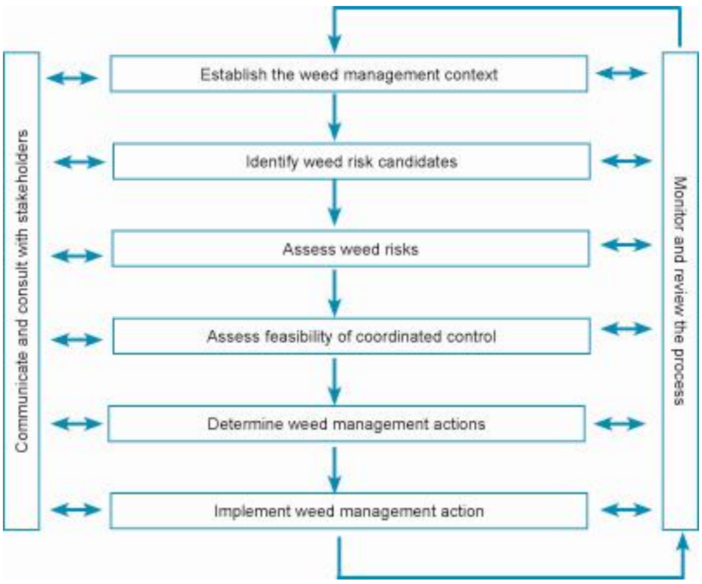

Figure 1. Key elements of the Weed Risk Management System (extracted from Virtue *et al.* (2006).

WRM – assessing weed risks

There are three criteria that are evaluated when assessing weed risk. These are: - the **invasiveness** of a species, that is how likely it is to spread or its rate of spread; the magnitude of the **impacts** the species causes to the economy, environment or community; and the total area at risk of invasion, that is the **potential distribution** of the species if it was allowed to spread unchecked.

A series of multiple choice questions are answered under these three weed risk criteria (Box 1). A score for each criteria is used to calculate a total weed risk score.

Box 1. Weed risk assessment questions in the NSW WRM system

Invasiveness

1. What is the ability of the weed to establish amongst existing plants?
2. What is the weed's tolerance to average weed management practices in the land use?
3. What is the reproductive ability of the weed: time to seeding, seed set and vegetative reproduction?
4. How likely is long-distance dispersal by natural means: flying animals, other wild animals, water and wind?
5. How likely is long-distance dispersal by human means: deliberate, accidental, contaminated produce and domestic/farm animals?

Impacts

1. Does the weed reduce the establishment of desired plants?
2. Does the weed reduce the mature yield or amount of desired vegetation?
3. Does the weed reduce the quality of products, diversity or services obtained from the land use?
4. What is the weeds potential to restrict the physical movement of people, animals, vehicles, machinery and/or water?
5. What is the weeds potential to affect the health of animals and/or people?
6. Does the weed have major, positive or negative effects on environmental health: food/shelter, fire regime, altered nutrient levels, soil salinity, soil stability and soil water table?

Potential distribution

What is the % area of land use that is suitable for the weed?

WRM – assessing feasibility of coordinated control

There are three criteria that are evaluated when assessing feasibility of coordinated control. These are:
the **current distribution**, that is the total area to be treated;
the annual **control costs** required for the infestations, that is cost/unit area; and
the number of years that will be needed to achieve the desired level of control, that is the **duration of control**.

Similar to weed risk, a series of multiple choice questions are answered under these three feasibility criteria (Box 2). A score for each criteria is used to calculate a total feasibility of coordinated control score.

Box 2. Feasibility of coordinated control questions in the NSW WRM system

Control costs

1. How detectable is the weed: distinguishing features, how long shoot growth present, height at maturity and pre-reproductive height in relation to other vegetation?
2. What is the general accessibility of known infestations?
3. How expensive is control in land use: costs for chemical, labour and equipment?
4. Likely level of cooperation from landholders within the land use?

Persistence

1. Effectiveness of targeted control treatments?
2. Minimum time period for reproduction?
3. Maximum propagule longevity?
4. Likelihood of reinfestation?

Current distribution

1. % area currently infested (area of all known plants).
2. Number of infestations and distribution (distinct infestations to be searched and treated).

Appropriate weed management actions can be determined by comparing relative weed risk and feasibility of coordinated control for each weed in the decision support matrix (Figure 2). Detailed management actions that are recommended for a number of the categories in the matrix are outlined (Box 3).

Very high risk/very high feasibility weeds are the first priority for management aiming to **eradicate** the species from the area. As risk and feasibility both decrease, management categories move through **destroy infestations** to **contain spread**. These are medium to very high weed risk and medium to very high feasibility weeds. Management actions are aimed at containing the spread of the weed species in the area. As weed risk and feasibility decrease, management actions move to **protect priority sites**, aimed at preventing the spread of weeds to key sites and assets of high economic, environmental or social value, and to **manage weeds**, aimed at reducing the overall economic, environmental and social impacts through targeted management.

WEED RISK	*FEASIBILITY OF COORDINATED CONTROL*					
	Negligible *(113+)*	Low *(56-113)*	Medium *(31-55)*	High *(14-30)*	Very high *(<14)*	
Negligible *(<13)*	*LIMITED ACTION*	*LIMITED ACTION*	*LIMITED ACTION*	*LIMITED ACTION*	*MONITOR*	
Low *(13-38)*	*LIMITED ACTION*	*LIMITED ACTION*	*LIMITED ACTION*	*MONITOR*	*MONITOR* *PROTECT PRIORITY SITES*	
Medium *(39-100)*	*MANAGE SITES*	*MANAGE SITES*	*MANAGE SITES*	*PROTECT PRIORITY SITES*	*CONTAIN SPREAD*	
High *(101-192)*	*MANAGE WEED*	*MANAGE WEED*	*PROTECT PRIORITY SITES*	*CONTAIN SPREAD*	*DESTROY INFESTATIONS*	*ALERT*
Very high *(192+)*	*MANAGE WEED*	*MANAGE WEED* *PROTECT PRIORITY SITES*	*CONTAIN SPREAD*	*DESTROY INFESTATIONS*	*ERADICATION*	

Figure 2. The decision support matrix used for determining weed management actions in the NSW WRM system.

As weed risk decreases further, management actions move to either **monitor** or **limited action** which aims at targeting the weed only if its presence could result in spread to areas where it ranks as a higher priority.

Species that are unknown in the area and that represent a significant risk are considered in the **alert** management category to the right of the matrix (Figure 2). Management aims at preventing the species from arriving and establishing.

The detailed management actions recommended from the decision support matrix are summarised (Box 3).

Box 3. Detailed management actions recommended for a number of categories in the decision support matrix.

ERADICATION

- Detailed surveillance and mapping to locate all infestations.
- Destruction of all infestations including seed banks.
- Prevention of entry to geographic area, and movement and sale within.
- Must not grow and all cultivated plants to be removed.
- Monitor progress towards eradication.

CONTAIN SPREAD

- Surveillance and mapping to locate all infested properties.
- Control of all infestations, aiming for a significant reduction in weed density.
- Prevention of entry to geographic area, and movement and sale within.
- Must not allow to spread from cultivated plants (if grown).
- Monitor change in current distribution.

PROTECT PRIORITY SITES

- Weed may be of limited current distribution but only threatens limited industries/habitats (lower weed risk), or the weed may be more widespread but is yet to invade/impact upon many key industries/habitats (higher weed risk).
- Surveillance and mapping to locate all infested areas.
- Identification of key sites/assets in the geographic area.
- Control of infestations in close proximity to key sites/assets, aiming for a significant reduction in weed density.
- Limits on movement and sale of species within geographic area.
- Must not allow to spread from cultivated plants (if grown) in close proximity to key sites/assets.
- Monitor change in current distribution within and in close proximity to key sites/assets.

MANAGE WEED

- Research and develop Integrated Weed Management (IWM) packages for the species, including herbicides and biological control where feasible.
- Promote IWM packages to landholders.
- Monitor decrease in weed impacts with improved management.
- Identify key sites/assets in the geographic area and ensure adequate resourcing to manage the weed species.

LIMITED ACTION

- Undertake control measures if required for the benefit of other land uses at risk.
- Otherwise limited advice to land managers if required.

ALERT

- Prevention of entry to geographic area.
- Ongoing surveillance for incursions of the species, for example nursery inspections.
- Training and awareness activities for the community to enable early detection.

PROCEDURES USED BY NSW DPI

The administrative process used by NSW DPI when processing weed declarations is outlined (Figure 3).

Once an application is received, it is initially assessed for completeness, that is that all the necessary information is there. The Technical and operational assessments are performed by the State Weed Control Coordinator and relevant staff.

After both assessments are complete, the paper, with recommendation from NSW DPI is presented to NWAC for consideration and identification of key stakeholders. If the proposal is recommended by NWAC, NSW DPI prepares a draft order that may require key stakeholder consultation before consideration by the Minister. NWAC may make a recommendation that differs from the opinion of NSW DPI. In this case, the Ministerial briefing will address both opinions and include the alternative recommendation from NSW DPI.

Statutory public consultation occurs after the Minister accepts the draft weed control order. NSW DPI reviews and assesses submissions from this statutory process and makes recommendations according to the outcomes. The final draft weed control order is sent to the Minister for approval and gazettal.

It is important to note that the process is sequential and delays at one step delay the whole process.

ROLL OUT OF THE REVISED PROCESS

Training of NSW DPI regional staff and LCA employed project officers occurred during 2008 and early 2009. Training of weed officers in the Northern Inland, North Coast, Mid North Coast, Hunter and Sydney regions has also occurred. NSW DPI anticipate offering training for the NSW WRM system for weed officers and all other interested parties as part of the ongoing NSW DPI Weeds Training Program calendar. The WRM training will be linked to assessment in Conservation and Land Management units of competency. This provides ongoing professional development and capacity building for participating weed officers and land managers across NSW. Further information on the training program is outlined below.

NSW DPI is committed to helping you with the revised process. During the transition period over the business years 2008/2009 and 2009/2010, NSW DPI will receive the submission of declarations using the old or revised process. We have trained NSW DPI regional weed coordinators and LCA project officers to support you in this process. As such we anticipate that after June 2010 declaration submissions will be able to be submitted using the revised process.

REFERENCES

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Management Protocol. Standards Australia, Standards New Zealand and the Cooperative Research Centre for Australian Weed Management. 76 pp.

FOR FURTHER INFORMATION

Further information on the NSW DPI training program can be obtained from

Steven Honeywood
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Gosford Horticultural Institute
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Gosford NSW 2250

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email: steven.honeywood@dpi.nsw.gov.au

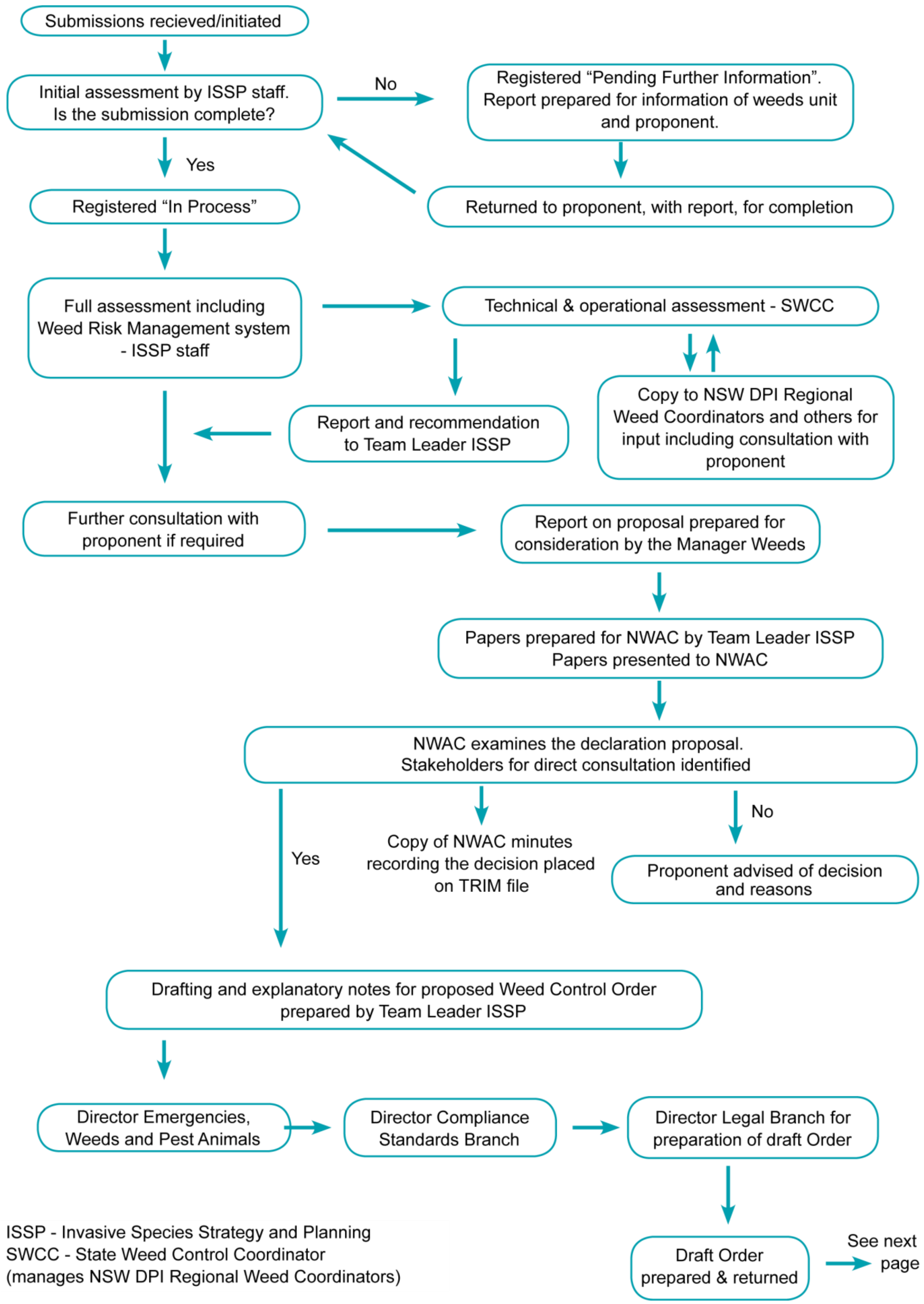


Figure 3. The procedures used by NSW DPI when processing noxious weed declarations.

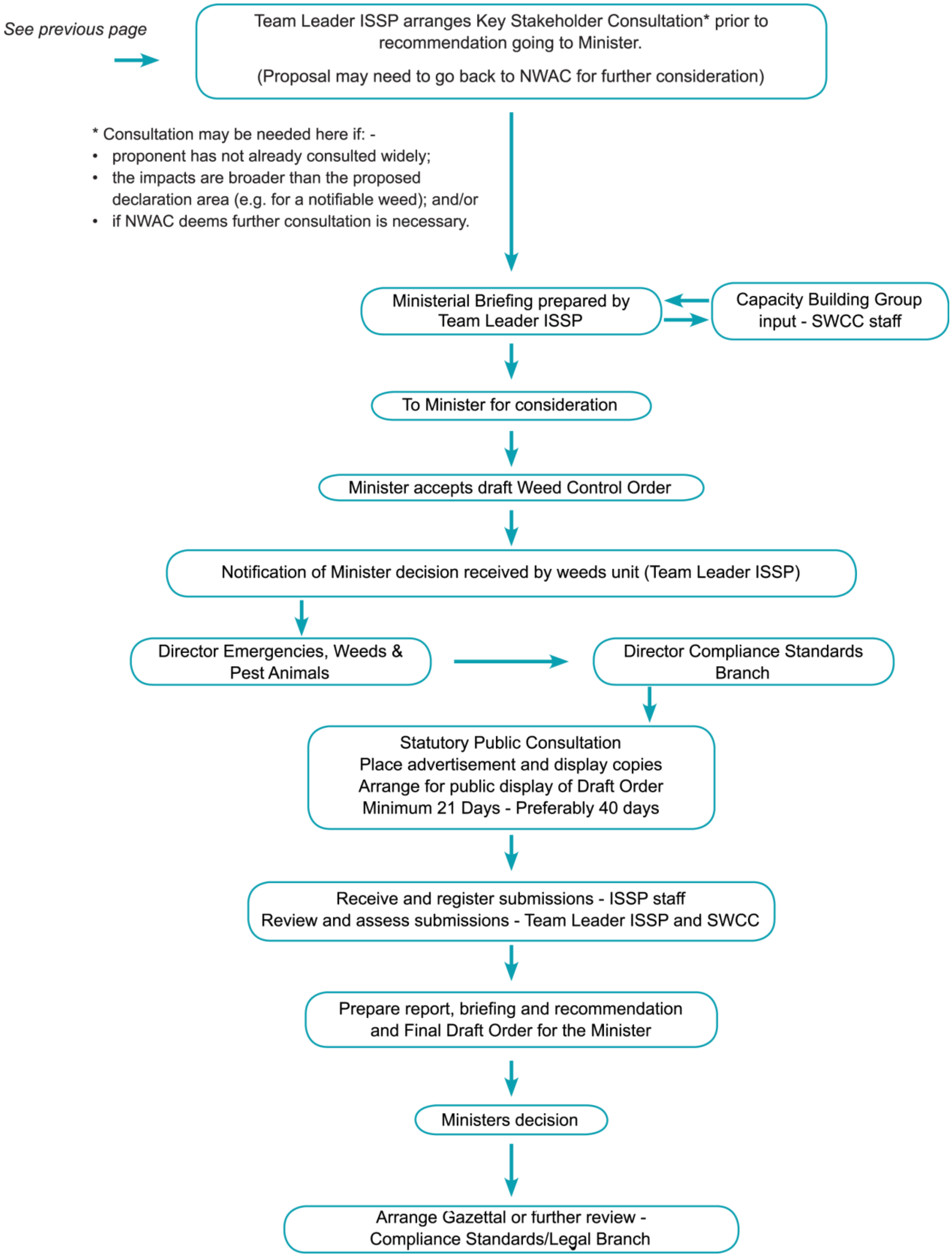


Figure 3 (contd)**.** The procedures for declaration of noxious weeds used by NSW DPI.

MID NORTH COAST WEEDS ADVISORY COMMITTEE INC

"Aboriginal Green Teams"

Mr Wayne Deer
Director Community Development & Health
Chairman, Mid North Coast Weeds Advisory Committee Inc.
Greater Taree City Council
2 Pulteney Street, Taree NSW 2430
www.gtcc.nsw.gov.au

BACKGROUND

- Mid North Coast Weeds Advisory Committee established 1997
- The regional area covers 16,000 square kilometres
- Membership of Committee – wide cross section

  - National Parks & Wildlife Service (NPWS), State Forest (SF), Department of Lands (DL), Department of Primary Industry (PI), Catchment Management Authority (CMA), Roads & Traffic Authority (RTA) and State Rail
  - Councils
  - Livestock Health and Pest Authority (LHPA)
  - Community Representatives
  - Aboriginal Lands Council Representative
  - NSW Farmers Association
  - Conservation Group Representatives
  - MCWAC Regional Weeds Strategy 2008 - 2012

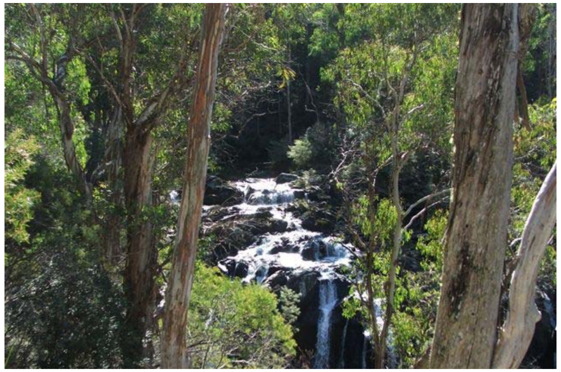
There are five LGA's – Kempsey, Port Macquarie/Hastings, Greater Taree, Great Lakes and Gloucester Shire Council

PHOTOGRAPHS

Each Area

Greater Taree City Council

Great Lakes Council



Gloucester Shire Council

Port Macquarie/Hastings Council

Kempsey Shire Council

VALUE ADDING

(looking outside the square)

- Major impediment to extending work of Mid Coast Weeds Advisory Committee was the lack of resources and funding
- Regional Weeds Strategy identified need to address this issue – 2000
- Looked at opportunities to extend capacity especially in Natural Resource Management areas
- 2003 Discussions with CMA's – timely as this coincided with introduction of Catchment Blue print plans at that time
- Amongst funding criteria was employment for Aboriginal people of the region
- Well established relationships with land holders and land managers through members of Committee and NOW's of each Council
- Submitted first application in 2003 for a Riparian Vine Weeds (Madeira Vine and Cats Claw Creeper) projects in the Nambucca, Macleay and Hastings Councils – NRCMA - $242,800
- Further applications that year were for Vine Weed (Madeira Vine and Cats Claw Creeper) in the Manning catchment – HRCMA - $120,000
    - Wallamba River Honey Locusts – HRCMA - $30,000
    - Aquatic Weeds in Urban Areas – HRCMA - $40,000
- Since 2004 – secured $1,896,000 for a variety of Riparian and Coastal Weeds projects
- All over and above core Noxious Weeds funding and was based on employment of local Aboriginal people in "Green Teams"
- Currently have $2.2m in Caring for our Country applications across our Committees region (Littoral Rainforest restoration, Bitou Bush, Asparagus Weeds, Lantana and Cats Claw biological control
- Also partnering Taree Indigenous Development Employment organisation in Working on Country - $4m over 4 years – Catchment reserves restoration and weeding projects

MNCWAC ENVIRONMENTAL WEED PROJECTS FUNDING

Project Details	**Funding Source**	**Amount**
Riparian Vine Weeds, 2004 Nambucca, Macleay & Hastings catchments	Northern Rivers C.M.A	$242,800 Completed
Invasive Weed Control: Manning Catchment Vine Weed, 2004	Hunter/Central Rivers C.M.A	$120,000 Completed
Invasive Weed Control: Wallamba Honey Locust, 2004	Hunter/Central Rivers C.M.A	$30,000 Completed
Invasive Weed Control: Aquatic Weeds in urban areas, 2004	Hunter/Central Rivers C.M.A	$40,000 Completed
Macleay Vine Weeds Project, 2005	Environmental Trust	$100,000 Completed
Riparian Vine Weeds Project, 2005. Nambucca, Macleay & Hastings Catchments	Northern Rivers C.M.A	$70,000 Completed
Riparian Vine Weeds, 2006. Hastings & Nambucca Catchments	Northern Rivers C.M.A	$50.000 Completed
Hastings Vine Weeds 2005. Hastings and Camden Haven Catchment	Hastings/Camden Haven Catchment Co-ordination Ctte	$14,300 Completed
Wallamba Honey Locust 2006/07 follow-up	Hunter/Central Rivers C.M.A	$15,000 Completed
Riparian Vine Weeds 2006/07 Macleay Catchment	Northern Rivers C.M.A	$85,300 Completed
Riparian Vine Weeds 2006/07 Hastings Catchment	Northern Rivers C.M.A	$20,000 Completed
Riparian Vine Weeds 2006/07 Nambucca Catchment	Northern Rivers C.M.A	$20,000 Completed
Thungutti Lands-Riparian Restoration 2006/07. Macleay Catchment	Northern Rivers C.M.A	$29,000 Completed
Riparian Vine Weeds 2007 Hastings & Nambucca Catchment	Northern Rivers C.M.A	$50,000 Completed
Riparian Tree Weeds 2007/08 Nambucca, Macleay & Hastings Catchment	Northern Rivers C.M.A	$50,000 Completed
Coastal Emerging Weeds, Greater Taree City Council & Great Lakes Council	Hunter/Central Rivers C.M.A	$250,000 Completed
Riparian Vine Weeds, Nambucca, Macleay & Hastings Catchments 2007/08	Hunter Rivers C.M.A	$40,000 Completed
Riparian Vine Weeds Coastal C.M.A's of NSW 2008/09	Hunter/Central Rivers C.M.A Northern Rivers C.M.A	$435,420 Active
Riparian Vine Weeds. Macleay, Hastings & Nambucca	Northern Rivers C.M.A	$25,000 Active
Riparian Environmental Weeds – Manning Catchment 2008/09.	Hunter Central Rivers C.M.A **$1,896,820**	$210,000 Active
Cats Claw Creeper Biological Control 2009/10	Caring for Our Country Control 2009/10	$98,000 Pending
Mid North Coast Littoral Rainforest & Coastal Habitat Link Project 2009/11	Caring for Our Country	$2,133,000 Pending
Mid North Coast Green Teams 2009/12	Working on Country	$4,050,000 Pending

ABORIGINAL GREEN TEAMS

- Initial discussions with local Aboriginal Lands Councils, Elders and interested community members – CDEP program partnership
- Discussion with CMA staff, Council NWO's, NP&WS and Department of Lands – to develop on ground work plans
- Training Plans established – First Aid Certificate, 4W Drive Training, OH&S, Chemical Certificate and Traffic Control
- Certificate II – IV Conservation and Land Management
- Some difficulties – literacy and numeracy skills, drivers license, work culture, supervisory capacity, not suited to all participants
- Advantages – Aboriginal people have affinity with land and natural resource management; full time work; often out performed contractors and social/family benefits

Before, working and after photos

Grazon Treatment

Before

Grazon Treatment

After

Middle Creek 2003

Middle Creek 2008

OUR EXPERIENCE SINCE 2004

- There are six teams located in Nambucca, Muswellbrook, Karuah, Bellbrook, Great lakes and Greater Taree

- NWO direct involvement engaging land holders and establishing teams

- Success – need management input and assistance, administration, grant submission, reporting and financial acquittal.

- Riparian Vine Weeds, Honey Locust, Cats Claw Creeper and Madeira Vine, coastal and emerging weeds, Yuccas, Glory Lily and other succulents, Aquatic Weeds and Spike Rush plus others found in peri-urban areas and garden escapes.

Statistics on work completed by Catchments

Catchment	Area	Length stream bank klms	Area Ha	No: of properties
Nambucca	Burrapine, Thumb Creek, Taylors Arm	39	58	29
Macleay	Upper Macleay River, Middle Creek to Blackbird Flat	56	450	14
Hastings/Camden Haven	Ellenborough, Hastings, Wilson and Camden Haven Rivers	81.6	170.6	43
Manning Great Lakes	Khatumbal Creek, BoBo Creek, Gloucester River, Cureeki Creek, Coolongolook River	39.54	59	15
Hunter	Hunter River at Muswellbrook	1	2	2
TOTALS		**217.14**	**739.6**	**103**

EXTERNAL ENDORSEMENT

Quote from Letter

The project has created employment for a number of community members that in the main have had no ‘wage paying’ employment for a significant number of years.

The Project has had a flow on effect not just for the employees but the whole of community. Such as:
- Young children now seeing and experiencing ‘working’ role models.
- Decrease amongst the group of over use/abuse of alcohol.
- Creating a demand from the general community to increase the project to enable more community members to have an employment opportunity.
- The inherent increase in a quality of life that an income provides.

Tapping into the natural skills of the employees who have a natural skill and desire to undertake the employment for the enhancement of the environment for every ones benefit.

Wesley Mission

SUGGESTIONS

- Reporting to Council on Weeds/Natural Resource Management achievements
- View weeds as part of whole Natural Resource Management issue
- Most NRM projects will have a weed component
- Regional Weed Advisory Committees – require wide cross section of stakeholders with management representation seen as essential in today's climate of competitive grants and the need to deliver outcomes
- Get involved, be supportive and you will see the **Rewards.**

QUESTIONS

WHO IS WHO IN THE WEED MANAGEMENT ZOO?

Sorting out the confusion around weed management in NSW

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SUMMARY
Weed management in New South Wales (NSW) can be likened to a zoo. There are lots of different things to see and do, but to best understand what we are looking at unless we need to be told about each of the animals and why they are important.

Weed management in NSW involves a wide range of stakeholders from the State Government through to private landholders, each with their own objectives and responsibilities. The way we manage weeds is not always clear either, with many weeds labelled as ‘noxious’, ‘environmental’, ‘agricultural’, or with no label at all. This range of stakeholders and management approaches results in confusion.

This paper outlines the roles and responsibilities of all stakeholders and how they fit together under the NSW Invasive Species Plan. It examines the various categories we put weeds into and the management approaches used.

We contend that all weed management in NSW can be broken into one of four broad management categories along an invasion continuum, these being prevention, eradication, containment and asset protection (see Charlton *et al*. 2009, these proceedings). NSW Department of Primary Industries has developed the NSW Weed Risk Management system to help determine where plants are best placed along this continuum. Aiding this, the NSW Department of Environment and Climate Change have developed the Weeds Impact to Native Species (WINS) assessment tool and triage approaches to prioritise the protection of environmental assets.

Confusion in weed management responsibilities, approaches and objectives results in poor coordination and compromises the best outcomes possible. By providing a common understanding of the roles and responsibilities of weed management stakeholders, and by explaining various management approaches and weed categories we seek to eliminate some of this confusion thus improving regional weed management.

INTRODUCTION
Good zoos and botanic gardens provide interpretive signage and literature so that people know what you are looking at and why what they are looking at is important. This paper attempts to interpret the weed management “zoo” in New South Wales (NSW) by explaining the roles and responsibilities of the various stakeholders under the NSW Invasive Species Plan (NSW Government 2008). It also clarifies the confusion around the current trend to categorise weeds and weed management approaches.

A BRIEF LOOK AT THE ANIMALS IN THE ZOO – NSW WEED MANAGEMENT STAKEHOLDERS

There are many animals in the weed management zoo in Australia and in NSW. The lead agencies include the Australian and NSW governments through NSW Department of Primary Industries (DPI). Other government agencies are also involved including the NSW Department of Environment and Climate Change (DECC), NSW Department of Lands (DoL), Catchment Management Authorities and Local government. Land holders, land occupiers and the general community also have an important part to play. The following section contains a brief look at these zoo animals.

Who sets the direction we all head in?

The Australian state, territory and Commonwealth governments set the direction for weed management in Australia. This is outlined in Australian Weeds Strategy (Australian Government 2007). This strategy was developed by the **Australian Weeds Committee,** which sits under the auspices of the Natural Resource Management Ministerial Committee (NRMMC). The NSW Minister for Primary Industries is one of the NRMMC members.

The NSW government sets the direction for weed management in our state through the **NSW Invasive Species Plan** 2008-2015 (NSW Government 2008). The Invasive Species Plan is consistent with the Australian Weeds Strategy and was developed to improve the management of all invasive species in NSW, whether terrestrial, aquatic or marine plants, vertebrates and invertebrates.

NSW Department of Primary Industries (NSW DPI)

NSW DPI is the lead agency for weed management and the implementation of the Invasive Species Plan in NSW. NSW DPI is principally responsible for recommendations to the **Minister for Primary Industries** on all aspects of legislative, policy, technical, state coordination, education and training for weed management. NSW DPI enacts legislative management of weeds through the ***Noxious Weeds Act 1993***.

NSW DPI provide administrative support for the **Noxious Weeds Advisory Committee (NWAC)**. The Minister also obtains advice and recommendations from NWAC.

NSW DPI are partnered by local government as they undertake operational responsibility for the Act. The NSW State Government provides funding to various stakeholders including local government, and other state agencies with land management responsibilities, for example Department of Lands.

NSW Department of Environment and Climate Change (NSW DECC)

NSW DECC develops and implements management strategies for invasive species on lands managed under the ***National Parks and Wildlife Act 1974***. This includes national parks, nature reserves, historic sites, aboriginal areas, state conservation areas and regional parks. NSW DECC also develops, coordinates and reports on state wide initiatives to reduce the impact of weeds on biodiversity. Such initiatives include **Threatened Species Priority Action Statements** and individual species **Threat Abatement Plans** (TAPs) through the ***Threatened Species Conservation Act 1995***.

Funding for these programs comes from a variety of sources including the State and Federal governments.

NSW Department of Lands (NSW DoL*)*

The DoL is the largest land manager in NSW administering approximately half the state as **Crown land**. They develop and implement invasive species management strategies on this land, as well as supporting activities by community groups and stakeholders that manage land on their behalf.

Catchment Management Authorities (CMAs)

Catchment Management Authorities facilitate the **management of all natural resources** within catchment regions. In this role, they have national responsibilities on managing and reporting on a wide range of Natural Resource Management (NRM) targets. This necessarily involves fostering cooperation, coordination and capacity building of all land managers to achieve the best on-ground outcomes. CMAs do not have a defined legislative role in the control of invasive species but play an important supporting role in providing a link between lead agencies, local government and other land managers.

The 13 CMAs across NSW prepare **Catchment Action Plans (CAPs)** to achieve a wide range of NRM outcomes. These CAPs may incorporate targets concerning the control of invasive species, including weeds. They provide government funding to various stakeholders to help achieve their CAP targets.

Local Control Authorities

Local Control Authorities (LCAs) are generally either the local government for the area, a county council which groups of neighbouring local government areas, in the case of Lord Howe Island, the Lord Howe Island Board, or in western NSW, the Western Lands Commission. LCAs are responsible for the **implementation of noxious weed control** under the *Noxious Weeds Act 1993*. This includes all **operational aspects** such as **enforcing** the Act, conducting **inspections** and controlling weeds on LCA managed lands. It also involves developing **weed strategies and policies**, and providing education, training and resources for both the public and staff.

Weed management is one of the key NRM issues facing local government. For example, a survey by the Local Government and Shires Association (LGSA) in 2008 revealed that weed management was the equal third highest priority NRM facing 23% of respondents (LGSA 2008). Weed management funding is sourced from the annual LCA operational budget <u>and</u> a wide range of state and federal agencies programs. Over 78% of respondents also relied on environmental levies for funding (LGSA 2008).

The Landholder or land occupier

Landholders and land occupiers are responsible for the **control of invasive species**, including weeds **on their land**. They have additional responsibilities if the weed has been declared noxious under the *Noxious Weeds Act 1993*.

Community organisations and special interest groups
Community organisations and special interest groups including Landcare, Dunecare and Coastcare have an important role to play in invasive species management in NSW. For example, 1082 Landcare groups in NSW are actively involved in weed control (Landcare Australia 2009). Individuals in all organisations and special interest groups provide thousands of hours each week assisting on in private and public lands through **control, monitoring** and in **other support** roles.

WHAT MAKES A PLANT A WEED AND WHY ARE THERE SO MANY CATEGORIES?

Two simple definitions of a weed
From a human point of view, a weed is simply a plant growing in the wrong place at the wrong time. Such plants generally have some negative effect or impact. In more specific terms, a weed is a plant (which may be native) that grows in a place where it is not wanted and usually has economic, environmental or social (community) effects (modified from Richardson *et al.* 2000).

Defining a noxious weed
Noxious weeds are more than just "really bad weeds", rather the term 'noxious weed' is a descriptive title for a legal definition (Blackmore 2008). Weeds are declared noxious by the Minister for Primary Industries under the *Noxious Weeds Act 1993*.

A plant that causes a negative impact on the economy, community or environment of NSW may be considered a candidate for declaration as a noxious weed. In saying this, potential weedy plants candidates must have a reasonable and enforceable means of control.

A noxious weed is any plant declared noxious by the Minister for Primary Industries under the *Noxious Weeds Act 1993*.

Noxious weeds generally have not yet arrived in the state, have arrived but are restricted in distribution or are more widespread but could still continue to spread.

It is also important to remember that declaration of a plant as noxious will result in enforced control. The benefits of this enforced control to all residents of NSW must be considered to see if these outweigh the costs and impacts of enforcing this control.

Defining an environmental weed
An environmental weed is a introduced or native plant that invades natural vegetation, usually adversely affecting native biodiversity and/or ecosystem functioning (modified from Richardson *et al.* 2000). It is important to note that for a native species to be classified as an environmental weed, it must not be native or indigenous to the area under consideration (even if it is native to another area in Australia).

There are currently 68 weeds that have serious environmental impacts and 20 weeds that have both environmental and primary production impacts declared noxious under the *Noxious Weeds Act 1993*.

88 weeds declared noxious in NSW have environmental impacts.

Only 25% of the 341 environmental weeds identified by Downey *et al.* (2009) are declared. This means that many environmental weeds are not under official control. This is also the case with those weeds listed under the *Threatened Species Conservation Act 1995.* The overcome this issue, best management approaches for the most significant of these species are under consideration by the NSW Government.

Defining an agricultural weed

An agricultural weed can be similarly defined as any introduced or native plant species that invades an agricultural ecosystem, usually affecting economic returns and/or the functioning of agricultural systems.

Weeds that affect society (the community, human health and culture)

Weeds may cause a wide range of impacts on society, particularly when they impact the community, human health and/or culture. For example, many trees in urban areas damage buildings, roads and footpaths, while trees (Willows), aquatic grasses (Hymenachne) and weeds (Giant reed) can damage bridges during flooding. A range of aquatic weeds including salvinia and water hyacinth and terrestrial weeds including lantana and blackberry hamper recreational activities. Other impacts include human health effects, for example Pellitory and Privet species causing breathing complaints, allergies caused by touching Rhus tree, and damage to cultural heritage sites or tourism caused by weeds. These weeds are classified as societal weeds and their true economic effects can not be accurately calculated in many cases.

Weeds with multiple impacts

Some weed species have the potential to impact the environment and/or primary production and/or human health.

In recognition of this, the objectives of the *Noxious Weeds Act 1993* are "to reduce the negative impact of weeds on the economy, community and environment" of NSW. This indicates that this legislation has a far broader scope than managing only agricultural weeds, despite any historical or widely held perceptions.

Declared noxious weeds impact primary production, the environment and the community. For example, Johnson and Downey (2008) found that over one third (37%) of all noxious weeds were principally managed for environmental outcomes, 50% were managed for their impact on primary production, while 11% were managed for both purposes. Less than 3% of all weeds were declared for human health purposes.

Some stakeholders have a narrow focus on the particular group of weeds they are concerned with, for example weeds that impact environmental values. Their justification for this approach is that they have specific outcomes to achieve, for example environmental targets. Such exclusive approaches can be ineffective for several reasons. For example, with such a narrow focus, some weeds that have the potential to impact their final outcomes will inevitably be missed. Secondly, succession of weeds often takes place if revegetation does not occur. A more holistic approach to weed management on a landscape scale is needed to avoid this. Lastly, fragmentation of weed management effort often occurs with poor coordination with other stakeholders at a regional scale leading to both duplication and failure to treat the highest priority weeds in a timely manner.

The use of such terms as ‘noxious’, ‘environmental’ and ‘agricultural’ as mutually exclusive classifications is limited. We suggest that use of the word noxious be retained and the use of the terms such as ‘environmental’ ‘agricultural’ and ‘primary production’ to describe weeds be discouraged. If categorisation is needed we suggest defining weeds based on the impacts they cause, for example ‘weeds that impact the environment’ or ‘weeds that impact the environment and primary production’.

FOUR WEED MANAGEMENT CATEGORIES

All weed management activities in NSW can be classified into one of four categories, **Prevention**, **Eradication**, **Containment** and **Asset Protection**. These four categories can be thought of in a similar way to the invasion process of a weed species from before arrival through to widespread establishment (Figure 1).

Prevention is aimed at preventing new weed species from arriving.

Eradication is aimed at removing newly arrived and naturalised weeds (all plant material) where this is achievable.

Containment is aimed at reducing the spread and/or severity of established weed infestations using defined geographic boundaries. Eradication is not feasible.

Asset protection is aimed at protecting assets from the impacts of established weed species. Assets may be of an environmental, primary production or community (human health, cultural or neighbours) nature. Control in areas with no defined assets is a low priority.

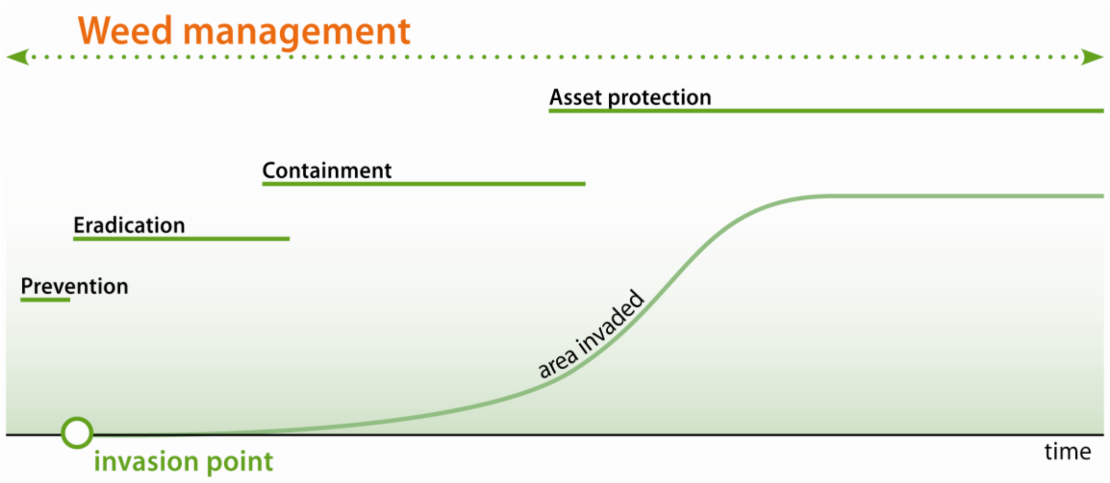

Figure 1. All weed management categories can be classified into one of four categories. These four categories can be thought of as an invasion process from before arrival to widespread establishment (from Charlton *et al.* 2009).

SPECIES-LEAD VERSUS SITE-LEAD WEED MANAGEMENT

The difference between species- and site-lead weed management approaches is one of management focus. Species-lead weed management attempts to manage a particular weed species and all individuals of that species. In contrast, site-lead management aims at management at a particular site or sites and does not aim to treat all individuals of the weed species.

Species-lead weed management approaches generally apply when management is aimed at prevention, eradication and containment, whereas site-lead approaches generally apply when management is aimed at containment and asset protection.

Species-lead approaches

Species-lead weed management approaches generally aim to prevent, eradicate and contain weed species. Decision support systems are used to prioritise which species need to be targeted at a national, state/territory and regional level (Virtue *et al.* 2006). Weed Risk Assessment and Management systems provide standard, accepted and transparent processes to help make decisions about the introduction, prioritisation, declaration and management of weed species (Johnson 2009). They rely on a risk management approach where weed risks are identified, analysed, evaluated and then treated (Virtue *et al.* 2006). There are key differences in the approaches and systems used by Biosecurity Australia and the NSW government. These differences are outlined below.

The Weed Risk Assessment (WRA) process used by Biosecurity Australia is an analysis tool for quarantine risk and determines the weed potential of proposed new plant imports (Australian Government 2009). It applies at a National level and operates before plant introduction into Australia helping in prevention or pre-border management. It is a species-lead approach.

The NSW Weed Risk Management (WRM system) is a post-border analysis and prioritisation tool. It assesses and priorities weeds once they have arrived (post-border). It is usually applied at a State or regional level but can be applied can be applied at all levels from specific sites, to local and to national scales to prioritise weeds for eradication, containment and asset protection purposes (Johnson 2009, Figure 2). Although the NSW WRM system aims at eradication, containment <u>and</u> asset protection, it is a species-lead approach.

The NSW WRM system

The NSW WRM system can be used to assess the **weed risk** and the **feasibility of coordinated control** of any plant species that impacts on primary production, the environment and the community. Weed risk is assessed by considering the invasiveness, impacts and potential distribution of the plant while feasibility is assessed by considering the control costs, persistence and current distribution. Separate assessments for each species occur.

Figure 2. Aims of the weed management principles outlined in the NSW WRM system.

Alert - prevent the species arriving and establishing in the area; or

Eradication - remove the weed species from the area; or

Destroy infestations - significantly reduce the extent of the weed species in the area; or

Contain spread - prevent the ongoing spread of the weed species in the area; or

Protect priority sites - prevent the spread of the weed species to key sites/assets of high economic, environmental and/or social value; or

Manage weed - reduce the overall economic, environmental and/or social impacts of the weed species through targeted management; or

Manage sites - maintain the overall economic, environmental and/or social value of key sites/assets through improved general weed management; or

Monitor - detect any significant changes in the species' weed risk; or

Limited action –targeting of weed species for coordinated control in the area only if its local presence makes it likely to spread to land uses where it ranks as a higher priority.

Site-lead approaches

Site-lead weed management approaches aim for: -

- the containment of weeds to specific sites, for example the National containment lines for Bitou bush, Boneseed and Lantana; and
- the protection of environmental assets using a site selection process where all weeds are managed, for example the Bitou bush Threat Abatement Plan (TAP, DEC 2006).

A triage approach for managing environmental assets threatened by a single weed species follows. Having said this, this system has the potential to assess sites for the threat posed by many different weeds and is a site-lead approach. A system for selecting managing non-environmental assets is yet to be established.

The triage approach for managing environmental assets

Widespread weeds have the greatest impacts on primary production, the environment and the community. Although the NSW WRM system allows prioritisation of weed species to identify the need for asset protection, and gives some general management principles for it, it is not specific enough to allow the prioritisation of individual assets.

Environmental asset identification and protection can be achieved by an alternative triage approach (NSW DECC & QLD DPIF 2009). This two-stage approach allows for the assessment, prioritisation and management of environmental assets. Although it determines the best sites to manage for asset protection purposes as well as sites for weed control, and is usually applied at a State, regional and local level, it can be applied levels ranging from a collection of sites up to a nation. The triage approach uses the Weed Impact to Native Species (WINS) assessment tool (Downey 2006) and a site ranking process.

The (WINS) assessment tool consists of four stages: -

(i) a literature review;
(ii) "collation and assessment of the knowledge from land managers, ecologists and botanists with specific involvement" in managing the weed;
(iii) an evaluation of the interim species or ecological communities at risk from the weed; and
(iv) ranking the revised list to determine which native species or ecological communities require protection (NSW DECC & QLD DPIF 2009).

The fourth or ranking stage identifies native species or ecological communities most likely to increase in threatened status in the short term (high priority), those that are under significant threat (medium priority) and those that are likely to persist with limited action in the short term (low priority). This is done by determining the extent to which the threatened species or ecological community distribution overlaps with the distribution of the weed, and the status of the species or community under threatened species legislation. This results in a rank of the **current level of threat to the asset**.

The fourth stage also includes a ranking system based on the likelihood of achieving successful weed control as well as the recovery of the high priority environmental assets (NSW DECC & QLD DPIF 2009). This process has similarities with assessing the feasibility of coordinated control approach recommended in the National Post-Border WRM Protocol (Virtue *et al*. 2006, and found in Johnson (2009)) although the post-border system is not generally applied to a specific site. An assessment of the ability to achieve weed control is similar to both systems as is an assessment of the impacts of the weed (although this is assessed in the weed risk section in the Protocol). Three other criteria are assessed by the NSW DECC & QLD DPIF (2009) approach, these being the condition of the environmental assets present (age structure of species), the site importance (population distribution of the species at risk) and the presence of other threats to biodiversity. An additive score with two criteria weighted determines a rank of the **probability of protecting the asset at a specific site** via weed management.

A decision or triage matrix comparing the current level of threat to the asset to the probability of protecting the asset at a specific site is applied (Figure 3). In this case, No. 1 sites (high probability of protection and high threat) are the most important sequentially through to No. 9 sites (low probability of protection and low threat site importance) being the least important. High probability of protection and high threat sites (No. 1 sites) may be further ranked within the group to ensure that the greatest variety of sites are protected (NSW DECC & QLD DPIF 2009).

Probability of protecting the asset at a specific site

Current level of threat to asset	High	Medium	Low
High	**1** – Weed management is critical, immediate, targeted and if long-term is likely to result in biodiversity recovery	**2** - Targeted management action needs to occur promptly and long-term	**5** - Broader management with other restoration (specific to assets) or reduce weed spread
Medium	**3** - Targeted management to minimise the threat over the long-term	**4** - General management to reduce the impact of lantana	**6** - General low level management to reduce the threat
Low	**7** - Actions to minimise the threat and prevent further elevation of the problem	**8** - Low level of management only	**9** - No immediate action, management action required only after completion of higher priorities

Figure 3. A decision support or triage matrix to protect threatened biodiversity sites from the strategic management of widespread weeds. Modified from NSW DECC & QLD DPIF (2009).

What is the difference between the NSW WRM and WINS Assessment tool?
While the NSW WRM system seeks to determine the weed risk and feasibility of coordinated control of individual plant species so that any potential impacts are lessened (species-lead), the triage approach identifies at risk environmental assets and then prioritises sites for management (site-lead).

While the two systems are used to prioritise weed management actions at different locations for different purposes, they lie along the same management continuum (Figure 1). Ideally, the triage system for environmental weeds, and a similar system that identifies and prioritises agricultural and societal assets, can used in conjunction with the NSW WRM system. In particular, such triage systems identifying key sites and assets are needed to progress the **protect priority sites** and **manage sites** management principles in the NSW WRM system into weed management actions (Figure 2).

SO WHICH WEED PRIORITISATION TOOL/S SHOULD WE USE?

Choice of the weed prioritisation/risk management tool used is a decision for individuals and regional/stakeholder groups. A number of factors influence this including: -

- the overall goals of the weed management program;
- the area in which you work;
- the stakeholders (those who benefit and those who pay);
- the policy and legislation that affects the decisions;
- what resources are available, what outputs are desirable, for example, a 50% reduction in new weed incursions in the next 10 years; and
- what outcomes need to be achieved, for example a regional list of priority weeds for coordinated control programs or an investment strategy for protecting biodiversity from weeds (Virtue *et al.* 2006).

The Randall system (Randall 2000) is popular among many local government and Catchment Management Authorities (CMA) across NSW, for example the weed strategies for the Lower Murray Darling and Sydney Metropolitan CMA's (Verbeek and Ash 2006 and Sydney Weeds Committees 2007, respectively).

The Randall system is one of many prioritisation systems. Other systems include the South Australian Weed Risk Management system (Virtue 2004) and Victorian Weed Risk Assessment systems (VIC DPI 2008). These state weed risk systems are consistent with the National Post-Border WRM Protocol (Virtue *et al.* 2006).

NSW DPI has developed the NSW WRM system to be consistent with the National Protocol (Johnson 2009, Johnson and Lisle, these proceedings). The NSW WRM system will be used to determine the legislative status of both declared and undeclared plants, as well as identifying and allocating research and limited management resources.

CURRENT USE AND FUTURE ROLL OUT OF THE NSW WRM SYSTEM

There is a limited degree of similarity between the NSW WRM and Randall systems (Johnson 2009). For example, while weed risk (invasiveness and impacts) is assessed similarly, the Randall system does not account well, or at all, for the potential distribution of the weed (an important component of weed risk), and all aspects of feasibility of coordinated control (control costs, persistence and current distribution). Use of the NSW WRM system will help prevent duplication of weed prioritisation and risk assessment efforts by local government and regional weed management stakeholders. Increasingly the duplication of using the Randall system for regional prioritisation and then the NSW WRM system to seek declaration will decrease.

At request from the regional weed management committees, NSW DPI has trained local government staff from five regions in the use of the NSW WRM system, these being the Hunter, the Mid North Coast, the North Coast, the Northern Inland and the Sydney region. In addition, training of NSW DPI Regional Weed Coordinators and Regional Project Officers employed by local government has occurred. The Hunter and Northern Inland regional weed committees are currently using the NSW WRM system. NSW DPI will integrate the NSW WRM system into the NSW DPI Weeds Training Program from 2009.

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Dr Paul Downey from the NSW Department of Environment and Climate Change provided information and helpful comments in the development and writing of this paper. Dr John Virtue of South Australia Department of Water, Land and Biodiversity Conservation also provided useful information for parts of this paper. Some information on roles and responsibilities of the various agencies was drawn from NSW Government (2008).

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HUDSON PEAR – COMING TO A PLACE NEAR YOU?

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SUMMARY
Hudson pear are branched shrub cacti with cylindrical green segments and spines 3-6 cm long. The common name includes the species *Cylindropuntia rosea* and *C. tunicata*, differentiated by flower and spine characteristics. This document examines the biology and management of these species.

The predominant species in Australia, *C. rosea*, infests 60 000-111 000 hectares around the opal fields of north western New South Wales. Smaller infestations occur in all mainland states except Victoria (Vic), whereas *C. tunicata* has only been recorded in NSW, Vic and South Australia.

Hudson pear reproduces vegetatively when plant parts come in contact with the ground. Seed production is not a significant source of reproduction because only *C. tunicata* produces viable seed. Vegetative material is dispersed when the plants spines attach to vehicle tyres allowing distribution over wide areas. Vegetative material is also transported in vehicles and on a variety of animals, people, and by water.

Hudson pear has significant negative economic and environmental impacts. The plant restricts movement by causing injury to people and animals with its large number of long sharp spines. Fragments of the detachable papery sheath that surrounds the spine often remain embedded after spine removal causing infection. The weed physically restricts animal production by inhibiting livestock movement and mustering.

Eradication is not possible because plants are spread over a large area and it is difficult to find and treat all vegetative segments. Management using chemical control is often made difficult by the types of terrain and vegetation in which infestations occur. For this reason, it is important to implement an integrated control approach. This will include herbicides to contain small outlying infestations, the introduction of effective biological control agents on core infestations, along with measures to prevent the further spread of the species.

INTRODUCTION

This paper outlines the basic biology and management of the two Hudson pear species *Cylindropuntia rosea* and *C. tunicata*. The most common of these species is *C. rosea* which is widespread throughout the opal fields of north western New South Wales (NSW) and has been found in scattered locations throughout mainland Australia. The other species, *C. tunicata*, is also found in north western NSW but is uncommon elsewhere in Australia.

Cylindropuntia rosea

Cylindropuntia rosea is a branched shrub cactus with a cylindrical trunk and although many plants are low growing, some reach 1.6 m high and to 3 m wide (Figures 1 and 2). The stem segments are rope-like, cylindrical, green to grey-green, up to 90 cm long and 4 cm wide (excluding spines). The tubercules (stem projections) are


Figure 1 and 2. *Cylindropuntia rosea* near Lightning Ridge, north western NSW. Figure 1 (left) growing on lighter stony red earths (Source: S. Johnson, NSW DPI). Figure 2 (right) Dr John Hosking with flowering *Cylindropuntia* rosea on heavier clay soil(Source: M. Goodwin, Walgett Shire Council).

Figure 3. (a) *Cylindropuntia rosea* in flower with pink-purple flowers and long white spines (left) and (b) *Cylindropuntia tunicata* in flower with pinkish yellow flowers and straw-coloured thorns (right) (Source: J. Hosking, NSW DPI).

Figure 4. The fruit of (a) *Cylindropuntia rosea* (left) and (b) *Cylindropuntia tunicata*. (right) (Source: (a) J. Hosking, NSW DPI and (b) R. Chinnock, State Herbarium of South Australia).

pronounced, elongate, up to 3 cm long and 1 cm wide, while the aeroles (small depressions on the tubercle) are elliptic, 3–7 mm long, c. 3 mm wide, with tan-coloured wool and clusters of yellowish-tan glochids (smaller barbed bristles), 1.5–2.5 mm long. There are generally 4-8 spines (up to 20 on older stems) that are white to silvery and 4.5 cm long on outer segments. Each spine has a sheath that is white, papery and that separates during the first year of development.

The flowers of *C. rosea* have pink-purple petal-like segments and are about 5 cm wide (Figure 3a). The fruit of the species are solitary, never forming chains, obovoid (wider towards the apex) ripening yellow, and 2–4.5 cm long (Figure 4a), with older fruits having fewer spines than younger ones. Seeds are not developed in this species.

Cylindropuntia tunicata

Cylindropuntia tunicata is a densely branched shrub cactus usually without a trunk, with older plants growing to 0.3–0.6 m high (Figure 5). The stem segments are rope-like, cylindrical, pale green to green, 5–20, sometimes to 25 cm long and 1.5–2.5 cm wide. The tubercles are prominent, 2–3 cm long while the areoles are round to elliptic, 4.5–8 mm long, 2.5–5 mm wide, with a yellow-tan wool aging to white or grey and clusters of pale yellow glochids 0.5–1.2 mm long. There are 5 and 12, yellow-, straw- or tan-coloured spines arising from most areoles. These are 3–6 cm long. The spine sheath is yellow- to tan-coloured.

The flowers of *C. tunicata* have yellow, yellow-green or yellow-pink, petal-like segments and are about 4 cm wide (Figure 3b). The fruits are solitary, never forming chains, obovoid, ripening yellow, yellow-green or yellow-brown, often tinged red, 2.5–5 cm long and 0.8–1.5 cm wide, spineless, or with a few spines (Figure 4b). Light tan, oval-shaped seeds are produced that are 2.5 mm long and 2 mm wide.

While this species is commonly known as thistle cholla in the United States of America (USDA, NRCS 2008) and in Victoria (Vic) (DPI VIC 2008), it is often referred to as Hudson pear in the opal fields area of NSW. This is mainly due to the resemblance of this species to *C. rosea* when vegetative.

Differences between *Cylindropuntia* species

Although both *C. rosea* and *C. tunicata* occur in north western NSW, they can be distinguished by floral and spine characteristics (for example Botanic Gardens Trust 2008, Figures 3 and 4). For example, *C. rosea* has pink-purple flowers in comparison to the yellow, yellow-green, to yellow-pink flowers of *C. tunicata* and the spines of *C. rosea* are white compared to the yellow-, straw- or tan-coloured spines of *C. tunicata*.

Cylindropuntia rosea and *C. tunicata* may also be confused with other naturalised *Cylindropuntia* spp. in Australia, particularly *Cylindropuntia imbricata*, a species with pink-purple flowers but with more rope-like segments that are, in general, not as wide as those of *C. rosea*. There may also be some confusion with *Cylindropuntia kleiniae*, *Cylindropuntia prolifera* and *Cylindropuntia spinosior*. These species all have features that differ from *C. rosea* and *C. tunicata* and are described at Botanic Gardens Trust (2008).

HISTORY

Both *C. rosea* and *C. tunicata* are native to Mexico. The original introductions of *C. tunicata* and *C. rosea* to north western NSW probably occurred in a cactus nursery/collection at Grawin. It is likely that the species either spread from here or from plantings originating from here during the late 1960s (Holtkamp 2006, L. Tanner pers. comm.). *Cylindropuntia rosea* was considered of little concern in the early 1970s as it only infested a small area at Grawin (L. Tanner pers. comm.).

The earliest NSW herbarium specimens of *C. rosea* were only collected in year 2000 with accurate identification in 2003 (Hosking *et al.* 2003, 2007). In contrast, the species was first collected in Queensland in 1973, while in Western Australia it was collected in 2002, in South Australia (SA) in 2005 and in the Northern Territory in 2007.

The earliest NSW herbarium specimens of *C. tunicata* in NSW were collected in 2003 with accurate identification also in that year. In contrast, the earliest recording of the species is from SA in 1980 (Kloot 1986) while in Vic the species was first recorded at Mittayack (Hosking *et al.* 1988) with a later specimen collected from Natya in 1994 (Stajsic and Carr 1996).

CURRENT DISTRIBUTION

Cylindropuntia rosea has been recorded in north western NSW, SA (from the Flinders Ranges south to Morgan), WA, the NT and Qld (Figure 6a).

In NSW, this cactus has naturalised on the north western slopes and plains and major infestations occur around the opal fields of Lightning Ridge, Grawin, Glengarry and in the Cumborah area. Current estimates of areas heavily infested by this cactus range from 60 000 to 111 000 hectares, although scattered plants are likely to be found throughout a much larger area, potentially up to 458 000 hectares (Holtkamp 2006, Walgett Shire Council 2008). Smaller infestations in NSW around Brewarrina, at the 'Five ways' south east of Coonamble, and Goodooga have also been reported. Continued spread occurs in opal mining areas where the weed is spread by vehicles and general mining activity. Measures to rehabilitate these sites after mining activities cease, for example the removal of weeds, rarely takes place (Braysher 2005).

In contrast, the only naturalisations of *Cylindropuntia tunicata* in NSW occur around the Grawin opal fields and appear to be near original plantings of the species (Hosking *et al.* 2007, Figure 6b). In addition, naturalisations of *C. tunicata* occur in Vic and SA (Australia's Virtual Herbarium 2008).

NATURALISED RANGE OUTSIDE AUSTRALIA

Cylindropuntia rosea has naturalised in Spain (Sanz Elorza *et al.* 2004) and South Africa (H. Zimmerman pers. comm.) while *C. tunicata* appears to have naturalised in Chile and Ecuador (Anderson 2001, Pinkava 2004), South Africa (Hosking *et al.* 2007) and Spain (M. Sanz Elorza pers. comm.).

CLIMATE AND SOIL REQUIREMENTS

Both *Cylindropuntia* species grow in areas of north western NSW receiving 400–500 mm of mean annual rainfall (summer dominant) and with mean monthly temperature ranges of maximum 17–36^{o}C and minimum 4–22^{o}C. In contrast, the species have

Figure 5. *Cylindropuntia tunicata* with fruit. (Source: J. Hosking, NSW DPI).

Figure 6. Australian distribution of (a) *Cylindropuntia rosea* (left) and (b) *Cylindropuntia tunicata* right), from Johnson *et al.* (2009). (Mapped by A. Maguire, NSW DPI).

established in far drier conditions in the NT, SA, WA and Vic (250–350 mm of mean annual, winter dominant rainfall).

In NSW, the species commonly grow on the lighter, stony, red earths, often found on slightly raised ridges (Figure 1) off the surrounding heavy and deeper grey clays of the riverine floodplains (Figure 2). The species also grow on red-brown, brown and calcerous loam soils.

GROWTH AND REPRODUCTION

New plants of both species can grow from any size vegetative segments, flowers or fruit, when they contact the ground and root (Holtkamp 2006). Flowering of *C. rosea* and *C. tunicata* has been recorded in late-spring and summer. Rapid growth of both species occurs after rainfall at warmer times of the year.

Cylindropuntia rosea is not known to produce viable seeds (Hosking *et al.* 2007). In contrast, seed is produced by *C. tunicata*, but it is probably not a significant source of dispersal as the fruit does not appear to be eaten by Australian animals, and the seed does not separate from the fruit (Hosking *et al.* 2007).

Segments and fruit of both species are easily detached from parent plants. These fragments are moved by a variety of animals including: livestock, for example sheep, cattle and horses; native species, for example kangaroos and koalas; feral animals, for example, rabbits; and domestic or working animals, for example cats and dogs.

Accidental movement of fragments occurs when spines become attached to tyres (Figure 7) and other parts of vehicles or machinery, including those used in mining. Intentional movement of the species as garden plantings has occurred in the past. Unconfirmed anecdotal evidence suggests that intentional plantings were used to deter human trespass on mining claims, and to deter dog trespass along fence lines in the Goodooga area of NSW.

Vegetative segments are moved by overland water flows and floodwaters. Such movement raises concerns regarding the further spread of the species should they move from the floodplains around the NSW opal fields into surrounding western waterways, for example The Big Warrambool and the Bokhara River. Spread to the Barwon and Darling Rivers, or the Narran River and Lake (a closed water system that does not flow into the Darling River) is possible.

IMPORTANCE

Human and economic loss

If left unchecked, infestations have the potential to reduce a range of agricultural enterprises and subsequent land values (Holtkamp 2006). The main impact caused by these species is the restriction of movement, and when movement is needed, the possibility of injury. This occurs because both species have a large number of long sharp spines, which can cause human injury and economic loss. The tips of these spines have barbs that aid spine attachment. Fragments of the detachable papery sheath that surrounds the spine often remain embedded after the spine is removed causing infection.

Spines easily penetrate human and animal flesh, footwear and vehicle tyres (Osmond 2006). Minor human injury commonly results, particularly to opal miners, but also to pastoralists, shooters, wild game harvesters and tourists.

Figure 7. Both *Cylindropuntia* species are dispersed by vehicle tyres, as is the case with *Cylindropuntia rosea* here. (Source: G. Grimshaw, NSW DPI).

Primary production
Livestock such as sheep, cattle and horses are often injured by the species. These injuries, and the time needed to address them, result in economic loss. The weeds physically restrict livestock production by reducing grazing areas and inhibit both livestock mustering and movement.

Environmental
These species have significant impacts on natural ecosystems including semi-arid woodland and native grassland. The spiny segments of both species injure native wildlife, for example kangaroos, and have been known to cause the death of some species, for example koalas (Osmond 2006, Holtkamp 2006) and birds. Relatively dense infestations restrict access for native animals, displace native flora and may impact on biodiversity (Walgett Shire Council 2008, Holtkamp 2006).

MANAGEMENT
Control of *Cylindropuntia* species using herbicides is made difficult by the types of terrain and vegetation in which infestations are located (Holtkamp 2006). As the plant occurs over an extremely large area there is no possibility of eradication (see Panetta and Timmins 2004) as this would require successful location and destruction of all cactus segments and this is not feasible (Carter and Johnson 2008). This conclusion stands in stark contrast to the conclusion of Braysher (2005) which states "it is recommended that a program be developed to control, and, if practicable, eradicate it".

Accordingly, it is important that integrated control measures be implemented, based on herbicides and other control measures, the introduction of effective biological control agents and the prevention of spread of the species. In particular, core infestations would be best managed using biological control agents whilst targeting outlying areas with herbicides or physical removal. Biological control agents, once established, would form self-perpetuating populations and gradually spread throughout the distribution of the species. An integrated weed management approach of this kind allows resources to be directed to prevention of spread from outlying infestations (Menz *et al.* 1980, Holtkamp 2006).

There are a number of reasons why it is impractical to solely rely on the application of herbicides to manage core infestations. These include the prohibitive cost of treating such large areas, the difficulties in ensuring herbicide contact occurs on all parts of the plant, in particular the lower parts, and the time needed to find and treat all vegetative segments over a large area. Rather it is more practical to create a buffer zone around the core infestations so that further spread does not occur outside the infestation boundaries. Destruction of these satellite infestations would then occur as well as other measures to prevent spread.

Prevention
Vehicular spread is one of the key means of dispersal. For this reason, vigilance in inspection and cleaning of vehicles and machinery is needed (Osmond 2006). In infested areas, it is recommended that vehicles not leave designated roads, or if this is unavoidable then the tyres and undercarriage be checked thoroughly for any segments of *C. rosea* or *C. tunicata*. These should be removed before leaving the infested area. It is also important that clothing, footwear, other equipment and the inside of vehicles

be checked in case transfer has occurred (Osmond 2006, Holtkamp 2006). Stock and other animal movement through infested areas should be minimised and any segments attached to animals should be removed before livestock are shifted to new areas. Given that movement of the species is possible on mining machinery, it would appropriate to inspect new mining areas, particularly those in semi-arid areas, to contain any new outbreaks of the weed.

Herbicides

Herbicide applications can result in successful control although care is needed to ensure total coverage of plants when spraying as any missed plants or segments have the capacity to form new infestations (Holtkamp 2006, Figure 8). The addition of a marker dye to the spray mix is helpful in determining which plants have been sprayed. Thorough spraying of both species with herbicide mixtures that incorporate a spray oil are effective at any time of the year if the plants are actively growing and not stressed (Holtkamp 2006). Spray failures are often observed when either less than complete herbicide coverage on plants occurs or when herbicide mixtures in water are used, possibly because evaporation occurs too quickly. Plants sprayed during cooler months may take longer to die than those treated during warmer months. Herbicide application is not recommended before flooding.

Three herbicides are currently registered in NSW for treating Cactaceae, including these species, under the Australian Pesticides and Veterinary Medicines Authority permit number 10544 (APVMA 2008). This permit allows the application of the herbicides Garlon 600 (600 g L^{-1} triclopyr), Grazon DS (100 g L^{-1} picloram + 300 g L^{-1} triclopyr) and Grazon Extra (100 g L^{-1} picloram + 300 g L^{-1} triclopyr + 8 g L^{-1} aminopyralid) as high volume and knapsack applications in certain agricultural and environmental areas according to label directions. Care is needed to prevent off-target damage.

Since single herbicide applications are rarely 100% effective, treated sites require monitoring for regrowth and follow up applications as necessary (Holtkamp 2006). Follow up applications may also be needed because anecdotal evidence suggests that herbicide control may often be hampered by ‘spray-blindness’ or the partial camouflage of small plants against surrounding vegetation and soil. Although *C. rosea* spines on large segments and plants have a shiny-silvery appearance (particularly when looking into the sun, Figure 1 and 2), the smaller grey-green fragments and white/silvery spines (and sheaths) often appear to blend in with dead leaf and grass material on the ground, and in standing dead vegetation. As a result, systematic checking of sprayed sites is recommended. The difficulty of finding and treating all vegetative segments, and the large costs involved with doing so make long-term management with herbicides alone difficult.

Other management

Isolated plants and small infestations are best dug up and removed by hand although the danger of physical injury should be considered. Care is also needed to remove all segments from the area and to ensure that none are attached to clothing or footwear. To avoid further spread, uprooted plants should be buried or burnt (Holtkamp 2006). Some opal miners dispose of plant material down disused mine shafts. Burnt material requires checking for any regeneration.

Figure 8. Untreated *Cylindropuntia rosea* segments that collapse to the ground after herbicide application can regrow. Note the dead plant in the centre. (Source: S. Johnson, NSW DPI).

Physical removal of larger infestations is not viable unless there is follow up because any missed plants or plant parts have the capacity to form new infestations if they fall to the ground and take root.

Biological control

The prospects for successful biological control of both *C. rosea* and *C. tunicata* are high as previous biological control programs have shown (Holtkamp 2006). *Dactylopius tomentosus*, a species of cochineal insect introduced for *C. imbricata* attacks *C. rosea* but is not particularly damaging. Recent South African research has shown that there are several biotypes of *D. tomentosus* present in Mexico, at least one of which is likely to be more damaging to *C. rosea* and *C. tunicata* (H. Zimmerman pers. comm.). There should be few host specificity issues associated with the introduction of additional *D. tomentosus* biotypes as there are no native Cactaceae species. Additionally, *D. tomentosus* is already present in Australia so relatively little quarantine testing should be required to obtain approval for release of a different biotype of this insect. Cochineal insects used to control cactus all appear to be very specific and this is likely to be the case with the biotype for these *Cylindropuntia* species. The approval process for the introduction of these biotypes into Australia is current.

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PRIVET SPECIES – ARE WE SITTING ON SPECIES TIME BOMBS?

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SUMMARY
The privet (*Ligustrum*) species are small trees or shrubs widely planted for hedge, shade, shelter and garden purposes. Two of these species, *L. lucidum* (broad-leaf privet) and *L. sinense* (narrow-leaf or Chinese privet) currently cause significant environmental, human health and agricultural impacts in New South Wales (NSW). Three further species that have a history of both weediness and deliberate cultivation, *L. vulgare* (European or common privet), *L. ovalifolium* (oval-leaf privet) and *L. japonicum* (Japanese privet) may be of concern in future. While this document examines the basic biology and management of all *Ligustrum* species, it particularly focuses on the latter three species that have started to naturalise, or are yet to do so.

Of the 22 cultivated *Ligustrum* species, ten are recognised weeds throughout the world. In Australia, *L. lucidum* and *L. sinense* have widely naturalised in coastal and tableland areas along the eastern seaboard while *L. vulgare* is increasingly naturalising in higher altitude areas of south eastern Australia. It is likely that all three species will continue to expand their distribution. The species *L. ovalifolium* and *L. japonicum* are yet to naturalise in Australia.

Ligustrum species primarily reproduce by seeds that are commonly spread by fruit-eating birds. The seeds generally persist no more than 1 year and masses germinate as soil temperatures rise above 15^{o}C. These seedling flushes survive in low light conditions until disturbance events stimulate growth. Seedlings may remain juvenile for up to four years, plants can produce up to 10 000 000 seeds at maturity. Vegetative reproduction is common in *L. sinense*, and to a lesser extent in *L. lucidum* and *L. vulgare*.

The *Ligustrum* species invade many natural ecosystems causing changes in native plant and animal diversity and abundance. They also invade forestry, horticultural crops and pasture. The perfume of the flowers can aggravate allergies, affecting sleep, social habits and general well-being in some people.

Ligustrum species have been managed successfully using weed management programs that involve community engagement and legislation. Integrated management approaches are successful and need to include a range of preventative, chemical, hand removal, regeneration and mechanical methods.

INTRODUCTION TO THE PRIVET SPECIES

Privet species belong to the genus *Ligustrum* which has 40-50 species, many native to south-eastern and eastern Asia (Kiew 1978, Webb *et al.* 1988, Hardin 1992, Swarbrick *et al.* 1999). Up to 22 species are cultivated, mainly as ornamental and hedge plants, and ten of these are recognised weeds (Griffiths 1994, Swarbrick *et al.* 1999, Randall 2002).

Three species have naturalised and become weedy in Australia, these being *L. lucidum* (broad-leaf privet), *L. sinense* (narrow-leaf or Chinese privet) and *L. vulgare* (European privet). A fourth species *L. australianum*, is native and grows in rainforest margins throughout coastal central and north eastern Queensland (Swarbrick *et al.* 1999).

It is unclear if *L. ovalifolium* (oval-leaf privet) has naturalised in southern Australia, for example Australia's Virtual Herbarium (2008) mentions the species but Hosking (in prep.) has questioned the correct identity of these records. In contrast, *L. ovalifolium* has occasionally naturalised in forest remnant margins, roadside banks and waste places on both islands of New Zealand (Webb *et al.* 1988, Swarbrick *et al.* 1999). Infrequent fruit production of the species is thought to have limited further New Zealand naturalisations (Webb *et al.* 1988).

At least six species are in cultivation in Australia, these being *L. lucidum*, *L. sinense*, *L. vulgare* and *L. ovalifolium* (mentioned above), as well as *L. japonicum* (Japanese privet), and *L. undulatum* (box-leaf privet) (Hibbert 2004, Shepherd 2004, Edmanson 2005, Thomson 2007).

Ligustrum japonicum is a significant weed in areas of the world including the United States of America (USA) (USDA-NRCS 2008) but has probably not naturalised in Australia (B. Lepschi pers. comm.). There have been no confirmed naturalisations of *L. undulatum* in Australia or around the world (Randall 2002), despite its popularity as a hedge plant.

The extent to which *L. ovalifolium*, *L. japonicum,* and *Ligustrum* species have been planted or are naturalised in Australia is unknown. While this document examines the basic biology and management of all *Ligustrum* species, it focuses on what is known of the less common *L. vulgare*, *L. ovalifolium* and *L. japonicum* which could be weeds of the future.

SPECIES DESCRIPTIONS

Ligustrum lucidum

This evergreen species grows as a shrub or small tree, generally single-stemmed, to a height of 4-10 m, and occasionally to 15 m high in cultivation (Webb *et al.* 1988, Hardin 1992, Wilson 1994, Swarbrick *et al.* 1999, Muyt 2001). The smallest branches have white lenticels (small corky pores) that allow gas exchange. The bark of the species is brownish with numerous lenticels (Clemson 1985, Benson and McDougall 1999, Mowatt and Smith 2004).

The leaves of *L. lucidum* are borne opposite each other, are generally oval to elliptic in shape, 40-130 mm long (occasionally to 24 cm long), 30-60 mm wide, on petioles 10-20 mm long (Goulding 1973, Webb *et al.* 1988, Stanley and Ross 1986, Hardin 1992, Wilson 1994, Swarbrick *et al.* 1999, AGIS 2008, Figures 1 and 2). The leaf tips taper gradually to a point while the bases are rounded. The upper leaf surface is dark green and glossy or shiny while the lower surface is paler with distinct venation (Clemson 1985, Hardin 1992, Swarbrick *et al.* 1999, Blood 2001). There are no hairs on the leaves. *Ligustrum lucidum* may partly defoliate in dry weather (Swarbrick *et al.* 1999).

The panicles (a branched cluster of flowers with flowers arising singly along the stalk) are 100-250 mm long, to 200 mm wide, are broadly pyramid- to cone-shaped, while the stalk of each flower is 1-3 mm long (Webb *et al.* 1988, Hardin 1992, Swarbrick *et al.* 1999). The calyx (the cup like structure that bears the flower) is tubular and 1-1.5 mm long (occasionally 2-3 mm long) with four shallow lobes (Hardin 1992, Wilson 1994). The flowers are white or creamy white, tubular in shape to 1.5 mm long with lobes that are 2-4 mm long and stamens around 4 mm long (Goulding 1973, Webb *et al.* 1988, Hardin 1992, Shepherd 2004, Figure 2). The flowers have a sickly sweet fragrance (Blood 2001).

The fruit is a berry, globular in shape, to 9 mm long, and to 12 mm in diameter, attached by short 2 mm stalks. The fruit is green when immature, turning to a red colour as ripening progresses, and blue to glossy or purplish-black in colour at maturity (Goulding 1973, Clemson 1985, Webb *et al.* 1988, Hardin 1992, Wilson 1994, Roy *et al.* 1998, Blood 2001, Figure 1). The oval-shaped seeds are about 5 mm long and ribbed (Webb *et al.* 1988, Jeanes 1999, Blood 2001). While some authors indicated there are generally two seeds per fruit, other research indicates this is less common. For example, Panetta (2000) found that two seeds were present in less than 10% of fruit, while Burrows and Kohen (1986) observed two seeds in 30% of fruit. Three seeds have been found in a very low percentage (0.4%) of fruits (van Aalst, in Swarbrick *et al.* 1999)

The root system of *L. lucidum* is woody, branching and thickened at the crown but mostly shallow in depth (Muyt 2001, Mowatt and Smith 2004).

Ligustrum sinense

Ligustrum sinense is a densely branched, multi-stemmed shrub 3-5 m tall and occasionally growing to a height of 7 m high (Webb *et al*. 1988, Auld and Medd 1992, Hardin 1992, Wilson 1994, Benson and McDougall 1999, Swarbrick *et al.* 1999, Batcher 2000, AGIS 2008). The brownish-gray trunk is not fissured and the branches are gray to green in colour (Miller 1999a). The young branches and new growth are covered in fine, short hairs (Webb *et al.* 1988, Hardin 1992, Benson and McDougall 1999, Miller 1999a) while the smallest branches have white lenticels that allow the exchange of gasses (Benson and McDougall 1999, Miller 1999a, Hosking *et al.* in prep.). Although generally considered to be evergreen, the species may be semi-deciduous in colder areas, for example in New Zealand and areas of the USA (Webb *et al.* 1988, Roy *et al.* 1998, Miller 1999a).

The opposite leaves of *L. sinense* are elliptic to oval-shaped generally from 10-70 mm long and 5-35 mm wide, on petioles 3-10 mm long (Goulding 1973, Kiew 1978, Buchanan 1981, Clemson 1985, Webb *et al.* 1988, Hardin 1992, Auld and Medd 1992, Wilson 1994). The tip of the leaf may taper to a point or be rounded while the base is generally wedge-shaped or rounded (Hardin 1992, Roy *et al.* 1998, Miller 1999a, Swarbrick *et al.* 1999, Figure 3). The mid-rib on the lower leaf surface is covered in short, fine hairs, while both leaf surfaces are similarly mid-to dull-green in colour (Webb *et al.* 1988, Hardin 1992, Miller 1999a, Swarbrick *et al.* 1999). In

Figure 1. A fruiting branch of *L. lucidum* (Source: S. Johnson, NSW DPI).

Figure 2. The white to creamy-white flowers of *L. lucidum* are borne in panicles (Source: James H. Miller, USDA Forest Service, Bugwood.org).

Figure 3. The elliptic to oval-shaped leaves of *L. sinense* with rounded leaf tips and bases. Note the white flowered panicles and green flower buds present (Source: J. Plaza, Botanic Gardens Trust 2008, used with permission).

Figure 4. Ripe fruit of *Ligustrum sinense* (Source: James H. Miller, USDA Forest Service, Bugwood.org).

contrast, some authors note the leaves may be lighter underneath (Clemson 1985, Jeanes 1999) and Mowatt and Smith (2004) indicate that leaves may be a yellow-green colour.

Ligustrum sinense often has sinuate leaves, that is leaves with a distinctly wavy margin (Buchanan 1981, Mowatt and Smith 2004, Figure 3). These leaves are held at right angles to the stems (Miller 1999a). *Ligustrum sinense* may partly defoliate in dry weather (Swarbrick *et al.* 1999).

The panicles are 50-120 mm long, although occasionally shorter, 30-50 mm wide, with the stalk of each flower 1-3 mm long (Goulding 1973, Kiew 1978, Webb *et al.* 1988, Hardin 1992, Wilson 1994, Swarbrick *et al.* 1999, Figure 3). The panicles are also covered in fine short hairs (Webb *et al.* 1988, Hardin 1992). The calyx is tubular, 1-2 mm long, but scarcely four-lobed. The flowers are white, very fragrant and borne as a tube that is 0.5-2 mm long, with lobes to 3.5 mm long, and with mauve to purple anthers (Goulding 1973, Webb *et al.* 1988, Hardin 1992, Wilson 1994).

The fruit is an ovoid or globular shaped berry, 4-10 mm long and wide, borne on hairy stalks that are 4-5 mm long. The fruit are green when immature and dull purple- or blue-black when ripe (Goulding 1973, Clemson 1985, Webb *et al.* 1988, Hardin 1992, Benson and McDougall 1999, Miller 1999a, Swarbrick *et al.* 1999, Muyt 2001, Shepherd 2004, Figure 4). The seeds are 3-4 mm long, oblong and shallowly grooved (Webb *et al.* 1988). Studies indicate that 3 to <10% of all fruit have two seeds (Burrows and Kohen 1986, Panetta 2000).

The root system of *L. sinense* is woody, branching and thickened at the crown but mostly shallow in depth (Muyt 2001, Mowatt and Smith 2004).

Ligustrum vulgare

This species is a deciduous or semi-deciduous multi-stemmed shrub that grows to 5 m high (Hardin 1992, Swarbrick *et al.* 1999). In contrast, both Jessop and Toelken (1986) and Jeanes (1999) state that *L. vulgare* is evergreen in Victoria and South Australia, but deciduous in even colder climates such as New Zealand (Goulding 1973).

The young branches are covered in fine hairs (Hardin 1992) which sometimes do not extend to the branchlet tips (Rawson and Marcussen 1960). The smaller branches have white lenticels, while the trunk is covered in a grey-brown, smooth bark (Hosking *et al.* in prep.).

The hairless lance-shaped to elliptic leaves of *L. vulgare* occur opposite each other, are 20-60 mm long and 7.5-25 mm wide, and on petioles 1-10 mm long (Webb *et al.* 1988, Hardin 1992, Batcher 2000, Muyt 2001, Figure 5). The leaves of immature shoots are often narrower (Webb *et al.* 1988). The leaf tip is bluntly pointed while the leaf base is wedge-shaped. Both surfaces of the leaf are more or less the same colour, a dark, shining green (Hardin 1992, Swarbrick *et al.* 1999). The lower leaf midribs are not hairy nor are the leaf margins wavy (Goulding 1973).

The pyramidal panicles are 20-80 mm long, 20-40 mm wide and the stalk of each flower is 1-2 mm long (Goulding 1973, Webb *et al.* 1988, Hardin 1992, Batcher 2000,

Figure 5. A flowering branch of *L. vulgare* (Source: Nava Tabak, Invasive Plant Atlas of New England, Bugwood.org).

Figure 6. The white flowering panicle of *L. vulgare* (Source: Nava Tabak, Invasive Plant Atlas of New England, Bugwood.org).

Swarbrick *et al.* 1999). The panicles are also covered in fine short hairs. The calyx is tubular, 1-1.5 mm long with four lobes that are generally 1-2 mm long. The flowers are white or cream and fragrant, with yellow anthers that are barely exserted from the tube (Goulding 1973, Hardin 1992, Figure 6).

The fruit is a berry which is ovoid to globular in shape, 3-10 mm long, 5-8 mm in diameter and borne on short, slightly hairy stalks. The fruit is a generally a shiny black to blue/black colour when mature (Goulding 1973, Jessop and Toelken 1986, Webb *et al.* 1988, Hardin 1992, Jeanes 1999, Batcher 2000, Swarbrick *et al.* 1999). The fruit of some varieties of *L. vulgare* are not black, for example 'chlorocarpum' has green fruits, 'leucocarpum' has white fruits and 'xanthocarpum' has yellow fruits (Bean 1978, in Mikowski and Stein 2008). There are usually two, 4-5 mm long, flattened, shallowly ribbed, oval- to ellipse-shaped seeds in each fruit (Webb *et al.* 1988, Jeanes 1999) although this can vary from 1-4 seeds (Obeso and Grubb 1993).

Ligustrum ovalifolium

Naturalisations of this species are not known in NSW (Botanic Gardens Trust 2008) but the species is likely to occur in cultivation (Hibbert 2004, Shepherd 2004, Thomson 2007).

Ligustrum ovalifolium is an evergreen shrub that grows to 5 m in height (Goulding 1973, Webb *et al.* 1988, AGIS 2008). The young twigs of this species are hairless (Swarbrick *et al.* 1999).

The opposite leaves of *L. ovalifolium* are elliptic to oval-shaped. They are generally 30-60 mm long but can be 20-90 mm long, 10-40 mm wide and grow on petioles to 5 mm long (Goulding 1973, Webb *et al.* 1988, Swarbrick *et al.* 1999, Shepherd 2004, Figure 7). The leaf tip is often pointed while the leaf base is wedge-shaped. The upper leaf surface is shiny (Webb *et al.* 1988, Swarbrick *et al.* 1999) while the lower leaf surface yellowish-green (Batcher 2000).

The pyramid-like panicles are 50-150 mm long and 100 mm wide (Webb *et al.* 1988, AGIS 2008, Figure 7). The flower calyx is 1.5-2 mm long and has shallow lobes. The flowers are white to creamy-white, very fragrant, and tubular, 4.5-6 mm long with reflexed lobes 2-2.5 mm long. The yellow anthers grow to 3 mm long and are barely exserted from the flower lobes (Goulding 1973, Webb *et al.* 1988).

The fruit is globular in shape, 5-10 mm in diameter and generally black to purplish- or bluish-black in colour, and stalkless (Goulding 1973, Webb *et al.* 1988, Batcher 2000, Swarbrick *et al.* 1999, Shepherd 2004). The ellipse-shaped seeds are around 4 mm long and ribbed.

This species is similar to *L. sinense* but can be distinguished from it since *L. sinense* has short, fine hairs and dull green leaves. In contrast *L. ovalifolium* is hairless and has shiny leaves (Roy *et al.* 1998).

Ligustrum japonicum

Naturalisations of this species are not known in NSW (Botanic Gardens Trust 2008) but the species is likely to occur in cultivation (Hibbert 2004, Shepherd 2004, Thomson 2007).

Ligustrum japonicum is an evergreen, thicket-forming shrub that grows to 3-6 m in height (Miller 1999b, Batcher 2000, Shepherd 2004). The trunk has light grey bark, is smooth and has no fissures. The branches are brown-gray in colour with raised lenticels. The young branches are pale green to gray (sometimes red) and are not hairy (Miller 1999b).

The leaves of *L. japonicum* are borne opposite each other, are oval-shaped, 40-100 mm long, 25-40 mm wide, and on petioles 10-20 mm long (Figure 8). The leaf has a sharp tip and a rounded base, is a shiny dark green above and is a lighter green below (Goulding 1973, Miller 1999b, Batcher 2000, Shepherd 2004). The leaves may be almost black in appearance (AGIS 2008).

The loosely branched, conical-shaped panicles are generally 60-150 mm long (Batcher 2000) although they may grow to 200 mm long and wide. The calyx has four lobes and the flowers are white and fragrant, with the flower tube shorter, or as long as the lobes (Miller 1999b, Shepherd 2004, Flora of China 2008).

The fruit is a berry that is 6-10 mm long and to up 5 mm wide. It is green when immature and a bluish-black colour when ripe (Miller 1999b, Miller 2003). The seeds are up to 7 mm long, oval-shaped and ribbed (Hurst 2008).

Figure 7. A flowering *Ligustrum ovalifolium* hedge. Note the elliptic- to oval-shaped foliage and the white flowers. (Source George Jansoone, Wikimedia commons).

Figure 8. A branch of *L. japonicum* with flower buds (Source: James H. Miller, USDA Forest Service, Bugwood.org).

Figure 9. Branches of *L. lucidum* (left) and *L. sinense* (right). Many of the leaves of *L. lucidum* are longer than 60 mm. (Source: Ted Bodner, Southern Weed Science Society, Bugwood.org).

Differentiation of *Ligustrum* species

Differentiation of the five *Ligustrum* species outlined above can be achieved by comparing vegetative and reproductive characteristics, for example Figure 9.

The most distinctive of these characteristics are outlined in the key below. It uses information from Goulding (1973), Miller (1999b), Swarbrick *et al.* (1999), Batcher (2000), AGIS (2008) and Flora of China (2008). The corolla lobes are the flower petals.

1	Young shoots and branchlets hairy; leaves not glossy above, often bluntly tipped; flowers stalked; corolla lobes spreading, not reflexed, or	**2**
	Young shoots and branchlets without hairs; leaves glossy above, pointed; flowers shortly stalked or stalkless; corolla lobes may or may not be reflexed.	**3**
2	Lower leaf midribs finely hairy, margins smooth to wavy; corolla tube shorter than lobes; anthers mauve to purple, exserted; fruits blackish-purple, on hairy stalks, or	***L. sinense***
	Lower leaf midribs not finely hairy, margins never wavy; corolla tube slightly longer than lobes; anthers white, barely exserted; fruits glossy black, on short, slightly hairy stalks.	***L. vulgare***
3	Leaves generally 30–60 mm long; corolla tube more than twice as long as lobes; anthers barely exserted from tube; fruits black, stalkless, or	***L. ovalifolium***
	Some leaves longer than 60 mm, anthers well exserted from tube, fruits bluish-black.	**4**
4	Leaves generally 50–130 mm long (dark green); corolla tube shorter or as long as the lobes; anthers well exserted from tube; fruits bluish-black, on short stalks, or	***L. lucidum***
	Leaves generally 40–100 mm long (very dark green to almost black); corolla tube shorter or as long as the lobes, anthers exserted from tube, fruits bluish-black on short stalks.	***L. japonicum***

The key point of differentiation between the five species is the presence of hairs on the young shoots and branchlets (as found in *L. sinense* and *L. vulgare*) as opposed to the other *Ligustrum* species described above. The leaves of *L. sinense* have finely haired midribs on the lower leaf surface, are 10-70 mm long, often with wavy margins while the flowers have mauve to purple anthers that are well exserted from the flower tube and the fruit are blackish-purple. In contrast, the lower leaf surface midrib of *L. vulgare* is not finely haired, the leaves are 20-60 mm long, they never have wavy margins, while the flowers have white anthers and the fruit are glossy black.

The key differences between the three other *Ligustrum* species are leaf size, anther exsertion from the flower tube and stalks on the fruit. The leaves of *L. ovalifolium* are only 30-60 mm long; the flower tube is more than twice as long as the lobes, the anthers are barely exserted from the tube, while the fruits are black and stalkless. The commonly found *L. lucidum* can be readily differentiated from *L. japonicum* because of the large leaves of *L. lucidum* (generally 50-130 mm long compared to 40-100 mm) and the anthers being well exserted from the flower tube.

Cultivars with different leaf colours or variegation are known for all five species (Goulding 1973, Everist 1981, Griffiths 1994, Swarbrick *et al.* 1999, Blood 2001, Shepherd 2004, AGIS 2008).

Hybrids between the various species of *Ligustrum* have not been reported (Swarbrick *et al.* 1999), with one possible exception between *L. ovalifolium* and *L. sinense* (Goulding 1973).

ORIGIN AND HISTORY IN AUSTRALIA

Ligustrum lucidum is native to either Japan and/or China (Hardin 1992, Wilson 1994, Benson and McDougall 1999), and perhaps to Korea (Goulding 1973, AGIS 2008). *Ligustrum sinense* is native to China, Hong Kong, Taiwan, Laos and Vietnam (Hardin 1992, Hosking *et al.* in prep.) while *L. vulgare* is native of southern Europe and northern Africa (Hardin 1992). *Ligustrum japonicum* is native to Korea and Japan while *L. ovalifolium* is native to Japan (Goulding 1973, Batcher 2000, AGIS 2008). Most other species of *Ligustrum* are native to south-eastern and eastern Asia (Bailey and Bailey 1976, Kiew 1978, Mabberley 1997, Swarbrick *et al.* 1999).

The first evidence of *Ligustrum* species in Australia is recorded in William Macarthur's earliest catalogue as occurring in south west Sydney, in cultivation (Anon. 1843, in Michael 1972). Three *Ligustrum* species, these being *L. japonicum*, *L. lucidum* and *L. vulgare* are also listed in a later catalogue (Anon 1857). It appears that *L. sinense* was introduced into Australia after the species mentioned above. *Ligustrum ovalifolium* probably arrived in Australia via a similar means and for a similar purpose (Swarbrick *et al.* 1999). The *Ligustrum* species were widely planted as hedges and shade trees after introduction (Swarbrick *et al.* 1999, Benson and McDougall 1999).

AUASTRALIAN DISTRIBUTION OF *L. lucidum. L. sinense* AND *L. vulgare*

Ligustrum lucidum is widely naturalised in eastern Australia, particularly in sub-coastal and tableland areas, but also inland to some extent (Figure 10a). It can be found from northern Queensland (Qld) to Vic and is particularly prominent around towns and cities (Carr *et al*. 1992, Swarbrick *et al.* 1999, Australia's Virtual Herbarium 2008). The species has also naturalised on Norfolk Island (Wilson 1984).

Ligustrum lucidum is widespread in the coastal areas and the adjoining slopes of NSW, north from around Bega (36^{o} 41' S, 149^{o} 50' E) on the south, central and north coast (Hardin 1992, Muyt 2001). It is a well known weed of Sydney bushland, especially in riparian areas. It has commonly naturalised in all tablelands areas (northern, central and southern) and in the Australian Capital Territory (ACT), which are also on the southern tablelands. Naturalisations occur inland in the north, central and south west slopes, as far west as West Wyalong (33^{o} 55' S, 147^{o} 12' E, Hardin 1992).

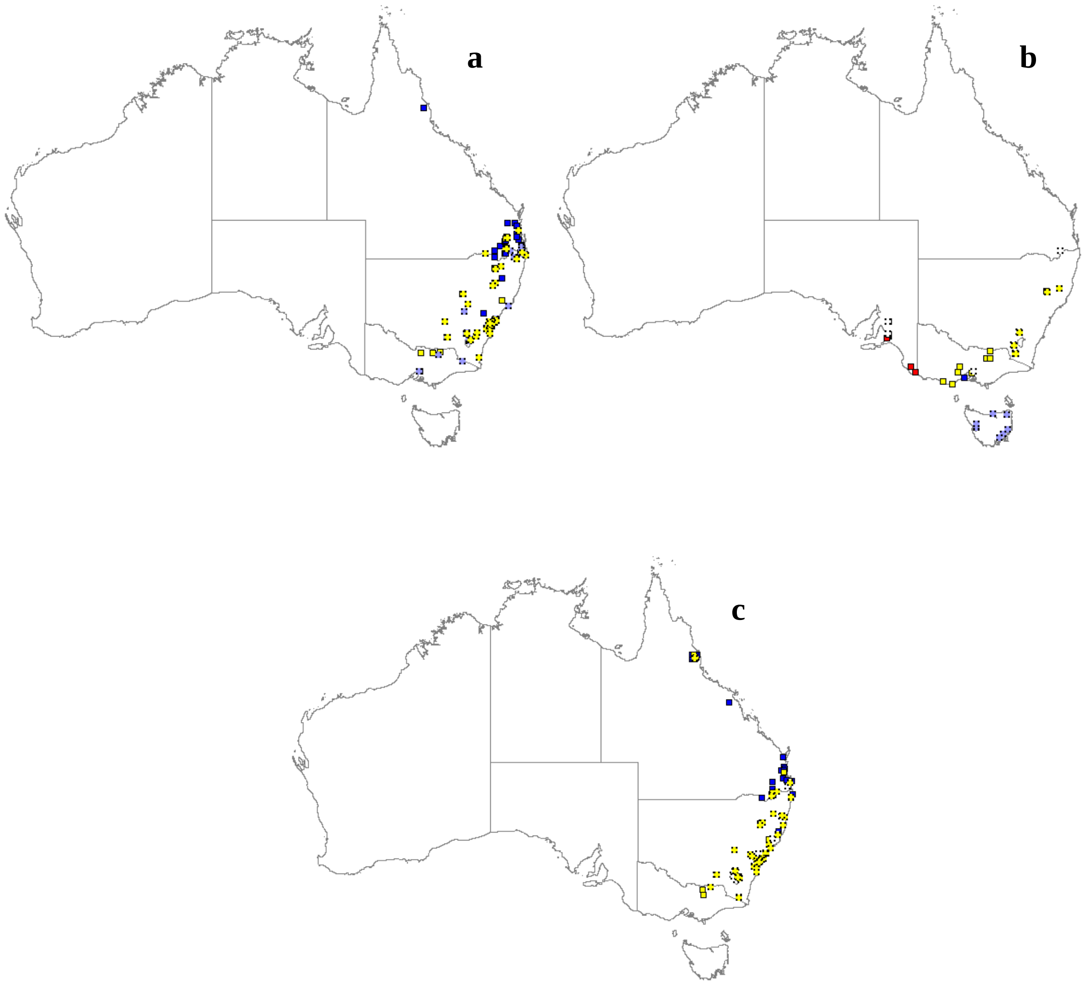

Figure 10. The current distribution of (a) *L. lucidum* (b) *L. sinense* and (c) *L. vulgare* in Australia (Source: Australia's Virtual Herbarium 2008).

Ligustrum sinense is also widely naturalised in sub-coastal eastern Australia and to a lesser extent in tableland and inland areas (Figure 10b). It can be found from northern Qld to Vic (Carr *et al*. 1992, Swarbrick *et al.* 1999, Australia's Virtual Herbarium 2008). It is an increasingly significant environmental weed on both Norfolk and Lord Howe Islands (Hardin 1992, Wilson 1994).

Ligustrum sinense has spread throughout eastern NSW, with infestations found on the north, central and south coast, tableland and slopes botanical areas despite the lack of records in Figure 10b (Hardin 1992, Hosking *et al.* in prep.). The species is found north of the Bombala area on the south coast (36^{o} 54' S, 149^{o} 12' E) and north of Albury in inland areas (36^{o} 05' S, 146^{o} 54' E) (Australia's Virtual Herbarium 2008). *Ligustrum sinense* has also naturalised in the ACT (Muyt 2001, Australia's Virtual Herbarium 2008).

Ligustrum sinense has naturalised in a number of Sydney suburbs and is commonly found in riparian areas (Clemson 1985, Benson 1992) and a number of former citrus and stone fruit orchard districts around Sydney and Gosford. It is considered to be more widespread than *L. lucidum* in Sydney (Mowatt and Smith 2004).

Ligustrum vulgare has generally naturalised in higher altitude areas in south-eastern Australia (Australia's Virtual Herbarium 2008, Figure 10c). It is most common throughout the tablelands and northern slopes of New South Wales, for example on the Northern Tablelands around Guyra, Armidale and south of Walcha, south to Jindabyne on the southern Tablelands, and on the North West Slopes around Yetman. Many of these records are not reflected by the herbaria records in Figure 10c (Hardin 1992, Australia's Virtual Herbarium 2008). Naturalisations also occur near Yass, Robertson and Yarrongobilly Caves, south east of Batlow (Hardin 1992, Australia's Virtual Herbarium 2008).

LIFECYCLE

The information in this section is predominantly focussed on *L. lucidum* and *L. sinense*. Few lifecycle studies have been performed for other *Ligustrum* species.

Both *L. lucidum* and *L. sinense* can have initial seed viability of up to 100% (Swarbrick *et al.* 1999, Blood 2001, Mowatt and Smith 2004). Field studies indicate *L. lucidum* seed has a maximum longevity of 1-2.5 years in the soil whereas no viable seeds of *L. sinense* were recorded six months after sowing (van Aalst 1992, in Panetta 2000, Panetta 2000). Limited seed viability tests after ingestion by pied currawongs indicated 83-91% viability (Buchanan 1989b).

Ligustrum lucidum seed will remain viable for up to two years either inside or outside of fruit if stored at low temperatures (Burrows and Kohen 1983), but similarly stored *L. sinense* seeds lost viability after only one year (van Aalst 1992, in Swarbrick *et al* 1999). Seed is killed during composting when temperatures are around 60^{o}C for several weeks (Mowatt and Smith 2004).

There are limited studies quantifying the seed bank of *Ligustrum* species. One study reported that while there may be 292-557 seeds/m^2, up to 54% of seed was damaged in some way and the remainder had low germinability (1-8%, Burrows and Kohen 1986). Other estimates of several hundred seeds/m^2 in soil under dense *Ligustrum* canopies are within the range of the data above (Muyt 2001). Bird regurgitation and defecation result in clustered seed distribution (Buchanan 1989b, Mowatt and Smith 2004).

The evidence for germination of *L. lucidum* and *L. sinense* seed germination while confined within fruits is limited, contradictory and requires further investigation (Panetta 2000). That author maintains that the germination of *L. lucidum* and *L. sinense* seeds "is not highly dependant" on the removal of seeds from fruit. In contrast, another study indicated higher seedling numbers arise from *L. sinense* fruits than from seeds (van Aalst (1992), in Panetta 2000). Shorter time period petri-dish experiments found no germination from *L. lucidum* fruit and limited germination (2%) from *L. sinense* fruit however (Burrows and Kohen 1986). Panetta (2000) concluded that the fruit of *L. sinense* generally had less inhibitory effects on seedling emergence than the fruit of *L. lucidum*. It is also believed that fresh seed that has passed through the guts of birds or other animals can germinate immediately but that dried seed may require cold stratification for germination to occur (Blood 2001).

Ligustrum lucidum and *L. sinense* seeds do not germinate on top of the soil and require shallow burial (to 1 cm) to germinate (Panetta 2000). Emergence is generally more rapid from buried seeds than from buried fruits. A summary of other research indicated that both species germinate and establish under low light conditions (Panetta 2000).

Seed of *L. sinense* commonly germinate within a temperature range of 15-25^{o}C (79-82%) while seed of *L. lucidum* germinates at temperatures near 15^{o}C (90-100%), with poor germination above 20^{o}C and below 10^{o}C (Burrows and Kohen 1983). Germination of *L. vulgare* may be achieved after cold temperature stratification (0-2^{o}C, Rudolf 1974, in Burrows and Kohen 1983). Those authors suggested that cold temperature stratification helps promote better germination of *Ligustrum* species under later warmer spring conditions, even though there is limited germination under the warm conditions that occur immediately after seed fall (Panetta and Robazza 1997).

Seedlings of *L. lucidum* and *L. sinense* grow rapidly under good light conditions forming a taproot that generally grows vertically down into the soil, but may grow horizontally in stony conditions (Buchanan 1989a). Such situations allow for easier removal of seedlings by hand (Swarbrick *et al.* 1999).

Densities of between 200 to >600 *Ligustrum* (*L. lucidum* and/or *L. sinense*) seedlings/m^2 may be found in infested areas (Adamson and Buchanan 1974, Buchanan 1989a) with instances of several thousand/m^2 reported in some cleared areas (Fox and Adamson 1986, Buchanan 1989a). Although soil moisture induced mortality is common, many seedlings survive. These seedlings commonly persist under shaded conditions for several years waiting until disturbance events such as weeding, clearing or over storey to occur. The resulting increased light and water levels stimulate rapid growth (Adamson and Buchanan 1974, Muyt 2001).

Privet seedlings appear to easily out-compete native seedlings because of their proliferation and because privet seedling growth is more rapid than native species under low light conditions (Adamson and Buchanan 1974, Fox and Adamson 1986). *Ligustrum* seedlings have five main morphological strategies that give them an advantage over native species (Fox and Adamson 1986). These are:-

1. no main stem branching so long as shoot tip damage does not occur. This results in a tall vertical single stem;
2. stem thickening does not occur. This contributes to taller *Ligustrum* seedlings under low light conditions;
3. if breakage of the main stem occurs then this stem stops growing allowing basal shoots and suckers to grow. These suckers are able to grow more quickly than the original seedling due to the established root system;
4. leaves are well spaced along the vertical stem reducing self-shading and the need to a thicker stem (in comparison to sweet pittosporum, Buchanan 1989a); and
5. the dense mat of fibrous roots near the ground surface that rapidly exploit soil nutrients and moisture.

Ligustrum species appear to have a long juvenile period before reaching reproductive maturity, for example four years in *L. lucidum* (Blood 2001). There is no information on the juvenile period of other *Ligustrum* species.

In Australia, *L. lucidum* forms flower buds in October-November and flowers between November and March (Goulding 1973, van Aalst 1992, in Swarbrick *et al.* 1999, Benson and McDougall 1999, J. T. Swarbrick unpublished data). A similar flowering period occurs in other southern hemisphere countries such as Argentina, New Zealand and South Africa, with a peak in flowering recorded in January in New Zealand (Dascanio *et al.* 1994, Roy *et al.* 1998, AGIS 2008).

Although *L. sinense* flowers earlier, in late winter and spring, a low level of flowering and fruiting occurs throughout the year (van Aalst 1992, in Swarbrick *et al.* 1999, Benson and McDougall 1999, Botanic Gardens Trust 2008). Other authors have noted flowering into early summer in Australia and the USA (Hardin 1992, Benson and McDougall 1999, Jeanes 1999, Miller 1999a, Munger 2003, Shepherd 2004) and to early autumn in New Zealand (Webb *et al.* 1988).

Ligustrum vulgare flowers over a similar period to *L. lucidum* in Australia, New Zealand and the USA (Goulding 1973, Webb *et al.* 1988, Hardin 1992, Benson and McDougall 1999, Jeanes 1999, Munger 2003, Shepherd 2004, Botanic Gardens Trust 2008).

Flowering of *L. ovalifolium* occurs between November and April in Australia and New Zealand (Goulding 1973, Webb *et al.* 1988, Shepherd 2004). In contrast, flowering of *L. japonicum* has been recorded in summer and autumn in Australia (Shepherd 2004), and spring and summer in the USA (Miller 1999b, Munger 2003).

The pollination of *Ligustrum* species has been discussed at some length elsewhere (Swarbrick *et al.* 1999). Those authors found that flowers in each panicle opened over a period of a week. Flower opening results in the release the distinctive flower scent. After the two pollen sacs split down their outer sides, they recurve with the pollen grains sticking lightly to the inner sides of the anther walls and to each other. These pollen grains are typically not wind borne, although some can be shaken from the anthers by the wind. Pollination occurs by medium sized insects such as honeybees, and also flies and beetles, with moths and butterflies also playing a minor role (Benson and McDougall 1999, Swarbrick *et al.* 1999). These insects are generally attracted by the distinctive scent, and the pale flowers that contrast with the dark green foliage. Pollination occurs under warm and moist conditions.

The fruit of *L. lucidum* ripen in late autumn (from May) and winter and are dispersed from then on until spring (Goulding 1973, Buchanan 1981, van Aalst 1992, in Swarbrick *et al.* 1999, Benson and McDougall 1999, Muyt 2001, J. T. Swarbrick unpublished data). Most fruit are dispersed by August in Australia, whereas peak fruit production occurs in September in Argentina, with some dispersal throughout the year (Dascanio *et al.* 1994, Swarbrick *et al.* 1999).

Although fruiting in *L. sinense* predominantly occurs from May-September in Australia, a low level of fruiting occurs throughout the year (Buchanan 1981, Benson and McDougall 1999, Muyt 2001). The fruiting period of *L. sinense* may occur earlier into autumn in the USA (Miller 1999a, Munger 2003).

Ligustrum vulgare appears to fruit from early autumn through winter in New Zealand and the USA (Goulding 1973, Munger 2003). Similarly, fruiting in *L. japonicum* occurs throughout autumn and winter in the USA (Miller 1999b, Munger 2003). There is only one record of when *L. ovalifolium* fruits, in May in New Zealand (Goulding 1973)

A significant number of *L. lucidum* and *L. sinense* fruit lack viable embryos (9.2% and 17.8% respectively (Swarbrick *et al.* 1999)). This resulted in an average of 110 and 85 intact seeds per 100 fruits respectively in one study, given that some fruit have more than one seed. Fruit production can average around 1300 fruit/m^2 of canopy for *L. sinense* and 400 fruit/m^2 for *L. lucidum* (Westoby *et al.* 1983). Those authors found that fruit production decreased with increasing shade such that 50-70% reductions in fruit production were found in full shade conditions compared with full light. In summarising a number of references, Ekert and Bucher (1999) concluded that seed production in *L. lucidum* could be as high as 100 000-10 000 000 seeds/plant with up to 90% germinability (Fox and Adamson 1986). Fruit production may vary significantly between years with heavy fruit production one year and light the next (Westoby *et al.* 1983). Fruit production is also favoured in moist summers over dry summers (Swarbrick *et al.* 1999).

Individual plants of *L. lucidum* and *L. sinense* have been estimated to live for 50-100 years (Benson and McDougall 1999, Blood 2001). Suckering around the base of *L. lucidum* trees (and probably many other *Ligustrum* species), potentially makes individual plants far longer lived (Swarbrick *et al.* 1999).

DISPERSAL

Seeds of all *Ligustrum* species are commonly dispersed by fruit eating birds particularly during periods where other food sources are limited (Carr *et al.* 1992, Ekert and Bucher 1999). The pied currawong is an important dispersal agent for *Ligustrum* species in eastern Australia (Bass, D. A. 1989, Buchanan 1989b, Bass 1990, Loyn and French 1991, Bass 1996).

Research indicates that pied currawongs can distribute seeds via regurgitation any distance up to 5 km away from where they were eaten (Bass, D. A. 1989, 1990). Large numbers of seeds have been collected from individual regurgitated pellets, for example 162 *L. sinense* seeds, or 67 *L. lucidum* seeds, even though averages are only 36 and 18 seeds respectively (Buchanan 1989b). In another study, Bass (1996) recorded that 38.4% of all seeds recovered after regurgitation belonged to *Ligustrum* species in comparison to seeds of the most numerous species recovered belonging to firethorn species at 55.5%. As a result, *Ligustrum* species made up 29% of all individuals at sites surveyed for ornamental weed flora. In contrast, silvereyes can peck away the flesh of *Ligustrum* fruit leaving the seeds intact, but also swallow and defecate whole seeds (van Aalst 1992, in Swarbrick *et al.* 1999).

A number of other bird species feed on *Ligustrum* fruit spreading it to varying degrees. These include blackbirds, crimson rosellas, eastern rosellas, figbirds, king parrots, Lewin’s honey-eater, mistletoe birds, pigeons (brown and white-headed), red-brown finches, red whiskered bulbuls, starlings and varied trillers, (Loyn and French 1991, Foreman and Walsh 1993, Benson and McDougall 1999, Ekert and Bucher 1999, Swarbrick *et al.* 1999, Stansbury and Vivian-Smith 2003).

Specifically, pied currawongs have been observed feeding on *L. sinense*, while Australian king parrots, satin bowerbirds and noisy friarbirds have been observed feeding on *L. lucidum* (Stansbury and Vivian-Smith 2003). Fruit eating birds are also important dispersal agents for *L. vulgare* (M. Baker pers. comm.).

Rabbits have been suggested as creating high local densities of seedlings after browsing on *Ligustrum* fruit flesh and leaving the intact seeds without swallowing them *in situ* (Burrows and Kohen 1986). Rabbits also graze on seedlings (Benson and McDougall 1999).

The fruit of *L. lucidum* and *L. sinense* is eaten by the grey-headed flying fox, although the role of this species in the dispersal of these species is unclear (Eby 1995, in Benson and McDougall 1999)

Human activity, both intentional and unintentional is an important means of dispersal of *Ligustrum* species. This includes the sale of plants via the nursery industry, garden centres and markets, the dumping of garden waste containing seeds (Blood 2001, Edmanson 2005, M. Baker pers. comm.) and the sale of the foliage with fruit and seeds in floricultural arrangements.

Seed of *L. lucidum* and *L. sinense* may be also be spread by water, presumably as overland flows (Fox and Adamson 1986, Muyt 2001).

VEGETATIVE REPRODUCTION

Vegetative reproduction occurs in some *Ligustrum* species such as *L. lucidum* (Figure 11), *L. sinense* (Figure 12) and *L. vulgare*. *Ligustrum sinense* is particularly known to reproduce by root suckers or sprouts (Westoby *et al.* 1983, Benson and McDougall 1999, Swarbrick *et al.* 1999, Muyt 2001, Harrington and Miller 2005, Figure 12). Other researchers have suggested that rhizomes are responsible for spread of *L. sinense* (Miller 1999a).

Ligustrum lucidum can also sucker (Westoby *et al.* 1983, Figure 11), although whether this is only from damaged stems and roots, or regrowth from cut stumps is unclear (Buchanan 1989a, Blood 2001, SCW 2008). Vegetative encroachment of *L. lucidum* through the production of multiple shoots also occurs (Lichstein *et al.* 2004). There is some evidence that *L. vulgare* suckers (Miller 2003, M. Baker pers. comm.).

Figure 11. Suckering at the base of *L. lucidum* plants (Source: S. Johnson, NSW DPI).

Figure 12. Vegetative reproduction in *Ligustrum sinense* with basal sprouting and possible root suckering near the stem (Source: Nancy Loewenstein, Auburn University, Bugwood.org).

HABITAT

Ligustrum species, including *L. lucidum* and *L. sinense* prefer warm and humid environments with moderate to high soil moisture throughout the year, although establishment will occur in drier environments where run-off water is available (Swarbrick *et al.* 1999, Muyt 2001). *Ligustrum vulgare* also prefers moist areas and there is evidence that a lack of soil moisture will restrict distribution (Gayek and Quigley 2001).

Seedlings of *L. lucidum* and *L. sinense* are tolerant of extremely low light levels (Adamson and Buchanan 1974, Buchanan 1989a, Swarbrick *et al.* 1999). Both species will germinate well under levels of 1-5% full sunlight under sweet pittosporum canopies (Buchanan 1989a). Few *Ligustrum* seedlings persist longer than several years unless there is a break in the canopy (Swarbrick *et al.* 1999). In contrast, seedlings of *L. vulgare* can not survive extreme shade (0.3% of daylight) and generally only establish and survive in high light conditions (Grubb *et al.* 1996, Gayek and Quigley 2001, Munger 2003).

Several authors indicate that *Ligustrum* species are adaptable to most soils (Westoby *et al.* 1983, Bailey and Bailey 1976, Muyt 2001, Shepherd 2004, PfaF 2008). In contrast, other authors indicate that *L. lucidum* and *L. sinense* do not thrive unless found on more fertile soils derived from shale and/or clay soils found in fertile riparian areas (Adamson and Buchanan 1974, Buchanan 1981, Fox and Adamson 1986, Ekert and Bucher 1999). Both of these species appear grow best in areas of increased nutrient and water status due to urban run-off, soil disturbance and the removal of native vegetation, particularly under high soil phosphorus conditions (Clements 1983, Fox and Adamson 1986, Swarbrick *et al.* 1999).

IMPORTANCE

Detrimental

Natural ecosystems

Ligustrum lucidum, L. sinense and *L. vulgare* are considered to be significant environmental and sleeper weeds throughout Australia (Randall 2001). In particular, the first two species are considered problematic in natural ecosystems in Vic, NSW, Qld and the ACT, while *L. vulgare* is only considered problematic in parts of NSW, Vic and SA at present.

Ligustrum lucidum is considered an aggressive and invasive weed of many ecosystems, especially in subtropical and coastal rainforest, and around rainforest margins (Stanley and Ross 1986, Hardin 1992, Stockard 1996, Ekert and Bucher 1999, Mowatt and Smith 2004). This species also invades warm-temperate and dry rainforest, wet and dry sclerophyll forests and woodland, grassy woodland, grasslands and riparian vegetation, in addition to drainage lines, roadsides and wasteland (Clements 1983, Carr *et al.* 1992, Ekert and Bucher 1999, Smith 2000, Blood 2001).

Ligustrum sinense has invaded both wet and dry sclerophyll forests and woodlands, riparian areas, on subtropical rainforest margins, and it grows along fence lines, roadsides and in wasteland (Clements 1983, Clemson 1985, Carr *et al.* 1992, Hardin 1992, Bale and Williams 1994, Benson and Howell 1994, Benson and McDougall

1999, NBII&ISSG 2005). In dry sclerophyll woodland for example, *L. sinense* has been recorded at 11% of Grey box – Forest red gum woodland sites in western Sydney (Benson 1992).

Populations of *L. vulgare* also pose a serious threat to grassy woodlands, riparian vegetation, vegetation on rocky outcrops, and wasteland and roadside banks (Carr *et al.* 1992, Botanic Gardens Trust 2008).

Ligustrum infestations are a particular threat to biodiversity. In their comprehensive NSW study, Coutts-Smith and Downey (2006) found that *L. sinense* severally impacted five threatened plant species, one threatened animal species (Coxen's Fig-parrot) and five endangered ecological communities including rainforest, coastal flood plain and sclerophyll forests. In comparison, the more common *L. lucidum* was a threat to the same animal species and three of the same endangered ecological communities. When assessed against the 1380 naturalised plant species in NSW, *L. lucidum* and *L. sinense* were found to be the 8th and 9th most threatening weeds respectively in terms of impact on biodiversity while *L. vulgare* was listed as 169th (Downey *et al.* 2008). Similarly, *L. lucidum* and *L. sinense* were listed as the 15th and 21st most invasive species respectively in south east Queensland while *L. vulgare* was not mentioned (Batianoff and Butler 2002), probably because it had infrequently naturalised.

Infestations of *L. lucidum*, *L. sinense*, *L. japonicum,* and potentially other naturalised *Ligustrum* species impact wildlife habitat, biodiversity and community structure in New Zealand, South Africa and the USA (Swarbrick *et al.* 1999, Batcher 2000, Munger 2003, Harrington and Miller 2005, NBII&ISSG 2005, ISSG 2006, AGIS 2008).

Human allergies

Pollen of *Ligustrum* species is widely reported as a cause of allergic reactions and hay fever (Auld and Medd 1987, Hardin 1992, Swarbrick *et al.* 1999). This claim is almost certainly incorrect because the pollen of *Ligustrum* species is adhesive and is mainly transported by insects (Webb *et al.* 1988, Benson and McDougall 1999, Swarbrick *et al.* 1999). It is unlikely that a large enough quantity of pollen would be present in the wind to cause allergenic reactions (Swarbrick *et al.* 1999).

Extensive clinical study and testing in Sydney (Bass, D. J. 1989, in Swarbrick *et al.* 1999) concluded that the pollen of *Ligustrum* species is not strongly allergenic. Instead, cross-reactivity occurs and people sensitive to grass pollen may also become sensitive to the pollen of *Ligustrum* species. Dr Bass suggests that it is the perfume of privet flowers which already sensitized people find irritating rather than the pollen. *Ligustrum* perfume is responsible for the "allergy-like symptoms such as acute breathing difficulties and irritation to the mucous membranes" (Shepherd 2004). She suggested that all species of privets be excluded from low allergen gardens (Bass, D. J. 1989).

The physiological effects outlined above result in a number of societal effects. For example, sleep, social habits and general well being suffer during flowering, that is from September in *L. sinense* to January in *L. lucidum* (Mowatt and Smith 2004, Smith 2005). In extreme cases, hospitalisations have resulted. For example an 88 year woman was hospitalised in north western NSW after being exposed to urban plantings of *Ligustrum* and suffering from an asthma attack. This hospitalisation nearly resulted in death (P. Durrant pers. comm.).

There is sound evidence that cross-reactivity between pollen allergens occurs from exposure to members of the Oleaceae family, for example Baldo *et al.* (1992) and Kernerman *et al.* (1992). In particular, exposure to olive pollen has been shown to sensitise people who then react to other pollens that they are not allergic to, including grasses like ryegrass and couch.

Human and animal toxicity
There is some conjecture on the toxic or poisonous nature of the *Ligustrum* species. Evidence suggests that there are no clear examples of human or stock poisoning from Australia despite citing several overseas sources from 1939 to 1968 for such toxicity (Everist 1981). This conclusion is valid for leaves and fruit of all *Ligustrum* species (Swarbrick *et al.* 1999). It is also pertinent to note that neither McBarron (1983) nor Dowling and McKenzie (1993) included *Ligustrum* species among the poisonous plants of New South Wales or Queensland respectively.

The apparent toxic principles of *Ligustrum* leaves and fruit have been investigated (Watt and Breyer-Brandwijk 1962, in Swarbrick *et al.* 1999). They suggest that "the available evidence points towards an irritant principle rather than a toxin" since the bark contains around 7% tannin and the fruit contains a number of possibly toxic chemicals, including ligustron and the glucoside syringopicrin (Swarbrick *et al.* 1999). Despite this, they did not cite any clear cases of *Ligustrum* poisoning of humans or stock.

On examining the evidence, it is likely that the suspected or claimed poisonings in citations in other literature are incorrect, for example Hardin (1992), Blood (2001), Shepherd (2004) and Thomson (2007).

Forestry and horticulture
Ligustrum species are troublesome weeds of native species forestry in Australia (Hall 1987) and hardwood forests in the south east of the United States of America (Miller 1998, Harrington and Miller 2005, USDA-NRCS 2008). *Ligustrum* species invade orchards in Queensland, New South Wales and in New Zealand (Little 1982, Swarbrick *et al.* 1999, Mowatt and Smith 2004). Although commonly grown in gardens, these species are also recognised volunteer weeds of gardens (Swarbrick *et al.* 1999, Mowatt and Smith 2004).

Pastures
Ligustrum lucidum and *L. vulgare* are known to invade pastures in parts of Australia and New Zealand (Curtis 1967, Buchanan 1989a, Blood 2001).

Other negative impacts
Similar to a large number of large shrub and tree species which are planted along side roads, *Ligustrum* species can cause problems with sighting and hard impact problems resulting in safety concerns and presenting potential crash sites (Figure 13).

Figure 13. Plantings of *L. lucidum* represent sighting and potential impact sites when planted along roadsides. This planting near Dorrigo on the Northern Tablelands has also been sign posted as an area where ice forms on the road in winter (Source: S. Johnson, NSW DPI).

Figure 14. *Ligustrum* hedges are commonly planted in tableland areas such as in Orange on the Central Tablelands (Source: S. Johnson, NSW DPI).

Ligustrum species also interfere with electricity and telephone networks in New Zealand (James and Mortimer 1984) and this is likely to be the case in Australia also.

Ornamental plantings of *Ligustrum* help to sustain pest bird numbers in urban areas to the detriment of populations of other birds (Blood 2001, Muyt 2001).

Beneficial

Ornamental

All species of *Ligustrum* currently in Australia have been introduced as hedge, shade, shelter and specimen trees and shrubs (Swarbrick *et al.* 1999, Figure 14). The species are tolerant of a broad range of environmental conditions, for example dry and wet soil, shady and dusty conditions, even thriving in industrial and urban areas (Goulding 1973, Swarbrick *et al.* 1999). The diversity of cultivars of the species *L. lucidum*, *L. sinense*, *L. vulgare*, *L. ovalifolium* and *L. japonicum* have been listed in detail elsewhere, for example Bailey and Bailey (1976) and Griffiths (1994).

Ligustrum lucidum is often planted as a hedge and windbreak in coastal and inland areas because of its hardy nature (Curtis 1967, Everist 1981, Clemson 1985, Stanley and Ross 1986, Hardin 1992, Jeanes 1999). This species is also planted as a garden ornamental (Blood 2001). That author noted that cultivars were prone to reversion to the wild type and that most seedlings produced were similar to the wild type.

Ligustrum sinense is also often planted as hedge or garden screen species in Australia (Clemson 1985, Hardin 1992, Jeanes 1999). Variegated forms of *L. lucidum* and *L. sinense* are common in cultivation (Swarbrick *et al.* 1999). The variegation can range from white through yellow to pinkish, and may be either on the leaf margins or blotchy across the leaves (Griffiths 1994). Variegation is most commonly observed in well-lit leaves and disappears in heavily shaded leaves. It has not been observed in naturalized plants (Swarbrick *et al.* 1999).

Ligustrum vulgare is grown in gardens and used as a hedge plant (Curtis 1967, Webb *et al.* 1988, Hardin 1992, Jeanes 1999). Information suggests that the species was a common hedge plant in Tasmania (Curtis 1967, M. Baker pers. comm.) and elsewhere, and that a number of green- and variegated-leaved cultivars were used in hedging (Rawson and Marcussen 1960, Everist 1981). The species responds well to clipping and shaping (M. Baker pers. comm.).

It is unclear the extent of plantings of *L. ovalifolium* in Australia, but it may have been planted extensively as a replacement for *L. vulgare* (Mabberley 1997). In New Zealand, *L. ovalifolium* is commonly planted as a hedge and most cultivated plants belong to cultivar ‘Aureo-marginatum’ (Webb *et al.* 1988). As the cultivar name suggests, it has golden leaf margins which readily revert to the green leaf form in naturalised plants. Variegated-leaf varieties are also available (Goulding 1973, Shepherd 2004). Goulding further noted that the planting of *L. ovalifolium*, particularly cultivars with yellow or variegated leaves, had largely replaced plantings of *L. lucidum* and *L. sinense* in New Zealand.

Several authors have suggested that the more common weedy species of *Ligustrum*, that is *L. lucidum*, *L. sinense* and *L. vulgare* are no longer being planted in Australia and New Zealand (Clemson 1985, Webb *et al.* 1988). At least one author has suggested this is because people are sensitive to the flowers perfume (Clemson 1985), but there are likely to be a number of other reasons. One of these is likely to be an increased recognition these species are environmental weeds while another is that newer species have replaced these now ‘out of vogue’ species.

This appears to be borne out in information relating to nursery industry availability. For example, only 13 nurseries are listed as able to supply the species *L. sinense* and *L. vulgare*, as well as *L. ovalifolium*, *L. japonicum* and *L. undulatum* throughout mainland Australia (Hibbert 2004). In particular eight nurseries list what is claimed to be the “non-invasive” species *L. undulatum* and/or its cultivar “Lemon, Lime and Clippers’.

Six of the nurseries mentioned above claim to be able to supply the less invasive species *L. japonicum* cultivar “Rotundifolium’ and *L. ovalifolium* cultivar ‘Aureum’. Only one nursery offered *L. sinense* for sale while a different nursery offered *L. vulgare*. Overall, it appears that the nursery trade for most weedy *Ligustrum* species is quite small. Having said this, fruiting stem sections of various *Ligustrum* species are used in floral displays and these are probably sourced from weedy or garden plants.

A range of *Ligustrum* species, particularly *L. ovalifolium* and *L. vulgare*, have been used a root-stocks for the production of other *Ligustrum* species and lilac (*S. vulgaris*), another Oleaceae species (Rawson and Marcussen 1960, Goulding 1973, Bailey and Bailey 1976). The advantages of budding lilac onto *L. ovalifolium* rootstock are that a saleable plant is produced in only two years (Silvester 1999). However, there are significant dis-advantages including graft incompatibility and untimely death of the lilac plant, the lack of root production of lilac roots, the less vigourous root system of privet not be able to support the vigorous lilac plant and suckering of the privet rootstock. Although this practice occurs in Australia, New Zealand and South America (K. Silvester pers. comm.), it is not considered best practice. Furthermore, at least three species of *Ligustrum* are used for bonsai purposes these being *L. sinense*, *L. vulgare* and *L. ovalifolium* (Bonsai4me 2004).

Other positive benefits

Clemson (1985) indicated that useful nectar and pollen supplies for honey bees were obtained from *L. lucidum*. The honey from this species is strongly flavoured and dark coloured. While nectar and pollen of *L. sinense* attract bees, the honey produced is dark amber, has a cloudy appearance, a distinctive flavour and a rather unpleasant after-taste (Clemson 1985), described by Mabberley (1997) as a “fishy smell”.

Ligustrum lucidum is noted for providing a replacement food source for a range of fruit-eating birds and source of habitat for other birds in the absence of native vegetation (Ekert and Bucher 1999). Those authors recommend the gradual removal of this species (and another exotic camphor laurel) combined with replacement of suitable native species to aid bird conservation efforts, for example by the methods outlined in Gosper and Vivian-Smith (2007). Coordinated removal of the weed and replacement plantings of native species over a local and regional area will be needed.

Ligustrum lucidum, *L. sinense*, *L. vulgare* and *L. japonicum* may be used for various medicinal purposes (Blood 2001, ISSG 2006, PfaF 2008). Historically, the wax deposited by white wax scale insects feeding on *L. lucidum* was collected and used for coating candles, as furniture polish, for sizing paper and for other purposes, particularly in 19th century China (Goulding 1973).

The timber of *L. lucidum* may have some potential for light furniture manufacture (Hosking *et al*. in prep.). The hard, close grained wood of *L. vulgare* is valuable for turning (if it is of sufficient size) and can be used to make small tools (PfaF 2008). The leaves, bark and fruit of *L. vulgare* can be used to make dyes and inks, the wood is a source of charcoal and the young twigs are used in basketry and hurdle making (PfaF 2008).

There is limited evidence that seedlings and trees of *Ligustrum* species may act as hosts for the native cherry (K. Boyd, pers. comm.).

Successful legislative and community responses
A five year program conducted by Orange City Council has significantly reduced the problems caused by *L. lucidum* and *L. sinense* (Smith 2005). There were a number of key actions involved including: -

- consultation with all potentially affected stakeholders including council staff before requests for declaration were made;

then once the declaration was granted,

- effective communication – including paid advertising and feature stories in the local paper, combined with privet information and control options sent with rates notices. This included briefing all council customer service staff so that a consistent message was achieved;
- production of a brochure explaining common garden species that may have been confused with the *Ligustrum* species and a static display of plants at the Civic centre. Other exotic and native species were suggested for replanting;
- a free-pick up service for cut material from outside residences;
- removal of the weed on high profile council land early in the campaign illustrating that council was serious about removal. This was complete on council land after three years;
- a phase in period of one year where council only acted on complaints but did not actively inspect properties, followed by inspections and notices in the second and subsequent years.
- enforcement of inspections was tempered by issuing a preliminary notice explaining the negative health affects caused by the species and requesting action by a certain date. This notice was issued, particularly in response to elderly residents who had neither the physical nor financial means to remove the species. Financial assistance organised via several providers made available where necessary, and in limited cases council staff carried out minor work with permission from the land owner; and
- following the non-legal preliminary notice with an official weed control notice (section 18 of the *Noxious Weeds Act 1993*) which was enforced where necessary.

During the period 1999-2004, well in excess of 800 truck and utility loads of the weed were transported to the waste depot to be chipped and used as mulch. At least $50,000 was expended on either inspections or collections (Smith 2005). The costs of the program decreased each year.

The success of the program has resulted in at least one other local government removal program. Armidale Dumaresq council have received around 500 trailer loads and 100 truck loads of privet when a fee waiver was applied to Armidale waste transfer station (Anon. 2008).

A regional approach is needed to effectively manage weeds such as *Ligustrum* that are dispersed over a wide area by birds. Conversely, a lack of legislative control in critical areas within a region weakens the ability of cooperating local control authorities to encourage and, enforce when necessary, the control of the species.

MANAGEMENT

An integrated approach is needed for the control of *Ligustrum* species. This will involve preventing spread to new areas and reducing and removing the species from existing areas (Mowatt and Smith 2004). The removal of trees that produce seeds, and the management of plants before seeds are produced is more easily accomplished than the prevention of seed dispersal by birds (Mowatt and Smith 2004). Effective management can be achieved when dispersal is reduced in that most (>95%) seeds of *L. lucidum* and *L. sinense* do not persist beyond 12 months (Panetta 2000).

Prevention

Replacing ornamental plantings of *Ligustrum* with native species that serve the same function is an important means of stopping invasions before they start (Bass 1996). In these instances, there are at least two considerations. The first is that the native species should have the same utility value as the *Ligustrum* species they replace, that is they are equally useful for hedging and screening and thus have no unwanted plant characteristics, for example thorns, spines or potential poisoning hazards. Secondly, if at all possible, these native species should be endemic to the area they are planted because even Australian native species can act as weeds when planted outside of their native range, for example Carr *et al.* (1992) and Bennet and Virtue (2004).

Since *Ligustrum* species appear to be favoured by increased soil nutrients conditions in riparian areas, one means of preventing infestations is to reduce or stop such nutrients from entering these area (Benson and Howell 1994). This would require both stopping nutrient movement in storm and runoff water from residential areas (for example by reducing fertiliser use in gardens) and preventing the dumping of garden waste from which nutrients move into riparian areas where *Ligustrum* may dominate. Increasing demands on water use and moves toward water and garden waste recycling in major cities in NSW may increasingly help prevent nutrient movement.

Herbicides

There are a range of effective herbicide options for most situations (Swarbrick *et al.* 1999). Current registrations for *Ligustrum* species in Australia include herbicides containing glyphosate, metsulfuron-methyl, picloram and triclopyr and mixtures of glyphosate and metsulfuron-methyl, and triclopyr and picloram (Australian Pesticides and Veterinary Medicines Authority 2008).

Herbicide treatments may be less successful under hot, dry conditions when the plants are stressed (Muyt 2001). This is particularly the case when certain herbicides such as triclopyr are applied under moisture stress conditions (Harrington and Miller 2005). It is thought that active shoot growth in late spring and summer results in the primary translocation of photosynthates upwards rather than to the roots under these conditions (Harrington and Miller 2005).

In Australia, herbicides containing metsulfuron-methyl and mixtures of metsulfuron-methyl and glyphosate may be applied as foliar applications to seedling flushes and bushes up to 3 metres high (James and Mortimer 1984, Buchanan 1989a, Ensbey and Johnson 2007). These plants need to be actively growing and complete coverage is needed to ensure successful translocation and plant death (James and Mortimer 1984).

Foliar applications of *L. sinense* in the USA indicated that glyphosate and imazapyr provided 90% control 12 months after application when applied in late summer and early autumn (Miller 1998). Metsulfuron provided 89% control when applied in late summer but this decreased to 73% in early autumn. Other herbicides gave less effective control. Studies from New Zealand indicated successful control of *L. sinense* (87-100%) using foliar applications of metsulfuron in summer and autumn, and glyphosate with an emulsifier in summer (James and Mortimer 1984).

Excellent control of *L. vulgare* was achieved by foliar applications of metsulfuron (95% mortality after three months) (James and Mortimer 1984).

Research on cut-stump applications indicated that 95-96% control can be achieved on *L. lucidum* in winter with metsulfuron-methyl, triclopyr and 2,4-D acid (Madden and Swarbrick 1990), and 95% control on *L. sinense* using glyphosate in autumn (Dellow *et al.* 1985). *Ligustrum vulgare* was successfully controlled with picloram and 2,4-D, and picloram and triclopyr (James and Mortimer 1984). Good control (86%) was also achieved using glyphosate on cut stumps of *L. lucidum* (Madden and Swarbrick 1990) and *L. sinense* using triclopyr with 83-89% control (Dellow *et al.* 1985).

High levels of control were achieved when *L. lucidum* and *L. sinense* were stem-injected with triclopyr or hexazinone, but variable control was achieved with glyphosate or dicamba (Mowatt 1981). In contrast, while stem injections of *L. lucidum* in winter using a range of herbicides including those used by Mowatt (1981) appeared promising after six months (68-96% control), only metsulfuron-methyl achieved excellent control (93%) after 14 months (Madden and Swarbrick 1990). Other stem-injection herbicides provided inadequate control.

Management via stem-injection was found to be the cheapest in terms of volume of herbicide used, labour and the most effective in reducing off-target damage, a consideration which is increasingly recognised as important in native vegetation and in production areas such as horticultural crops (James and Mortimer 1984, Swarbrick *et al.* 1999). The potential for off-target damage, particular of native vegetation or horticultural plants must always be considered with the use of non-selective herbicides (James and Mortimer 1984, Batcher 2000).

Aside from good control of *L. lucidum* using triclopyr as a wet-stem (basal-bark) application in winter (71%), wet-stem applications of metsulfuron-methyl and 2,4-D acid provided very poor control (57 and 28% control respectively) (Madden and Swarbrick 1990). In contrast, triclopyr resulted in poor control of *L. sinense* (27-

46%), as did hexazinone (28%) when applied in autumn as wet-stem applications (Dellow *et al.* 1985). That trial indicated that glyphosate yielded the best wet-stem control herbicide with 95% mortality (Dellow *et al.* 1985).

Hand removal and regeneration

Hand removal is one of the best means of managing *Ligustrum* species while preventing further disturbance and damage to native species. Hand removal techniques were originally developed from 'the Bradley method', and these techniques of minimal disturbance are now widely used by bushland regeneration groups (Mowatt and Smith 2004).

These methods involve hand weeding of small and medium sized *Ligustrum* plants. The workers need to be trained to both recognise the differences between native and introduced plant species but also how to remove the weed species so that minimal disturbance occurs to the native species. It is thought that the gaps left after weeding need to be similar to those that would occur naturally after the death of a native plant. It is also important to minimise soil disturbance to prevent seedling recruitment (Adamson and Buchanan 1974). In many instances regeneration of seedlings of long suppressed native species will occur, for example Buchanan (1989a). Those authors also indicated that revegetation with native species may have some role in preventing further infestations after hand removal techniques.

Plants of *L. lucidum* are easily removed by hand when the stem diameter is less than 2-3 cm (Little 1982, Mowatt and Smith 2004), particularly after rainfall (Batcher 2000, Clarence Valley Council 2008). Because of the large number of seedlings emerging concurrently, hand weeding may only be needed once per season (Buchanan 1989a). In contrast, similarly sized *L. sinense* are less easily removed. Having said this, roots are very likely to break away from the root systems of plants if they are pulled such that it is often better to dig plants up to prevent re-shooting (Muyt 2001). Pulled plants should be hung off the ground to prevent re-rooting (Clarence Valley Council 2008).

Following on, hand removal of larger *L. lucidum* and *L. sinense* plants should involve the removal of stem material and large surface roots to prevent reshooting (Buchanan 1981, Blood 2001, Mowatt and Smith 2004, Harrington and Miller 2005). This is particularly the case with *L. sinense*, with root segments buried to a depth of more than five times the root diameter able to resprout (Mowatt and Smith 2004). Those authors also recommended that uprooted plants be placed with their roots in the air to dry out.

It is more difficult to remove large plants and speciality equipment such as a mattock or winch pullers may be needed (Swarbrick *et al.* 1999, Harrington and Miller 2005). Such measures have limited overall control, for example a 56% reduction in density was achieved in one study on 12-month regrowth (Harrington and Miller 2005). The major problems with these techniques are that they are time-consuming, that regrowth from root material left in the ground is frequent and that the resulting soil disturbance may result in further privet recruitment (Adamson and Buchanan 1974). Ringbarking is similarly ineffective (Blood 2001, Mowatt and Smith 2004).

Correct plant identification is one of the most crucial factors to ensure bushland regeneration efforts involving hand removal techniques are successful. *Lucidum* species may be confused with a number of native species including sweet pittosporum, lilly pilly, grey myrtle, cheese, native mulberry, coachwood, mock olives and sweet morinda (Buchanan 1981, Blood 2001, Muyt 2001). Further, *Ligustrum* species may be confused with the weedy camphor laurel where they co-occur (Blood 2001). Potentially, the similarity of weedy and ornamental *Ligustrum* species in gardens may also lead to confusion (Blood 2001).

As stated earlier, replacement of weedy *Ligustrum* with native species that are endemic to the area and that serve the same function for birds (Bass 1996) will help prevent future weed spread. This is particularly important in formerly heavily infested areas as these will have lost some capacity to regenerate native species due to seed bank depletion (Swarbrick *et al.* 1999).

Mechanical removal
The physical removal of *Ligustrum* trees by earth-moving equipment may be suitable in certain situations (Swarbrick *et al.* 1999 Mowatt and Smith 2004). This is particularly the case where there is an absence of native or desirable plants and where soil disturbance does not result in other environmental problems. Advice should be sought from the Department of Environment and Climate Change prior to clearing near watercourses or on steep land. Mechanical clearing may also negatively impact of native species regeneration by disturbing seed banks and existing native plants.

Ligustrum seedlings and regrowth may be slashed, removed by hand or treated with herbicides. Mowing and cutting will control the spread of *Ligustrum* species but generally not eradicate the plants. One exception is a reported eradication of *L. vulgare* in the USA after two cutting treatments (Batcher 2000). Depending on the final end use of the area, revegetation should occur, whether with trees, shrubs and ground cover species, grass, or tree plantations (Mowatt and Smith 2004), again ideally with species and genotypes that are endemic to the area. Maintenance of these areas is necessary to prevent weedy regeneration and reinfestation.

Fire
The *Ligustrum* species appear to be susceptible to fire (Swarbrick *et al.* 1999, Batcher 2000, Munger 2003). Fire will kill a proportion above ground seedlings and stems but resprouting should be expected (Munger 2003). In particular, *L. lucidum* is susceptible due to its thin bark and lack of other fire-protective features (Swarbrick *et al.* 1999).

The main difficulties to using fire in invaded Eucalyptus woodlands and forests is that many perennial grasses such as kangaroo grass other ground species that would carry a fire through these ecosystems have been shaded out by the *Ligustrum* invasion. Having said this, experience in Toowoomba has shown that during dry winters in El Niño periods, *L. lucidum* largely defoliates on exposed slopes and ridges and that this and other material will carry a hot fire (Swarbrick *et al.* 1999). Those authors found that most saplings and small trees under 5 cm diameter were killed by the fires. Thicker trees were also killed but in a number of cases plants regenerated from the unburnt stem material. Treatment of regrowth by cut stump herbicide treatments can then be used the following summer. It was also postulated that these hot fires killed much of the weed seed bank at and near the soil surface. Persistent annual ‘cool’ burns have been shown to eliminate *L. sinense* and *L. vulgare* from areas in the southern USA (Munger 2003). Similarly, frequent fires are probably essential to control seedling establishment of *Ligustrum* species in infested sclerophyll forests and woodlands in Australia (Swarbrick *et al.* 1999).

Biological

Although there are no biological control agents that have been intentionally released against the *Ligustrum* species in Australia, there are a number of natural fungal, bacterial, viral and insect pests of species of the genera (Pirone 1978, Swarbrick *et al.* 1999, Batcher 2000).

Although reportedly toxic when eaten in large amounts, grazing animals and stock eat seedlings and fresh growth thereby keeping *Ligustrum* species under control (James and Mortimer 1984, Swarbrick *et al.* 1999). This includes both deer and goats (Stromayer *et al.* 1998, Batcher 2000, Miller 2003, Munger 2003). Very few native Australian vertebrate and invertebrate species damage *Ligustrum* species, with one notable exception being the larvae of the native hawk moth (Fox and Adamson 1986).

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Further details on the biology and management of the privet species can be found in the two publications

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