



NSW WEEDS CONFERENCE

16th NSW Weeds Conference

Proceedings

18th - 21st of July, 2011
Pacific Bay Conference Centre,
Coffs Harbour

Proudly hosted
by



Primary
Industries



Thank you to our Gold Sponsors



Silver Sponsor



Bronze Sponsors



Introduction:

The NSW Weeds Conference held in Coffs harbour 18-22 June 2011, is the 16th in a series organised by NSW Department of Primary Industries in partnership with various other organisations. The 2011 Conference was organised in partnership with Coffs Harbour City Council, NSW North Coast Weeds Advisory Committee, The Weed Society of NSW Inc. and NSW Weed Officers Association.

Organising Committee:

Rod Ensbey, NSW Department of Primary Industries
Birgitte Verbeek, NSW Department of Primary Industries
Tony Cook, NSW Department of Primary Industries
Warwick Felton, Weeds Society of New South Wales Inc.
Tim Scanlon, National Parks & Wildlife Service
Reece Luxton, Clarence Valley Council
David Merrikin, Northern Rivers Catchment Management Authority
Ian Turnbull, Bellingen Shire Council
Barry Powells, Coffs Harbour City Council

Conference organiser:

Michelle Aubert, Coffs Harbour City Council

Citation:

Proceedings of 16th NSW Weeds Conference, Coffs Harbour, July 2011

Disclaimer:

The contents of these proceedings have undergone limited editorial or peer review. Papers have been critiqued (reviewers) for incorrect information, excessively controversial content and politically sensitive or libellous information prior to their publication.

Paper Reviewers:

Rod Ensbey
Birgitte Verbeek
Elissa van Oosterhout
Phillip Blackmore
Alan Maguire
Peter Gray
Tony Cook

ISBN 978 1 74256 211 7

Monday 18th of July

Registration from 4.30pm – Foyer Pacific Bay Conference Centre.

Welcome Reception 5.30pm – 7.00pm Amongst the trade display, Pacific Bay Conference Centre.

Day 1 – Tuesday 19th of July

Opening Session - Auditorium	
Chair	Bruce Christie, Principal Director Biosecurity NSW DPI
8.30	Welcome to Country
8.35	Conference Welcome – Mayor Keith Rhoades, Coffs Harbour City Council, President of the Local Government Association
8.45	Conference Opening - Minister for Primary Industries, Hon. Katrina Hodgkinson MP
9.00	Keynote speaker – Professor Jim Pratley , Emeritus Professor, Charles Sturt University. Weed education - making a difference.
9.30	Keynote speaker – Honourable John Kerin AM. National research, policy and political perspectives on weed management.
10.00	Morning tea and trade display
Mid Morning session - Strategic Planning	
Chair	John Tracey, Manager Invasive Species Program, NSW DPI
10.30	The Australian government's involvement in weed management and future investment. <i>Ian Thompson, Executive Manager, Sustainable Resources Division, DAFF</i>
11.00	The NSW Biosecurity Plan and weeds management. <i>Bruce Christie, Principal Director Biosecurity, NSW DPI</i>
11.30	National quarantine procedures and risk assessment of new plant introductions. Belinda Mitterdorfer , <i>Manager Weed Risk Assessment, Plant Biosecurity, DAFF, Canberra</i>
12.00	Lunch – Sponsored by NSW Weed Officers Association
Mid Afternoon session - How could reform radically improve weed management?	
1.00	Chair: Birgitte Verbeek, Leader Invasive Species Extension, NSW DPI . Introduction to session
1.05	Can anything be done about the institutions that limit the effectiveness of weed management? Professor Paul Martin , <i>Director, Australian Centre for Agriculture and Law, UNE Armidale</i>
1.20	What might happen if we thought differently about weed risk and risk management? Elodie LeGal PhD candidate , <i>Agricultural Research Centre for Agriculture and Law, UNE, Armidale</i>
1.35	How can we radically improve weeds laws? Dr Robyn Bartel , <i>Senior Lecturer, UNE, Armidale</i> & Dr Sophie Riley , <i>Senior Lecturer, Law, UTS</i>
1.50	Questions and clarification

Day 1 Continued – Tuesday 19th of July

2.00	<p>DEBATE - It's about time we realised that we are getting the business side of weed management all wrong! Chair: Honourable John Kerin AM</p> <p>Team 1. Terry Schmitzer - Regional Weeds Management Officer Phil Blackmore - Invasive Species Officer, NSW DPI Dr Jim Pratley - Emeritus Professor, CSU</p> <p>Team 2. Ian Sauer - Primary Producer Ian Turnbull - Manager, Bellingen Shire Council Andrew Storrie - Weeds Agronomist</p>	
2.40	Audience feedback forum – Professor Paul Martin	
3.10	Afternoon tea and trade display	
Day 1 - Afternoon Concurrent sessions		
	On-ground Programs	Weed Threats to Biodiversity
Chair	Carmen Muldoon	Jeff Thomas
3.30	Alligator weed – just add water. Melissa Kahler , NSW Aquatic Weed Project Officer, NSW DPI, Grafton	Kurnell 2020 project. Paul Price , Pest Species Officer, Sutherland Shire Council
3.50	Peak Hill project. Matthew Bailey , Noxious Weeds and Pest Species Officer, Parkes Shire Council & Colleen Farrow, Acting Catchment Coordinator – Tablelands, Central West CMA	Managing widespread weeds for biodiversity conservation. Leonie Whiffen , Project Officer, National Parks & Wildlife Service, Hurstville
4.10	Riparian baseline assessment case study. Shaun Morris , Catchment Officer – Rivers, Northern Rivers CMA, Coffs Harbour	Progress on reducing the threat of widespread weeds to biodiversity: five years of implementing threat abatement planning. Mark Hamilton , Project Officer (Weed Monitoring), National Parks & Wildlife Service, Hurstville
4.30	Session Ends	
4.45	NSW Weeds Officers Association AGM	
6.30	Social networking dinner at Charlie's Restaurant Novotel Pacific Bay Resort	

Day 2 – Wednesday 20th of July

Opening Session		
	Strategic Approach to Weed Management	Strategic Approach to Weed Management
Chairs	Jim Willmott	Mark Asquith
8.30	A zoned approach to the management hymenachne. Craig Magnussen , National Coordinator, Biosecurity Queensland, Warwick	Strategic implementation of WoNS containment lines. <i>Jonathan Lawson</i> , Catchment Officer Invasive Species, Border Rivers/Gwydir CMA & James Browning Senior Weeds Officer, New England Weeds Authority
8.50	Eradicating boneseed in NSW. Hillary Cherry , National Coordinator, Bitou bush and Boneseed, OEH NSW, Pest Management Unit, Hurstville	Building nationwide gorse partnerships. Michael Noble , WoNS Coordinator – Gorse DPI TAS
9.10	Eradication: Lessons learnt from the siam and four tropical weeds eradication programs. Mick Jeffery , Project Coordinator (Tropical Weed Eradication) Biosecurity Queensland	Athel pine management in NSW. Kay Bailey , National Athel Pine Coordinor, NRETAS, Alice Springs
9.30	The challenges of weed management in native pastures. Jo Powells , Acting District Agronomist, NSW DPI, Goulburn	Parthenium weed in NSW – a model for continuing success. Phil Blackmore , Invasive Species Officer, NSW DPI, Armidale
9.50	Morning tea and trade display	
	Weed Management Technologies	Weed Partnerships
Chairs	Reece Luxton	Rod Ensbey
10.20	Weeds in Paradise ! Eradication versus control - An 'Island Wide' landscape approach to weed management on Lord Howe Island. Sue Bower , Flora Management Officer & Hank Bower , Manager Environment/World Heritage, Lord Howe Island Board	Strategic use of Weed legislation to limit the spread of weeds in NSW. Dr Stephen Johnson , Weed Ecologist Strategic Response, NSW Department of Primary Industries, Orange

Day 2 Continued – Wednesday 20th of July

10.40	Tropical soda apple herbicide trials and resistance. Tony Cook , <i>Technical Specialist Weeds, Department of Primary Industries NSW, Tamworth</i>	Alligator Weed Control in An Urban Environment. Barry Powells , <i>Chief Weeds Officer, Coffs Harbour City Council</i>
11.00	Glyphosate resistance threatens Australian weed management. Andrew Storrie , <i>Australian Glyphosate Sustainability Group & Agronomo</i>	Battling bitou bush for biodiversity. Melinda Fletcher , <i>Catchment Coordinator, Northern Rivers CMA</i>
11.20	Flaming fireweed. Professor Brian Sindel , <i>Professor of Weed Science, University of New England, Armidale</i>	Integrated environmental weed management on the far South Coast of NSW. Stuart Cameron , <i>Far South Coastal Weeds Project Officer. Consultant Botanist, on behalf of Bega Valley Shire Council and Southern Rivers Catchment Management Authority</i>
11.40	Flame weeding and alternatives to herbicide use. Cameron Bennell , <i>Bushland Coordinator, Willoughby Shire Council</i>	Darrundar Wajaar repair to country green team. Tim Scanlon , <i>Senior Ranger (Pests), NSW National Parks & Wildlife Service, Dorrigo</i>
12.00	Take away lunch boxes	

Day 2 Continued – Wednesday 20th of July

Field trips – Departing at 12.20

Option 1 - Surfers Safari Tour

The Surfers Safari will provide participants with a first hand experience of what it is like to undertake weed control in one of the most beautiful sections of NSW coast. With names like Sapphire Beach and Look at me Now Headland this tour is sure to appeal to the weed professional who likes to enjoy their surroundings as they work. National Parks & Wildlife Service will illustrate staged regeneration of littoral rainforest and coastal vegetation complexes over a 7 - 8 year period. Diggers Headland will showcase the littoral rainforest regeneration and boardwalk and *thameda* grassland recovery undertaken through a collaborative effort.

Option 2 - Fruit Salad Tour

Ever thought Blueberries grew in square plastic packets on supermarket shelves? Have we got a tour for you! The fruit salad tour visits two of the Coffs regions vital ingredients. Blueberry farming is big business in the Coffs region and with over 1000 acres of crops there is weed management required to produce these tasty fruit. The tour will also take you to some cyclone free banana plantations and provide attendees with some first hand insight into managing these crops.

Option 3 - Rainforest Rave

Travel through the luscious Bellinger Valley stopping off at Bellingen Island to see the restoration and challenges of an endangered rainforest in the middle of town which is home to tens of thousands of flying foxes. On top of this, the whole island is flooded almost annually – and you thought you had weed challenges! Travel up the Dorrigo Mountain through the World heritage rainforest to the spectacular rainforest centre.

5.00 - Return from field trips

6.30 Conference Dinner - including awards, presentations and entertainment. Reef Room, Pacific Bay Conference Centre.

Day 3 - Thursday 21st of July

Opening Session		
	Education Programs	New Weed Issues
Chair	Tim Woodward	Greg Egan
9.00	Weed awareness – Why bother? Roger Smith , <i>Natural Resources Coordinator, Orange City Council & Jessica Grantley</i> <i>Extension Officer, Invasive Species, NSW Department of Primary Industries, Grafton</i>	Tropical soda apple, a new weed incursion. Terry Schmitzer <i>Regional Weed Management Officer, Mid North Coast Weeds Co-ordinating Committee & Josh Biddle</i> <i>Weeds Officer, New England Weeds Authority</i>
9.20	Can't see the fish for the weeds. Charlie Mifsud , <i>Aquatic Weed Project Officer, NSW DPI, Grafton</i>	In the footsteps of cows, using technology to trace new weed incursions. Scott Charlton , <i>Weeds Strategy & Planning Officer, NSW DPI, Orange & Robyn Henderson</i> <i>Invasive Species Officer, NSW DPI, Orange</i>
9.40	Paddock plants – grasses, legumes and herbs. Harry Rose , <i>Education Officer, NSW DPI, Kempsey</i>	Mahonia – one of the top 5 plants you need to have. Ian Turnbull , <i>Manager Sustainability & Natural Resources, Bellingen Shire Council</i>
10.00	Promoting biological control and weed warriors in the community. Paul Sullivan , <i>Invasive Species Officer, NSW Department of Primary Industries, Tamworth</i>	Where might we find invasive alien plants under novel climate regimes? Rodney Jones , <i>Research Scientist Biosciences Research Division, VIC DPI, Frankston</i>
10.20	Morning tea and trade display	
	Strategic Management	Garden Escapes
Chair	Tony Cook	Tim Scanlon
11.00	Natural resource management in an age of mobile GIS. Peter Michael <i>Team Leader - Bush Regeneration, Port Macquarie-Hastings Council</i>	Nursery and garden industry initiatives. Michael Danelon , <i>Industry Development Officer, Nursery & Garden Industry Association of NSW & ACT</i>
11.20	Weed biological control programs in NSW. Royce Holtkamp , <i>Strategy Leader Invasive Species, NSW DPI, Tamworth</i>	Garden escapes and other weeds of bushland and reserves. Terry Inkson , <i>Noxious Weeds Inspector, Great Lakes Council</i>

Day 3 Continued - Thursday 21st of July

11.40	A community in crisis. Ann Herbert , <i>Weeds Manager, Bega Valley Shire Council</i>	Common exotic weed species of Coffs Harbour LGA. <i>Aaron Hartley, Bush Regeneration Officer, Coffs Harbour City Council</i>
12.00	Conflict between the Noxious Weeds Act 1993 and other NSW legislation. Dr Stephen Johnson , <i>Weed Ecologist Strategic Response, NSW DPI, Orange</i>	Water Hyacinth Case Study. Mel Wilkerson , <i>Noxious Weeds Inspector, Tumut Shire Council</i>
12.20	Lunch and trade display	
	Weeds Action Program	
Chair	Ian Turnbull	
1.30	NWAC activities. Maria Woods	
1.50	Weeds Action Program implementation, Regional Weed Project Officers	
2.10	Weeds Action Program overview, Robert Williamson, NSW DPI	
2.30	Conference Summary, David Pomery, Weeds Officers Association	
3.00	Conference Closes	
3.30	WeedMap Pro users meeting	
3.30	NSW Athel Pine Forum	

Program subject to change without notice.

WEED EDUCATION – MAKING A DIFFERENCE?

Jim Pratley

Professor of Agriculture

Charles Sturt University, Wagga Wagga, NSW

ABSTRACT

Weeds comprise an estimated 15% of the nation's flora. Some two thirds of the plants now considered weeds have been deliberately imported for ornamental or agricultural purposes. In the period 1998-2008 some 21 new exotic weeds of concern to plant health in Australia have been found. Control of weeds costs an estimated \$4 billion dollars annually and, despite the availability of many tools available in the IWM armoury, the costs of weed management do not seem to be abating. We can expect there to be jobs for weed scientist, advisers and control officers well into the future although they will be different from jobs of the past.

The processes of weed management have changed. In agriculture, we have moved from a dependency on cultivation and other physical methods to a dependency on herbicides. Whilst this has had dramatic impacts on weed management, as well as on plant and animal production, it has brought a new set of academic challenges. The evolution of herbicide resistance and associated weed shifts is encouraging us to look for new ways and improved efficiencies.

As well as technical change, concerns in the community about safety of pesticides are exerting their own influences on our industry. The introduction of GM crops, for example, has raised fear-mongering to new heights despite the capability of the technology to reduce inputs of pesticides substantially.

There is a need to elevate awareness and education about weeds and their control in order to reduce weed impacts and spread. We ignore or defer the problem to our peril. However, the complexities and sophistication of primary production and of weed management in environmental areas currently and into the future demand a highly educated and skilled workforce. Achieving this is the biggest challenge of all.

Introduction

Technically, education is the process where society deliberately transmits its accumulated knowledge, skills, and values from one generation to another. In agriculture education is achieved in two main ways. We can build our knowledge by

trial and error and thus be better informed through experience. Working with someone with experience enhances that process. Alternatively we can hasten the process by formal education that provides the recipient with best practice as currently known and principles for basing future actions. Experience provides a value-adding component. With the pace of change, the increase in technology, the expectations of the community, the compliance requirements and various other pressures, it is increasingly difficult for experience alone to provide newcomers with the expertise needed to meet employment requirements. Formal education and training therefore becomes an imperative. Addressing the weed menace is no exception to the education paradigm. Experience has allowed adaptation to occur but it was research, development and education which resulted in transformation of farming systems or the eradication or control of particular pests. Let us reflect on the evolution of farming in temperate Australia from a weeds perspective.

From the beginning

It is reasonable to expect that the pioneer farmers and graziers would adopt practices from the UK in their attempts to make a living from Australian lands. In respect of weed control, the early technology involved the use of the mouldboard plough which provided a tillage event and at the same time buried weed seeds at depth. Whilst this was successful in the mild, relatively moist conditions in soils of high organic matter in England, it was less successful on the highly weathered, infertile soils here where climatic conditions were more challenging. Using mouldboards in our environments increased the need for more tillage to provide a suitable seedbed and in the process contributed to a decline in soil structure. This has been reviewed by Callaghan and Millington (1956) and Pratley and Rowell (2003).

At the turn of the 20th Century, the north American technology of the disc plough was increasingly adopted. This was faster, particularly with the introduction of the tractor, thereby allowing more cultivations to effect weed seedling control. The impact on soil structure was harsher and soil erosion was rife. With any farming system, weeds adapted to the particular regime will tend to prosper, and so the south eastern Australian cropping zone became infested with skeleton weed (Cuthbertson, 1967). This weed was adapted because it had the ability to generate new plants from fragments created by the cutting action of the discs. Not only did it compete with the crops but it became a major source of blockage in harvesting equipment and made cropping almost untenable in some situations.

RD&E delivered a transformation of farming in the affected areas. It was shown that a period of pastures (3-5 years) could reduce the infestation sufficiently for a cropping phase of the same duration to be feasible. Incorporating a legume together with superphosphate also provided a fertility boost to the soil such that the crops could benefit (Morrow and Hayman, 1940). The “sub and super story” is one of the great advances in our agricultural history and the ley farming system of farming has served us

well since that time. Whilst soil erosion was an underlying reason for change, it was a weed that forced the transformation to a more sustainable system.

Lesson 1: weeds can adapt to simple systems

Weeds of the 20th Century

Skeleton weed is one of numerous weeds which have threatened agricultural production. It was introduced accidentally before 1916. It became the subject of study by weed luminaries such as Cuthbertson and Groves. It was Hull and Groves (1973) who documented the three forms and subsequently there was developed a rust fungus for the biological control of the main narrow leaf (Type A) form (Burdon *et al.*, 1981). As a consequence the importance of this weed has been substantially diminished in broadacre agriculture.

Challenges have also been brought by weeds such as prickly pear, Paterson's curse, annual ryegrass and wild oats. The first three were deliberate introductions whilst wild oats (in its various forms) was from a series of accidental introductions most likely in fodder or bedding.

Prickly pear was introduced in the 1700s-early 1800s, initially for a possible cochineal industry, but also for possible stock feed in dry areas and as a hedge plant in NSW and Queensland. It was reported as a serious weed as early as 1870. It proceeded to colonise 25 million ha and forced many farmers off their land. Through RD&E the biological control agent *Cactoblastis cactorum* was introduced in 1926 and achieved major control in about 6 years (Dodd, 1940)

Paterson's curse was introduced as a garden flower at Albury in the 1850s. The garden was adjacent to a travelling stock reserve and so was spread on the wool of sheep across south-eastern Australia. It has colonised large areas of south eastern Australia (Piggin and Sheppard, 1995) and is the subject of a diverse biological control program which has not yet delivered. It is a Class 4 Noxious Weed in NSW which requires landholders to control it. Clearly the weed has not read the legislation.

Annual ryegrass was introduced into Australia in the 1880s as a pasture plant (Kloot, 1983). In that role it has been very useful but it has evolved to be our worst weed of temperate crop production. It thus has a conflicted role in our primary production system.

Lesson 2: Potential weed species should not be imported to Australia. Their specific natural control agents are unlikely to be in Australia unless also introduced and the native plant species will be less likely to have competitive mechanisms against the chemical armoury of the introduced weed. (This is a most under-researched area in Australia)

Interestingly, weeds comprise an estimated 15% of the nation's flora. Some two thirds of the plants now considered weeds have been deliberately imported for ornamental or

agricultural purposes. In the period 1998-2008 some 21 new exotic weeds of concern to plant health in Australia have been found. Some lessons are harder to learn than others and need constant reinforcement.

The move to chemical farming

One of the technical advances made through war (World War II) was that of herbicides. The phenoxy chemicals, 2,4-D and 2,4,5-T, eventually became available to farmers and 2,4-D was particularly useful to farmers for skeleton weed management as well as some other broadleaf weeds (Amor and de Jong, 1984). Its restriction was that it could not be used before the completion of tillering of the cereal crop and so became a tool for reducing harvest complications rather than for early control of competition and thus crop yield benefits.

This was followed in the 1960s by pre-planting, soil-incorporated herbicides for wild oats and ryegrass control (eg triallate and trifluralin). Although reasonably effective in that control, they required a seedbed of fine tilth and needed mixing in with the soil. Rather than reduce the need for cultivation, these herbicides increased it. The result was catastrophic as soil erosion became a major issue and surface soil structures were destroyed, resulting in surface crusts with impaired crop and pasture germinations.

At the time there was much research into sowing times. It was clear that delaying sowing beyond the optimum time reduced crop yields dramatically. In the past, farmers delayed sowing so that they could destroy the main burst of weed seedlings that would come with sowing rains to minimise the competition effects in crop – that is, offsetting the loss of crop yield through late sowing with reduced loss of yield caused by weed competition.

The introduction of these pre-planting herbicides, in theory, overcame the need for delayed sowing. In practice, however, the situation was often worsened because, particularly in wet starts to the season, the soil became non-trafficable as there was no soil structure to support vehicles sufficiently without bogging. Timeliness was rarely achieved.

The conservation farming revolution

At around this time ICI was undertaking research and demonstration on the use of bipyridyl herbicides (paraquat and diquat) as complete knockdown of vegetation for preparation of seedbeds for direct drilling. In combination, the herbicide Spray.Seed™ opened the door to crop production without tillage (Hood *et al.*, 1963). Soils were able to retain or regain structure and erosion events were curtailed. This chemical option had limitations in that some weeds (eg Paterson's curse) were difficult to control with Spray.Seed, as were perennials and advanced plants. The herbicide was also at the more dangerous end of the herbicide spectrum. Nevertheless, the concept of conservation farming was established.

It was fortuitous that in 1978 the herbicides diclofop methyl (Hoegrass™) and glyphosate (Roundup™) became available to crop farmers in Australia. Glyphosate was important in that it was able to do what Spray.Seed could not – ie control a broader spectrum of plants including perennials and advanced seedlings – and was safer to use. The only drawbacks were its slower action and that some weeds such as silvergrass (*Vulpia* spp) were not strongly receptive. Diclofop provided for the first time the ability to control both annual ryegrass (*Lolium rigidum*) and wild oats (*Avena* spp) post-emergence, thereby obviating the need to commit to pre-emergent, soil-incorporated control measures. The tools for conservation farming were in place and farmers were provided with simple advice of “graze/spray/sow/post-emergent weed control”.

With the greater adoption of conservation farming there was a greater dependence on herbicides for weed control. More selective herbicides became available for both grass and broadleaf weeds and in most cases were highly effective and relatively easy to use. The mantra of “when on a good thing stick to it” became engrained in the farming system and this simplification led to instability in the form of herbicide resistance. This resistance is exhibited in numerous species and to several modes of action but annual ryegrass, through its widespread existence and propensity to evolve resistance to most modes of action, is Australia’s and the world’s worst example of this phenomenon. The extent of herbicide resistances in annual ryegrass in Australia is given by Broster and Pratley (2006).

Lesson 1 again: Simple is unstable. A successful ecosystem practice becomes unstable as there is a shift to organisms, in this case weeds, which are adapted to the system.

Lesson 3: we need to protect the tools (particularly glyphosate) that deliver the outcomes we want

The increased dependence on agricultural chemicals brought new challenges. There were concerns about:

- safety to users (this was mainly to insecticides but herbicides also became involved);
- unintended consequences (eg spray drift)
- efficacy of use (weed identification, apply to the label rates, under the right conditions and at appropriate stages of growth etc.)
- technology challenges (nozzles, adjuvants, formulations, crop tolerances, withholding periods etc.)

It became apparent that much education needed to take place on chemical application and the industry embarked on a chemical users’ training program, now known as ChemCert (or an alternative program SmartTrain) and this has evolved to the point where the use of agricultural chemicals requires users to have the appropriate certification.

Evaluation of the small data sets on accidents with agricultural chemicals suggests that the safeguards are effective. A Victorian study (Cassell *et al.* 2008) showed that over the period 2004-2006, chemical poisonings on farms accounted for only 1.4% of hospitalisations from farm accidents and 0.5% of emergency department visits. Even in the cotton industry, where historically pesticide use has been high (mainly insecticides until GM varieties were introduced), Fragar and Temperley (2008) reported that the number of pesticide poisoning events has been very small compared to the volumes and frequency of pesticides applications in the cotton industry. This was related to the adoption of best management practice and training programs that were in place.

Reducing chemical dependence

At the same time the RD&E community have been addressing the issue of herbicide resistance and the sustainability of valuable herbicides, including reducing the dependence on chemicals. Through a program called integrated weed management (IWM) there has been a focus on encouraging crop producers to rotate herbicide modes of action to minimise selection pressure in weeds towards resistance. Also included are non-chemical options to relieve the overall dependence on chemicals. Such options include;

- competitive varieties where the crop outcompetes the weed (eg Lemerle *et al.*, 1966)
- reducing weed seed set; if the weed seedbank is low then so will be the weed burden in-crop.
- seed capture at harvest for subsequent destruction (Walsh and Powles, 2004)
- crop rotations including pasture phases and the use of livestock, etc

Such action is also responding to community concerns where there is a desire to reduce the inputs of pesticides in the production of our food supply and into the environment. To that end the recent introduction of GM varieties contributes to this agenda. The Roundup Ready suite of crops has halved the herbicide used in the production of those crops, with only one herbicide being used, ie glyphosate. The farming system has been made much simpler. However their extensive use, particularly in other countries, has shown that weed species shifts take place in that system to those species (eg fleabane) which have a known tolerance to that herbicide. There is also an increased risk of glyphosate resistance evolving as its use transfers from only pre-plant to being a selective in-crop as well.

Lesson 1, again: Simple is unstable. A successful ecosystem practice becomes unstable as there is a shift to organisms, in this case weeds, which are adapted to the system.

To the future

This has been a brief history of crop production in temperate Australia in respect of weed management. There have been two revolutions to date in respect of weeds in these systems – ley farming and chemical farming/conservation farming. There are likely to be others, probably GM crops for example. These changes have involved discovery, development of the application and implementation by the practitioner. In the process there has been the need to educate through both experience and formal education. We can be proud of what has been achieved with increases in productivity consistently through many decades, and food and fibre products which are the envy of the world for their quality, consistency and their relative “cleanness and greenness”.

What changes might we expect? Perhaps:

- crop varieties that control (at least partially) their own weeds? There are rice and wheat varieties now that do that overseas
- a change from synthetic herbicides to natural herbicides/bioherbicides to appease the community concerns?

Interdependency

It would be folly for agriculture to think it operates in isolation. In fact the industry is highly dependant on the biosecurity sector, including quarantine services, to minimise the introduction of weeds and other organisms that provide a threat to agricultural productivity. Agriculture is also reliant on the network of weed field officers to reduce the threat of weeds from non-agricultural lands and have been so reliant for a long time. Their role has perhaps not been appreciated as it should. The network contains many officers with a long history of experience. The age distribution is skewed with a higher proportion at the older end and we risk losing that wealth of experience over time. It is encouraging to know that the training programs that now exist will help to fill that void. It is pleasing also to note that a good proportion of the younger brigade have formal qualifications at the diploma and degree level within the NSW system (Bartlett-Taylor and Honeywood – unpublished).

Conclusion

Whatever way we go, including addressing the here and now, we will require a well-trained and educated workforce at all levels of the agricultural industry – from the scientist to the adviser to the implementer of the applications. The pertinent issue is that the supply of qualified people is in sharp decline and the product from tertiary institutions is now well below sustaining the current workforce.

Acknowledgements

The author wishes to acknowledge the following people for their help in developing this talk: Birgitte Verbeek, Deirdre Lemerle, Tony Lower.

References

- Amor,RL and de Jong RW (1984) Changing weed problems in cereal cropping in Victoria since 1920. *Journal of Australian Institute of Agricultural Science* 49 139
- Broster JC and **Pratley JE** (2006) A decade of monitoring herbicide resistance in *Lolium rigidum* in Australia. *Australian Journal of Experimental Agriculture* 46(9), 1151-1160.
- Burdon JJ, **Groves RH** and Cullen J.M (1981) The impact of biological control on the distribution and abundance of *Chondrilla juncea* in southeastern Australia. *Journal of Applied Ecology* 18: 957-966.
- Callaghan AR and Millington AJ (1956) *The Wheat Industry in Australia*. (Angus and Robertson, Sydney)
- Cassell E, Clapperton A and Reid N (2008) Preventing unintentional farm injury. *Hazard*, Edition 68, Victorian Injury Surveillance Unit
- Cuthbertson EG (1967) Skeleton weed – distribution and control. NSW Department of Agriculture Bulletin 68
Dodd AP (1940) The biological control of prickly pear in Australia. *Imperial Bureau Pastures Bulletin* 131-143
- Fragar L and Temperley J (2008) The impact of biotechnology and other factors on health and safety in the Australian cotton industry. Australian Centre for Agricultural Health and Safety, The University of Sydney
- Hood AEM, Cotterell R and Jamieson HR (1963) Destruction of pastures by paraquat as a substitute for ploughing. *Nature* 197 748
- Hull VJ and **Groves RH** (1973) Variation in *Chondrilla juncea* L. in south-eastern Australia. *Australian Journal of Botany* 21: 113-135
- Kloot, PM (1983) The genus *Lolium* in Australia. *Australian Journal of Botany* 31, 421-435.
- Lemerle D, Verbeek B Cousens BR and Coombes NE (1996) The potential for selecting wheat varieties strongly competitive against weeds *Weed Research*, 36, S05-S1J
- Morrow JA and Hayman RH (1940) *Journal of Department of Agriculture, Victoria* 38, 205
- Piggin, C.M. & Sheppard, A.W. (1995) *Echium plantagineum* L. *The Biology of Australian Weeds*, VOL. 1 (eds R.H.Groves, R.C.H.Shepherd & R.G.Richardson), pp. 87–110. Richardson, Melbourne, Australia
- Pratley JE and Rowell L (2003) Evolution of Australian Agriculture. In “Principles of Field Crop Production”, ed. J Pratley, pp.1-25 (Oxford University Press: Melbourne).
- Walsh M and Powles S (2004) Herbicide resistance: an imperative for smarter crop weed management *Proceedings of 4th International Crop Science Congress* Brisbane, Australia, www.cropscience.org.au

SPEECH TO NSW WEEDS SOCIETY ANNUAL CONFERENCE, COFFS
HARBOUR, JULY 19, 2011, BY THE HON JOHN KERIN

‘NATIONAL RESEARCH POLICY and
POLITICAL PERSPECTIVES ON WEED MANAGEMENT’

This will not be a ‘key note’ speech. It will be a ‘low-note’ speech. Let me explain why. The super-efficient Conference organisers wanted a title quite some time ago and I thought that the title I quickly provided would suffice. The problem is that the more I thought about it and having attended earlier weed conferences, the more I looked into what has been said along these lines, has all been said before. I even looked into ‘the fog of Google’.

However, having been in the Australian Parliament for eighteen and a half years and having been a Minister for ten years, I now have vast wisdom and by not being in any political Party and being totally disenfranchised, I can say things about policy and politics that people still engaged in politics or in official positions, can’t!

Although irrelevant to most people in their day to day lives, the art of politics, policy, policy implementation and political decisions are still quite important. I realise this is a heretical view. But then again, I am now an absolute relic, if not a fossil, totally confused by the ultra-pressured policy and media environment that Ministers, Parliamentary Secretaries and politicians work in today.

When I first heard about the NSW Conference, I thought I should offer to say a few words about weed research having chaired the Boards of the two weed CRC’s, 1995-2007. Having also chaired the Board of the Tropical Savannas CRC for the same period, I became more than well acquainted with, or terrified by, the weed invasion in the top 26% of Australia. I also chaired the Board of the CRC on Soil and Land Management, and again the relationship of soil health to weeds was seen as important.

A lot was learnt during the life of the two weeds CRC’s and a lot of work also went into the provision of technical advice and education, including production of a bunch of post-graduates, most of whom gained employment in weed or weed related areas. Before the CRC was initiated by industry, university and CSIRO people, it was estimated that in all Australian universities about 2.3 people were engaged in any lecturing on the weed sciences. Time will not allow me to summarise the scientific research work carried out by the two CRC’s.

Under the guise of a CRC for invasive plant species, another weed CRC bid failed to gain a third iteration due to Minister McGauran changing the CRC rules to stop public good CRC’s, when he was Science Minister. There was also a government obsession to turn CRC’s into companies and profit making ventures.

The CRC program’s funding is gradually being reduced, which possibly reflects some arcane political judgement or the government responding to new priorities. It has been my view that two terms of funding should be enough to demonstrate the virtue of

research collaboration to the interested parties. If a need is revealed for a longer term collaborative approach to a crucial challenge, than other means have to be established.

However, the Rudd and Gillard Governments have cut \$103m out of the programme, with another \$33m to be cut over the next four years, and the number of CRC's has dropped from seventy to forty six. This doesn't actually reveal overwhelming enthusiasm for the co-operative cum collaborative research principle and new priorities don't seem to have been revealed.

The outgoing Weed CRC CEO, Dr Rachel McFadyen, now battling Madeira Vine up near O'Reilly's, fellow Board members and I decided we needed a 'permanent' weed research institution, (not that anything can be really permanent). We lobbied the three main political Parties. (We assumed the Greens would back anything that was warm and fuzzy and involved public expenditure).

Being embarrassed by his previous decision, the by then Agriculture Minister, McGauran was opposed, his co-Minister Senator Abetz was in favour as was the Opposition spokesperson on Agriculture, Senator Kerry O'Brien. However, Senator O'Brien wasn't anointed when the Lord God thy Rudd (who unfortunately seemed not to believe in Responsible Cabinet Government) and my old mob was elected in 2007.

Industry Minister Kim Carr thought it might be best if we went down the CRC path again. Having been in Cabinet when Chief Scientist Ralph Slatyer persuaded the Prime Minister's Science Committee to establish the CRC system, I was of the belief that two terms should be enough for most CRC's. And, as I have said, if a crucial long term challenge such as weeds is revealed then there has to be a collaborative research body of a more long term nature.

After some bloody-minded persistence, nagging and making a pest of myself, Agriculture Minister Tony Burke endorsed the promise and nominated me, in two stages, to chair a board and then a Committee, which combined eventually met over two years. With weed research I have form.

However, I assure you that I am not obsessed with weeds. There are lots of other things I want to do in the time left to me before I push up daisies-or capeweed? Weed research, possible control and management are all part of plant bio-security. I simply believe that we need to have a 'permanent' weed research institution established within a collaborative framework, in keeping within the realities of the way this country is governed, to tackle the weed menace and ongoing weed invasion.

Institutions are where wisdom and knowledge grow. Necessity and knowledge are the mothers of innovation. If you want to research bio-control, you need a decent period of time. To prevent duplication, to gain the benefits of cross-fertilisation of ideas and sciences, to build the most comprehensive data-base, you need some centrality of administrative function.

Regardless of the priority given to weed research and management by governments, primary producers, research organisations, such as the Grains Research and Development Corporation (GRDC), and other land managers, my only motivation to keep involved into

my old age is because weeds are by far the second most serious cost concern to farmers and graziers, in terms of the affect of weeds on their production.

That is, in terms of matters, vaguely within their control, unlike the weather, markets, the exchange rate, external events and Climate Change; if they believe the latter is not a giant hoax perpetrated by Julia Gillard as a vote winner? Further, our unique natural environment, national parks, state forests and public lands are also under the same growing threat. Only the WWF of the environmental NGO's seems to take a strong interest in weeds, which is regrettable.

I hasten to add that, while I know quite a bit about research and its administration, generally, I only know a little about the various weed research disciplines. I know very little about weed management, get confused or forget the name of herbicides and e.g., can't tell the difference between Poa Grass and Serrated Tussock.

Worse, my Welsh spouse thinks Paterson's Curse looks lovely in spring and my neighbours on the coast rejoice in having vast vistas of Agapanthus, which inflict themselves on our patch of infertile silica, which poses as soil.

The first Board I chaired was named the Interim Advisory Board of the Australian Weed Research Centre and the good people Tony Burke appointed worked through the second half of 2008 and until June 2009. The title gave me hope. We consulted with the States and Territories and the Agricultural Research and Development Corporations (RDC's), universities, research institutions, such as the CSIRO, some environmental NGO's (WWF) and people from the disbanded Land and Water Australia's Defeating the Weed Menace Programme.

DAFF provided the Secretariat and a succession of people who worked assiduously with us as did a succession of young women in the Minister's Office. One very nice young woman asked me what Landcare was. I asked her age. I'm amazed that the child care centre she had attended at the time didn't tell her about Landcare. As we only had funding in the forward estimates of \$15.3m for four years, we made an open call for projects. The \$0.3m was for a special research programme on Fireweed.

We were swamped with applications and appointed two scientists to assess them and some 30 or so projects were signed off. We employed a professional corporate planning organisation and a firm of lawyers and recommended to the Minister a Centre by way of a company to be at elbow's length from government, put forward a funding mechanism, a Business Plan, an Operational Plan and a Business Proposal.

As far as we can work out, this was rejected by the Minister some time in the second half of 2009. I was feeling a bit like Sisyphus, the character in Greek mythology, who was allegedly 'the most cunning knave on earth', who had to push a rock, or something, uphill for punishment, but it kept rolling back.

I then wrote on behalf of the Board to Minister Burke, suggesting that the Rural Industries Research and Development Corporation (RIRDC) be given the task because it has an excellent Strategic Plan, that it is a very professional organisation, that it knows how to let and supervise contracts and is familiar with all the accountability and compliance requirements of government, which keep the corporate consultant industry

endlessly happy. My blood type, mother's maiden name and buying habits are now available in cyber-space, but, being an ex-politician, I am resisting truth tests.

The Minister agreed with me and he engaged with the executive of the RIRDC. So, in mid-2010 I chaired the National Weeds and Productivity Research Programme Advisory Committee, which, again, was composed of a very relevant, capable group of people nominated by the Minister.

A workshop was convened in mid-year where a lot of prominent players in the weed research and management game were assembled. Out of the voluminous findings, a consultancy firm in conjunction with the RIRDC drew up a national Weeds and Productivity Research Program, R&D Plan, 2010-2015. It was decided to make an open call for projects which would be signed off by the Minister, who was Senator Joe Ludwig by this time.

Luckily, we also now have Dr Mike Kelly as Parliamentary Secretary for Agriculture Fisheries and Forestry, who is interested in weed management and research. I say this not because he is here but because I know of his interest in the weeds in his electorate, which covers a lot of the CMA I'm on the Board of. There are some very active weed committees in his electorate of Eden Monaro, one of which I attend.

We still had some \$11.6m in the kitty but we held funds back for commissioned projects hoping to fill in any gaps. This time, well over two hundred submissions were received, stringent criteria for assessment were drawn up and the thirty three successful proposals have now been announced by the Minister, to be completed by May 2012.

The commissioned projects have now also been announced. It is hoped that a policy analysis of all these projects should enable RIRDC to put a developed proposal for an ongoing research facility before the Government next year. The range of and number of proposals tells us either there is an enormous demand to carry out weed research or that if some funds are made available, research organisations are desperate for any research funding ; probably both.

I'll now go back a step and talk about research more generally.

Due to circumstances, probably only within my partial control, I became a 'bush-economist' when I gave up farming and joined the Bureau of Agricultural Economics (BAE) in 1971. I should have become some species of 'bush-scientist'.

It was there that I learnt that a raft of scientific work on the objective measurement of wool, starting in 1937 in Leeds, U.K., and a lot of work in the University of NSW in the 1950-60's could be combined with sound economic policy to the financial advantage of and better product marketing for wool producers.

It only took thirty four years to see the science adopted! This lesson has stayed with me all my life. Agricultural innovation has been constant and science and scientific research is at the base of most progress, especially with respect to productivity gain but often at the expense of the natural resource base. Weed control and management is very much a natural resource management (NRM) issue, as well as a bio-security issue.

One cannot say that we don't have a comprehensive infrastructure for weed 'control' and management. It is basically the Constitutional responsibility of State Governments, which divert implementation to local government and various instrumentalities within their quasi-control. Implementation is bound by laws, including the Noxious Weeds Act in NSW, that apply to land managers but Councils lack the funds to carry out the inspection work, let alone get heavily into control. Some NSW Rural Lands Protection Boards were concerned with weeds but since becoming Livestock Health and Protection Authorities they seem have enough on their plate.

Farmers get stuck with the bill and if it is not paid it can come out of the estate. Further, State agencies also fail to carry out control measures in areas of their clear responsibility for the same reason; lack of funds. This is not to say that the States and Territories are not involved or concerned.

But they don't have the money, nor is there the obvious political will to deal with the problem comprehensively and, as a substitute, they plan. I've seen some great plans.

Two political beliefs or directions have had an enormous influence on where we have arrived at in agricultural policy today. One was the constant parroting by the conservative political Parties of 'States Rights' until well into the 1980's and the 'protection all round' policies until the early 1970's, which were directed to commodity production at the expense of other growing concerns, such as environmental impact and neglect of the natural resource base.

The Australian Government is only able to influence agricultural policy by the provision or denial of funding, protection policies, negotiation or 'carrot and stick' measures. The word 'agricultural' did not appear in the name of any Australian Government Department or Ministry until 1942 and the BAE, now the Australian Bureau of Agricultural and Resource Economic Research and Science (ABARES), was not formed until 1945.

The problems of the Murray Darling Basin are a classic case of the lack of co-operation between the States on an NRM issue and where the Australian Government has to pick up the bill due to irresponsibility. Most agricultural research in Australia was carried out by the CSIRO and the universities until quite recent times. Co-funding by industry did not commence until the 1950's and there were only five product based research funds by the early 1970's.

In the first speech I made as Minister for Primary Industry I said that I intended establishing a Bureau of Resource Science as an equivalent of the BAE. My idea was that such a body could advise me on natural resource management issues and the science in, e.g. fisheries and forestry management.

Weeds were only brought to my notice twice for the whole time I was Primary Industry Minister, 1983-91. I was once flown by a crusty old Queensland cattle grazier, John Stewart, in a helicopter west of Charters Towers to have a look at Rubber Vine and also saw some of the other invasive plants in that part of the world. The rubber vine grew along the water courses and was a harbour for feral pigs; John's concern was about the threat of an exotic disease getting into the feral pig population.

The other time was when I visited a property at the back of Nambucca Heads, where I saw massive infestations of Lantana. I was also greatly concerned by this and volunteered the naïve view to the property owner that we needed a biological control for the weed. I was assured by him that the Lantana did provide a good cover crop for one of the district's main cash crops!

While not obsessed by weeds, I am a bit obsessive about the need for research. The obsession isn't just about intellectual curiosity but pragmatism. Australia has 0.3% of the world's population and we are the stewards of a flat, mainly desert and semi-desert continent, with a wet fringe but mainly poor soils.

We also have a somewhat unique natural environment. Unless we invest heavily in research and development and education we will fall further behind the industrially developed and parts of the developing world. Australia 'produces' about 2% of the world's research findings. The trick is to have enough expertise to access and adapt the other 98%, where relevant.

Although I get all the credit for the establishment of the agricultural research and development corporations in the 1980's, the work was carried out by many. We built on the past and what had been learned and what we perceived as the need. The theory, concepts and design was the brainchild of the Deputy Secretary, later Secretary of the Department, Dr Geoff Miller.

It took two acts of Parliament, countless hours of work over six years, argument and negotiation to get thirteen RDC's and five research councils established. For the first time, we gained a secure funding base, which the Department of Finance, or a Cabinet intent on cost cutting over function, has not yet been able to tear down. The Department of Finance will always be in there trying.

Three RDC's were set up with budgetary funding, rather than matching funding, to research generic and cross-industry, cross-cutting issues and also, in RIRDC's case, to assist smaller agricultural industries. They were, firstly, the Energy Research and Development Corporation, which John Howard immediately wiped out on coming to office. With all that coal I suppose we don't have any researchable energy problems. Then there was the Land and Water R&D Corporation, later to become Land and Water Australia (LWA) which was wiped out by the Department, as I understand it. The drought was over I suppose.

Then there was the RIRDC, which had \$3m chopped out of its annual allotment of \$13m in the Budget before last. All corporations were able to leverage funds and seek contracts. RIRDC was also able to set up minor industry research funds, if a fair system for levies or negotiated funding could be agreed to. LWA was able to build its funding base to about \$40m p.a. and well managed the Defeating the Weed Menace Program, which adopted a valuable 'think tank' type role in dealing with weed research.

The Howard Government, always intent via the Nationals, to put farmers on boards, turned the RDC's into three kinds of models ranging from corporate to private companies and, stupidly, put some back into statutory marketing authorities. Cross cutting and cross-industry issues have tended to go out the window, except for the work of RIRDC and previous work of LWA. The RDC's are yet again being reviewed.

The most recent report on research and innovation by Dr Terry Cutler (1) provided an excellent analysis of the research challenge, stating that innovation is being re-shaped, that our research architecture is out of date and that we need a cohort of researchers as aware as the competition to participate at international scale.

Traditionally, it has been the States, the universities and the CSIRO which have carried out most weed research. The RDC's are about determining research directions for funding and the CRC's were also involved in longer term research collaboration and funding, often being involved with the RDC's, universities, CSIRO, producers and the private sector.

The States have been gradually cutting back on research and extension expenditure and we also face a dramatic shortage of agricultural scientists and economists in the coming years. Large agri-business companies and agricultural consulting firms are picking up some of the research extension role. State based research is being situated in universities. I was recently in the Boggo Road research precinct in Brisbane where the University of Queensland, the relevant Department (DEEDI) and CSIRO are jointly located.

I even saw an Argentinian fly which hopefully just loves to eat Mesquite Bush and a bug which hopefully loves to attack Lantana; both are undergoing species testing. It would seem the partnership approach with the universities is now the way to go. But it may only give more power to the so-called 'sandstones' at the expense of regional universities, which still retain weed science expertise, e.g., UNE and CSU. I am well aware of the work being carried out in both these universities and, particularly, of Paul Martin and Brian Sindel at UNE.

Now being only a voter, but non-innocent bystander, I give all governments and politicians a hard time. Being one quarter Irish, I'm basically against all governments. Unfortunately, I still read newspapers cum opinion sheets, but luckily I know there is very little in them you can believe and only about 15% of people read them.

Being a troglodyte, I don't believe all knowledge and wisdom comes from a computer screen, twits or blogs. But credit where credit is due. The Howard Government endorsed the process of identifying weeds of national significance (WONS) on 1 June 1999 and, as well, the Australian Weeds Strategy (AWS) was endorsed in November 2006. The two relevant Ministerial Councils, ARMCANZ and ANZEC and the Forestry Ministers endorsed the WONS process and the AWS. That's a lot of political heave. Both decisions saw facilitators and specific weed committees appointed.

Allegedly, the AWS is an integrated approach to national bio-security encompassing national strategies for invasive species such as those for terrestrial vertebrate and marine pests. The WONS twenty critical weeds are being reviewed and the Board is working to make itself a more powerful voice.

The infrastructure is available, including Landcare and the fifty six regional natural resource management authorities or boards are now well placed to engage in some implementation of weed control and management at both national and local level or at least be a conduit for information and a broker of research results.

With respect to the CMA's in NSW, they are in an excellent position to act as conduits for weed research information and the development of local weed control or management plans and to work closely with local government. The two Reports I did for the NSW Government (2) convinced me of the wisdom of regional NRM- we'd tried everything else. All local governments are not the same, quite apart from who gets elected onto them.

The areas that councils west of the Divide have to cover are immense- some Council areas only have 800 rate-payers. Some small Councils with large areas lack expertise. The councils on the coasts of NSW and in the cities have to deal with population pressures above all else.

The problem here is that Caring for Our Country has nearly halved the money for CMA's in favour of major or icon environmental challenges and the decision to pump billions of \$ into the regions (which most of us welcome) is a national approach that is overwhelming the local and stifling the essential need for the complementary bottom-up part of NRM.

Another issue that the farm sector and those knowledgeable are currently concerned about is, as I have said, yet another review of the RDC's, the latest one being by the Productivity Commission, which looked at the public funding of research only a couple of years ago, giving it a clean bill of health on the basis of spill-over affects.

A lot of advice on research is going to the Minister(s). If the recommendation in the draft report of a major NRM RDC goes ahead with a halving of matching funds for the commodity based RDC's, this will cause massive problems for overall agricultural research. The RIRDC is well placed to pick up this gap if a new overall NRM RDC is not agreed to. The adoption of a RDC model under the auspices of the RIRDC to specialise in weed research, would work very well, because people are familiar with the systems involved.

Back to my violin. To my mind, the big lack, the big gap, is for there to be an Australian Weed Research Centre- there's plenty of infrastructure and institutions around to deal with the issue of invasive plant species. I accept that there are always better ways of carrying out research and managing weeds and we'll be discussing this at this Conference.

But there is also an obvious lack of funding, overall. Being on the Board of CSIRO, I know that the current government wants to do more in the research area, once the budgetary implications of the GFC are past. (Not that the GFC ever happened and if it did, it was all over in three months) Yet a majority of us here, as weed insiders, knowing the problems at many levels still feel not enough priority is being given by governments to the issue.

Why is this so? "Too hard", "weeds can't be controlled only managed", "it's a black hole for \$", "it's beyond us", "why aren't environmental NGO's more vociferous?" "Or are there no votes in it and other issues are more pressing?" Well it could be all of these things. I also well know that regardless of it being the public or private sector, that when the going gets tough, the easiest expenditure to chop is research. The bottom line rules.

Government is complex. Government in a federation is difficult. Government at the national level, particularly, has to take everything into account because everything is related to everything else. We are part of a globalised world that is in a new guise.

All the dots have to be joined. Governments can't just deal a single issue at a time. Polls are only ever snapshots in time unless an issue builds. Government can't or shouldn't take notice of shock jocks or focus groups who are only interested in the very short term or their own pockets or display of ignorance, respectively.

Yet, the Australian Government has a lot more flexibility than State governments. For example, thanks to the late Osama bin Laden, militant religious fundamentalism and regional wars we now have thousands of people working in Canberra on security that weren't there before.

The most recent Australian Government budget saw an increase for mental health funding. The need had been recognised for a long time, the point being that it takes a long time for some desirable policies to be enacted and then implemented. It is also very hard to spend money wisely, quickly.

Major research institutions, that have relatively large funding, are also constantly re-examining priorities and how to do more with less in an environment where they have to specialise and meet new demands.

I can see the way through quite easily but it depends on political will- \$10-12m p.a.- would the sky fall in? If, after the completion of the projects now under way at the RIRDC, a case for a permanent centre is not accepted, then we'll have to look at other approaches; perhaps combinations of universities, a colloquium approach, perhaps down a Centres of Excellence path, perhaps a novel way to work with RDC's and the precinct model?

I'll stick at it a little while yet. Who knows? – anything may happen.

Thank you.

(1) "Venturous Australia", report on Australia's National Innovation System, being the report of an expert panel chaired by Dr Terry Cutler, Sep 2008.

(2) Report into The Western Division and The Premier's Advisory Taskforce's Report on "Farming and Natural Resources"- both gathering dust!

NATIONAL QUARANTINE PROCEDURES AND RISK ASSESSMENT OF NEW PLANT INTRODUCTIONS

Belinda Mitterdorfer
Manager, Weed Risk Assessment
Plant Biosecurity, DAFF, Canberra

SUMMARY

Following the 'Beale' review of Australia's quarantine and biosecurity arrangements, Plant Biosecurity and the Australian Quarantine and Inspection Service (AQIS) are now more closely aligned to streamline quarantine services, including efforts to prevent pests from entering Australia. Plant Biosecurity undertakes science-based risk assessments and provides quarantine policy advice to AQIS who implement it at the international border. Australia has strict quarantine standards designed to protect our unique environment and our agricultural and horticultural industries. When developing import protocols and quarantine conditions, Australia complies with international obligations (including the World Trade Organisation and the Agreement on the Application of Sanitary and Phytosanitary Measures).

A proportion of plant species previously imported into Australia for both horticultural and agricultural purposes have become weeds in Australia. As a result of the 1996 'Nairn' review of quarantine, a pre-border screening system was developed to strengthen the risk assessment process for new plant introductions. The new screening system became known as the Weed Risk Assessment (WRA) System and was formally adopted by Australia in 1997. The WRA System is currently the primary method for assessing the weed potential of new plants before they are permitted entry to Australia. Results obtained from the WRA System form the basis of policy determinations for the importation or prohibition of plant species, implemented by AQIS under the *Quarantine Act 1908*.

AQIS is responsible for quarantine activities at Australia's international borders. With more than 60,000 kilometres of coastline offering a variety of pathways for exotic pests, AQIS plays a critical role in reducing the risk of these pests entering Australia. Border control activities focus on intercepting and managing potential quarantine threats at Australia's airports, seaports and international mail centres. This involves AQIS screening, inspecting and clearing the millions of people, mail parcels, baggage, ships, animals, plants, and cargo containers entering Australia every year using X-ray machines, surveillance, and, of course, the instantly recognisable detector dogs.

INTRODUCTION

Australia currently has one of the most effective quarantine systems in the world and as a result remains free from many serious plant pests that affect environmental and agricultural sectors in other countries. However, Australia's past quarantine policy predominantly focused on preventing insects or diseases from entering with plants rather than plants as pests themselves (Nairn 1996). Consequently, many plant species historically imported into Australia for horticultural or agricultural purposes are now naturalised in Australia (Groves et al., 2005, Nairn et al., 1996).

Due to concerns of pests entering Australia through increasing international trade and movement of people, two major reviews on Australia's quarantine and biosecurity

arrangements have occurred over the past 15 years (Nairn et al., 1996, Beale et al., 2008). The 'Nairn' review resulted in the implementation of the Weed Risk Assessment (WRA) System to screen all new plant introductions. The WRA System is used as the primary tool to prevent species which are likely to become weeds in Australia from being allowed importation. Both the 'Nairn' and 'Beale' reviews aimed to streamline and produce greater efficiency in Australia's quarantine border procedures (Nairn et al., 1996, Beale et al., 2008).

The Commonwealth Government is primarily responsible for international border procedures. As part of the quarantine portfolio, Plant Biosecurity is responsible for developing quarantine policies for the importation of plant and plant products. Plant Biosecurity ensures that it develops policies in accordance with the rights and obligations Australia has as a signatory to both the World Trade Organisation and the International Plant Protection Convention.

Quarantine policy implementation is the responsibility of the Australian Quarantine and Inspection Service (AQIS). The Australian Quarantine and Inspection Service regulates the importation of all types of plant material into Australia under the *Quarantine Act 1908* and subordinate legislation.

This paper will discuss Australia's current measures to keep weeds out of Australia including Australia's WRA System and quarantine border controls.

AUSTRALIA'S WRA SYSTEM

History

Quarantine in Australia was reviewed in 1996, following a number of incursions of exotic pests and diseases into Australia (Nairn et al., 1996). The review recommended that the regulations governing the importation of plants and plant products should be based on a list of plant species permitted to be imported rather than a list of plants prohibited from importation. The 'prohibited list', in place at the time, contained plant species that had known quarantine pests associated with them and/or were widely recognised as weeds elsewhere in the world. However, this approach was not effective for all weeds as many plants which have become weeds in Australia have not been recorded as weeds overseas (Walton, 2001). Consequently, Australia adopted the WRA System in 1997 as the primary method for assessing the weed potential of new plants. This system is used to assess all new plants imported as seeds, nursery stock or tissue culture regardless of their country of origin or intended end use. The Department of Sustainability, Environment, Water, Population and Communities and a wide range of stakeholder groups have endorsed the operation of this system.

Plant Biosecurity undertakes Weed Risk Assessments on all proposed new plant introductions for species not already listed on the AQIS Import Conditions Database (ICON)¹ and/or the Permitted Seeds List (Schedule 5 of the *Quarantine Proclamation 1998*).

¹ The import conditions database can be found on the AQIS website: <http://www.aqis.gov.au/icon>.

Weed Risk Assessments are completed in two tiers:

Tier 1: Presence/absence in Australia

- The first tier involves verifying if a species is present in Australia or under *official control*. A plant present in Australia and not *under official control* is not assessed for its weed potential. The species is then added to the Permitted Seeds List, provided there are no pest and disease concerns associated with it. Ultimately, the species will also appear on ICON as *permitted* (along with any specific quarantine requirements that may have been identified during the initial determination).
- As a signatory to international agreements (including the World Trade Organisation and the Agreement on the Application of Sanitary and Phytosanitary Measures), Australia has the right to prevent the introduction and spread of pests but also the obligation to ensure measures are not unnecessarily trade restrictive. Demonstrating that a plant is under *official control* is one method to justify applied import restrictions to prevent further instances of a weed entering Australia or becoming more widespread. For a species to be deemed under *official control* it must be listed as requiring action in relevant state or territory noxious weeds legislation and is the focus of on the ground control measures (FAO 2010). If the species is present in Australia and is under *official control* then the species is added to ICON as *prohibited*. If the species is not present in Australia it proceeds to the second tier for the science based weed risk assessment.

Tier 2: Weed Risk Assessment

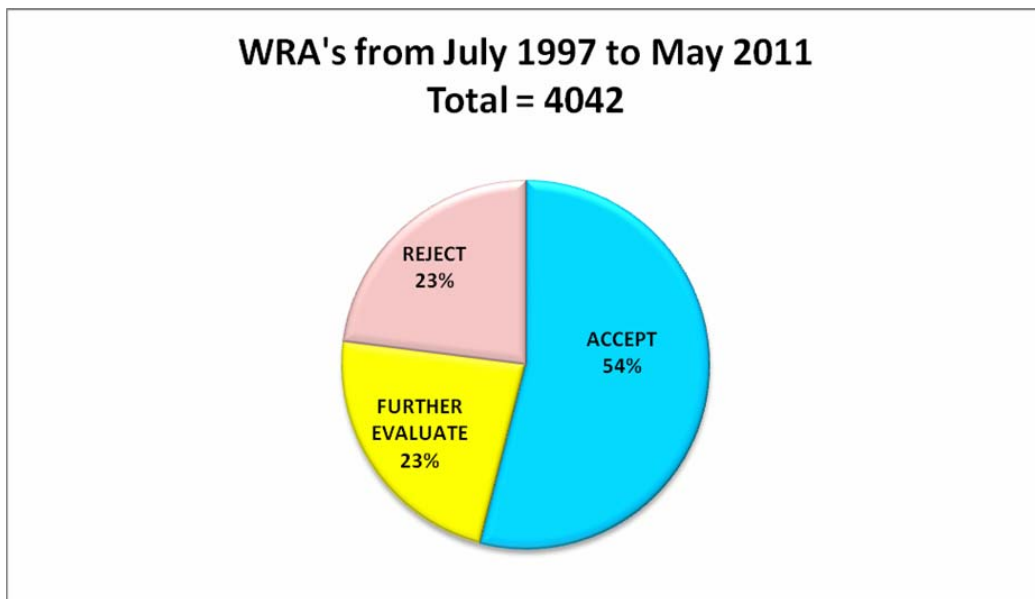
- The second tier is a formal weed risk assessment for those species absent from Australia. The assessment requires the collection of as much primary and tertiary data as possible and also, where available, advice from relevant experts in the field. It is a question based assessment which involves researching and answering 49 questions and takes into account both weedy and non-weedy species traits. The questions are based on the domestication of the species, climate suitability, distribution, weed status elsewhere in the world, type of plant (for example, grass, aquatic), reproductive methods, dispersal mechanisms, undesirable traits (for example, spines, toxicity) and persistence attributes². Answers are generally in the form of ‘yes’, ‘no’ or ‘unknown’, and are used to produce a score related to weed potential. The score generated by the process is used to determine an import policy recommendation of *accept*, *reject* or *further evaluate*.
- *Accept*: the species has a low potential to become a weed in Australia and can be imported (with appropriate conditions for invertebrate pests and diseases).
- *Reject*: the species has a high potential to become a weed in Australia and importation is prohibited. However, the species may be imported with a special permit and grown under quarantine controlled conditions at approved premises.
- *Further evaluate*: the species is prohibited importation until it can be assessed further.

² A full description of the WRA System can be found on the Biosecurity Australia website:
<http://www.biosecurityaustralia.gov.au>.

This score is usually generated when there is little information available on the biology of the species, often occurring if the species is newly described or relatively unknown to horticulture. When new information becomes available, the plant can be reassessed.

Since the adoption of the WRA System, over 4,000 species have been assessed. Fifty-four per cent of the species assessed have resulted in an *accept* outcome, 23 per cent of species *rejected* and 23 per cent required *further evaluation* (Figure 1).

Figure 1. Results of the 4,042 WRA's conducted since the start of the WRA System until May 2011 (from data held by Plant Biosecurity, Department of Agriculture, Fisheries and Forestry).



Adoption of the WRA System

The Australian WRA System is recognised around the world as one of the best systems for determining the potential of plant species to become weeds of agriculture and/or the environment. Reviews of the WRA System have supported its implementation; for example, Keller *et al.* (2007) demonstrated that the WRA System produced considerable net bioeconomic benefits to Australia within a decade of its implementation. Another study (Gordon *et al.*, 2008a) compared the accuracy of the WRA System across the geographies in which it has been tested and demonstrated that the system rejects an average of 90 per cent of known invasive species and accepts an average of 70 per cent of known non-invasive species.

The WRA System has been utilised by countries around the world. The WRA System was adopted by New Zealand (with little change) at approximately the same time as it was adopted by Australia. The WRA System has also been tested, generally with minor modifications to suit local conditions, in: Japan (Kato *et al.*, 2006, Nishida *et al.*, 2009), the Czech Republic (Křivánek and Pyšek, 2006), Florida (Gordon *et al.*, 2008b), Hawaii (Daehler *et al.*, 2004), the United States (Gordon and Gantz, 2008), Tanzania (Dawson *et al.*, 2009) and the Pacific Islands (Daehler *et al.* 2004). Due to the WRA System being

used internationally, comprehensive guidelines for answering the Australian weed risk assessment questions were developed and published (Gordon *et al.*, 2010).

BORDER QUARANTINE IN AUSTRALIA

Implementation of quarantine policy

The Australian Quarantine and Inspection Service implements quarantine policy and regulates all types of plant material imported into Australia. Outcomes of species assessed by the WRA System are forwarded to AQIS who update the Permitted Seeds List and ICON. Thereby, any plants declared to AQIS officers at Australia's international borders, or plant material detected in mail, cargo or undeclared passenger items, are immediately checked against ICON to see if they are permitted or have any disease concerns. If the species is not listed on the ICON database then the importer may request a weed risk assessment or the plant material is seized and destroyed.

Border control programs

The Australian Quarantine and Inspection Service border programs operate in a complex and dynamic environment. Increasing globalisation brings a greater risk of pests entering Australia through the movement of people and goods. Following the 'Beale' review, AQIS has developed a risk-based intervention approach in assessing incoming passengers and mail (Beale *et al.*, 2008). As quarantine risk material is not evenly distributed in arriving passengers and mail, screening now targets the areas of highest risk. This involves using X-ray machines and detector dogs more efficiently to capture quarantine material by targeting high risk mail classes and passengers from high risk countries.

Passengers, cargo and mail arriving at Australia's main entry points are required to meet quarantine conditions. To regulate this requirement involves AQIS:

- screening 140 million mail items;
- screening 13 million air passengers and crew;
- inspecting 1.7 million cargo containers; and
- inspecting 14,000 international vessels, each year (ABARE, 2009).

In 2010, AQIS seized 35,402 consignments of seeds and 9,415 items of live plant material. They were intercepted at international mail centres and from passengers at airports and seaports around the country. The main method of entry was through international airports with 25,356 seed items and 6,073 items of live plant material (Figure 2). Indonesia was the most common country of origin for seized seeds (Figure 3) whilst Thailand was the most common country of origin for prohibited live plant material (Figure 4). India and the United States, feature in the top four countries for both seed and live plant material seized in Australia.

Figure 2. Pathways of entry for seed and live plant material seizures in 2010 (data provided by AQIS, Department of Agriculture, Fisheries and Forestry).

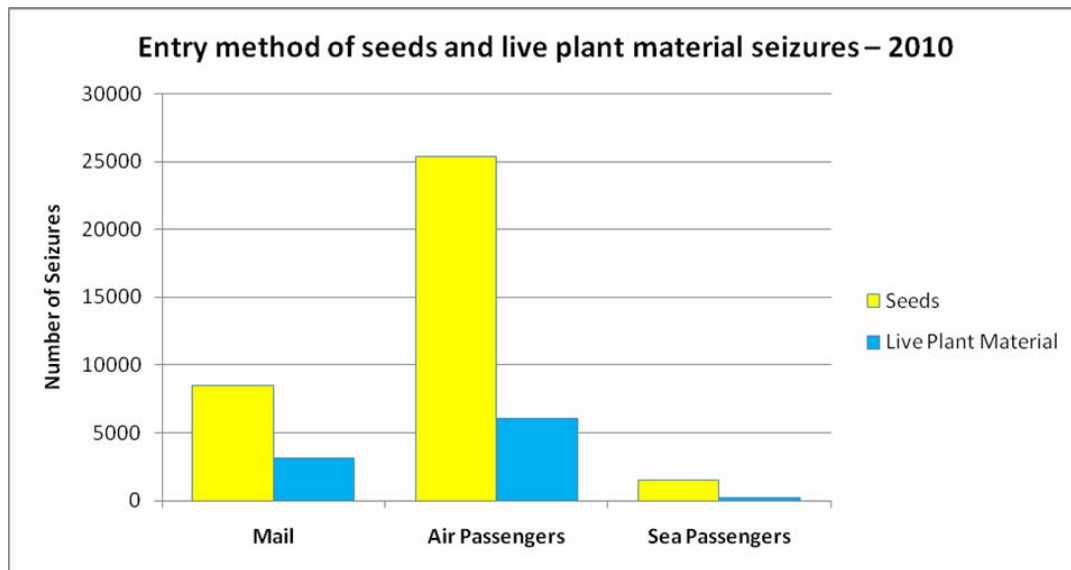


Figure 3. The top ten countries of origin for seized seed consignments in 2010 (data provided by AQIS, Department of Agriculture, Fisheries and Forestry).

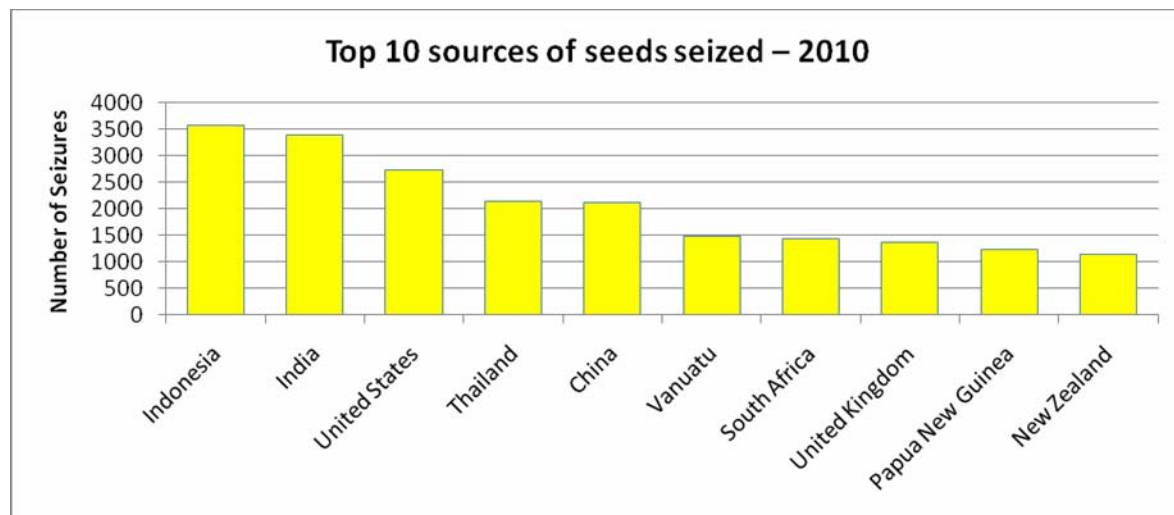
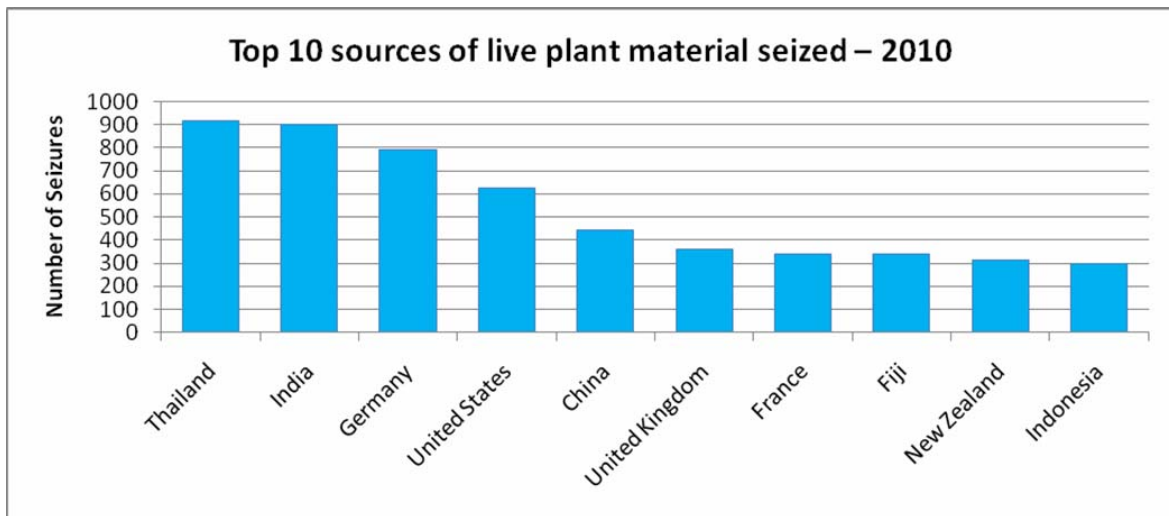


Figure 4. The top ten countries of origin for seized live plant material in 2010 (data provided by AQIS, Department of Agriculture, Fisheries and Forestry).



Northern Australia Quarantine Strategy (NAQS)

Quarantine in northern Australia is critical because of its proximity to Southeast Asia and the Pacific, which have many weeds, invertebrate pests and diseases not present in Australia (AQIS 2010). The NAQS program works to develop and implement measures for early detection of target pests in coastal northern Australia. Measures include managing quarantine aspects of border movements through the Torres Strait and undertaking pest surveillance in coastal northern Australia, Papua New Guinea, Indonesia and East Timor (AQIS, 2010). There is also a large amount of work conducted on educational and awareness programs by NAQS which encourages local communities to keep watch for any unusual pests (AQIS 2010).

CONCLUSION

Australia's quarantine system has been successful in keeping Australia free from most serious plant pests. However, the increase in global trade means that Australia needs to remain vigilant in its defence against pest incursions to help maintain its favourable plant health status and access to overseas export markets. Australia's international quarantine efforts are divided between AQIS, which is responsible for border control, and Plant Biosecurity which develops quarantine policy.

Weeds are among the most serious biosecurity threats to Australia's environmental and agricultural systems. Following a review of quarantine in 1996, plant import policy changed from using a 'prohibited list' to a 'permitted list'. This means that any plants absent from Australia, and not listed on the 'permitted list', require a weed risk assessment to determine their weed potential before being allowed entry. The WRA System has received widespread approval both nationally and internationally. It is well established and is proving effective in preventing new weeds from establishing in Australia.

Plant policy on assessed species is implemented by AQIS and involves updating the Permitted Seeds List and ICON, and regulating plant material at the national border. National quarantine border controls encompass screening (or inspecting) millions of passengers, mail and cargo arriving at Australia's main entry points. In 2010, AQIS seized nearly 35,500 seed consignments and approximately 9,500 items of live plant material. Procedures used to detect the items of quarantine concern included X-ray machines, detector dogs, visual inspection and surveillance (AQIS 2010).

The NAQS program also plays a vital role in keeping pests entering Australia from Southeast Asia and the Pacific. The program works to develop and implement measures for early detection of target pests in coastal northern Australia such as surveillance and educational programs.

Plant Biosecurity and AQIS work closely together in keeping Australia's biosecurity strong. The goal of the Australian Government is to continuously improve quarantine procedures in order to minimise the risk of exotic weeds, invertebrate pests and pathogens entering the country.

REFERENCES

- ABARE 2009. *Australian commodity statistics 2009*, Canberra, Department of Agriculture, Fisheries and Forestry.
- AQIS 2010. AQIS at a glance. Canberra: Department of Agriculture, Fisheries and Forestry. Available at <http://daff.gov.au/aqis/about/reports-pubs/at-a-glance>
- BEALE, R., FAIRBROTHER, J., INGLIS, A. & TREBECK, D. 2008. *One Biosecurity—a working partnership, independent review of australia's quarantine and biosecurity arrangements, report to the Australian government*, Barton.
- DAEHLER, C. C., DENSLOW, J. L., ANSARI, S. & KUO, H. 2004. A risk assessment system for screening out harmful invasive pest plants from Hawaii's and other Pacific islands. *Conservation Biology*, 18, 360–368.
- DAWSON, W., BURSLEM, D. F. R. P. & HULME, P. E. 2009. The suitability of weed risk assessment as a conservation tool to identify invasive plant threats in East African rainforests. *Biological Conservation*, 142, 1018–1024.
- FAO 2010. International Standards for Phytosanitary Measures No 5: Glossary of phytosanitary terms. Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome.
- GORDON, D. R. & GANTZ, C. A. 2008. Potential impacts on the horticultural industry of screening new plants for invasiveness. *Conservation Letters* 1, 227–235.
- GORDON, D. R., MITTERDORFER, B., PHELOUNG, P. C., ANSARI, S., BUDDENHAGEN, C., CHIMERA, C., DAEHLER, C. C., DAWSON, W., DENSLOW, J. S., TSHIDADA, N. J., LAROSA, A., NISHIDA, T., ONDERDONK, D. A., PANETTA, D., PYŠEK, P., RANDALL, R. P., RICHARDSON, D. M., VIRTUE, J. G. & WILLIAMS, P. A. 2010. Guidance for addressing the Australian Weed Risk Assessment questions. *Plant Protection Quarterly*, 25, 56–74.
- GORDON, D. R., ONDERDONK, D. A., FOX, A. M. & STOCKER, R. K. 2008a. Consistent accuracy of the Australian Weed Risk Assessment System across varied geographies. *Diversity and Distributions* 14, 234–242.
- GORDON, D. R., ONDERDONK, D. A., FOX, A. M., STOCKER, R. K. & GANTZ, C. 2008b. Predicting invasive plants in Florida using the Australian Weed Risk Assessment system. *Invasive Plant Science and Management* 1, 178–19.

- GROVES, R. H., BODEN, R. & LONSDALE, W. M. 2005. *Jumping the garden fence: invasive garden plants in Australia and their environmental and agricultural impacts*. CSIRO report prepared for WWF-Australia, Sydney, WWF-Australia.
- KATO, H., HATA, K., YAMAMOTO, H. & YOSHIOKA, T. 2006 Effectiveness of the weed risk assessment system for the Bonin Islands. *In*: F. KOIKE, M.N. CLOUT, M. KAWAMICHI, M. DE POORTER & K. IWATSUKI, eds. *Assessment and Control of Biological Invasion Risk*, Kyoto, Japan and IUCN, Gland, Switzerland. Shoukadoh Book Sellers, 65–72.
- KELLER, R. P., LODGE, D. M. & FINNOFF, D. C. 2007 Risk Assessment for invasive species produces net bioeconomic benefits. *National Academy of Sciences USA*, 203–207.
- KŘIVÁNEK, M. & AND PYŠEK, P. 2006. Predicting invasions by woody species in a temperate zone: a test of three risk assessment schemes in the Czech Republic (Central Europe). *Diversity and Distributions*, 12, 319–327.
- NAIRN, M. E., ALLEN, P. G., INGLIS, A. R. & TANNER, C. 1996. *Australian quarantine: a shared responsibility*, Canberra, Department of Primary Industries and Energy.
- NISHIDA, T., YAMASHITA, N., ASAI, M., KUROKAWA, S., ENOMOTO, T., PHELOUNG, P. C. & GROVES, R. H. 2009. Developing a pre-entry weed risk assessment system for use in Japan. *Biological Invasions*, 11, 1319–1333.
- WALTON, C. S. 2001. Weed risk assessment for plant introductions: B. Implementation of a permitted list approach. *In*: VIRTUE, J. G., ed. *1st International Workshop on Weed Risk Assessment*, Adelaide. CSIRO.

Can anything be done about the institutions that limit weeds management?

Professor Paul Martin
Director, Australian Centre for Agriculture and Law
University of New England

Discussions with farmers, weeds officers and managers, and environmentalists suggest that there is a consensus about the institutional arrangements for weeds management, reflected in statements like: 'there is never enough money' or 'too much money gets wasted', 'the laws do not do what they are meant to', 'lots of committees, too little real action', 'landowners are not committed/not equipped to do what they must' and 'no-one values the work we do'. However whilst marked institutional improvement is needed to weed management institutions, specific reform proposals are largely missing. This paper explores why this may be the case, what types of reform may be possible, and presents a proposal for pursuing reform.

Weeds are a 'vicious' systems problem

Weeds are a vicious systems problem. The viciousness is founded in the biophysical character of weeds, compounded by social and economic issues that create institutional challenges. Biophysical complexity arises from the enormous variety of species, diverse and evolving characteristics and the variety of their habitats, and the range of human and natural vectors for their spread. This results in a great variety, complexity and cost of potential control methods. The fact that Australia is a massive sparsely populated landmass, in many places with limited economic productivity per hectare, results in a fundamental control problem. Neither labour nor funds are available to allow for effective control in many areas. Coupled with this are the diversity of land tenures and land-manager motivations for weed control, and the fragmentation from three levels of government generating complex jurisdictional and coordination issues. Some coordination mechanisms exist, but their limitations are obvious when it comes to overcoming the impediments of 'sovereignty' over farming tenures, Aboriginal lands, mining tenures, domestic sites, national parks, pastoral leaseholds and so forth.

What a farmer sees as a weed problem requiring action will often be different to the perception of a sheep grazier or a cattle baron. This will be different to the perception of a national park manager, a mine site manager, a conservationist or a remote Aboriginal Land Council officer. In the absence of means to force coordinated action, the result of legally-endorsed fragmentation is a limited capacity to respond in a coordinated manner to the system characteristics of weeds.

Institutional limits restrict effective control

Weed management is a systems management challenge. Effective weed control should be about coordinated eradication based on sound intelligence, maintenance of resilient habitats, vector controls and the management of inter-related eco-system elements. Our institutional arrangements focus on species-specific eradication measures, based on limited information, implemented through 7 states, 560 local government areas, 56 regional natural resource management bodies, a myriad of authorities, and uncountable private and public tenures. Few

institutional incentives exist to oblige coordination or cooperation, other than the very limited species-specific controls over noxious plants. Our institutional arrangements are poorly aligned to the fundamentals of the challenge they are meant to address.

CAN WE THINK OF ALTERNATIVE PARADIGMS?

Received beliefs about weed management institutions in Australia limit the sorts of institutional innovations that are likely to be considered. Conventional thinking accepts that personal responsibility of landowners is essentially limited to where their private interests are prejudiced and coercion is restricted to limited controls over 'declared' pest species. The paradigm places great emphasis on government funds to address all other issues including policing and on-ground control where private markets fail to stimulate responsible action. It accepts the sovereignty of land ownership as largely inviolable even if this results in serious harm to neighbours through failures to cooperate in weed control, and accepts the absence of private market incentives or large scale philanthropic funding. It accepts the inevitability of 'missing market' to more effectively incentivise weed control, and the fragmentation of our system of public governance of natural resource issues (including weeds). What options might exist if we were to abandon that paradigm, and think of radical change?

Rule harmonisation?

The literature is replete with complaints about the red tape and complexity of environmental regulation and administration, and the failings of natural resource governance structures. In recent times, the national organisation of environmental regulators has begun to move towards harmonisation of environmental regulation, and this could be applied to invasive species regulation.

One option is to integrate the suite of biodiversity protection and restoration rules, and at the same time to shift the weeds-regulation focus from species specificity to systems protection and restoration. The Environment Planning and Biodiversity Conservation Act is a reasonably modern approach, involving the capacity to co-regulate within a federal approach whilst maintaining national coordination, and embracing the concept of system protection. It would not be beyond the wit of man to transform the plethora of state weed rules and local government regulations into a unified system with delegated and supervised authority within this framework.

Should this be 'a bridge too far' a less threatening reform could be procedural harmonisation across the various government agencies. A small step in this direction has been taken with the WONS committees and other coordinating arrangements, but a more adventurous proposal would be to unify all of the forms and processes that are used across Australia into a single system. An even more adventurous step, just short of regulatory harmonisation, would be to merge weed administrations.

A related step, being taken in a number of jurisdictions, is to merge invasive plant and animal programmes, and sometimes biosecurity, into a unified programme. Whilst this has arguably been more driven by the pursuit of budget cuts than effectiveness, potential synergies exist such as shared knowledge about coordination of eradication and control programmes across tenures, coordination of biodiversity protection, and the potential for shared scientific expertise in modelling and impact evaluation, do exist.

What is the substantial benefit that might be achieved by harmonisation? The fact that the relevant agencies have sought to coordinate more closely through committees like WONS is recognition that a lack of harmonisation results in reduced sharing of knowledge, higher transaction costs for both government and land managers, dis-economies on staff training and instruction, and a reduced scale and sophistication in the development of control technologies and extension approaches.

Better regulatory design?

Under Companies law, shareholders who resist a takeover when more than 90% of other shareholders have accepted are forced to sell their shares¹. Under invasive species management, a neighbour who chooses not to cooperate (and thereby maintains the reservoir of weeds or other invasive species) is not subject to any effective coercion. Why is it that in one case coercion is an economically justified overriding of private ownership, but in the second it is seen as unreasonable?

One of the design failings of most Australian invasive species regulation is that it maintains an 18th Century orientation, in which the focus is upon individual species and individual sites. This is reflected in the emphasis on noxious species control orders that target specific plants on specific lands controlled by nominated individuals. Whilst this approach is necessary for the purpose of controlling recalcitrant landowners, it is not sufficient for the purpose of implementation of systemic programmes.

There have been great advances in risk and systems science. To some degree these have been reflected in the Environment Planning and Biodiversity Conservation Act. However weeds legislation (with the exception of quarantine rules) by and large does not adopt a systemic risk management approach. Only after a weed problem is proven to exist and be harmful are resources allocated, instead of having a risk-control funding pool (akin to an insurance scheme). It is only after protracted review that species are declared, and action authorised. Given the biophysical nature of the risk, the deficiencies in delayed response are obvious. What might better regulatory design involve? Weeds practitioners, given the opportunity, would probably have many suggestions but they are minimally likely to want far greater capacity to require cooperation in regional control programmes, a stronger focus on preventative and early intervention actions, and faster response times. The systematic management of risk is quite a different thing to the management of established species, and the rules that are used need to be adjusted to this different reality.

Closing the accountability gaps?

An aspect of the regulatory problem is the failure of some landowners and land managers to take responsibility for problems to which they contribute, or where they could be part of the solution. Under our existing paradigm the ultimate bearers of the cost of such failures of responsibility are other landowners and managers, the public purse and future generations who will inherit a diminished environment or less productive lands.

Analysing a weeds pathway usually highlights a large number of decisions taken by different individuals along that chain of (potential) responsibility. Yet few of those involved have any accountability for the harms that they contribute to producing.

1 Corporations Act 2001, S664A

What sorts of accountability interventions might be considered? The current approval system for new plants introduced into Australia takes a legitimately precautionary approach to guard against 'weediness', as does the system for the management of genetically modified organisms. However no amount of caution can remove the weeds risk completely, and it is a feature of man's nature to see as benign those things that will maximise our private interest. Intending introducers will convincingly support their case that the risk is negligible, and will be less energetic in producing evidence counter to their case. Once a plant is approved for introduction, the introducer bears no further economic liability should the approving decision prove to be misguided. As a result the public purse will generally be the funding source for any control measures. Similarly, but to a lesser degree, once a GMO is approved the obligation of its proponents and propagators is limited to conditions set on its approval, and the balance of the risk is borne by neighbours or the public purse.

It is not only in the introduction of new species where weeds risk can apply. Because plants behave differently in different conditions, they can be weeds in some situations and benign in others. The Nursery Industry Association has adopted a code to ensure responsibility by its members for the labelling of plants that are potentially weedy in different situations. Debate continues about whether this approach should be extended to impose mandatory obligations ('capturing' nurseries that do not subscribe to the voluntary code), and whether there should be an 'approved plant for this area' (or 'white list') approach. The nursery industry is relatively tractable and cooperative for weed management purposes. Improved accountability mechanisms may also be required for the landscaping sector (both private and public), individual propagators, and many others whose decisions are the triggers for the distribution of potentially invasive plants.

The most powerful form of accountability mechanism is legal liability. Whilst the case law has generally not supported legal liability for weeds (largely for evidentiary reasons related to the difficulties of proving causation of the harm), this is not an insurmountable barrier should society decide that it needs more effective accountability. Legislation can alter evidentiary requirements, even to the extent of imposing strict liability, as is the case with liability for worker's injuries. It is possible to create industry-wide liability and insurance schemes, and to aver that a member of the liable class is likely to have caused the harm even whilst it is not possible to specify which member and in what way the harm has been caused. This approach has been taken to help provide sufficient funds to manage the costs of control and remediation of oil spills.

Clear accountability by harm-doers, who are generally in the best possible position to prevent the harm or intervene quickly should harm arise, is a proven behavioural mechanism to manage complex risk. To date Australian weed management institutions have been prepared to accept a default position of minimal accountability, but there is no fundamental reason why this needs to remain the case.

Improved funding mechanisms?

The most consistent complaint about the inadequacy of weeds institutions is the insufficiency of funds, and given the accepted institutional paradigm this ought not be surprising. However even to the seemingly intractable problem of funding there are options that might be explored.

The power of tax-effective investments to secure large sums is well demonstrated. Whilst there are limited taxation supports for natural resource conservation investment, there are

options for far more generous support that could be designed to include invasives control. Some potential structures include leveraged tax deductions for landscape conservation investment, more stringent sustainability standards built into rural production or other tax-deduction programmes, and more generous treatment of environmental philanthropy. Even without improved tax treatment, there seem to be some possibilities for better targeting of philanthropy. There exist a wide variety of environmental philanthropic schemes, but none seem to target the serious biodiversity impacts of weeds. Might it not be possible, for example, to create a philanthropic fund to support the significant amount of voluntary work that is done by Landcare and other groups in controlling weeds? Or to give weed control additional leverage alongside regional conservation investment programmes by the securing of private donations?

It is not only the amount of funds that is significant, it is also the way in which funds are targeted and managed. Sophisticated decision science can materially improve weed control return-on-investment. Other decision science options include community heuristic tools for evaluating the costs of inaction versus the cost of various community strategies, and decision-support for strategies that integrate control of a number of weeds along with biodiversity or other environmental or production value benefits. Improving the science base for weeds management investment should result in better outcomes from whatever amount of funds is available.

Linking investment to regulatory harmonisation, one key institutional reform is to reduce the transaction costs associated with weed management investment. One can only suspect how much of the total dollars theoretically attributed to weed management 'hits the ground', after all of the array of institutional processes (and their associated costs) have taxed the investment. There has been a great deal of work done on the use of market-like auctions to allocate government environment investment, but as yet little to reduce the number of hands that touch the money that is available before it is applied to weed control.

Greater behavioural effectiveness?

There is great work done by weed professionals and others who seek to inspire, inform and educate the community. However, the use of behavioural or communication sciences, and the scientific method of theorising, testing and refining theory to weeds-related behaviour change, is limited. One reason is because the use of behavioural science in extension generally is limited, another is the effects of fragmentation in reducing awareness of the amount of investment going into behaviour modification, and the third is that weed professionals seem not to appreciate how much their role involves the pursuit of substantial behaviour change with limited resources.

There are many potential behavioural and social science approaches that might improve the science of weeds management. I have mentioned economics in the allocation of control resources, but of course the design of incentives is an important aspect of behaviour modification. There have been significant advances in social marketing, and in adult education and communication that could form the basis for scientifically disciplined weed management interventions. Research informed advertising and communications is perhaps the *conditio sine qua non* of commercial marketing but commercial techniques do not seem to normally inform weed communications and education. Social marketing media opens up new channels for communication and education that will require significant changes in the strategies (and therefore the skills) applied to weed control communications.

An interesting opportunity is the use of ‘cocktails’ of interventions, combining regulation with social marketing, or using ‘smart regulation’ approaches that integrate regulation with economic incentives, markets and social action. Whilst such integration does already occur in an informal manner in weed control programmes, the approaches are not systematically advanced in the weed management sector. One can only conjecture the extent of improvement in outcomes that is possible with a scholarly focus upon behaviour change science in weed management.

Truly collaborative governance?

Collaborative governance, and its associated concepts of co-regulation and engaged or reflexive regulation, seeks effective partnerships between government, industry and the community whose actions are to be managed. The seeds of collaborative governance exist in many places along the weeds pathway. I have mentioned the NIA code of conduct in the nursery industry, to which can be added various EMS or best practice systems and the potential for weed-status issues within ‘green certification’ schemes or the supply chain initiatives of the major retailers.

Whilst aspects of sustainability (such as chemical use and contamination) are addressed by voluntary industry programmes weed issues do not feature to the degree that perhaps they ought. One reason may be deficiencies in measures of weed contamination or weeds risk, or in the capacity to estimate the ecological impacts of weed contamination.

A further aspect of collaboration is the engagement of the community in weed management directly. The excellent work of landcare, coastcare, bushcare and other voluntary groups has often been harnessed by weed control professionals, but of course there is always much room for improvement. The potential for community science to improve intelligence about weed issues seems to be largely untapped, perhaps because of the absence of a science framework for this to occur, perhaps because mainstream science and policy agencies are distrustful of non-professional science data.

Weed Decision Intelligence systems?

Reliable intelligence is the fuel for good management decisions. With the Weeds CRC in particular, a lot of effort has been invested in improving decision intelligence, but much is left to be done. Weed management modelling, policy decision support, rule of thumb ‘heuristics’ to help communities make better decisions, more reliable and predictive mapping of weed prevalence, and the design and evaluation of strategies that combine weed, invasive animal and biodiversity elements in an integrated manner all are areas where significant improvements are possible.

Intelligence, like regulation, is most likely to work best when linked to drivers for action such as personal economic incentives. In a prior national weeds conference it was suggested that it is possible to use information to generate private incentives to control weeds. It is easy to envisage a property inspection and certification scheme targeting weeds. Property buyers would be given an inspection certificate along with the title search data they obtain at the time they negotiate a purchase. The dynamic of property negotiation would inevitably lead to weed contamination being priced into land value, substantially reducing the ‘missing markets’ problem of weed control. Extending this approach to leased crown lands management, or negotiations to access public grants or private philanthropy, would apply information strategies to tackle institutional deficiencies.

CAN WE MOVE TO A DIFFERENT INSTITUTIONAL MODEL?

That our existing institutional arrangements are suboptimal, and that there are many possible ways to improve that model, is easy to demonstrate. What is harder to understand is why we have not as yet been adventurous in the changes we are prepared to make in our institutional arrangements.

There are many possible explanations of this apparent lethargy. The obvious one is that the community just does not see these issues as important enough. However, that explanation is hard to reconcile with the enormous amount of money and effort that is invested in attempts to control, and the economic and ecological costs associated with, invasive plants.

The 'political economy' literature, particularly 'public choice', points towards considering the incentives and beliefs of those who are directly involved. This literature would suggest that it may not be in the interests of many people who are embedded in the existing system to change that system. This may be true, but an alternative view is that for many, after years of fruitless pursuit of improvement, their confidence in their capacity to achieve significant change has been eroded. The complexity of the institutional system we have makes the task of seeking significant change daunting, and the institutional path that is in place is self-reinforcing.

There are also economic impediments to change. Radical change is costly, and would require some redirection of resources into this task and therefore away from front-line work in the short term.

Some reform proposals will inevitably be counter to personal interests. To propose more effective coercive regulatory or civil liability instruments may trigger antagonistic responses (notably from the farm sector, probably the most likely beneficiary but generally antagonistic to government coercion). Regulatory harmonisation will require that state and federal agencies adjust their own instruments and programmes, which may cause concern among those who have invested large amounts of their time and effort in creating and pursuing their own strategies.

The institutional redesign challenges

Finding an effective new paradigm will involve a number of disciplinary fields including weed science, landscape and farm management, risk science, communications and behavioural science, decision science, economics and law. Achieving support and adoption will involve skills including political and administrative expertise. Multi-disciplinary research and engagement sounds like a good idea, but the reality is that it is very difficult and too frequently founders on the difficulties of competing concepts and values, and the challenges of combining the 'apples and oranges' of different types of knowledge.

Whatever the impediments, real progress is not likely without specific well-developed proposals. There are challenges in moving from a conceptual paper like this one, to the stage where proposals for institutional reforms are sufficiently advanced to support serious debate. The greatest impediment is likely to be the mental state of those whose attitudes and beliefs have been shaped by long involvement within the current paradigm. As with paradigm change generally: imagination of what is possible is constrained by history.

The imperative for change

The question that this raises is whether the game of institutional innovation is worth burning the candle of creative thinking and political activism. Is there sufficient reason to move from merely complaining about the institutional failings to engaging constructively with finding solutions to them?

Weeds threaten biodiversity and they reduce productivity. They cost millions of public and private dollars. Our current institutions drain the resources and the energies that are needed to tackle the problem. These are ample reasons to act, but as yet these have not been sufficient to trigger serious reform.

Perhaps the growing awareness of food security issues, and of the accelerating loss of biodiversity attributable to the combination of climate change and habitat destruction through plant and animal invasions will create a stronger sense of urgency. Possibly the combination of 'green' and farmer political pressures at a federal and state level, and the constant pressure to reduce red-tape in natural resource governance and farming will coalesce in a more energetic movement towards reform.

Regardless of the triggers and timing, any serious reform movement will need to be armed with well-reasoned and supported proposals.

As a starting point a research project will commence in July 2011, to scope out a research programme for the pursuit of weed institutional innovation and reform. This paper has suggested some possible directions for this study, but the participants in this conference, together with many other 'weed professionals', scholars, farmers and policy maker will undoubtedly have many more ideas that ought be reflected in future weeds law, strategy, policy and management.

WHAT MIGHT HAPPEN IF WE THOUGHT DIFFERENTLY ABOUT WEED RISK & RISK MANAGEMENT?

**The potential of innovations in laws and policies to address weeds infestations:
an illustration with the case study of second-generation biofuels crops**

Elodie Le Gal

PhD candidate

**Agricultural Research Centre for Agriculture and Law, University of New England,
Armidale**

ABSTRACT

What might happen if we thought differently about weed risk and risk management? In two recent national weeds conferences there have been research papers pointing the potential of innovative market economy concepts - as alternative or complementary mechanisms to current domestic laws and policies - for addressing the weed risk. These suggestions are being explored as part of a PhD program undertaken at the Australian Centre for Agriculture and Law, University of New England. The goal of this research is to explore new legal and regulatory avenues for addressing the old weeds challenge by focusing on the case study of second-generation biofuels crops. These, despite their invasibility features, could play a key role in the production of bio-ethanol to enhance an ecologically sustainable economic development. This project also aims to reinforce corporate accountability by ensuring that the costs of the biofuels weeds risk are borne by the risk beneficiaries and improve the NRM model for weeds control and weeds management. More specifically, it investigates the potential use of innovative risk management strategies developed in the commercial and financial sector to address the depletion of natural resources and the environmental services provided by natural ecosystems. Risk information, risk pricing, risk pooling and risk sharing are the key elements of these commercial instruments. This is the aim of this presentation to expose the key elements underpinning such a novel approach to manage the weeds risk. It is argued that the conceptual architecture for a co-regulatory risk management model which has been developed since the beginning of this research could be transposed within the weeds context to address effectively this challenge. The developments of this conference paper revolve around two key questions: why and how to think differently to address the weeds risk?

Table of Contents

ABSTRACT 1

INTRODUCTION..... 3

WHY THE BIOFUEL WEED RISK? 3

WHY THINK DIFFERENTLY? 3

HOW TO THINK DIFFERENTLY? 4

 Using risk-based innovations 4

 Other research themes to improve the traditional legal model for weeds control 5

 ‘Smart’ regulatory targeting 5

 The potential of co-regulation 8

CONCLUSION : WHAT MIGHT HAPPEN IF WE GO DOWN THIS PATH?..... 8

INTRODUCTION

What might happen if we thought differently about weed risk and risk management? In two recent national weeds conferences there have been research papers pointing the potential of innovative market economy concepts - as alternative or complementary mechanisms to traditional NRM laws and policies - for addressing the weed risk (Martin 2006, Martin 2008a). These suggestions are being explored by Elodie Le Gal, a European lawyer and PhD candidate at the Australian Centre for Agriculture and Law, University of New England. The goal of this research is to explore new legal and regulatory avenues for addressing the old weeds challenge by focusing on the case study of second-generation biofuels crops. This project also aims to reinforce corporate accountability by ensuring that the costs of the biofuels weeds risk are borne by the risk beneficiaries. This presentation outlines the key elements of this novel approach and the resultant conceptual co-regulatory biofuels risk management model.

WHY THE BIOFUEL WEED RISK?

Second-generation bio-fuels crops,ⁱ which include native species, and crops considered for importation such as woody or grassy weeds, exotic species and plants modified by plant breeding or genetic manipulation (Rath, 2008) can play a major role in the production of bio-ethanol to enhance ecologically sustainable economic development, achieve a low-carbon economy and strengthen the regional economic resilience of rural Australia (Biofuels Taskforce, 2005). On a global and national scale, the production of biofuels has gained a growing interest from both the public and the private sectors.ⁱⁱ At the Commonwealth and state levels, energy policies tend to support bio-energy markets.ⁱⁱⁱ However recent analysis suggests that bio-fuels weeds risk could be one of the 'downside' of this potential major industry (IUCN 2009, GISP 2008).

With second-generation biofuels, a significant new set of land uses and land management changes, which is likely to amplify the vulnerability of natural environments to the spread of weeds, are emerging. As opposite side of the same coin, business opportunities always carry with themselves risks (e.g. investment) and risk to the public interest (e.g. depletion of natural resources, biodiversity loss). It is possible that commercial prospects from bio-ethanol production will result in new weed invasions, for which existing institutions are ill-prepared. This provides a window of opportunity to discuss alternatives to the traditional model for weed governance within which ESD principles have also to be factored in. It is also the role of the law to find the 'right' balance between conflicting economic, environmental and social interests as illustrated with the water reform.

WHY THINK DIFFERENTLY?

Professor Paul Martin, likes quoting Einstein's definition of insanity as 'doing the same thing over and over again and expecting different results'^{iv} when discussing current weeds laws and policies. These revolve around a complex suite of instruments (e.g. weeds bans against import, interdiction to plant hazardous species and removal orders), voluntary action and government expenditure (Martin *et al.* 2007, Riley 2008, Senate Environment, Communication, Information Technology and the Arts References Committee 2002) and suffer from a certain number of criticisms which provides the rationale for a possible wider reform at the national level. These include:

- defects and instrumental limitations;
- excessive normative and institutional fragmentation;
- Implementation faces substantial impediments in the insufficiency of economic and human resources, and the almost overwhelming social pressures to consume natural resources, against which NRM strategies must compete.

To summarise, the effectiveness of this model is constrained by bureaucracy, by the transaction costs of detection, prosecution and enforcement and by the limited private incentive for landowners to invest in control except where the weed prejudices their own economic activities. Public and voluntary programmes for weed removal are constrained by limited financial and human resources, by the difficulties of coordination across landscapes with multiple tenures, and by the high costs of weed detection and control. This suggests that the present legal and regulatory strategy for weeds control/management faces key challenges. Can we overcome these by thinking differently?

HOW TO THINK DIFFERENTLY?

Using risk-based innovations

Quarantine pre-border and post-border risk management protocols focus on the prevention of introduction of new weeds without taking into consideration the social and economic benefits associated with commercial crops.^v Additionally apart from the *Emergency Plant Pest Response Deed* ('EPPRD,')^{vi} a risk sharing mechanism recently adopted by the Commonwealth, States and territories and the plant-related industry to fund emergency responses^{vii} to weeds infestations and technical risk assessment tools used to evaluate weed risk and to design on-ground strategies (Koike *et al* 2006, Virtue *et al* 2006) the traditional NRM model for weeds control/management remains relatively unsophisticated from a risks perspective. It does not provide backed-up mechanisms like insurance, or extended clean-up liability supported by bonds, or any other possible commercial instruments, to pre-empt future public or private costs should the initial introduction prove to be ill-advised (Martin 2006, Martin 2008a). Beyond risk control (e.g. risk avoidance and risk mitigation), there are other possible strategies for managing environmental risks. This is illustrated with commercial risk management instruments developed by the insurance and financial sectors to finance the potential economic losses and corporate legal liability risks associated with environmental risks such as biodiversity loss, water scarcity, carbon pollution and oil spills. These encompass techniques which rely on risk financing strategies including self-insurance and risk transfer mechanisms on insurance, reinsurance and capital markets (e.g. risk securitisation, risk hedging) (Bodanski *et al* 2004, Banks 2004, Faure 2003, Labatt *et al* 2002, Mills 2009). Contributing to the new field of 'environmental finance', they are embedded into complex institutional arrangements revolving around corporate, contract and tax law, and are underpinned by specific financial engineering techniques. Informed by probabilistic methods and supported by high commercial value information management systems which aim to improve the corporate risk management decision-making process, they involve high degree of expertise from a wide range of actors. Risk information, risk pricing, risk pooling, risk spreading and risk sharing are some of the key elements of these innovative commercial risk management strategies.

Innovations in risk instruments could be used as a 'lever for change' (Martin *et al* 2006) to address the weeds challenge while creating new commercial opportunities. This is

suggested with the conceptual risk management model exposed in table 1 located at the end of this presentation (Martin *et al* 2010). Although it is beyond the scope of this presentation to detail these complex mechanisms in-depth, this is one of the goals of this presentation to highlight how these techniques could be transposed within the biofuels weed risk context by providing this audience with the following practical example.

As part of a conditional licensing/permit system, on approval to plant or introduce new bio-fuel species, or establish production facility, private entrepreneurs could be imposed by law to prove they have sufficient financial capacity to fund environmental restoration costs should the crops become invasive. They could be required to lodge environmental performance bonds which are imposed upon natural resource users such as in the mining or construction industry. Alternatively, they could subscribe individually to an environmental risk insurance policy which would transfer the potential weeds-related costs (e.g. control, rehabilitation) onto insurance companies. These financial contributions, calculated on the basis of the risk undertaken (risk pricing) could be pooled into a common risk sinking funds (risk pooling) to spread the weed risk among industry participants (risk spreading/risk sharing). Product evaluation schemes against environmental standards such as certification and eco-labelling schemes could also provide market incentive for consumers to lower the biofuels weeds risk. The use of insurance-based mechanisms, if transposed within the NRM context, could be – at least in theory – more effective and effective in managing the weeds risk. Through this mechanism the fundamental economic problem of unpriced environmental externalities is minimised. A commercial insurer with an economic incentive to control a hazard can generate cost-effective risk management methods. It is in their private interest to create effective risk management systems and to control ‘free riders’ who do not manage their risks well. Such a mechanism reinforces corporate accountability by ensuring that the costs of the biofuels weeds risk are borne by the risk beneficiaries, which could help create an accountability loop between the source of the risk and its control (risk accountability). Thus there should be less need for government to rely upon bans because the accountability for risk (and the costs of restoring damaged interests) would be primarily addressed within the private sector. Government would unavoidably remain the risk-underwriter of last resort but with a residual rather than primary role given more comprehensive market mechanisms. Such an approach to risk management implies that there are sufficient incentives/disincentives for private actors to control environmental risks. Within this context, the law can maximise the opportunities associated with biofuels crops production while minimising the risk attached to them. It can also ‘legitimate and regulate new market-driven actions (Martin 2008b).

Other research themes to improve the traditional legal model for weeds control

‘Smart’ regulatory targeting

To ensure reliability of the strategy and to better encircle the biofuels weeds risks both timely and geographically, it is proposed to use a safety net of safeguards, using multiple instruments at different points of legal and regulatory points of intervention (Faure 2009, Gunningham *et al* 1998, Martin *et al* 2006,^{viii}) and link them with the actors who drive them. Their theoretical identification should be made possible with the use of the biofuels weeds pathway as represented below (Martin 2008, Martin *et al* 2010, Le Gal 2010). This is an extension of the weeds pathway approach (Sindel 2008) used in weed science design

for mapping the transactions within the natural and socio-economic systems. The map presents a linear sequence of transactions and events. These include transactions where a human actor (or actors) makes and implements a decision that contributes to weed creation or diffusion, such as the decision to introduce a new species, or modify a species. The second is autopoietic events,^{ix} where weed establishment and spread does not require human decisions. An example is evolutionary acclimatisation leading to plants that are more able to spread. This diagram traces the pathway of plant genetic material from its first scientific evaluation (entry), through identification of its bio-energy crop potential, establishment as a commercial crop, acclimatisation, naturalisation and spread in the natural environment. This places emphasis on key transactions and the decisions that drive them. It also well points out risk considerations along this pathway and the actors involved with the trajectory of a second-energy bio-fuel crop becoming a weed. The analysis identifies possible focii for risk-management interventions to improve risk accountability. With a systematic approach, it is possible to target possible policy, legal and regulatory points of intervention. These points include the evaluation, importation, propagation, distribution, plantation operation and hazard control stages to which different types of legal and regulatory instruments can be then located.

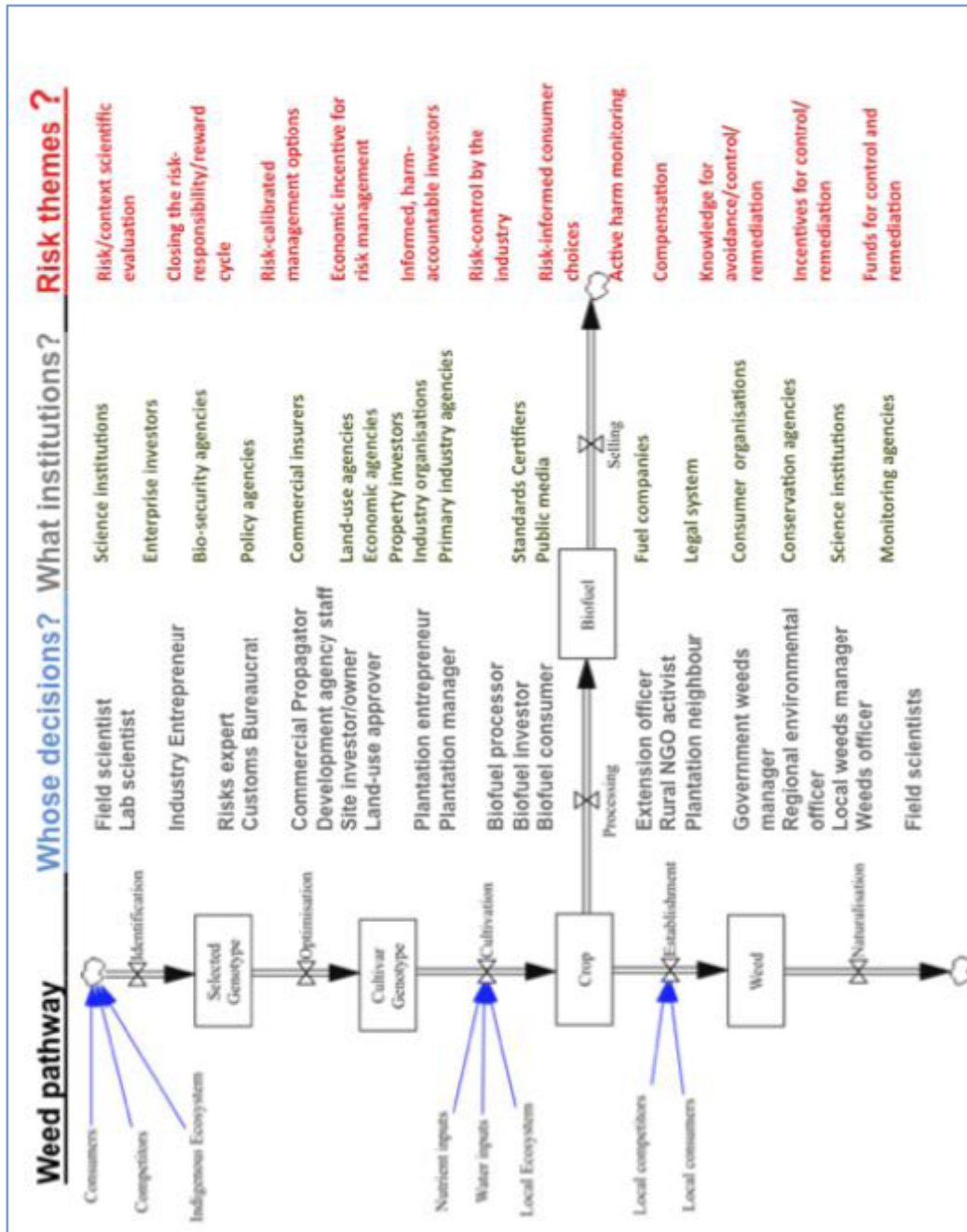


Figure 1 Bio-fuel weeds risk pathway^x (Martin *et al* 2010). This pathway was developed by Martin.

The potential of co-regulation

The difficulty of establishing individual responsibility for weeds introduction and/or spread, as illustrated with GMOs^{xi}, justifies an industry collective accountability approach. Because it is difficult to trace particular weeds to particular sources and incidents, it is almost impossible to apply conventional methods of legal liability. This would be an argument for simple risk avoidance ban of the potential weed. However if the need to prove individual accountability is replaced by a credible mechanism of collective responsibility, this argument for a ban is weakened. This logic could justify the embrace of a collective industry risk management responsibility managed by the bio-fuels industry and monitored by governmental authorities to ensure that the risk governance framework is reliable and that the public interest is effectively protected. This should embrace a meaningful contingent cost to the industry should self-regulation fail. Examples of corporate risk management programs have been for example adopted in the chemical industry (Gunningham et al. 1998) and the Green Dot program in Germany to incentivise the industry to manage packaging waste (Rousso et al. 1994).

CONCLUSION: WHAT MIGHT HAPPEN IF WE GO DOWN THIS PATH?

We acknowledge that there are many complexities embedded in these commercial risk management instruments which are not risk-free. The recent catastrophic Queensland floods highlighted some of the challenges associated with insurance mechanisms, including the inconsistent definition of floods in insurance policies and insurers' resistance to compensate victims. The reform proposals within the water context also illustrated the difficulty of integrating contested scientific data into the legal and policy framework as well as the complexity of balancing various conflicting interests to achieve environmental, social and economic outcomes. However, we hope that this research, and the proposals within this thesis, will help to provide the stimulus for greater legal and institutional innovation.

CONCEPT/ MECHANISM		APPLICATION OF THE MECHANISM	INCIDENCE OF THE MECHANISM	INDUSTRY EXAMPLES
FINANCIAL RESPONSIBILITY MECHANISMS	Civil liability	Statutory liability for weed cost (economic, cleanup, or ecological harm). Financial liability arises should invasiveness emerge. Liability insurance may create a market mechanism to price the risk characteristics of alternative crop types and management regimes.	Liability for a failure to control bio-fuel weeds potentially imposed upon importers, seed or plant supply companies, crop growers. Liability arises upon proof of harm (to the legally required standard).	G.M.O. liability Pollutant emission liability Contaminated site liability
	Individual performance bonds/ guarantees	Mandatory financial guarantee (deposit or bank) to fund environmental restoration or economic loss.	On approval to plant or introduce new bio-fuel species, or establish production facility. Cost imposed at point of approval (deposit) or on proof of harm (bank guarantee).	Mine site rehabilitation bonds (e.g. Queensland Environment Protection Act, 1994) Construction guarantees
	Industry pooled risk sinking funds	Industry risk-management funding pool for prevention, control and restoration). Firms must: <ul style="list-style-type: none"> contribute to the pool funds, and prove they have risk protection under the scheme. A scheme can also be state-sponsored and administered.	Potentially levied across the bio-fuels supply chain; or selected participants Potentially levied on states to provide funding for a national invasiveness response	US Oil Spill Liability Trust Fund (OSLTF)/ US Oil Pollution Act, 1990) California's oil spill strategy (Lempert-Keene-Seastrand Oil Spill Prevention and Response Act, 1990, California) US States' Interstate Pest Control Compact/ Pest Control Insurance Fund
	Environmental risk insurance	Contractual mechanism to transfer environmental risks to third-party insurers to pool the risk of invasiveness and the costs of control and rehabilitation. Facilitated by civil liability.	Similar to risk pooling	Similar to risk pooling. Insurance products such as storm or other natural disaster.

Table 1 Theoretical Market Mechanisms For invasives Control (Martin and Le Gal, 2010)

CONCEPT/ MECHANISM		APPLICATION OF THE MECHANISM	INCIDENCE OF THE MECHANISM	INDUSTRY EXAMPLES
ENABLING MECHANISMS	Invasiveness risk inspection in property transactions	Independent reporting of the potential costs of control and eradication of invasive plants at the time of property transfer. Information and incentive to negotiate over and price invasiveness risk (and an incentive to minimise the risk)	At the time of transfer of a property upon which bio-fuel plants are grown.	Contaminated lands inspection and reporting. Pre-sale weed inspections proposed in Martin (2008).
	Plantation permits	Permits to grow potentially invasive species. Synergistic with weed risk inspection mechanism. Legal obligation to eradicate if no permit is held.	Owners and establishers of bio-fuel crop plantations, and vendors of affected properties require permits for the level of risk/plantings proposed. The permit vendor certifies the eradication of the species on the site from which the permit is transferred or lapses.	Theoretical model proposed by Horan and Lupi (2005) for ballast water invasive species control. Tradable development rights (e.g. Chesapeake Bay). Reported success to date has been limited. Emissions permit to control air quality risk.
	Bio-fuel 'green' investment standards	Green standards to inform investors of the social performance of publicly listed bio-fuel enterprises. Invasive species risk could be included.	Publicly listed bio-fuels enterprises.	Sustainable investment indices and funds. Bache Commodity Green Index SM
	Eco-certification and eco-labelling	Product evaluation against environmental standards potentially including invasiveness risk. Market incentive to lower environmental risk.	May be public certification or labelling, or industry through bio-fuel purchaser chains (at wholesale or retail level), or non-government certification and labelling	Voluntary Environment Management standards (e.g. ISO 14001, 14040). 'Green' certification and consumer information programmes. Supply chain purchasing standards

Table 1 Theoretical Market Mechanisms For invasives Control (Martin and Le Gal, 2010)

ACKNOWLEDGMENTS

Thanks to the ever-supporting research environment provided at the Australian Centre of Agriculture and the School of Law of the University of New England. I also thank my supervisors (Professor Paul Martin, Dr. Amanda Kennedy and Dr. Jacqueline Williams) all the participants involved to varying degrees in this project. The conceptual architecture for a co-regulatory biofuels weeds risk management model is a result of an ongoing collaboration with my principal supervisor Professor Paul Martin. I also specifically thank the University of New England for funding this research as well as the specific financial contribution of *Conservation Farmers Inc.* and *Williams & Partners* in the early stage of this project. Also thank you to Michael Burgis, Andrew Perkins and John Rochecouste.

REFERENCES AND FURTHER INFORMATION

BANKS, E. (2004). *Alternative risk transfer: integrated risk management through insurance, reinsurance, and the capital markets*, Chichester, John Wiley & Sons Ltd.

BIOFUELS TASKFORCE. (2005). Report of the biofuels taskforce to the Prime Minister.

BODANSKY, D. & FREESTONE, D. (Eds.) (2004) *Eco-Finance: The legal design and regulation of market-based environmental instruments*, The Hague, Kluwer Law International.

DEPARTMENT OF RESOURCES ENERGY AND TOURISM. (2009). National energy Policy – Framework 2030: Strategic directions paper. Retrieved 16 April 2011 from <http://www.ret.gov.au/energy/Documents/Energy%20Security/Strategic%20Directions%20for%20Energy%20White%20Paper%20March%202009.pdf>.

FAURE, M. (2009). Instruments for Environmental Governance: What Works? Proceedings of the 7th Annual Colloquium of the IUCN Academy of environmental law. Wuhan, 1-5 November 2009. Retrieved 18 April 2011 from website http://www.iucnael.org/index.php?option=com_content&view=article&id=104&Itemid=78.

GISP. (2008). Biofuels crops and the use of non-native species: mitigating the risks of invasion. Retrieved 16 April 2011 from < <http://www.gisp.org/publications/reports/BiofuelsReport.pdf.pdf>>.

GUNNINGHAM, N. AND GRABOSKY, P.N. (1998). *Smart regulation: designing environmental policy*. (Clarendon, Oxford).

FAURE M. AND HARTLIEF, T. (Eds.) (2003), *Insurance and Expanding Systemic Risks*, Paris, OECD Publishing.

HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON PRIMARY INDUSTRIES AND RESOURCES. (2010), *Farming the Future: the Role of Government in Assisting Australian Farmers to the Impacts of Climate Change*. Parliament of the Commonwealth of Australia, Canberra. Retrieved 16 April 2011 from < <http://www.aph.gov.au/house/committee/pir/australianfarmers/report/Final%20Report.pdf>>.

IUCN. (2009). Guidelines on biofuels and invasive species. Retrieved 16 April 2011 from <http://cmsdata.iucn.org/downloads/iucn_guidelines_on_biofuels_and_invasive_species_.pdf>.

KOIKE, F., CLOUT, M., KAWAMICHI, M., DE POORTER, M. & IWATSUKI (Eds.) (2006) *Assessment and Control of Biological Invasion Risks*, Kyoto, Gland, SHOUKAHOH Books Sellers and the World Conservation Union (IUCN).

- LABATT, S. & WHITE, R. R. (2002) *Environmental Finance: A Guide to Environmental Risk Assessment and Financial Products*, Hoboken, New Jersey, John Wiley & Sons, Inc.
- LE GAL, E. (2010) Methodological approach for testing a co-regulatory bio-fuels weeds risk management model. Postgraduate Research Conference (University of New England, 5-9 July 2011). Forthcoming.
- MARTIN, P. (2006). Weeds: new strategies for an old problem. Proceedings of the 15th Australian Weeds Conference, pp. 118-21. (Weed Management Society of South Australia, Adelaide).
- MARTIN, P. & VERBEEK, M. (2006) *Sustainability Strategy*, Annandale, NSW, The Federation Press.
- MARTIN, P., BARTEL, R. L., SINDEN, J. A., GUNNINGHAM, N. & HANNAM, I. (2007). Developing a good regulatory practice model for environmental regulations impacting on farmers. Australian Farm Institute, and Land and Water Australia.
- MARTIN, P. (2008). Cross pollination or cross-contamination? Directions for informing the management of invasives with market-economy concepts. Proceedings of the 16th Australian Weeds Conference, pp 6-13. (Queensland Weed Society, Brisbane).
- MARTIN, P. (2008) The Changing Role of Law in the Pursuit of Sustainability. IN JEFFERY, M. I., FIRESTONE, J., BUBNA-LITIC, K. (Eds.) *Biodiversity Conservation, Law + Livelihoods - Bridging the North-South Divide*. New York, Cambridge University Press.
- MARTIN, P. and LE GAL, E. (2010) Concepts for Industry Co-Regulation of Bio-fuel Weeds. *eJournal*, issue 1, IUCN Academy of Environmental Law.
- MILLS, E. (2009) From Risk to Opportunity: 2008 - Insurer Responses to Climate Change. Ceres. Retrieved 17 April 2011 from <http://www.ceres.org/Document.Doc?id=417>.
- RATH, K. (2008). The Potential for green gene technology in biomass production – a legal examination, in BRECKLING B., REUTER, H. and VERHOEVEN, R. (Eds), *Implications of GM-Crop Cultivation at Large Special Scales*. Theorie in der Ökologie. Proceedings of the GMLS-Conference 2008, Bremen, Peter Lang, Frankfurt, pp 163-168.
- RILEY, S. (2008). Invasive Alien Species and the Protection of Biodiversity: the Role of Quarantine Laws in Resolving the Inadequacies in the International Legal Regime (PhD Thesis, UNSW).
- Rouso, A. S. and Shah S.P (1994). Packaging taxes and recycling incentives: The German Green Dot Program, *National Tax Journal* 47(3): 689-701.
- SENATE ENVIRONMENT, COMMUNICATIONS, INFORMATION TECHNOLOGY AND THE ARTS REFERENCES COMMITTEE (2004), Turning back the tide – the invasive species challenge. Report on the regulation, control and management of invasive species and the Environment Protection and Biodiversity Conservation Amendment (Invasive Species) Bill 2002' (Report) Canberra. Retrieved 17 April 2011 from http://www.aph.gov.au/SENATE/committee/ecita_ctte/completed_inquiries/2004-07/invasive_species/report/index.htm.
- SINDEL, B., VAN DER MEULEN, A., COLEMAN, M. & REEVE, I. (2008) Pathway Risk Analysis for Weed Spread within Australia - Final Report. Land and Water Australia
- VIRTUE, J., CUNNINGHAM, D., C. HANSON, C., HOSKING, J., MILLER, I., PANETTA, D., PHELOUNG, P., RANDALL, R., TIMMINS, S., WALTON, C., WEISS, J., AND WILLIAMS P. (2006) National Post-Border Weed Risk Management Protocol. HB 294:2006. Sydney, Australia, and Wellington, New Zealand: Standards Australia and Standards New Zealand.

ENDNOTES 10PT

ⁱ The House of Representatives Standing Committee on Primary Industries and Resources reports that:
Second-generation technology [...] represents a step change in technology – it has been physically demonstrated but is not yet commercial due to scale-up issue, or it is not commercially viable due to very high conversion costs.’

HOUSE OF REPRESENTATIVES STANDING COMMITTEE ON PRIMARY INDUSTRIES AND RESOURCES (2010) *Farming the Future: the Role of Government in Assisting Australian Farmers to the Impacts of Climate Change*. Parliament of the Commonwealth of Australia, Canberra. p 72. Retrieved 18 April 2011 from

< <http://www.aph.gov.au/house/committee/pir/australianfarmers/report/Final%20Report.pdf>>.

ⁱⁱ See for example the strategic national directions released in 2009 by the Department of Resources Energy and Tourism in its energy white paper available at <<http://www.ret.gov.au/energy/Documents/Energy%20Security/Strategic%20Directions%20for%20Energy%20White%20Paper%20March%202009.pdf>>.

ⁱⁱⁱ Under the *Renewable Energy (Electricity) Amendment Act 2009*, 20% of the Australian electricity supply will have to be sourced from renewable energy through the national Renewable Energy target (RET scheme). The state of New South Wales has already adopted in its *Biofuels Act 2007* (NSW) a 10% mandated target biofuels (ethanol) for commercial fuels by 2011.

^{iv} As noted in (Martin 2008a:13), this is more accurately attributed to John Dryden in his play *Spanish Friar* (Act II, st.1), 1681.

^v For example, the Pheloung WRA system has been criticised for being too risk adverse and disregarding cost-benefit analysis. See NWRAS REVIEW GROUP (a Joint Natural Resource Management Standing Committee – Primary Industries Standing Committee Sub-committee), *Review of the National Weed Risk Assessment System*, 30 November 2005 (document approved for publication at NRMSC 12 Canberra, 2 August 2006), pp 17-18.

^{vi} The deed is available at Plant Health Australia’s website <<http://www.planthealthaustralia.com.au/go/phau/epprd>>

^{vii} It is also reported that ‘several national eradication cost-sharing programs [are] underway’ in RURAL INDUSTRIES RESEARCH AND DEVELOPMENT CORPORATION (2010), *National Weeds and Productivity Research Program R&D Plan 2010 to 2015*. Retrieved 18 April 2011 from < <https://rirdc.infoservices.com.au/items/10-209>> p 9.

^{viii} The smart regulatory strategy has been suggested in a series of research studies including these already listed in the bibliography. See (Martin and Verbeek 2006, Faure 2009, Martin 2006, Martin, 2008.

^{ix} Autopoiesis is a term for the processes self-generated within a system, e.g. the evolution of abstract representation in art or performance, or evolution of species within natural systems.

^x More specifically, this diagram has been created by Professor Paul Martin.

^{xi} In Australia, there is no special liability regime that regulates damage caused by GMOs. In common law actions under the doctrine of negligence, legal responsibility require that a legally protected interest has been harmed and that a causal connection is established between the plaintiff’s damage/injury and the defendant’s act or omission. There is no obligation upon GMOs growers to inform anyone that that they are planting GMOs. On the difficulty of allocating liability see the Canadian case *Hoffman v Monsanto* [2005] SKBB225.

HOW DO WE RADICALLY IMPROVE WEEDS LAW?

Critical action for wicked problems

**Robyn Bartel, Senior Lecturer, University of New England and
Sophie Riley, Senior Lecturer, University of Technology Sydney**

ABSTRACT

This paper discusses the weed dilemma arguing that weed regulation in Australia needs a radical overhaul, primarily with respect to capacity and commitment in order to align interests and improve interaction amongst stakeholders. The analysis commences with an overview of the problem before moving to a discussion of four areas of regulation that demand critical action: disunity, proactivity, complexity and laxity. Law reform needs to take into account community heterogeneity (disunity), the difficulties in mandating action (proactivity), the needless confusion of laws and legal instruments between jurisdictions (complexity) and the history of slow and inadequate response and poor monitoring and enforcement (laxity). Radical improvements are required in three main areas. First, commitment generation is required to generate moral and norm agreement around weeds as undesirable. Second, radical improvement is required in the area of capacity generation, and of capacity facilitation through harmonisation of regulation. Third, radical improvement is required in the area of compliance generation, of those who are non-compliant and unlikely to respond to softer mechanisms such as education. A combination of market incentives could be used here; although moral hazards must also be avoided. Where enforcement action is adopted, care must also be taken that the regulated are not discouraged and commitment undermined as a result.

INTRODUCTION

Invasive plant species are a major threat to land and ecosystem functioning, biodiversity and agricultural productivity, costing agricultural industries approximately \$4 billion per annum (Sinden et al, 2004). In the twenty first century, these difficulties are poised to worsen as they converge with other problems, such as climate change (Steffen et al, 2009). While the precise impacts of climate change are uncertain, concentrations of carbon dioxide are anticipated to contribute to modifications in rainfall patterns and increased temperatures across Australia (Kriticos et al, 2000). Such changes will increase the ability of non-native species, including plants, to ‘invade new areas’ (Thuiller et al, 2007 and see also Stachowicz et al, 2002). This prediction extends to species that regulators do not currently regard as invasive (Steffen et al 2009), highlighting the importance of designing regimes to prevent and control weed invasions in a dynamic context (Low, 2008).

Weed regulation is multi-faceted and squarely conforms to the ‘wicked’ problems described by scholars of regulatory theory (Van Bueren et al, 2003 and see also Lazarus, 2008-9 and Ayoub et al, 2009). Such problems are characterized by fragmented decision-making, difficulties that are complex and contested (Van Bueren et al 2003) and stakeholders who do not have a shared appreciation of the problem (Ayoub et al, 2009). Indeed, as with wicked problems, weed regulation involves a complex mix of issues. These include: matters related to technical aspects of weeds; the need to develop regimes against the backdrop of scientific uncertainty; difficulties inherent in structuring regimes that incorporate legal, social and economic concerns articulated by a range of stakeholders who hold varying views and opinions on what constitutes a weed; and, differences amongst stakeholders regarding the

best way to deal with the weed problem. In essence, the issues focus on ‘problems of interaction’ (Van Bueren, 2003).

This paper discusses the weed dilemma arguing that weed regulation in Australia needs a radical overhaul, primarily with respect to capacity and commitment in order to align interests and improve interaction amongst stakeholders. The analysis commences with an overview of the problem before moving to a discussion of four areas of regulation that demand critical action: disunity, proactivity, complexity and laxity.

The problem

Weeds laws in Australia have been introduced in an attempt to stem the most pressing impacts of weeds. Under State, Territory and Commonwealth legislation, species which have been identified as problems have been categorised according to the threats which they pose, with actions prescribed that correspond to their level of seriousness.

One would think such laws would be successful; after all, they should benefit from broad social agreement, since who likes weeds? However the situation is more complicated. The protection which the law currently affords is insufficient, due to the following:

- *Disunity*: Some people do like weeds. Over half of all weed species are garden escapees and many weeds are still cultivated, sold and bought as ornamentals. Commercial nurseries have a vested interest in continuing to sell ornamental weeds. Moreover, not all parts of society agree on how some plants should be classified. The plant *Echium plantagineum*, for example, is regarded as “Paterson’s Curse” by Australian graziers, because its leaves are poisonous to cattle, while bee-keepers refer to it as “Salvation Jane”, because its pollen provides food for bees (Groves et al 2005).
- *Proactivity*: Laws that require action to be taken by citizens, where the chief constraints on the ability to remove weeds are time, labour and capital, are unlikely to be successful. Even where government funding is available to eradicate or control weeds, for funding to be effective, it needs to be synchronized with the life cycle of the plant, including the seed cycle (Bellamy et al, 2005). These are not traditionally problems that the law is designed to solve.
- *Complexity*: Laws are inconsistent between jurisdictions, creating confusion (Bellamy et al, 2005). The number of jurisdictions involved hampers a coordinated approach to weed control through, for example, commercial nursery regulation;
- *Laxity*: Laws are not enforced and are slow to change in response to new weeds and threats, leaving gaps in the (limited) protection which is afforded by the law. The emerging issue of climate change and its impact on weed distribution is a case in point. Ecosystems are not static and climate change will add to the changing dynamics within ecosystems and of ecosystems themselves (Thuiller et al 2007 and see also Steffen et al, 2009 and Congress of the US, 2005). Accordingly, regulators need to be aware of these changes in order to design effective regimes. For example, in the Australian state of New South Wales, the Department of Environment and Climate Change is leading a project to gather information on ‘the impacts of climate change on a range of invasive plant and animal species’. This information will be used to make decisions on how IAS are to be managed and controlled (DECC, 2007). Yet, even where states and territories identify which plants are most likely to become invasive, the data will need to be consistently monitored and updated – a type of action that is not always carried out.

In order to deal with the wicked problems of weeds, regulators need to address the underlying policy and management issues that have led to the development of disunity, as well as difficulties stemming from proactivity, complexity and laxity. The discussion which follows addresses each of these issues and investigates whether improvements and indeed what

radical improvements to the law might be necessary and available to garner these advancements.

DISCUSSION

Disunity

Radical improvement is required in the area of *commitment* generation, to generate moral and norm agreement around weeds as undesirable. Laws will operate most effectively where they are also norms, and where there is little moral ambiguity, and in culturally homogenous societies (Low and Gleeson, 1998). There are many forces at play which are available to underpin broad social disapproval of weeds. Weeds are undesirable on a number of counts – amenity, biodiversity and productivity. Productive agriculture experiences severe losses due to weed infestation. Agencies charged with public land management and seeking preservation and conservation are also required to counter weed infestation. Tree-changers and sea-changers seeking amenity are also likely to disapprove of weeds. These three sectors are those described by Holmes (2006) as the main occupants of the increasingly multi-functional landscape in rural areas. The trouble is, of course, that farmers and parks services are frequently resource-constrained, as discussed under the next heading, and tree- and sea – changers may or may not be better resourced and well-intentioned, or more knowledgeable.

Garden escapees comprise 66% of Australia's weeds (Coutts-Smith and Downey, 2006; Csurhes, 2006). The point of sale may be an opportunity to educate buyers about lower risk species and bans or market instruments introduced for higher risk plants (Martin et al, 2007). Alternative legal avenues may also offer cure, for example, civil action might offer a disincentive for mis-labelling of invasive species at nurseries (Martin, 2006). Litigation for misleading conduct or suitability for purpose under the Australian Consumer Law (previously the Trade Practices Act), or common law tort-based actions have the potential to trigger legal liability for those who trade in invasive species (Martin et al, 2007).

Laws will also operate effectively when harmful activities are demonstrably treated as punishable activities. Punishment and sanctions for illegal weed behaviours are addressed under the fourth heading (laxity). The educative role of law can have good effect, but broader education about weeds, weed identification and weed removal are obviously areas which could yield results, in both generating the commitment required for voluntary (and beyond) compliance and also the capacity required for control and prevention. Weeds are a chronic rather than an acute threat and therefore educational approaches need to be well-resourced, proactive and continuous (since a high-profile disastrous event is unlikely to provide free media coverage to be able to be 'piggy-backed' for larger impact).

Proactivity

Listed weed species generally require landholders to undertake control plans; and funding may or may not be available, depending on the jurisdiction. Even where landholders have the know-how for weed control, they may not have the fiscal or human power available. Laws do not generally underwrite time, labour and capital, although policy measures, such as tax breaks and incentives, can be administered through the law. Such incentives for proactivity have been largely under-utilised. Funding for voluntary (rather than incentives for legally required action) activities has been sporadic and the lack of continuity and changing funding requirements can undermine public confidence and trust.

This can lead to what has been described as 'dialogues of the deaf' where neither sector is truly responsive to the needs of each other, or to the problem at hand (Van Bueren et al, 2003). It is possible for government to re-construe the problem by devising a 'common frame of reference' (Van Bueren et al, 2003) and a common purpose, or 'shared-fates'

approach (Bartel and Barclay, 2011). This can help landowners and government acknowledge their interdependencies and assist in undertaking cooperative and coordinated action.

Radical improvement is required in the area of *capacity* generation. The next discussion point also addresses capacity – if laws are less complex then it is easier to comply.

Complexity

The National Weeds Strategy, developed by the Australian Weeds Committee, defines twenty of the most threatening invasive plant species in Australia as Weeds of National Significance'. The list is endorsed by both Federal and all State and Territory governments. Beyond these top 20 there are lengthy official listings in each jurisdiction, as well as unofficial lists (Glanzign et al 2004). Listing on one jurisdiction's list does not translate as listing on another. Instead, each jurisdiction has separate legislation, which has evolved independently, that may be administered by different levels of government and which have different administration and enforcement arrangements, compromising the capacity for knowledge transfer and coordination. Systems (and capacity) of detection and prevention of new, as opposed to known, threats are also different.

While fine-tuning policy or implementing regimes may be more successful if addressed at a localised level, such as occurred with the removal of kikuyu grass from Montague Island (DECCW, 2004), this type of regulatory structure can also lead to the development of a fragmented regime. The difficulty stems not so much from the fact that issues are addressed at a regional or local level, but from the lack of strategic guidance and coordination.

While it is stepping somewhat on the Constitution, States could exercise their constitutionally derived responsibility for environmental management to address the weed threat cooperatively through harmonised prevention, control and abatement systems. Existing attempts to do this via Ministerial Councils and Committees have been patchy and cumbersome and may be resented by States if seen as being imposed from outside (Martin et al, 2007). In any case, these are currently undergoing reform. COAG has recently announced the formation of two new standing councils on primary industries (including biosecurity), and environment and water. However, the national picture is unlikely to change much, as weeds are not one of the areas currently prioritised for harmonisation, and the areas which have been identified have not had much success (Bartel and Stone 2011). This situation persists despite the fact that in 2009 a review of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) recommended that COAG 'develop criteria and management protocols for the movement of potentially damaging exotic species between State and Territories' (Hawke, 2009). There is far greater political will required here.

Radical improvement is therefore required in the area of capacity improvement through *Harmonisation*. Harmonisation between jurisdictions could assist, so long as the best are learned from and emulated, rather than from the lowest common denominator (Bartel and Stone, 2011). While there may be an argument made for a more localised, rather than nationalised, approach (since weeds are a biological threat and bioregional boundaries seldom equate to political ones) the mobility of plant materials around the nation would point to a nationalised approach.

Laxity

Capacity and commitment-focused initiatives are vital to generate voluntary, and beyond, compliance behaviours. For non-compliance there still must be enforcement action taken and this has been lax and patchy, even for the Weeds of National Significance (WONS). In 2004, the Senate Environment, Communications, Information Technology and

the Arts References Committee attributed this to a ‘lack of political will’ on the part of the States and Territories:

The WONS are agreed to be the 20 most problematic weeds in Australia. They have to be vigorously attacked on a unified basis before the country can move on to address its next priorities. The national effort to overcome invasive species is only as strong as the weakest link - and control and eradication efforts in one region are quickly undone in other regions that adopt a less aggressive regulatory stance. (Commonwealth of Australia, 2004).

The time lag evident here between WONS listing, Committee criticism and the relatively unchanged regulatory landscape point to a considerable laxity also in response times taken to address the issues. Not only does the regime develop in a piecemeal way but it also fails to identify in a timely manner those species that are changing from a localized problem into a widespread problem. By way of illustration, one of the most harmful invasive species that is toxic to many plants is Cinnamon or root rot fungus (*Phytophthora cinnamomi*). This species was thought to have been introduced into Western Australia at the turn of the twentieth century and by the 1940s it had spread to Tasmania and Victoria. Yet it was only in the 1970s that regulators undertook concerted efforts to control this fungus (Burgman et al 2009).

Lax laws will also play a part in minimizing the nature and scope of the problem in the minds of the public. Humans have difficulty visualizing problems that they cannot imagine and in such cases tend to misconstrue cause and effect linkages (Lazarus, 2008-9). Weed problems, for example, may not manifest for many decades after a plant’s first introduction. Some studies indicate average lag times of 147 years are not unusual (Wittenberg, 2005), with other studies increasing this figure to 170 years (Low, 1999). Consequently, regulation often anticipates that stakeholders will initiate remedial action for events that may not occur during the stakeholder’s lifetime – something that conceptually people may find difficult to do (Lazarus, 2008-9).

It is for this reason that gardeners may not believe that their ornamentals are the next potential lantana or alligator weed. The danger lies in the fact that the public will underestimate the problem of weeds, further intensifying difficulties of disunity and proactivity. Yet societal choices can also be swayed. Hence, in addition to techniques such as education, already mentioned under the heading of ‘disunity’, laws can encourage people to make choices and thus be a driver of personal preferences (Lazarus, 2008-9).

Indeed, in the context of responsive regulation (Ayers and Braithwaite, 1992; Wright and Head, 2009) commentators acknowledge that the threats of penalties and sanctions are necessary for the optimum operation of regimes (Braithwaite, 2002). Yet, penalties are seen as a last resort. Responsive regulation focuses on conduct and how best to guide that conduct towards securing compliance. The regulatory pyramid, therefore, starts with persuasion (Braithwaite, 2002) that may take many forms, such as warning letters, compliance notices, and market incentives.

Principally, radical improvement is required in the area of *compliance* generation, of those who are non-compliant and unlikely to respond to softer mechanisms such as education. A combination of market incentives could be used here; although moral hazards must also be avoided. Where enforcement action is adopted, care must also be taken that the regulated are not discouraged and commitment undermined as a result (Bartel and Barclay, 2011).

CONCLUSIONS AND FURTHER WORK

Weeds law do need radical overhaul, chiefly in the areas of capacity and commitment generation, as well as more traditional enforcement for non-compliance. In similarity with many other regulatory dilemmas, the problem of weeds is defined by the imperfect interaction of biophysical, legal, social and economic criteria (Kinzig, 2001). There are therefore three areas for further work:

- *Commitment*-generation;
- *Capacity*-generation, including harmonisation to reduce the barriers for compliance such as confusion; and
- *Compliance*-generation.

Regulatory issues, of course, are not the only factors impeding weed control. Weeds practitioners, whilst frustrated by regulatory problems, point also to the inadequacy of funds, even when regulation is available; gaps in science; and insufficient community action (Martin et al, 2007). Addressing all of these areas would place pressure on the public purse, so there are also strong arguments for a risk-based, prioritized approach which is cognizant of opportunity costs while also being ‘precautious’ in the evaluation of risk. Such an approach should engage local communities in order to harness the necessary social engagement and voluntary behaviours required, as well as generate capacity and commitment along the way. Indeed, the way forward lies in generating ‘collective action’ (Van Bueren et al, 2003) in a radical approach to deal with the wicked problem of weeds.

#

REFERENCES

- Ayoub, Nasser, Rafael Batres and Yuji Naka, 2009. ‘An Approach to Wicked Problems in Environmental Policy Making’ (2009) 5 (3) WSEAS Transactions on Environment and Development, 229, 229-230.
- Ayers, Ian and John Braithwaite, 1992. *Responsive Regulation: Transcending the Deregulation Debate*, Oxford University Press (New York) p 4.
- Bartel, Robyn and Elaine Barclay, 2011. Motivational Postures and compliance with environmental law in Australian agriculture, *Journal of Rural Studies*.
- Bartel, Robyn, and Christopher Stone, (2011 Forthcoming). A rising tide that lifts all boats? Lessons for harmonisation, INECE International Network for Environmental Compliance and Enforcement, Conference 17-21 June.
- Bellamy, Jennifer, Dan Metcalfe, Nigel Weston and Steven Dawson, 2005. Evaluation of Invasive Species (Weeds) Outcomes of Regional Investment, Australian Government, 70.
<http://www.nrm.gov.au/publications/books/pubs/evaluation-weeds.pdf>
- Braithwaite, John 2002 ‘Rewards and Regulation’, 29 (1) *Journal of Law and Society*, 12, 12.
- Burgman, Mark, Terry Walshe, Lee Godden, Paul Martin, 2009 ‘Designing Regulation for Conservation and Biosecurity’ 13 (1) *Australasian Journal of Natural Resources Law and Policy* 93, 105-6.
- Commonwealth of Australia, 2004. Senate Environment Communications Information Technology and the Arts References Committee, *Turning Back the Tide - The Invasive Species Challenge: Report on the Regulation, Control and Management of Invasive Species and the Environment Protection and Biodiversity Conservation Amendment (Invasive Species) Bill 2002*, (Commonwealth of Australia), 113.
- Congress of the United States, 2005. *Uncertainty in Analyzing Climate Change: Policy Implications*, Congress of the United States, Congressional Budget Office at 2. Available from <http://www.cbo.gov/ftpdocs/60xx/doc6061/01-24-ClimateChange.pdf> > (last visited May 2010).
- Coutts-Smith, Aaron and Paul Downey, 2006. *The Impact of Weeds on Threatened Biodiversity in New South Wales*, Technical Series 11 (CRC for Australian Weed Management).
- Csurhes, Steve 2006. “‘Turn the Tap Off Before you Mop up the Spill’”: Exploring a Permitted-List Approach to Regulations Over the Sale and Interstate Movement of Potentially Invasive Plants in the States and Territories of Australia’, presented at Fifteenth Australian Weeds Conference (Adelaide).
- Department of Environment and Climate Change, NSW, 2007. *Adaption Strategy for Climate Change Impacts on Biodiversity* DECC, 34.
- Department of the Environment, Climate Change and Water, 2004. ‘Montague Island Nature Reserve – Seabird Habitat Restoration Project’ New South Wales Government, Department of the Environment, Climate Change and Water, May 2004.

- Glanznig, Andreas, Kristi McLachlan, and Ouerdia Kessal, 2004. Garden Plants that are Invasive Plants of National Importance: An Overview of their Legal Status, Commercial Availability and Risk Status, (WWF).
- Groves, Richard Robert Boden and Mark Lonsdale, 2005. Jumping the Garden Fence Invasive Plants in Australia and their Environmental and Agricultural Impacts a CSIRO report for WWF, WWF-Australia 29.
- Hawke, Allan, 2009. The Australian Environment Act – Report of the Independent Review of the Environment Protection and Biodiversity Conservation Act 1999, Commonwealth of Australia, 149.
- Holmes, John 2006 Impulses towards a multifunctional transition in rural Australia: Gaps in the research agenda *Journal of Rural Studies*, 22(2): 142-160 .
- Kinzig, Ann, 2001 'Bridging Disciplinary Divides to Address Environmental and Intellectual Challenges', 4 (8) *Ecosystems* 709, 709.
- Kriticos, Darren, Robert Sutherst and Steve Adkins, 2000. Exotic Woody Weeds: Use of Simulation Models to Predict Future Distributions Under Climate Change, RIRDC vii.
- Lazarus, Richard, 2008-9 'Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future', 94 *Cornell Law Review* 1153, 1159.
- Low, Tim, 1999. *Feral Future* Viking Victoria, Australia 216-17.
- Low, Tim, 2008. Climate Change and Invasive Species: A review of Interactions, November 2006 Workshop Report, Department of the Environment, Water, Heritage and the Arts, Commonwealth of Australia 35
- Low, Nicholas and Gleeson, Brendan, 1998. *Justice, Society and Nature: an exploration of political ecology*, Routledge, London.
- Martin, Paul, 2006 'Weeds: New Strategies for an Old Problem', presented at Fifteenth Australian Weeds Conference (Adelaide).
- Martin, Paul, Robyn Bartel, Jack Sinden, Neil Gunningham, and Ian Hannam, 2007. Developing a good regulatory practice model for environmental regulations impacting on farmers, Australian Farm Institute and Land & Water Australia.
- Sinden, Jack Randall Jones, Susie Hester, Doreen Odom, Cheryl Kalisch, Rosemary James, and Oscar Cacho, 2004. *The Economic Impact of Weeds in Australia*, Technical Series 8 (CRC for Australian Weed Management).
- Stachowicz, John, Jeffrey Terwin, Robert Whitlatch and Richard Osman, 2002. 'Linking Climate Change and Biological Invasions: Ocean Warming Facilitates Nonindigenous Species Invasions', 99 (24) *Proceedings of the National Academy of Sciences of the United States of America*, 15497, at 15497.
- Steffen, Will, Andrew Burbidge, Lesley Hughes, Roger Kitching, David Lindenmayer, Warren Musgrave, Mark Stafford Smith and Patricia Werner, 2009. *Australia's Biodiversity and Climate Change (Summary for Policy Makers 2009)* Department of Climate Change, Commonwealth of Australia, 6
- Thuiller, Willfried, David Richardson and Guy Midgley, 2007. 'Will Climate Change Promote Alien Plant Invasions?', (2007) *Ecological Studies*, 193, 197-8.
- Van Bueren, Ellen, Erik-Hans Klijn and Joop Koppenjan, 2003. 'Dealing with Wicked Problems in Networks: Analyzing and Environmental Debate from a Network Perspective', 13 (2) *Journal of Public Administration Research and Theory*, 193, 193.
- Wittenberg, R (ed) 2005. *An Inventory of Alien Species and Their Threat to Biodiversity and Economy in Switzerland*. CABI Bioscience Switzerland Centre report to the Swiss Agency for Environment, Forests and Landscape (SAEFL) p 26.
- Wright, John S F and Brian Head, 2009 'Reconsidering Regulation and Governance Theory: A Learning Approach', 33(2) *Law and Policy* , 197, 198.

#

CAN THE COMMON LAW OF NUISANCE EFFECTIVELY MANAGE WEED SPREAD?

Philip J. Blackmore
Invasive Species Officer (Weeds)
Department of Primary Industries
Armidale NSW

When weeds spread to new areas, landholders in the newly infested areas suffer economic losses because of that spread. Weed spread creates external costs (Menz and Auld, 1977; Pannell, 1994; Jones, 2000). External costs occur when the actions of individuals impose unintended impacts on others. For more than one hundred years, New South Wales has had legislation requiring landholders to control certain weeds on their land. This has been seen as the most appropriate method to limit weed spread and the external costs that are created by that spread. However, questioning the need and the purpose of current legislation is a worthwhile exercise as other methods may exist to deal with the problem that the legislation addresses.

The common law, specifically the tort of private nuisance, may be seen as an alternative to statute (currently the *Noxious weeds Act 1993*) as a means to limit weed spread. The judgement of a recent case in the NSW Land and Environment Court, *Robson v Leischke* [2008] NSWLEC 152, provides a discourse on the law of private nuisance. This is particularly relevant to actions in the civil courts over spreading weeds. This paper examines the role private nuisance claims in civil courts can play in managing weed spread in NSW.

DEFINITION OF PRIVATE NUISANCE

Private nuisance is defined by Chief Justice Preston in *Robson v Leischke* at para 42 as “an excessive act or omission which is an unreasonable interference with, disturbance of, or annoyance to a person in the exercise or enjoyment of his or her ownership or occupation of land or some profit or right used in connection of the land.” Private nuisance attempts to balance the right of an occupier to use his or her land freely with that of his or her neighbour to enjoy the use of his or her land without interference.

Private nuisance and negligence are closely related yet distinct causes of action. Negligence involves a failure to take reasonable care which results in foreseeable albeit unintended injury or damage. In contrast, a person may still be liable in nuisance despite taking all reasonable care (see *Don Brass Foundry Pty Ltd v Stead* (1948) 48 SR (NSW) 482).

Types of nuisance

In *Robson v Leischke*, Chief Justice Preston held that nuisance involves fault of some kind and the type of fault varies depending on whether the defendant continued, adopted or created the nuisance.

Chief Justice Preston describes the three types of interference that are recognised as constituting a nuisance:

1. Causing encroachment on the neighbour's land,
2. Causing physical damage to the neighbour's land or any building, works or vegetation on it,
3. Unduly interfering with a neighbour in the comfortable and convenient enjoyment of his or her land.

The third type is relevant to the natural spread of weeds as they generally arise from something emanating from the defendants land (*Preston CJ Robson v Leischke*).

HISTORY OF THE APPLICATION OF NUISANCE TO WEED SPREAD

Prior to 1890, liability for weed control in New South Wales had been governed by the tort of nuisance at common law, under the maxim *sic utere tuo ut alienum non laedus*. This is taken to mean “you must use your own land in such a way as to not injure another” (Menz and Auld, 1977). This duty was balanced by the common law right of owners to do as they wish with their own property (Burns, 1974).

In 1890 an English case, *Giles v Walker* (the thistledown case), rejected this maxim in relation to the spread of weeds from one property to another. While the plaintiff was initially successful, the claim was dismissed on appeal. Lord Coleridge stated that “there can be no duty as between adjoining occupiers to cut thistles, which are the natural growth of the soil”. The court was drawing a distinction between harm to a neighbour caused by the normal germination, growth and subsequent spread by natural forces of an established species and harm caused by the spread of a species that has been deliberately planted (Goodhart, 1932).

This principle was subsequently applied in the courts of Commonwealth countries and the United States (Burns, 1974). It is thought to have originated in early days of settlement when most land was unsettled or uncultivated and the burden of inspecting the land and controlling any spreading weeds would have been both unduly onerous and out of proportion to any likely harm to neighbouring land (Prosser, 1971).

A subsequent Australian case, *Sparke v Osborne* (1908) 7 CLR 51 involved damages caused by the uncontrolled spread of prickly pear. The High Court upheld the defendants appeal, finding that, in an extension of *Giles v Walker*, “a person was liable for damage caused by weeds only if the weed growth was encouraged by the intervention of his human act. Normal farming operations did not constitute such intervention”, (Menz and Auld, 1977; Gardner, 1998, *French v Auckland City Corporation*).

These decisions found that the common law did not impose a duty on occupiers of weed infested land to prevent the weeds from spreading to adjoining properties, on the basis that weed spread is a natural occurrence rather than a deliberate human act. The courts were reluctant to impose such a duty on individual landholders for the community benefit, seeing it as a role for legislators. In the judgement of *Sparke v Osborne*, the Chief Justice stated that “in nearly all of the Australian States provision has been made by the legislature for cases of this kind requiring a person to take precautions to prevent the pest from spreading to his neighbours” (Goodhart, 1932).

Therefore, in the early part of the 20th century, as landholders affected by weeds spreading from neighbouring property had no remedy at common law, the control of weeds spreading from one property to another needed either to be regulated by statute or left to the market. In this legal climate, and two years prior to the final resolution of *Sparke v Osborne*, a noxious weed statute (Section 45) was introduced in NSW within the *Local Government Extension Act 1906*.

DEVELOPMENT OF THE COMMON LAW

In 1932 the common law of nuisance and the duty of occupiers to suppress a nuisance being caused by things occurring naturally on land under their control was reviewed by Goodhart (1932). With particular reference to *Proprietors of Margate Pier and Harbour v Town Council of Margate*, a case involving accumulation of rotting seaweed in Margate harbour, Goodhart (1932) concluded that “the correct principle seems to be that an occupier of land is liable for a nuisance of which he knows or ought to know, whether that nuisance is caused by himself, his predecessor in title, a third person or by nature”. This was a return to *Sic utere tuo ut alienum non laedus*, which had previously been rejected by the courts in relation to the spread of weeds through natural forces.

This opinion took some time to be accepted by the courts. Seven years after the review by Goodhart (1932), *Molloy v Drummond* found that an occupier allowing a tree to grow, from which falling gumnuts, leaves and twigs blew onto a neighbour's roof, making a noise and blocking the drain pipes, was not an excessive or unreasonable use of the land by the defendant. Two points were relevant to this case. The tree did not overhang the plaintiff's land and the tree was not planted by the defendant and there was no evidence as to whether it grew naturally or was planted.

However, over time the courts started to accept that occupiers did have a liability for things naturally on land. Three cases have particular relevance. *Sedleigh-Denfield v O'Callaghan* [1940] AC 880, *Goldman v Hargrave* [1967] 1 AC 645 and *French v Auckland City Corporation* [1974] 1 NZLR 340.

Sedleigh-Denfield v O'Callaghan involved a drain, built without authority of the owner of the land and not remediated by the owner when he became aware of it, that became blocked and overflowed in heavy rain causing damage to a neighbour's property. This case involved the “adoption” of a nuisance. It had long been established that an occupier may be liable for knowingly continuing a nuisance caused by a third party (see *Noble v Harrison*) (Goodhart, 1932). *Sedleigh-Denfield v O'Callaghan* established that an occupier may “adopt” a nuisance caused by a third party or by nature by making use of the thing that constitutes the nuisance.

In *Goldman v Hargrave* a landholder felled but failed to properly extinguish a tree on his property set alight by lightning. The tree subsequently reignited and started a fire that caused considerable damage to his neighbour's property. The landholder was found liable for damages for having failed to take reasonable measures within his capacity and resources to extinguish the fire.

In *Goldman v Hargrave* the Privy Council regarded three factors to be of critical significance in relation to the existence of a duty of care by the occupier (Burns, 1974):

1. knowledge of the hazard,
2. ability to foresee the consequences of not checking or removing it, and
3. the ability to abate the hazard,

However the Privy Council qualified the duty of an individual to the extent that “what it is reasonable to expect of him in the circumstances” in both a physical and financial sense (Burns, 1974, Gardner, 1998). A reciprocal duty was also imposed on neighbours to take similar reasonable steps to protect their own interests. This duty might include creation of a barrier or buffer zone or providing financial assistance to carry out works on the neighbours land (Gardner, 1998).

French v Auckland City Corporation was an action in nuisance about the spread of variegated thistle (*Silybum marianum*) from land owned by the City to land occupied by the plaintiff. At the time French had taken up occupancy of his land, both it and the neighbouring land were heavily infested with weeds of which the most serious was variegated thistle. French subsequently had made considerable efforts to control weeds including variegated thistles on his land but the City Corporation’s attempts at weed control were cursory. French was successful in his action, even though variegated thistle was widespread on his land and was not a noxious weed in the district. This case may be seen as a replay and ultimately a rejection of *Giles v Walker* (the thistledown case) (Burns, 1974).

This case also involved the continuation of a hazard, in this case by Auckland City Corporation, which had leased their land to two consecutive tenants but failed to require them to control variegated thistle, despite knowing that it was prolific on the land.

French v Auckland City Corporation placed limits on the liability of the occupier for the consequences of allowing weed spread. For a claimant to be successful, they must establish that the annoyance or damage suffered was substantial (Burns, 1974).

CONCLUSION

Actions in nuisance to seek damages for the spread of weeds of minor significance are likely to fail. Even in the case of more serious weeds, for a claim to be successful the required tests are reasonably onerous for a claimant to establish:

1. The defendants knowledge of the hazard,
2. The defendants ability to foresee the consequences of not checking or removing it, and
3. The defendants ability (both physically and financially) to abate the hazard,

Furthermore, a claim for damages can only be brought for harm that has already occurred, not for potential harm. An injunction may be sought to prevent potential damage to the neighbour’s property by the spread of weeds, but such an injunction might only be granted if there is proof that the potential damage is:

- i. imminent or likely to occur in the near future, and
- ii. is very substantial or almost irreparable (*Robson v Leischke*).

This would be very difficult to establish in relation to most weeds.

If enough private nuisance actions for weed spread are successful, the threat of costly litigation may be enough to encourage errant landholders to improve their weed

management practices. The tort of private nuisance may therefore prove to be an additional tool for landholders who are prepared to bring a civil claim.

However, civil claims such as actions in private nuisance cannot replace the important role played by statute in limiting weed spread and controlling new incursions to an area. Private legal action, because it is reactive by nature and is discrete rather than universal in immediate effect, is unlikely to prevent weed spread at an early stage of invasion. Early action against new incursions is the most cost effective approach to weed management (Hobbs and Humphries, 1995).

To rely on civil claims that may or may not be brought would lead to unsatisfactory outcomes for industry and the environment. Nuisance is of limited use in protecting the community's interest because it only protects an individual's interest in land. Therefore, the continued management of weeds by government regulation is necessary for the protection of the community, the environment and industry.

ACKNOWLEDGEMENT

The assistance of Ms Cathie Warburton, Principal Legal Officer (Legislation), NSW Department of Industry & Investment, in providing editorial and referee comment is greatly appreciated.

REFERENCES

- Burns, P. (1974). Liability for blowing thistle down and seed: a thorny problem resolved. *The Modern Law Review*, **37**: 702-5
- Gardner, A. (1998). The duty of care for sustainable land management. *The Australasian Journal of Natural Resources Law and Policy*, **5(1)**: 29-63.
- Goodhart, A.L. (1932). Liability for things naturally on the land. *4 Cambridge Law Journal* 13.
- Hobbs, R.J. and Humphries, S.E. (1995). An integrated approach to the ecology and management of plant invasions. *Conservation Biology*, **9(4)**: 761-70.
- Jones, R.E. (2000). The economics of weed control. In *Australian Weed Management Systems*, ed. B.M. Sindel, pp 267-83. R.G. and F.J. Richardson, Melbourne.
- Menz, K.M. and Auld, B.A. (1977). Galvanised burr, control and public policy towards weeds. *Search*, **8**: 281-7.
- Pannell, D.J. (1994). Economic justifications for government involvement in weed management: a catalogue of market failures. *Plant Protection Quarterly*, **9(4)**: 131-7.
- Prosser, W.L. (1971). *The Law of Torts*, 4th Edition. West Publishing Company, St Paul Minnesota USA.

CASES

- Don Brass Foundry Pty Ltd v Stead* (1948) 48 SR (NSW) 482
- French v Auckland City Corporation* [1974] 1 NZLR 340
- Giles v Walker* (1890) 24 QBD 656
- Goldman v Hargrave* [1967] 1 AC 645
- Molloy v Drummond* [1939] NZLR 439

Noble v Harrison [1926] 2 KB 332, 338

Proprietors of Margate Pier and Harbour v Town Council of Margate (1869) 20 L.T. (N.S.) 564

Robson v Leischke [2008] NSWLEC 152

Sedleigh-Denfield v O'Callaghan [1940] AC 880

Sparke v Osborne (1908) 7 CLR 51

ALLIGATOR WEED – JUST ADD WATER

The history of alligator weed in the Riverina region

Melissa Kahler
NSW Aquatic Weed Project Officer
NSW Department of Primary Industries, Grafton

Abstract

Alligator weed has persisted in the Riverina for nearly 40 years. This plant has continually eluded weed managers and cost millions of dollars in control. There are two isolated locations where alligator weed occurs. North of Albury near the small town of Woomargama and further west near the city of Griffith. Both these infestations have unique histories and have developed very different growth characteristics suited to the prevailing climate conditions in these areas. This paper discusses the history of these infestations, the management implications involved and the assets at risk of invasion of alligator weed.

Introduction

The south western area of NSW is often renowned for its high level of agricultural productivity and diversity of inland ecosystems. This region stretches from the South Western Slopes bioregion which is classified as a sub-humid climate, to the Riverina bioregion further west, that experiences a hot semi-arid climate (DECCW 2011). The mean annual rainfall varies from 360mm-1260mm in the South Western Slopes to 240mm – 620mm in the Riverina (DECCW 2011). The mean annual temperature is higher in the Riverina bioregion compared to the South Western Slopes; and the soil is dominated by heavy red, brown or grey clays as opposed to more alluvial sands and loam soils in the South Western Slopes bioregion (DECCW 2011).

Alligator weed is a declared noxious weed across Australia. Within this region it is declared a Class 2 noxious weed under the *NSW Noxious Weeds Act 1993*. This means it is regionally prohibited and must be eradicated from the land and the land kept free from the plant. Alligator weed is a perennial stoloniferous plant that can grow on both land and in water, this adaptation makes the appearance and management of the species very difficult. Plants growing in water have brighter foliage, with hollow upright or sprawling stems that float as a mat over the water. Terrestrial plants have a more prostrate growth habit with the stems spreading along the ground and rooting at each node, they are more fibrous and roots are deeper and more extensive. The leaf shape and size between the two growth forms can also vary due to the different moisture and soil conditions, terrestrial leaves are shorter and rounder whereas aquatic leaves are longer and more spear shaped.

There are two known infestations of alligator weed within the region (Figure 1). The longest known infestation occurs on a private property approximately 40km north east of Albury, near the village of Woomargama. It is believed to have been introduced to a dam either as or contained within an ornamental pond plant in the 1960's. This dam is located in the upper reach of Mountain Creek which flows approximately 50km before joining the Billabong Creek. The Billabong flows several hundred kilometres west to the town of Moulamein where it joins the Edward River which then flows into the River Murray in the town of Kenley on the Victorian border.

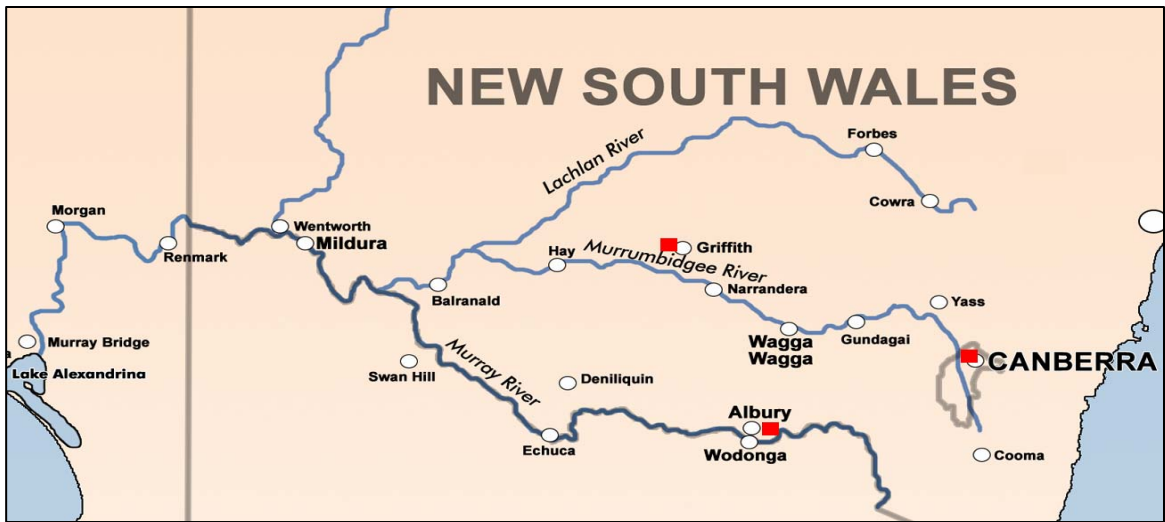


Figure1: Alligator weed locations in Southern NSW

The second infestation of alligator weed occurs 270km northwest of Woomargama near the town of Griffith. This infestation is much larger and management is more complex. In 1993 the weed was found growing in Barren Box Swamp (BBS) (Figure 2), the main water supply outlet for the Murrumbidgee Irrigation Area (MIA). It is believed to have been introduced into Willow Dam by equipment from duck shooters. Willow Dam is at the mouth of Mirrool Creek which is the main water supply into the Swamp. At the time of detection the infestation covered a vast majority of the Swamp, which has an area of 3,200 hectares, and the surrounding irrigation channels (MIA 2011). After initial herbicide treatment and manual removal efforts the plant fragmented and spread further down the drainage/supply network of the Wah Wah Irrigation District which provides water for rice and other irrigated crops. Once alligator weed established in these channels, it spread via fragments onto farmland, through flood irrigation practices.



Figure2: Barren Box Swamp, Murrumbidgee Irrigation Area (MIA), Griffith

Discussion

The Asset at Risk:

The Riverina region supports some of the Nations most iconic environmental habitats and fertile productive landscapes. Agriculture in the Riverina is signified by an unmatched diversity that is based upon dryland farming and the Murrumbidgee and Coleambally Irrigation Areas (I&I NSW 2011). Alongside crops such as rice, maize and canola, the region boasts:

- over 25 per cent of NSW fruit and vegetable production
- 90 per cent of NSW citrus products
- 80 per cent of NSW wine/grape production
- livestock feedlots, sales and processing facilities
- almond and walnut production
- and nearly 20 per cent of all NSW crop production and two thirds of its total economic value.

In a normal drought free year, total agricultural and horticultural production in the Riverina is worth more than \$1 billion (I&I NSW 2011).

Both the infestation at Woomargama and Barren Box Swamp threaten these agricultural industries. The Wah Wah Irrigation District near Griffith, which has been infested with alligator weed since 1993, lies within the Murrumbidgee Irrigation Area. Rice is one of the dominant crops produced in this area, of which in 2005/06 the Central Murray Rice Industry generated a local production value of \$137 million accounting for approximately 50% of Australia's rice production (Hyder Consulting 2010). The rice industry is most at risk of alligator weed invasion as it is a flood irrigated crop requiring large quantities of water; which provides a highly suitable habitat for alligator weed to invade.

The Riverina region also supports several unique ecosystems that are rich in biodiversity. The Murray Cod, Macquarie Perch and many waterbird species such as the migratory Australasian Bittern, are at risk of habitat loss due to the invasion of alligator weed (DECCW 2011). The regions key wetlands include the Lowerbidgee Floodplain, which contains 217,000ha of ecologically significant wetland habitat (WetlandCare 2008), and the Ramsar listed Fivebough and Tuckerbill Swamp (F&TWT 2011). The agricultural, economic and environmental assets at risk of invasion from alligator weed are clearly evident. If it were to escape these isolated infestations and spread into both the artificial and natural waterway systems across the Riverina the impact would be devastating.

The Problem: Woomargama

The Woomargama infestation is located on private land in a large dam which flows into Mountain creek. By the time it was detected, in the early 1970's alligator weed entirely covered the 1,700m² dam and occurred in scattered infestations up to 3km downstream of the dam overflow. Throughout the 1970's and 1980's the Water Resources Commission and the property manager carried out the control program, which consisted of herbicide treatment and mechanical removal. They breached a hole in the dam wall and drained it into the creek. Once dry, the plant material was bulldozed into a large hole on the southern end of the dam and covered with 1.5m of clay soil. The dam wall was repaired and soon after alligator weed was found on the west side of the bank. Reports at the time by the NSW Agriculture Officer, Mr Hugh Milvain, state that by 1980 there were estimates of over 1,000 plants persisting on the dry land surrounding the dam and if totalled together the infestation would cover half a hectare. Also that there were 10 individual infestation found within the 3km stretch downstream, each being on average less than 1m².

Throughout 1982 to 1992 the Water Resources Commission treated all known sites and reported to have reduced the infestation by 99% to a level of spot spray and hand removal of individual plants. In Mountain creek, all plants found were manually removed to avoid chemical contamination of the creek water leaving six remaining sites that required ongoing control. In 1992 a change of staff and agency controlling the infestation occurred, with now the Local Control Authority, Holbrook Shire Council, being responsible for inspecting and ensuring sufficient management. Moreover the property manager changed which resulted in many files being lost and required new staff to learn about the responsibility of managing the alligator weed.

Between 1992 and 2004 the site was inspected annually and all known sites were treated with glyphosate or metsulfuron-methyl. Around 1995 drainage lines were dug on the south side of the dam to drain the area and enable grazing to occur. Soon after these earthworks alligator weed started to appear growing on the mounds of overturned soil. It was then realised that this was the deposition area of the plant material that had been mechanically removed in the 1970's. It is likely that alligator weed had always been persisting in this area but not dense or tall enough for detection. The creation of furrows to drain the area and the turning over of old soil enabled alligator weed fragments to reshoot and invade the newly dried land.

In 2006 new infestations were found downstream from the dams outflow point. At this time there were three known areas infested with alligator weed, the dam site was approximately 0.5ha; and two creek sites an upstream site which was 0.5ha and a downstream site 0.02ha in size. A working group, which was supported by the National Aquatic Weeds Management Group, was established to coordinate the management of the site which after four months of liaising selected mechanical removal and deep burial as the initial control action. Support and funding was received from the Murray Catchment Management Authority and the NSW Department of Primary Industries noxious weeds grant to undertake this initial control work. The upstream site was mechanically excavated whereby all soil and plant material were removed and buried 500m up the hill away from the creek. The hole was lined with industrial plastic and buried to a depth of three metres with soil used to cover the hole. This location was GPS marked and a stake put in place to mark its location and to ensure it's never disturbed. The creek at the downstream site branched into many small arms, some were dry and only flowed during high rainfall. The alligator weed was growing in one of the arms that carried water and therefore the idea to divert the main creek upstream of where it branched was suggested. This would enable the site to dry out, be treated with alternative herbicides and be easier to manually remove. In late 2006 a new trench was dug to divert the creek which allowed the site to dry and be treated with ongoing herbicide application. Inspections at this time were conducted up to eight kilometres downstream to the bridge on Fairburn Road with no alligator weed detected.

Since 2006 to the present, the alligator weed density has slowly been reducing. This is aided by the severe drought period, during this time, which limited water availability and prevented large scale growth, and also due to the success of the mechanical removal in the upstream site and the creek diversion downstream in 2006. The dam site continued to maintain infestations that were sprayed and removed where possible. In early 2010 the drought broke and serious flooding occurred at the site through to 2011. The number of alligator weed sites increased due to the flood causing fragmentation of plants and those fragments starting new infestations. This increase in sites sparked the re-establishment of a working group to ensure swift action was taken in containing these sites and preventing spread further downstream.

The type of control varied amongst sites; however a combination of hand removal and herbicide treatment with metsulfuron-methyl is proving to be effective. The control methods applied are those recommended in the National Alligator Weed Control Manual (Van Oosterhout 2007). The difference with the current management plan in comparison to previous years is the frequency and detail at which inspections are being undertaken. Over the summer of 2010-11, inspections have been conducted by five people every 5-6 weeks over a six month period. Significant contributions from Murray CMA, NSW DPI and Greater Hume Shire Council have resulted in greater detection rates, improved mapping of individual plant locations, on the spot control by hand removal or spraying and an increase in understanding of alligator weed growth and persistence. In this short period of time, the first inspections in November and December 2010 resulted in approximately 30 garbage bags of material being hand removed from the creek, this included a new large site with floating stems stretching 3m over the water; the recent inspection in April resulted in 10 garbage bags removed from the same stretch of creek. The most recent inspections have managed to cover approximately two kilometres downstream from the last known site and no alligator weed has been detected.

The management plan for the coming five years is shifting from ongoing suppression to possible eradication. The last six months have proved that serious reductions in alligator weed can be achieved if inspections are conducted with more than two people every six weeks in a diligent manner, and if control is undertaken instantly when a plant is detected, preferably via hand removal and for larger sites sprayed then hand removed 1-2 weeks later. This action has resulted in all plant material in the flowing part of the creek being eliminated, significantly reducing the risk of fragments being spread. The remaining sites are all located on dry land outside the flowing water and can be intensely treated with herbicide and eventually hand removed once smaller regrowth occurs. It is envisaged that the sites in the flowing water, that have been hand removed, will regrow, however with frequent inspections removal will be much easier as the plants will be detected early and less time will be required to remove smaller plants. The key to the success of this project is frequent detailed inspections resulting in instant manual removal of any plants found over the next five years. The group now has an established baseline with known GPS locations, improved knowledge on removal techniques and clear direction in the season's actions, this puts it in good stead to measure change over the next few years.

The Problem: Barren Box Swamp

The alligator weed infestation near Griffith first occurred in Barren Box Swamp in the early 1990's. Murrumbidgee Irrigation is the organisation responsible for managing the alligator weed within BBS and the surrounding channels. Barren Box Swamp is the main water storage facility that distributes water into the Wah Wah irrigation district for crop production. It is a 6km wide basin totalling 3,200 hectares that was once an ephemeral wetland supporting a Black Box vegetation community (MFN 2008). In December 1993 and January 1994, a plant mass growing in supply channels was causing problems for irrigators in the Wah Wah Irrigation District. By February, very little water flow was being received at the end of the system. After investigation, the plant was identified as alligator weed, which sparked frenzy amongst landholders, industry groups & government staff about how to promptly manage this new aquatic weed threat.

Initial infestations were found to be occurring in the Wah Wah Main Channel, the Barren Box Outfall and the Corgenia Channel. These infestations were between 2 – 10m² in size, and were reducing flow by at least 50%. By mid March 1994 it was becoming clear that approximately 40 km of channels, 4 km of the Mirrool Creek floodway west of Barren Box Swamp and a substantial area of the swamp's perimeter were affected by alligator weed, including the Mirrool Creek bywash downstream of Willow Dam.

Also by March 1994 two terrestrial infestations had been reported on private property in the irrigation district. One occurred on a property adjoining the swamp where alligator weed contaminated soil from the swamp had been used to fill 500 metres of channel. The other infestation occurred in a rice crop at a point where water first entered the crop, and covered an area of 10m². Throughout that year several more infestation were found growing in rice crops.

A control strategy was developed in association with CSIRO, the Department of Water Resources and NSW Agriculture in February 1994, and ongoing control and management of alligator weed within the MIA has been in place since then. The initial control strategy aimed to treat all known infestations as quickly as possible and contain the spread of the infestation as much as possible. This was carried out primarily with herbicide treatments, some physical removal, ongoing surveillance and follow up treatment of regrowth over two growth seasons in 1994 and 1995.

Initial spraying started at the end of February 1994, focussing on the infestations in the channels downstream of the swamp, and then in the swamp itself. Truck mounted sprayers with bucket arms were used to allow spray operators to be positioned out over the weed mats in the channels and to spray toward the banks. Glyphosate based herbicides were used on all the aquatic areas. Metsulfuron methyl was used to target terrestrial plants on the banks and dry channels, and dichlobenil herbicides were used on a limited basis in areas that had plants growing in shallow ponds. An air boat and a helicopter were brought in to allow the entire body of water to be treated. Spraying recommenced in December 1994, and a total of five treatments were carried out with the last in June 1995. Two seasons of spray treatments had reduced the density of alligator weed in the system, but further infestations in the Mirrool Creek Floodway had been difficult to treat due to stock grazing. This area had to have stock excluded before effective treatment could commence. Most of the irrigators placed screens in front of their water wheels to catch fragments of alligator weed that may have not been caught in the channel screens. An excavator was brought in to remove dying plant mass from the channels where herbicide treatments had been carried out. A boat with a two-man crew was deployed to patrol the channels and remove any plant fragments from the channels, and this continued until July 1994.

In the following years between 1995 and 2000 Murrumbidgee Irrigation coordinated the control program for the BBS and channels, whilst Carrathool Shire & Griffith City Council coordinated the inspection program on Council and private land. By July 2000 approximately 600 alligator weed plants averaging 30cm in diameter were treated in Barren Box Swamp; 70 plants treated in the channel system; and 45 plants in the floodway. It was clear that significant efforts were still needed to contain the infestations.

Severe drought over the past decade coupled with reduced irrigation water allocations has assisted in the fight against alligator weed, but it has also given a false sense of security to managers that the alligator weed would not have survived the dry spell. Recent field observations indicate fragments will persist in semi-arid climates with minimal to no moisture. The weed inspector's have found plants growing next to saltbush with root systems travelling up to two metres deep and stems sprawling 4 metres wide, all adaptations of a highly invasive aquatic weed in a dry climate. A number of on-ground projects were completed during this phase including: forming new internal channels around existing infestations; fencing infestations from stock and planting native vegetation; water flow inlets on properties were re-arranged to avoid infestations; and drainage systems were reconfigured to avoid spreading the weed within and between properties. Much of this work was funded by the Federal Defeating the Weed Menace grant system. Observations have proved that alligator weed will grow all year round in this semi-arid

climate, with above ground foliage dying off during heavy frosts or intense periods of heat, but the root system will always remain viable and reshoot when conditions prevail.

In the last four years significant success has been achieved in manually removing known infestations, as opposed to applying ongoing herbicide. The managers in this area have pioneered the technique of manual removal for the state, with deep roots and heavy clay soils making removal difficult, vigilance and patience is slowly paying off for the managers, with less re-growth occurring each year. To date approximately 50 active sites persist on private land and in the associated channel system, which includes seven new plants being recorded this season. Within Barren Box Swamp and the channels managed by MIA approximately 30 active sites persist, with two large infestations being found this season in the bywash & outfall channel as a result of the recent rainfall. The last line of defence is a box culvert established at Cameron's Lane designed to prevent vegetation flowing under the road and through the culvert. It is approximately 27km from Cameron's Lane to the Mid Western Highway and to date no alligator weed has been recorded in this section of the Floodway. It is imperative to maintain this culvert and undertake frequent inspections to prevent the spread of fragments further west where the floodway eventually joins the Lachlan River approximately 120km downstream. With a bumper season over the summer of 2010-11 and full scale cropping back in business, the future challenge will be locating and suppressing new sites that have been dormant for the past ten dry years.

The Investment:

Significant investment has been allocated to both alligator weed sites in the Riverina with the main aim to protect the asset at risk. In the Woomargama site approximately \$110,000 from 1971 to 2011 has been invested, this figure is excluding in-kind contributions. In the Barren Box Swamp infestation in excess of \$2,200,000 has been allocated between 1993 and 2011 to combat the alligator weed threat. The basis of this funding has come from the Federal defeating the weed menace program, state Noxious Weed grants and Catchment Management Authority projects. In-kind contributions have come from the Local Control Authorities, including Carrathool Shire, Griffith City, Hay Shire, Greater Hume Shire Council's, Murrumbidgee Irrigation and private landholders. These in-kind contributions have been excessive over the history of these two infestations.

Conclusion

The management implications that have occurred at these two sites are similar. Both have proved very difficult to contain with spread still occurring, even if at a very slow pace; high turnover in managers resulting in loss of knowledge and momentum, allowing the weed to persist; and difficult detection conditions with thousands of hectares at Griffith and thick tall vegetation at Woomargama to inspect, it can be compared with trying to find a needle in a haystack. Significant resource investment over a lengthy timeframe is also apparent at both sites, justifying that alligator weed never has a quick fix option.

Recommendations for future weed managers who either find a new alligator weed site or manage a small isolated site are similar to those suggested in the Alligator Weed Control Manual

- Detecting and controlling sites early will increase the chances of eradication
- Inspections of known sites need to be highly vigilant and frequent (no more than 8 weeks apart)
- Control needs to be instant to prevent growth and spread, and needs to incorporate manual removal if eradication is to be achieved. Sites are rarely eradicated when only using herbicide.
- Weed managers need to be committed

Significant challenges remain in regards to eradicating these two infestations. The challenge of finding the last plant fragment is highly difficult; often in large infestations the best result is to contain the site at very low densities for the short to medium term. There are 2 phases of management feasible for the Riverina that would span over a 10 year period, in the first 5 years infestations need to be suppressed to low densities, which is partly completed to date. Advances in best practice management such as new herbicide compounds or application techniques would greatly assist this eradication effort and enable complete control of all sites in the proceeding 5 years of the plan.

ACKNOWLEDGMENTS

- Neil Hibberson, Senior Weeds officer, Greater Hume Shire Council
- Paula Bosse, Riverina Noxious Weeds Project Officer, ERNWAG & WRNWAG
- Birgitte Verbeek, Team Leader Weeds Extension, NSW Department of Primary Industries
- Anthony Berry, Alligator Weed Project Officer/Noxious Weeds Inspector, Griffith City Council
- Jeffrey Shaw, Team Leader Weeds & Drains, Murrumbidgee Irrigation Ltd
- Andrew Petroschevsky, National Aquatic Weeds Coordinator, NSW Department of Primary Industries
- Barren Box Swamp Alligator Weed Taskforce meeting minutes and reports from its members since establishment
- Woomargama Alligator Weed working group members and reports from previous managers

REFERENCES AND FURTHER INFORMATION

DECCW 2011, Department of Environment, Climate Change & Water, *Bioregions of NSW*, last updated 27th February 2011, accessed 1st April 2011 from <http://www.environment.nsw.gov.au/bioregions/Riverina-Climate.htm>

F&TWT, Fivebough & Tuckerbill Wetlands Trust 2011, *Ramsar Wetlands*, accessed 20th May 2011 from <http://fivebough.org.au/ramsar-wetlands/>

Hyder Consulting Pty Ltd 2010, *Central Murray Rice Industry Case Study*, published 11th October 2010, accessed 12th April 2011 from <http://www.berriganshire.nsw.gov.au/Portals/0/documents/central%20murray%20%20synthesis%20report%20part%20%2022%20Dec.pdf>

I&I NSW 2011, Department of Industry & Investment NSW, *NSW Regions: Riverina*, last updated 9th March 2011, accessed 12th April 2011 from <http://www.business.nsw.gov.au/invest-in-nsw/regional-nsw/nsw-regions/riverina>

MFN, Murrumbidgee Field Naturalists 2008, *Barren Box Swamp*, accessed 20th May 2011 from <http://www.mfn.org.au/barrenBox.html>

MIA 2011, Murrumbidgee Irrigation Authority, *Barren Box Swamp Wetlands*, accessed 6th April 2011, from <http://www.mirrigation.com.au/BBS/Overview.htm#Snapshot>

Van Oosterhout, E 2007, *Alligator Weed Control Manual: eradication and suppression of alligator weed (*Althernanthera phiolxeroides*) in Australia*, NSW Department of Primary Industries, Orange.

WetlandCare Australia (2008), *Wetlands & water birds of the Lowbidgee Floodplain*, accessed 20th May 2011 from http://www.wetlandcare.com.au/Content/templates/research_detail.asp?articleid=87&zoneid=23

CONFERENCE PAPER

PEAK HILL PROJECT

Author: Matthew Bailey

Position: Noxious Weeds and Pest Species Officer

Organisation: Parkes Shire Council

Address: PO Box 337, Parkes NSW 2870

Author: Colleen Farrow

Position: Catchment Officer

Organisation: Central West Catchment Management Authority

Address: PO Box 174, Mudgee NSW 2850

PROJECT SUMMARY

This project aims to prevent noxious weeds from spreading onto adjoining properties and to reduce weed seeds from regenerating. In addition the project will improve the scenic views for Peak Hill residents and visitors which will benefit the whole community in the long term.

This project is successfully utilising proven control methods and integrating local knowledge to carry out long-term management of Weeds of National Significance (WoNS) on Aboriginal land at Peak Hill. Bridal Creeper, Blackberry and other invasive species are the target of this project and through funding supplied by the Central West Catchment Management Authority (CWCMA) and in-kind contributions from Parkes Shire Council (PSC) and the Peak Hill Local Aboriginal Lands Council (PHLALC) the culturally significant area is undergoing a regenerative process, both for its owners and the existing vegetation.

The three organisations are already noticing significant benefits from this ongoing partnership and are confident that the positive changes will be far-reaching - both locally and regionally.

OBJECTIVES

* To reduce weed seeds from regenerating and inhibit the spread of targeted weed species (Blackberry, Bridal Creeper) and secondary weed species (African Boxthorn, Green Cestrum, Prickly Pear, Wheel Cactus, Devils Rope Pear, Mother of Millions) in order to provide long-term vegetative protection and erosion control at the site.

* To reduce the spread of invasive species into important nearby waterways (Bogan River) and adjoining properties.

* To employ best management practices, while maintaining ground cover and reducing the competition for the native vegetation.

* To assist the community to reduce the habitat for feral animals and fruit fly whilst improving natural habitat for endemic faunal species.

* To carry out a project on public land that everyone can access

* To successfully work together to build long-term relationships that will encourage a sense of ownership and pride amongst the Aboriginal and non-Aboriginal people of Peak Hill.

* To provide employment to a member of the Peak Hill Local Aboriginal Lands Council, who works alongside experienced staff from Parkes Shire Council to gain knowledge in the control and management of invasive weeds.

* To improve an amenity for Peak Hill residents and visitors this will benefit the whole community in the long term.

* To map and record the presence of noxious weeds on this reserve so that the success of the control program can be monitored utilising GPS technology.

* To carry out monitoring over the life of the management program in order to gauge the ongoing success of the methods utilised.

RATIONALE

The site is locally and regionally significant due to the existing native vegetation and importance to the local Aboriginal people. This area is identified as containing a high floral diversity with a mixture of native grass, shrubs and trees. White Box (*Eucalyptus albens*) is present at the site. This species forms an Endangered Ecological Community and its presence is of regional importance. Parkes Shire Council places a high priority on the protection of remnant vegetation and this project aims to preserve this woodland in the best condition possible.

The site is considered of great cultural importance to the local Aboriginal people and it is used as a meeting place and camping spot.

While the development of this project focused on the significance of these two important issues, its additional strength is the fact that it has brought together three organisations that are working together to achieve the objectives. Parkes Shire Council built upon existing relationships to approach the Central West Catchment Management Authority and the Peak Hill Local Aboriginal Lands Council to develop the project. Funding was allocated through the Central West CMA Weeds of National Significance project and objectives were prioritised, based on the weeds present, resources available and existing knowledge.

IMPLEMENTATION

Target Audience

- Peak Hill residents
- Members of the Peak Hill Local Aboriginal Lands Council
- General public

Who's Involved?

- Parkes Shire Council staff
- PHLALC (including 1 paid member)
- CWCMA staff

Stage 1

- WONS project budget is \$15,570. This includes purchasing herbicides, labour and vehicle running costs for Parkes SC as well as the employment of a Local Aboriginal person from Peak Hill. Approximately 40,000 litres was used for stage 1 on initial control works

Stage 2

- A further \$7000 was obtained to complete the project in 2011. This consists of re-employing the Local Aboriginal person, and Parkes Shire Council contribution towards travel time, water for project, planning time and consultation time.

ACHIEVEMENTS

The project has enabled existing partnerships to be strengthened. The Parkes Shire Council has built upon relationships with the Central West CMA to develop strong work ethics which will result in future joint projects. The Central West CMA saw the value in continuing to work with the Parkes Shire Council and are very keen to explore future projects.

An unexpected outcome of this project is that it has enabled Parkes Shire Council to employ a member of the Peak Hill LALC. This is an opportunity for staff to share their knowledge, as well as gain an understanding and importance of the Peak Hill area in return. This results in an expansion of weed control knowledge in this community, and the possibility of future employment opportunities.

The objectives are constantly being evaluated using regular contact between the three organisations, and the use of project management tools to carry out ongoing assessment of the objectives. As an ongoing project that requires continual checking and spot spraying, the project is tracking to target.

As of 23 August 2010 Parkes Shire Council has put out a total of approximately 36,000 litres on the WoNS project to control the primary and secondary weeds. This work has been carried out using the Shire's Quick Spray units (1 twin and a single) and employed the services of a local Aboriginal person from Peak Hill for a total of approximately 6

days.

Integrated Weed Control Techniques used are foliar spraying with selective and non-selective herbicides; Cut Stump Method in a small section or in sensitive areas but found to be too slow; Basal Bark using a 15 litre back pack on the Prickly Pear species such as Wheel Cactus and Devils rope pear using a Garlon and diesel mixture.

It has taken approximately 8 days to put out the 36,000 litres and averaged approximately 4,500 litres per day.

The hours worked on the project so far is 140 hours which is broken down with PSC staff contributing 110 hours and the Aboriginal employee with 30 hours.

CHALLENGES

Monitoring will continue regularly with photos taken before, after and during to show progress. The site has been mapped by Parkes SC using the in-house designed PestMapper program. The project was delayed one month due to the erratic seasonal conditions.

A monitoring point has been set up and will be used as part of the monitoring process and this involves using the "step by step" method and data at each step is recorded over 100 steps. On the 10 June 2010 it was determined that 12% of the area was Bridal Creeper with Oxalis (15%) and Poa species (8%) and Curly Windmill Grass (6%) the main vegetation. The main trees and shrubs are made up of *Eucalyptus* spp. (21%) and Peppercorn trees (12%). The ground cover is rated at 29% vegetation and 9% bare and is considered to be an excellent reserve for remnant vegetation.

This WoNS project will be successful in the long term if we continue to follow up on the work already completed. This includes continuing to employ local people and protecting this high conservation area.

This whole project does not just concentrate on just one weed species (like most projects) in particular but priority was given to the WoNS weeds such as Bridal Creeper. Secondary weeds such as African Boxthorn, Prickly Pear species and Mother of Millions were also managed. This project has brought the stakeholders of Central West Catchment Management Authority, Parkes Shire Council and Peak Hill Local Aboriginal Lands Council together as a working partnership whilst employing outside staff.

By continuing this project the following goals will be achieved:

1. Reducing the impact of Weeds of National Significance - in this case Bridal Creeper and Blackberry.
2. Catchment Management Plan (CAP) Management Targets will be targeted including:
 - MTV3 (restore and enhance the area of high conservation value vegetation)
 - MTV6 (reduce area in the Catchment affected by environmental weeds)

- MTV7 (all public land be managed according to integrated management plans that optimise nature conservation and, where appropriate production)
- MTVPC3 (increase knowledge and understanding of the wider community of aboriginal culture and cultural projects)
- MTCH1 (protection of culturally significant aspects of the landscape, both aboriginal and non-aboriginal)

3. Strengthen containment lines and bring core infestations under management control, reducing the risk of new infestations.

4. After the first and second stage of work is completed the Peak Hill Lands Council could use it as part of Caring for the Country program.

5. It will achieve Goal 3 (reduce the impacts of widespread invasive species) in the NSW Invasive Species Plan 2009-2015.

6. Will achieve outcomes of the Macquarie Valley Regional Weeds Strategy including:

- Goal 3.1.1 (Partner CMA'S to achieve common goals)
- 3.1.2 (partner with neighbouring RWAC'S)
- 3.2.1 (collate baseline data for current distribution and abundance of weeds)
- 3.2.2 (collect weed data and publish maps)
- 3.3.4 (Maintain open communication between public and weed managers)
- 3.5.4 (success stories publicised)
- 4.2.4 (local field days held).

PROMOTION

This project has been promoted at the Annual Peak Hill Show on the 25 August 2010 through Parkes Shire Councils noxious weeds display. This particular project has been mentioned numerous times through Parkes Shire Council's reports which are open to the general public. It also featured in the Central West Catchment Management Authority Spring/Summer Newsletter issue 10 (page 3) and has been available through the website. Peak Hill Local Aboriginal Lands Council has been informed of the progress of the project;

An article also appeared in the Western Magazine on the 6 December 2010..

A sign has been erected in front of the reserve, which informs residents about the project and to show who the main stakeholders are along with who carried out the work.

On the 3 February 2011 the stakeholders Catchment Management Authority (2 people), Parkes Shire Council (2 people) and the Aboriginal employee got together to look over the progress of the project and discussed any issues or problems.

From this meeting various media releases are planned and will feature in the local papers of The Champion Post, The Peak Hill Times, and The Central Western Magazine and will appear in the next Central West Catchment Management Authority Newsletter along with an article on Parkes Shire Council's Web Site.

This project won an award at the 2010 Local Government and Shire Association of NSW for Excellence in the Environment Awards under the Weed Management Award Category for the Weeds of National Significance project at Peak Hill. This award recognises outstanding achievements by local government in managing and protecting the environment.

KURNELL 2020 PROJECT

The restoration of the vegetative corridors of the Kurnell Peninsula.

**Paul Price
Pest Species Officer
Sutherland Shire Council**

Introduction

Kurnell 2020 is a landscape scale project which aims to build biodiversity corridors and resilient ecosystems across the Kurnell Peninsula. It will buffer and enhance Sydney's only internationally recognised Ramsar Wetland at Towra Point and conserve eight endangered ecological communities, 315 fauna species and 24 different vegetation communities.

The Kurnell 2020 Project is based around developing partnerships and collaboration with public and private landholders including the La Perouse Aboriginal Land Council. The initiative aims to work with these landholders to control pests and protect local plant species.

Kurnell 2020 was funded in the 2008-09 with an investment of \$266,000 through the Australian Government's Natural Heritage Trust. In 2009 further funding of \$227,000 through the Australian Govt Community Coastcare program. Funding has also been confirmed for 2010 – 2012.

Background

The Kurnell Peninsula located south of Sydney, historically has been a significant part of Australia's European history being herald as the birth place of modern Australia with the landing of Captain James Cook in 1770.

Since the European settlement of Sydney, the Kurnell Peninsula has been subjected to grazing, land clearing, sand mining, introduction of both residential and industrial land uses and the proliferation of noxious/environmental weeds and vertebrate pests.

To combat the constant threats to vegetative corridors and the Kurnell Peninsula's biodiversity both public and private land holders had undertaken both weed and vertebrate pest control measures to evade the potential destruction of the natural assets of the area. Such efforts have had varying success due to limited funding and sporadic private land holder participation.

The Kurnell 2020 project aimed to combat these land tenure and financial barriers through a strategic and collaborative approach to restoration of the vegetative corridors of Kurnell Peninsula.

Vision goals and objectives of the project

The vision of the Kurnell 2020 project is that by 2020 the condition of the natural areas on the Kurnell Peninsula will be improved.

To achieve such a large task the following goals were set in conjunction with the Sydney Metropolitan Catchment Management Authority (SMCMA) and the founding members of a proposed project steering committee.

These were as follows:

- Establish location of biodiversity corridors
- Improvement of degraded areas via funded contracts SMCMA, SSC and KBBNP.
- Collaborative approach to land management on public lands
- Participation of private commercial landholders
- Involvement of Aboriginal community
- Participation of local and broader community

To complete the process and to provide scope to successfully tackle the large task at hand, a strategy was established with tasks assigned to the major land holders/participants within the steering committee.

These were as follows:

- Set up Steering Committee to meet quarterly (SMCMA)
- Manage contracts for weed control, vertebrate pest management and revegetation with Sutherland Shire Council (SSC) and Kamay Botany Bay NP (KBBNP)
- Establish a Seed and Plant database (SSC)
- Formulate an Integrated Pest Species Management Strategy (SSC contractor)
- Deliver community education forum, workshops, walks (SMCMA, SSC and DECCW)
- Graph and map progress

GOALS AND SUCCESSFUL OUTCOMES

Vegetative Corridors established

Created as a part of a Fauna Survey by K. Brendon (DECCW 2009), priority corridors were mapped with scope for the potential flora and fauna movements through the Kurnell Peninsula. Refer Fig 1.

Such efforts provided a basis for all potential on ground works within the Kurnell Peninsula 2020 program. The corridors were selected and highlighted for their 'core habitat' potential and in relation to the ever changing land uses of the area.

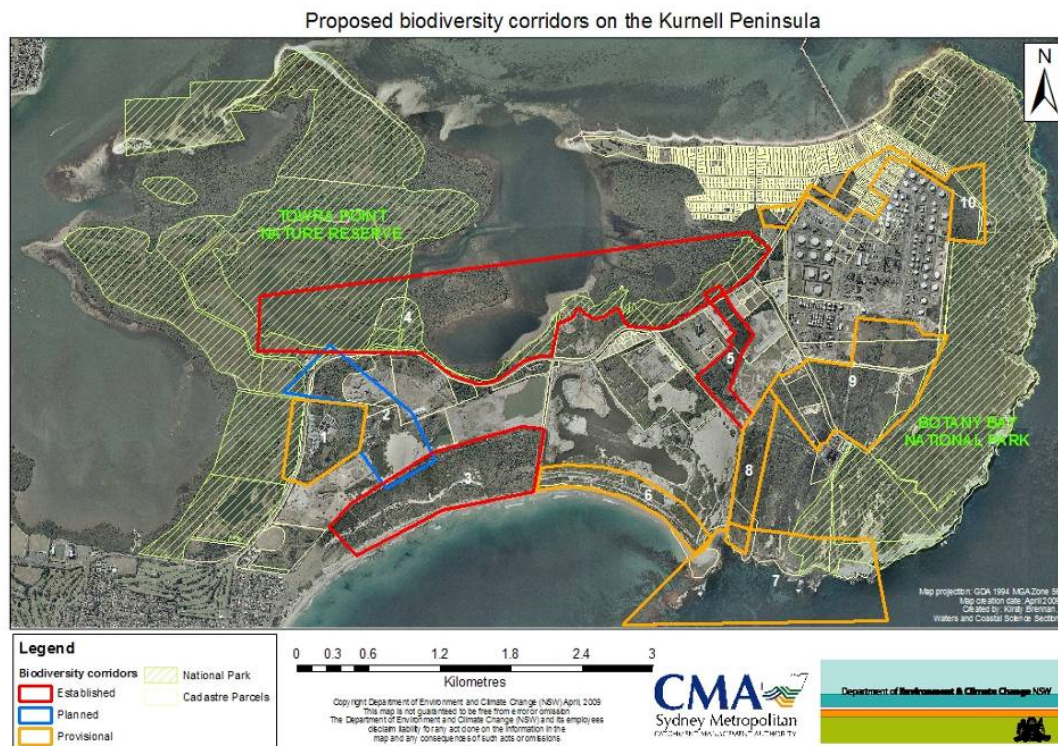


Figure 1: Proposed Biodiversity Corridors on the Kurnell Peninsula

Integrated Pest Species Management Strategy

To document the issues of the Kurnell Peninsula and strategically mentor the project at hand, an Integrated Pest management Strategy was prepared by UBM Ecological Consultants (2010).

The strategy aimed to gather all the existing literature regarding the management of the Kurnell Peninsula whilst incorporating the ever changing landscape and land tenure of the area.

The result was a document for which highlighted the going pressures to biodiversity of the Kurnell Peninsula whilst providing scope for future management and application for further grant assisted funding.

A Seed and Plant database

The longer term needs of restoring biodiversity corridors will place pressure on limited resources. A seed bank database was developed of existing seed and plant stores to manage ongoing plant production and protect the existing plant resources under Flora Bank Guidelines.

The audit provided an inventory of available seed; plant propagation resources and nursery facilities identified future needs and capabilities to supply the necessary plants for revegetation projects. To maintain the upkeep of the audit, a census of all seed and available stock is to occur every 6-8mths and displayed on Sutherland Shire Councils Website.

An integrated approach to pest management

To combat the ongoing pressures of both weed and vertebrate pests on the Kurnell Peninsula and integrated approach to pest management was initiated. The works thus far has been highly successful.

Exotic weeds species targeted during the project include but not limited too, Weeds of national Significance, Noxious Weed Species and secondary environmental weed species.

To date, covering all land tenures, approx 250ha of land has been treated for exotic plant species on the Kurnell Peninsula. This was achieved through a combination of manual and chemical methods i.e. backpack and high volume spraying. Refer Fig 2



Figure 2: Examples of successful weed removal, before and after results.

To compliment the restoration activities on the Kurnell Peninsula, University of Wollongong used a study site at Wanda Beach as a part of its 60 sites study for the development of The Restoration Guidelines for Foredune Scrub Research.

The management of vertebrate pests was coordinated around the protection of Towra Point Nature Reserve and its affiliation with the current DECCW Red Fox Threat Abatement Plan. Towra Point Nature Reserve is an internationally recognized RAMSAR wetland due to its roosting and breeding areas for migratory bird species such as the Little Turn.

The main target species during the project were Red Fox, European Rabbits and Cane Toads. The results of the program are as per table 1.

Pest	Total animals destroyed
Rabbit 2008-present	217
Fox 2008- present	322
Cane Toads 2010-present	523

Table1: Results of Vertebrate pest program to date.

Aboriginal involvement

As a part of the Kurnell Peninsula 2020 project there was further training of a group commonly known as the 'Towra Team'. This component of the project enabled a small dedicated group of young men from the La Perouse to obtain training in land management practices, fauna surveying and native plant propagation. Through the project the team has obtained their Certificate 3 in Conservation and Land Management through assessment by Ryde TAFE.

To compliment these activities, the SMCMA has funded cultural experience events at Kamay Botany Bay and at Community Land at La Perouse.

Community participation

To enlighten the broader community, The Kurnell Biodiversity Forum was held to inform landowners and the community as to the ecological values of the Kurnell Peninsula and the need for a collaborative approach to protect the asset. To support such an event the SMCMA published 'Kurnell a guide to the plants, animals, ecology and landforms on the Peninsula'.

Supporting activities to involve the general public included Native Plant Identification workshops, guided walks, bus tours and community and corporate planting days.



Figure 3: Native Plant Identification workshop



Figure 4: Guided walks

The next step

Currently, the Kurnell Peninsula 2020 project is its third year of success. It is hoped through additional funding and support of the SMCMA that the project will continue until its 2020 deadline.

ACKNOWLEDGMENTS

Nerida Gill: Sydney Metro Catchment Management Authority
Judy Christie: Sydney Metro Catchment Management Authority
Christine Guthrie: Bushland and Nursery Coordinator
Stewart Harris: Pest Species Officer

REFERENCES AND FURTHER INFORMATION

[Kurnell 2020 project news:](#)



Managing widespread weeds for biodiversity conservation using an asset-based site-led approach

Leonie K. Whiffen¹, Peter J. Turner¹, and Stephen B. Johnson²

¹Project Officer, Pest Management Unit, National Parks & Wildlife Service, Office of Environment & Heritage (OEH), PO Box 1967, Hurstville, NSW 1481, Australia

²Weed Ecologist, Invasive Species Unit, NSW Department of Primary Industries (DPI), Locked Bag 21, Orange, NSW 2800, Australia

Corresponding author: Leonie.Whiffen@environment.nsw.gov.au or Pete.Turner@environment.nsw.gov.au

Web: www.environment.nsw.gov.au/cmaweeds/index.htm

ABSTRACT

Weeds pose the second greatest threat to biodiversity after land clearing and associated habitat loss in New South Wales (NSW). Many weeds that threaten biodiversity are widespread and usually beyond the scope of prevention and eradication programs developed to deal with new and emerging weed threats. To reduce the impact of widespread weeds on biodiversity (biological assets), control programs need to be prioritised to areas where control is both achievable and likely to have the greatest benefit to native biodiversity, independent of land tenure. Such a site-led approach will ensure maximum benefit from the resources available for the management of widespread weeds. In a joint venture between OEH, DPI and the 13 CMAs, a threat abatement approach was used to identify and prioritise widespread weeds impacting on biological assets and sites for weed control within each CMA region. Following 39 workshops held across NSW, information from 2,631 sites have been collected. Results from these regional assessments are available to individual CMAs and other stakeholders and include regional priority lists of widespread weeds, biodiversity threatened by these weeds and a ranked list of sites for control. Additional tools are also available, including a site ranking spreadsheet so additional sites can be ranked and a standardised monitoring manual to assist in measuring the response of weeds and biological assets following management. This asset-based triage approach will address widespread weeds, including those listed in Key Threatening Processes under the NSW *Threatened Species Conservation Act 1995*. As such it will help address Goal 3 of the NSW Invasive Species Plan which is to reduce the impacts of widespread invasive species. It is therefore distinct from, but complementary to, weed-led approaches that address Goal 1 – prevent the establishment of new invasive species and Goal 2 – eliminate or prevent the spread of new invasive species.

INTRODUCTION

In New South Wales (NSW), weeds pose the second greatest threat to biodiversity after land clearing and habitat loss (Coutts-Smith and Downey 2006). Many weeds that threaten biodiversity are widespread and usually beyond the scope of eradication and containment programs developed to deal with new and emerging weed threats.

To reduce the impact of widespread weeds on biodiversity (biological assets), control programs need to be prioritised to areas where control is both achievable and likely to have the greatest benefit to native biodiversity, independent of land tenure (Downey et al. 2010b). Such a site-led approach will ensure maximum benefit from the limited resources available for management of widespread weeds (Williams et al. 2009). The then NSW Department of Environment and Conservation, (DEC – now known as the Office of

Environment and Heritage) developed a process for identifying and prioritising biological assets and sites at risk from widespread weeds during the development of the threat abatement plan (TAP) for *Chrysanthemoides monilifera* (L.) Norl. (bitou bush and boneseed) in NSW (DEC 2006). This TAP approach was subsequently applied to *Lantana camara* L. (lantana) nationally (NLMG 2010). The TAP approach ensures weed management reduces the impacts of individual weed species on biological assets. These strategies aim to: (i) abate, ameliorate or eliminate the adverse effects of the weed on threatened species, populations or ecological communities; and (ii) prevent species, populations or ecological communities that are not listed from becoming eligible for listing as threatened.

There are over 1600 naturalised alien plant species (or weeds) in NSW. More than 340 of these weeds are thought to be impacting on biodiversity (Downey et al. 2010a), and many are listed as key threatening processes (KTPs) under the NSW *Threatened Species Conservation Act 1995* (TSC Act). It is not feasible (or an optimal investment) to apply the TAP approach to every individual weed species impacting biodiversity, as many have overlapping distributions, impacts and management requirements. An approach that applies the TAP process to multiple weed species on a landscape scale is needed. Catchment Management Authorities (CMAs) facilitate the management of natural resources across their regions using a catchment-based approach across all land tenure and play a crucial role providing links between government agencies, councils, other land managers and the community. The CMAs also play an important role in facilitating on-ground weed control as they are ‘the primary means for the delivery of funding from the NSW and Commonwealth governments to help land managers improve and restore the natural resources of the State’ (CMA NSW 2005). As such, it is appropriate to develop site-led weed management priorities for biodiversity conservation on a regional or catchment-based scale in NSW.

In a joint project between DPI, OEH, and the 13 CMAs, the TAP approach was adapted to identify and prioritise widespread weeds impacting on biological assets and sites for weed control within each CMA region in NSW. Because most weeds listed as KTPs in NSW are widespread and thus unlikely to be eradicated, the focus of any threat abatement strategy must be on reducing the impacts on biological assets, rather than actions solely associated with eradication, prevention, reducing spread, or improving control techniques. This report focuses on widespread weeds and their impacts on biodiversity and as such will help address Goal 3 of the NSW Invasive Species Plan, which is to reduce the impacts of widespread invasive species. While this approach complements other goals in the plan, including Goal 1 – prevent the establishment of new invasive species and Goal 2 – eliminate or prevent the spread of new invasive species, it differs in that it is a site-led approach as distinct from weed-led approaches needed to address Goals 1 and 2.

This paper outlines the site-led approach taken to produce widespread weed threat abatement strategies for each of the 13 CMA regions. The approach uses four steps:

1. Identify the major widespread weed threats.
2. Identify the biological assets (native species and ecological communities) at risk from the weeds identified in step 1.
3. Identify and prioritise sites for weed control based on the likelihood of achieving a positive biodiversity response.
4. Monitor and report on the effectiveness of weed management programs at high priority sites, specifically the response of biological assets to control.

METHODS

Many CMAs and/or regional weed committees have developed regional weed strategies. Most have used a prioritisation process based on Randall's system (Randall 2000). Here, weeds are placed in categories with an emphasis on (i) potential weed threats, (ii) new weeds, (iii) emerging weed problems and (iv) widespread weeds, in that order. Some widespread weeds are not included in these assessments because they were already widespread throughout Australia. The Randall process gives priority to weed species listed under the NSW *Noxious Weeds Act 1993*, specifically those listed in control classes 2 and 3 and those easily eradicated, over widespread species (Williams et al. 2009). As this project focuses on widespread weeds that are impacting on biodiversity, it is complementary to these existing strategies. In addition, any lists of widespread weeds developed under these existing regional strategies were used as a starting point for our project.

In the majority of CMA regions, the stages to identify widespread weeds and biodiversity at risk were applied through literature reviews, a series of targeted workshops and feedback from a wide range of stakeholders. In addition, stakeholders provided site information where the weeds posed a threat to these assets. Each site was then assessed based on standard criteria to ensure that management of widespread weeds was prioritised to areas where control is both achievable and likely to have the greatest benefit to native biodiversity (see DPI and OEH 2011). Widespread weeds are defined as exotic species that have established well in the landscape and are close to reaching their maximum potential distribution in a region or sub-region. Given the large variation in environmental conditions at the CMA regional scale it is likely that very few weeds will be widespread across the entire area under consideration. For this reason, a consideration of the preferred habitat conditions of each weed was necessary. For example, weeds of riparian areas may only grow in riparian environments. If a particular riparian weed is widespread within these environments then it is considered widespread across the region (see DPI and OEH 2011 for full description of methods used and www.environment.nsw.gov.au/cmaweeds/index.htm for individual CMA regions).

Thirty nine workshops were held across NSW between 2007 and 2009. Workshop attendees included representatives of major stakeholders and land managers in the region including local government, state agencies, weeds committees, conservation and community groups as well as consultants, individuals and experts with local knowledge of weed impacts, threatened biodiversity and sites under threat from widespread weeds. Such workshops to determine weed threats to biodiversity have been effective in collating a large amount of information in a short period of time (see Downey 2006, Turner and Downey 2010). Using the interim lists created above, workshop participants and other stakeholders were asked to nominate sites (across all tenures) for assessment based on level of impact of weed/s, feasibility of control and biodiversity condition at each site. A standardised site nomination form was developed to ensure that the same assessment details were collected for every site nominated. A set of instructions was also provided to help stakeholders complete the site nomination form.

Draft reports were provided to each CMA and other major stakeholders for comment and review in July 2009. The draft reports contained information on the first 2 steps, as well as the list of site nominations received. Summary information from site nominations was provided in the draft reports to highlight any important assets or tenures that may have

been missed in the initial site nomination process. As the framework is applicable to all widespread weeds impacting on biodiversity, sites in NSW that were previously included in the Bitou TAP (DEC 2006) and national lantana plan (NLMG 2010) were incorporated into this project. Further site nominations were then sought and any nominations received from 2009 to August 2010 were included and ranked. Sites were ranked into six control categories (see DPI and OEH 2011). Site rankings were based on where investment in weed control will result in the greatest reduction in the impact of widespread weed species on biodiversity; primarily, but not exclusively, on threatened assets (plant and animal species, populations and ecological communities listed under the TSC Act and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* - EPBC Act). All sites in highest category (control category 1) were further ranked based on the total number of biological entities (BEs) at risk from weeds, in which the total BEs = number of threatened fauna species + number of threatened flora species + number of endangered ecological communities + number of wetlands of national importance + number of RAMSAR wetlands. Threatened here relates to assets listed under the TSC Act and/or the EPBC Act.

RESULTS

Fourteen documents reporting on this project have been prepared. The first is an overarching document that outlines the statewide framework used to develop the regional priorities for management of widespread weeds for biodiversity conservation in each of the 13 CMA regions (DPI and OEH 2011). The remaining 13 parts (Parts A–M; one for each CMA region), document the specific assessment outcomes for each individual region using the approach outlined in the statewide framework (DPI and OEH 2011). They include the major widespread weed threats for that region and list the identified biological assets (native species and ecological communities) at risk from these weeds (see individual Parts A to M – DPI and OEH 2011). The most frequently cited widespread weeds that impact biodiversity (based on the number of CMA regions) are listed in Table 1.

To date information on 2,631 sites across NSW has been collected. The distribution of sites across the six categories is presented in Table 2. The collation and prioritisation of sites is an ongoing, dynamic process and is still continuing in all CMA regions. Therefore, the lists of priority sites for control are held electronically so they can be updated as new site information becomes available. The lists can also be used by stakeholders to identify additional regional priorities for weed control that are not already captured.

Table 1. The most frequently cited widespread weeds that impact biodiversity in NSW.

Scientific name	Common name	No. of CMA ^s	KTP ¹	WoNS ²
<i>Lycium ferocissimum</i>	African boxthorn	11	Y*	#
<i>Rubus fruticosus</i> agg.	blackberry	11	Y*	Y
<i>Salix</i> spp.	willows	11	Y*	Y
<i>Ligustrum lucidum</i>	large-leaf privet	10	Y*	
<i>Ligustrum sinense</i>	small-leaf privet	10	Y*	
<i>Eragrostis curvula</i>	African lovegrass	9	Y	
<i>Hypericum perforatum</i>	St John's wort	9	Y*	
<i>Asparagus asparagoides</i>	bridal creeper, florist's smilax	8	Y	Y
<i>Phyla canescens</i>	lippia	8	Y*	
<i>Xanthium occidentale</i>	Noogoora burr, cockle burr	8		
<i>Ailanthus altissima</i>	tree of heaven	7	Y*	
<i>Bryophyllum delagoense</i>	mother of millions	7		

Scientific name	Common name	No. of CMAs	KTP ¹	WoNS ²
<i>Cestrum parqui</i>	green cestrum	7	Y*	
<i>Hyparrhenia hirta</i>	Coolatai grass	7	Y	

¹KTP= Weed listed under a Key Threatening Process in the TSC Act; ²WoNS = Weeds of National Significance; Y = yes, where the species is listed under a KTP or as a WoNS, * = Proposed only (Preliminary Determination under the TSC Act). All listings as at 31 August 2010. # = Potential new WoNS.

Table 2. The number of sites in each of the six categories across all of NSW.

	Categories						Not valid [^]	Total
	1*	2	3	4	5	6		
Number of sites	852	358	365	476	249	71	260	2631

*Category 1 represents the highest priority for action – see Appendix 4 of the *statewide framework* (DPI and OEH 2011) for further information.

[^] insufficient information was provided to reliably allocate these sites to a category.

SUMMARY

The resultant lists of priority sites provide investment guidance for each CMA region with respect to widespread weeds and biodiversity conservation. A range of implementation options are provided to help guide investment. Whilst these priorities were developed based on CMA regions, implementation of the approach outlined here is dependent on managers of all land tenures and they may also inform decisions at smaller (local) and larger (state) scales.

Priority should also be given to increasing community involvement (to encourage additional site nominations and at the implementation stage) by developing partnerships between stakeholders. Site-specific management plans should be developed for high priority sites as they will detail the important role community groups, volunteers and Indigenous Peoples play at specific sites (see Appendix 5 of the *statewide framework* – DPI and OEH 2011). The development of site-specific management plans will also reduce the risk of off-target damage caused by weed management, ensure control is consistent with the statewide strategy (e.g. weeds are controlled to protect assets), as well as account for differences at individual sites by considering other threatened species found at sites.

To address the monitoring requirements of this project, and to ensure that the data collected is consistent and comparable across programs, the Monitoring manual for bitou bush control and native plant recovery (Hughes et al. 2009) is recommended. The manual outlines a three-tiered approach to monitoring with techniques ranging from simple qualitative assessments to robust research studies, allowing managers to adopt the level most suitable to their objectives and desired outcomes, skills and resources. The manual has been tested and is applicable for use on most other weeds, except for aquatics and some exotic vines.

In July 2009, the draft ‘Biodiversity priorities for widespread weeds’ report and the individual CMA reports were released to CMAs for comment. The draft documents have been revised based on the written submissions received. In November 2009, this approach was endorsed by the NSW Natural Resource and Environment CEO Cluster Group as an effective way to address the threat from widespread weeds in NSW. The priorities established need to be embedded into the various planning mechanisms for the control of invasive species for biodiversity conservation, including the Priorities Action Statement (TSC Act), Catchment Action Plans (NSW *Catchment Management Authorities Act 2003*)

and NPWS Regional Pest Management Strategies. Given the number of significant weed species impacting on biodiversity in the state, it is critical that all land managers work together to reduce this threat.

ACKNOWLEDGMENTS

Funding for this project was provided by the Australian Government, Central West CMA, Hawkesbury-Nepean CMA, DPI and OEH. The 14 documents for this project were prepared by Leonie K. Whiffen, Moira C. Williams, Natalie Izquierdo, Paul O. Downey, Peter J. Turner (OEH), and Bruce A. Auld and Stephen B. Johnson (DPI). Thanks also to Claire O'Brien, Hillary Cherry, Alison Foster, Mark Hamilton, Alana Burley, Marion Winkler, Andrew Leys (OEH) and Sean Brindle and Scott Charlton (DPI). The selection of priority weed species and sites was based on a series of regional workshops held in CMA regions as well as consultation with a wide range of land managers. The input from these participants was critical to the development of the strategy and their inputs are acknowledged.

REFERENCES AND FURTHER INFORMATION

CMA NSW 2005. Catchment Management Authorities: an overview. Catchment Management Authorities, NSW. www.cma.nsw.gov.au, accessed 31/5/2007.

Coutts-Smith, AJ and Downey, PO 2006. Impact of weeds on threatened biodiversity in NSW. Technical Series 11. Cooperative Research Centre for Australian Weed Management, Adelaide.

DEC 2006. NSW Threat Abatement Plan: invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush and boneseed). Department of Environment and Conservation (NSW), Hurstville: see www.environment.nsw.gov.au/bitoutap/.

Downey, PO 2006. The weed impact to native species (WINS) assessment tool: results from a trial for bridal creeper (*Asparagus asparagoides* (L.) Druce) and ground asparagus (*Asparagus aethiopicus* L.) in southern New South Wales. *Plant Protection Quarterly* 21:109–116.

Downey, PO, Scanlon, TJ and Hosking, JR 2010a. Prioritising alien plant species based on their ability to impact on biodiversity: a case study from New South Wales. *Plant Protection Quarterly* 25:111–126.

Downey, PO, Williams, MC, Whiffen, LK, Auld, BA, Hamilton, MA, Burley, AL and Turner, PJ 2010b. Managing alien plants for biodiversity outcomes: the need for triage. *Invasive Plant Science and Management* 3:1–11.

DPI and OEH 2011. Biodiversity priorities for widespread weeds. Report prepared for the 13 Catchment Management Authorities (CMAs) by Department of Primary Industries and Office of Environment & Heritage, Orange.

Hughes, NK, Burley, AL, King, SA and Downey, PO 2009. Monitoring manual for bitou bush control and native plant recovery. Department of Environment and Climate Change, Sydney, NSW: see www.environment.nsw.gov.au/bitouTAP/monitoring.htm.

National Lantana Management Group (NLMG) 2010. Plan to protect environmental assets from lantana. Biosecurity Queensland, Department of Employment, Economic Development and Innovation, Yeerongpilly, Queensland.

Randall, R 2000. 'Which are my worst weeds?' A simple ranking system for prioritising weeds. *Plant Protection Quarterly* 15:109–115.

Turner, PJ and Downey, PO 2010. Ensuring invasive alien plant management delivers biodiversity conservation: insights from an assessment of *Lantana camara* in Australia. *Plant Protection Quarterly* 25:102–110.

Williams, MC, Auld, BA, Whiffen, LK and Downey, PO 2009. Elephants in the room: widespread weeds and biodiversity. *Plant Protection Quarterly* 24:120–122.

Progress on reducing the threat of widespread weeds to biodiversity: five years of implementing threat abatement planning

Mark A. Hamilton¹, Deb Holloman², Geoffrey James³, Stephen Booth⁴, Tegan Burton⁵
Jeffrey Thomas⁶ and Hillary Cherry¹

¹Pest Management Unit, NSW Office of Environment and Heritage (OEH), PO Box 1967,
Hurstville, NSW 1481, Australia

² NSW National Parks and Wildlife Service (NPWS), PO Box 1477, Gosford NSW 2250

³ NSW NPWS, Locked Mail Bag 99, Nelson Bay DC NSW 2315

⁴ NSW NPWS, PO Box 127, Byron Bay NSW 2481

⁵ NSW NPWS, PO Box 3056, Asquith NSW 2077

⁶ NSW NPWS, PO Box 361, Grafton NSW 2460

Corresponding author: Mark.Hamilton@environment.nsw.gov.au

In 2006, the NSW Bitou Bush Threat Abatement Plan (TAP) outlined an approach for the protection of environmental assets from bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*). This approach was then applied to develop the National Plan to Protect Environmental Assets from Lantana (*Lantana camara*). The implementation of these plans is a combined effort involving many stakeholders including the OEH (including NPWS), Catchment Management Authorities (CMAs), other government agencies, local councils, Aboriginal communities and other community groups, and contractors. Two core objectives of these plans are to: (i) undertake control where benefits to biodiversity are greatest, including control alleviating immediate impacts to priority biodiversity, and containing the northern and southern spread; and (ii) evaluate the effectiveness of control programs in protecting biodiversity. This paper presents an update on the statewide bitou bush mapping (with emphasis on the progress of containing bitou bush), and results from biological monitoring undertaken at high priority sites. Monitoring was undertaken using aspects of the 'Monitoring manual for bitou bush control and native plant recovery'. This manual allows assessment of: (i) the response of environmental assets to control, (ii) the response of all weed species following control, and (iii) the costs incurred. Biological monitoring results to date indicate that the strategic TAP approach is effective in environmental asset-protection. For example, at Wamberal Lagoon Nature Reserve bitou bush density was reduced from >75% to <5% and the cover and abundance of native plants increased. At Cape Byron State Conservation Area (SCA), bitou bush cover decreased from >80% to being absent and native species richness increased. At Maroota Ridge SCA, lantana cover decreased from >50% to <5% and native species richness increased by 28%. Results from national bitou bush mapping shows a significant reduction in density in northern and southern containment zones, particularly in the higher density categories.

INTRODUCTION

Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata* (DC.) Norl.) and lantana (*Lantana camara* L.) are invasive shrubs that occur across wide expanses of eastern Australia. Bitou bush was inadvertently introduced to Australia, then deliberately planted on the New South Wales (NSW) coast from 1946 to 1968, to stabilise coastal sand drifts and revegetate dunes following mining. Lantana was probably introduced to Australia as a garden plant prior to 1841. They are Weeds of National Significance (WoNS) (Thorpe and Lynch 2000) and recognised as two of the top 20 worst weeds in Australia. Furthermore, in NSW, lantana and bitou bush were ranked as the first and second most damaging weeds to biodiversity (Coutts-Smith and Downey 2006). As both weeds are widespread and unlikely

to be eradicated, control efforts are best targeted to containing spread and protecting important environmental assets, as per the NSW Invasive Species Plan (DPI 2008).

Strategic threat abatement planning

In 1999, the invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush and boneseed) was recognised as a Key Threatening Process (KTP) under the NSW *Threatened Species Conservation Act 1995* (TSC Act). In response to this listing, a Threat Abatement Plan (TAP) was developed for bitou bush in 2006 (DEC 2006). During the TAP development, the then NSW Department of Environment and Conservation, (DEC – now known as the Office of Environment and Heritage (OEH)) developed a process for identifying and prioritising environmental assets and sites for control (DEC 2006, Burley *et al.* 2008). The TAP identified a range of native plant species, populations and ecological communities at risk from bitou bush (DEC 2006, Hamilton *et al.* 2008); and 349 sites were prioritised for control based on the environmental assets at risk and the likelihood of effective control. Following a similar KTP listing for lantana, the TAP approach was applied to lantana nationally and the National Plan to Protect Environmental Assets from Lantana (Lantana Plan) was completed in 2010 (NLMG 2010).

The implementation of these plans is a combined effort involving many stakeholders, including the OEH (including the NPWS), the five coastal CMAs, the Crown Lands Division of the NSW Department of Primary Industries (former Land and Property Management Authority), local councils, community groups, Aboriginal communities and contractors, and other bush regeneration contractors (Strehling *et al.* 2008). Implementation across all land tenures has allowed management to occur in a coordinated and strategic manner for biodiversity conservation. Implementation of the Bitou TAP began in 2006 and occurs across 114 sites. Implementation of the Lantana Plan began in 2008, and there are now 20 sites in NSW where the plan is being implemented. The control of bitou bush and lantana occurs at all sites following the completion of five-year, site-specific management plans that tailor weed control to protecting environmental assets (priority native species and ecological communities) at the site.

The Bitou TAP and Lantana Plan place high importance on monitoring the effect of control on the target weed species and the response of the environmental assets to control. Monitoring the response of environmental assets to weed control can be hampered by lack of time, resources, and expertise (King and Downey 2008). To address monitoring requirements under the TAP, the ‘Monitoring Manual for Bitou Bush Control and Native Plant Recovery’ (Hughes *et al.* 2009) was developed. The manual is composed of three tiers to accommodate the varying skill levels, resources and monitoring requirements of land managers and community groups (Downey and Hughes 2010). Each tier sets out a series of techniques and standardised datasheets to ensure data is collected in a consistent manner. The Manual is designed to be used on all widespread weed except aquatic weeds, and has been successfully used for monitoring at Lantana Plan sites (see below).

While the primary aim of the Bitou TAP and Lantana Plan is to alleviate the immediate impact to environmental assets within the core weed distribution, they recognise containing the spread of these widespread weeds is vital. Therefore, both plans include strategic objectives to limit weed spread. Thus the core objectives of the Bitou TAP and Lantana Plan are to: undertake control in areas of greatest benefit to biodiversity (including in the core distribution and to contain the spread); and evaluate the effectiveness of this control with respect to the response of environmental assets. This paper will: i) report on the

success of bitou bush containment efforts through evaluation of 2008 bitou bush mapping; and ii) present case studies detailing results of monitoring programs at four high priority sites.

NATIONAL BITOU BUSH CONTAINMENT EFFORTS

Three previous surveys have delimited the distribution of bitou bush in Australia, the most recent in 2001 (Thomas 2002). As part of the bitou bush WoNS program, a fourth survey of the national distribution and density of bitou bush was undertaken in 2008. Here we present a selection of results to highlight the success of national bitou bush containment efforts since 2001.

The northern and southern bitou bush containment lines were established to prevent northern and southern spread respectively. The northern national containment line was established along the Tweed River on the NSW/Queensland border in the late 1980s (Bushland Restoration Services 2009). Since that time it has progressed south to the boundary of Tweed and Byron Local Government Areas (LGA), a distance of 35 km. The southern national containment line was established in 2002 at Tuross Heads, NSW (Southern Tablelands and South Coast Noxious Plants Committee 2007). The line has progressed north 105 km since 2002 and currently stands just south of Sussex Inlet, in the Shoalhaven LGA. To analyse progress related to the northern and southern containment efforts, this study identified a: northern containment zone, which includes all coastal areas in NSW north of Byron LGA; and a southern containment zone, which includes all coastal areas in NSW south of Sussex Inlet. This study compared the area and density of bitou bush in 2008 to 2001 in the northern and southern containment zones.

Mapping data was provided by a range of land managers and community groups in a standard format (McNaught *et al.* 2006). Data was then collated using GIS software and compared with the 2001 survey. In the northern containment zone, the total area of bitou bush declined by almost 6%, with the most marked reductions in the heavy (94%) and medium (89%) density categories. The high density category represented bitou bush canopy cover >40% and the medium category was canopy cover between 10-40%. Similarly, the area of bitou bush in the southern containment zone decreased by approximately 34%, again with the most marked reductions in the heavy (88%) and medium (97%) density categories. These dramatic reductions in the highest density infestations illustrate the sustained efforts in the northern and southern containment zones to control and reduce the impact of bitou bush. These strategic control programs must continue in order to ensure ongoing reduction in the distribution and density of bitou bush.

MONITORING CASE STUDIES

Cape Byron Headland, Cape Byron State Conservation Area (SCA)

This reserve is in the northern rivers region of north east NSW, east of Byron Bay. Prior to it being reserved as a SCA, bitou bush was widely planted in the area in the 1950s, following mining for mineral extraction. It became widespread throughout the 10 ha site and led to impacts on a suite of threatened plant species and ecological communities, including Littoral Rainforest, an Endangered Ecological Community (EEC). The site is ranked second highest priority in the Bitou TAP and is managed by Cape Byron Trust, a collaborative partnership of the local Arakwal Aboriginal people, NPWS, and the local community. Bitou bush control at the site consisted of an initial aerial spray in 2008 with metsulfuron methyl and a follow up aerial spray in 2009, which was preceded and followed by spot spraying using a knapsack sprayer, to maintain the treated area.

An annual monitoring program was put in place, consisting of five randomly located line-intercept transects (20 m in length) to measure cover of bitou bush and other shrubs, and 15 1 x 1 m quadrats (placed along the transects) to measure sub-canopy species. This level of monitoring is outlined in the advanced tear of the Monitoring Manual (Hughes *et al.* 2009). Monitoring results revealed that bitou bush cover decreased from >80% in 2008 to being totally absent (along the transects) in 2010, and the average number of native species (species richness) within quadrats increased from an average of 4 to 8.7 per m², including a new record of *Lepturus repens* (G.Forst.) R.Br., a tropical and sub-tropical native species that is uncommon in NSW and a high priority species in the TAP.

Glenrock SCA

Glenrock SCA is a coastal reserve situated south of Newcastle on the central coast of NSW. Bitou bush infestations at the 3 ha site were threatening the high priority EECs, Littoral Rainforest and Themeda Grassland on Seacliffs and Coastal Headlands, and *Diuris praecox* D.L.Jones, a vulnerable orchid, as well as numerous other rare or regionally significant species. Control began at the site in 2007, and consisted of hand pull, cut and paint, splatter gun, and ground and aerial spray techniques.

Two 20-metre line-intercept transects were established in, or partly within, the Littoral Rainforest EEC at the site. All native and exotic plant species, and their intercept lengths, were recorded along the transects. Results are presented from two sampling periods in 2007 and 2009. Bitou bush cover decreased from an average of 69.9% in 2007 to 6.1% in 2009, with other weeds increasing from 0% to 2.8% cover. Average native species cover (including the Littoral Rainforest species, *Acmena smithii* (Poir.) Merr. & L.M.Perry, *Cissus antarctica* Vent., *Cupaniopsis anacardioides* (A.Rich.) Radlk. and *Notelaea longifolia* Vent.) increased from an average 24.4% in 2007 to 42.9% in 2009.

Wamberal Lagoon Nature Reserve

This 5 ha site is situated on the central coast of NSW, east of Gosford. Bitou bush invaded the fore- and hind-dunes, in the habitat of three threatened species and Littoral Rainforest EEC. In 2007, bush regenerators cut tracks through the bitou bush and sprayed it with splatter guns using small volumes of high concentration glyphosate, with NPWS Staff spraying along the fore-dune. Bitou bush was also controlled with cut and paint and hand removal techniques. Secondary and maintenance control has occurred since the initial control efforts.

Results from two of the total seven nested quadrats that experienced similar control history (as described above) and monitoring frequency are presented here. Quadrats covered an area of 1024 m² and were sampled three times between 2007 and 2010. Bitou bush cover was reduced from >75% to <5% cover, while average native species richness increased only slightly from 16 to 16.5, and average cover abundance remained the same at <5%. Exotic species richness remained constant with an average of 5.5, as did exotic cover abundance at less than 5%. The site will require ongoing maintenance and restoration until the native canopy and ground cover have fully re-established.

Maroota Ridge SCA

Maroota Ridge SCA is a high priority site in the Lantana Plan. The site is on the outskirts of north west Sydney and has two threatened species populations under threat from lantana infestations, *Olearia cordata* Lander and *Zieria involucreta* R.Br. ex Benth..

Implementation of the Lantana Plan has occurred since 2008 with the assistance of bush regeneration contractors and a local four wheel drive club, which the local NPWS staff collaborate with. The control plan takes a zoned approach, with ground spraying and hand removal techniques focusing first on sweeps through wide areas of scattered occurrences, then progressively working towards the highest density infestations.

The Monitoring Manual (Hughes *et al.* 2009) was trialled at this site to determine its appropriateness for use on lantana. Monitoring consisted of four 20 x 10 m (200 m²) quadrats, two with high density lantana in the habitat of the threatened species, and two being reference plots with the threatened species present and low density lantana (which was subsequently removed). Sampling occurred in 2008, prior to control, and again in 2010. After two years of control, lantana cover in the two high density lantana plots decreased from 50-75% cover to <5%; native species richness increased by 28%; and average exotic species richness increased from 5.5 to 8. In the low density-lantana reference plots, counts of *O. cordata* revealed an almost doubling of individuals present, while *Z. involucrata* numbers increased slightly by 4%. Threatened species remained absent from the high-density lantana treatment plots in 2010.

CONCLUSION

The case studies above represent the culmination of five years collaborative implementation of the Bitou TAP and three years of the Lantana Plan. They illustrate that strategic plans implemented across tenure and in collaboration with stakeholders can produce positive biodiversity outcomes. Bitou bush mapping has shown that national containment efforts are successful in restricting the spread and contracting the core bitou bush distribution, preventing reinvasion into treated and invasion into uninvaded areas.

The interim case study results presented here suggest that the TAP approach is successful in focusing weed control on protecting native biodiversity. Results illustrate that biodiversity outcomes are achievable where sound planning is enacted and where sites are prioritised for weed control to achieve the greatest conservation outcome. The Bitou TAP is currently being reviewed in accordance with the TSC Act. As part of the review, a full examination of the monitoring data showing the responses of the environmental assets at risk will be conducted. These data will also form part of the Monitoring Evaluation and Reporting requirements under Goal 3 of the NSW Invasive Species Plan (DPI 2008), which is to report on the reduction of impacts of widespread invasive species.

The outcomes of strategic weed management presented here were, typically, drastic reductions in the abundance of target weeds and encouraging results from the response of environmental assets at risk. Bitou bush and lantana control led to varying increases in native species richness and abundance, which has also been observed in other studies (Mason and French 2007). However, the Bitou TAP and Lantana Plan aim to recover threatened species and ecological communities (DEC 2006, NLMG 2010), and three years of control and monitoring can be a short time in terms of ecological recovery and restoration (French 2010). The process of restoring ecosystems following weed invasion can be an extremely difficult and long term one (French 2010). For this reason, and to confirm the positive biodiversity trends presented here as long term, site management and monitoring (according to site management plans) may be required to occur over long timeframes, to achieve (and detect) sustained biodiversity outcomes.

ACKNOWLEDGEMENTS

This work was supported by the five coastal CMAs in NSW, an Australian Government Natural Heritage Trust and Caring for our Country grants. We acknowledge Peter J. Turner and Leonie K. Whiffen for critical review of the manuscript and the hard work and dedication of the land managers and community groups that contributed to the results described above. We also thank Marion Winkler and Natalie Izquierdo for assisting in collecting and collating mapping data.

REFERENCES

Burley, AL, King, SA and Downey, PO 2008. The NSW Bitou Bush Threat Abatement Plan: the first two years. In 'Proceedings of the 16th Australian Weeds Conference', eds RD van Klinken, VA Osten, FD Panetta and JC Scanlan, pp 383-385. Brisbane, Queensland Weeds Society.

Bushland Restorations Services 2009. Bitou Bush National Northern Containment Zone Management Plan. Bushland Restorations Services, Pottsville.

Coutts-Smith, AJ and Downey, PO 2006. Impact of Weeds on Threatened Biodiversity in NSW. Technical Series 11. Adelaide, CRC for Australian Weed Management.

DEC (2006). NSW Threat Abatement Plan – Invasion of native plant communities by *Chrysanthemoides monilifera* (bitou bush and boneseed). Hurstville, Department of Environment and Conservation (NSW).

Downey, PO and Hughes, NK 2010. Monitoring protocols to assess the recovery of native plant species following the control of widespread weed species. Proceedings of the 17th Australasian Weeds Conference, ed. S.M. Zydenbos, pp. 445-448. (New Zealand Plant Protection Society, Christchurch, New Zealand).

DPI 2008. New South Wales Invasive Species Plan 2008-2015. Orange NSW, Department of Primary Industries (NSW).

French, K 2010. A Framework to Guide Ecological Restoration: Coastal Fore-dune Scrub and Temperate Littoral Rainforest. South Coast, University of Wollongong, Wollongong.

Hamilton, MA, Winkler, MA and Downey, PO 2008. Native Plant Species at Risk from Bitou Bush Invasion: A Field Guide for New South Wales. Hurstville, Department of Environment and Climate Change (NSW).

Hughes, NK, Burley, AL, King, SA and Downey, PO 2009. Monitoring Manual for Bitou Bush Control and Native Plant Recovery. Sydney, Department of Environment, Climate Change and Water (NSW). (<http://www.environment.nsw.gov.au/bitouTAP/monitoring.htm>)

King, SA and Downey, PO 2008. Assessing the recovery of native plant species following bitou bush control - the need for monitoring. Plant Protection Quarterly 23, 40-41.

Mason, TJ and French, K 2007. Management regimes for a plant invader differentially impact resident communities. Biological Conservation 136, 246-259.

McNaught, I, Thackway, R, Brown, L and Parsons, M 2006. A field guide for surveying and mapping nationally significant weeds. Canberra, Bureau of Rural Sciences.

NLMG (National Lantana Management Group) 2010. Plan to Protect Environmental Assets from Lantana. Biosecurity Queensland, Department of Employment, Economic Development and Innovation, Yeerongpilly, Queensland.

Southern Tablelands and South Coast Noxious Plants Committee 2007. South Coast Bitou bush and Boneseed Regional Weed Management Plan.

Strehling, N, Rendell, N, King, SA and Downey, PO 2008. Implementing the Bitou bush Threat Abatement Plan across different land tenures: challenges and successes. Plant Protection Quarterly 23, 45-7.

Thomas, J. 2002. Bitou Bush 2001 Mapping Report. Grafton, NSW National Parks and Wildlife Service.

Thorp, JR and Lynch, R, 2000. The Determination of Weeds of National Significance. Launceston, National Weeds Strategy Executive Committee.

A Zoned Approach to the Management of *Hymenachne* A Weed of National Significance

Craig Magnussen
National Coordinator
Biosecurity Queensland, Warwick

ABSTRACT

Effective weed management depends on local actions but these will be more effective and efficient when they are part of a broader scale strategic approach. The application of this idea is illustrated using the case of the invasive wetland grass *Hymenachne amplexicaulis* in Australia. For widespread weeds, different objectives and approaches are appropriate for different parts of a species' introduced range and areas that it might yet invade. In the case of *H. amplexicaulis* this is because further spread is inevitable unless effective action is taken; there is substantial spatial variation in the risk of invasion and in its impacts; control options and values attributed to the species differ widely from region to region. This paper defines four distinct objectives (prevention, eradication, containment and asset protection) and proposes a continent-wide strategy based on 21 management zones that cover mainland Australia and relevant off-shore islands. One of the four objectives is assigned to each zone, commensurate with the status of the plant and the feasibility of achieving particular outcomes. This approach could be usefully applied to more effectively address the broad-scale management of other invasive species. Management zones should reflect the habitat preferences and dispersal mechanisms of the species being targeted.

INTRODUCTION

It is widely recognised that the effective and efficient management of invasive species requires a strategic approach. Strategies may be devised to address either individual or multiple species and the area to which they apply may range from local (e.g. a catchment or administrative district) to continental. An example of such a strategy at the national/continental level is the Australian National Weeds Strategy developed in 1997 by The Australian Weeds Committee (ARMCANZ 1997) and revised as the Australian Weeds Strategy in 2006 (NRMMC 2006). Its broad objectives are to "prevent new weed problems", "reduce the impact of existing priority weed problems" and "enhance Australia's capacity and commitment to solve weed problems" (NRMMC 2006). This strategy does not have explicit spatial elements other than the fact that it aims to address weed issues across the Australian continent.

One element of the Australian Weeds Strategy involved the identification in 2000 of 20 Weeds of National Significance (WoNS) that are each to be the target of species-specific strategies in order to address, at a national scale, the problems associated with them. These species-specific strategies (NRMMC 2006) were each coordinated by committees that consisted of experts and representatives of groups with an interest in the outcomes of the efforts to target the WoNS. At least some of them contain elements that are spatially differentiated. For example, a prominent element of the national strategy for *Cryptostegia grandiflora* (rubber vine) (ARMCANZ 2000a) is a "containment line" that focuses management effort on areas south and west of the main areas of the species' current distribution in north-eastern Australia. The strategy for *Chrysanthemoides monilifera rotundata* (bitou bush) also refers to "containment

lines” near the northern and southern extremities of the species range on the east coast of Australia (ARMCANZ 2000b; Cherry *et al.* 2008).

Hymenachne amplexicaulis is another species that was listed as a WoNS (Thorp and Lynch 2000). It is a robust, perennial, stoloniferous grass of wetland habitats and was introduced to Australia in 1973 for use as a forage species for cattle. It is known in Australia as Olive hymenachne, or simply as hymenachne, thus risking confusion with a native species *Hymenachne acutigluma* (Wearne *et al.* 2010). The species was widely distributed for cultivation around northern and north-eastern Australia but also naturalised and spread by various means into a range of agricultural, pastoral and natural environments. The main problems that it causes are as a weed of sugar cane, blocking of irrigation channels and other waterways and degradation of native wetlands and riparian zones through the formation of monocultures (Wearne *et al.* 2010). The problems caused by *H. amplexicaulis* are recognised in the declarations of the species under the respective pest plant legislation of all mainland states of Australia.

In line with approaches taken with other WoNS, a national strategy for the management of *H. amplexicaulis* was developed and released in 2000 (ARMCANZ 2000c) and a National Hymenachne Management Group (NHMG) was formed in April 2004 to oversee implementation of that strategy. It aimed to deliver four primary outcomes:

- (i) to prevent the spread,
- (ii) to minimise the adverse impacts,
- (iii) to establish and maintain a national commitment, and
- (iv) to ensure the strategy does not trigger the introduction and use of additional non-indigenous ponded pasture species.

In 2008, the NHMG recognised a need to refine its strategy and particularly the importance of addressing regional differences in the abundance, impacts and use of the species and in what might reasonably be expected to be achieved.

In this paper we propose a spatially differentiated strategic plan for *H. amplexicaulis* and justify it in the light of knowledge of the ecology and management of the species. We indicate how and why the approach exemplified with *H. amplexicaulis* could be applied to other species.

METHODS

To develop a spatially differentiated strategic plan for *H. amplexicaulis* we (i) acquired the best available information on the distribution, abundance and impacts of the species; (ii) devised a set of four simple, mutually exclusive, general objectives that could be assigned on a regional basis; (iii) delimited strategic management zones, each of which exhibited some internal consistency in the severity and extent of infestations of *H. amplexicaulis* and (iv) assigned one of the four objectives to each region.

The literature on invasive plant species includes numerous references to various goals, aims and objectives that might be regarded as strategic, though often terms are used without clear definitions being provided (Grice 2000). These terms may be as vague as “control” or more specific as in “eradication” and “containment” for which the

literature provides some definitions (Grice 2006, 2009; Panetta 2007; Grice, Clarkson and Spafford 2008; Grice *et al.* 2010). We have drawn on this literature to define a small set of strategic objectives that are both specifically relevant to *H. amplexicaulis* and can be more generally applied to invasive plant species.

The delimitation of zones and the categories assigned to them was made, initially, by the authors, refined during a workshop organised by the National Hymenachne Management Group and subsequently finalised by the authors in discussion with individuals knowledgeable about the distribution and abundance of *H. amplexicaulis* in different regions.

RESULTS

Distribution, abundance and impacts of *H. amplexicaulis*

Hymenachne amplexicaulis is not evenly distributed in Australia. Its current range extends from north-eastern New South Wales, through coastal and sub-coastal Queensland, into the northern portion of the Northern Territory as far as its border with Western Australia. Even within this extensive area, the species is patchily distributed at several scales. At the habitat scale it is much more abundant in riparian zones and natural and artificial freshwater wetlands. Overall, spatial heterogeneity in the species' distribution and abundance reflects both variation in environmental factors and the as yet incomplete invasion process (Wearne *et al.* 2010). The impacts of the species and future threat vary accordingly.

In some areas, *H. amplexicaulis* is widespread and abundant. Examples include the lower sections of Fitzroy, Tully-Murray and Johnson catchments in Queensland and the lower sections of the Adelaide, Mary and Wildman catchments in the Northern Territory.

The species is somewhat less abundant and widespread in catchments such as the Gilbert and lower Burdekin in Queensland and sections of the Finnis, Daly and Victoria River catchments in the Northern Territory.

In other catchments, *H. amplexicaulis* exists as relatively few, small, scattered infestations. These catchments include the Tweed, Richmond and Brunswick in north-eastern New South Wales, the Brisbane, Noosa and Mary in southern Queensland, several catchments on Cape York Peninsula and the Goyder catchment in the Northern Territory.

Finally, there are no known infestations across large areas of southern and central Australia (Figure 1) though at least some parts of this extensive region possibly include areas of suitable habitat for the species (Wearne *et al.* in press).

Different strategic objectives are appropriate for this diversity of situations.

Strategic objectives

We defined four broad strategic objectives to cater for different regional situations. These are:

- (i) **Preventing** establishment of *H. amplexicaulis* in regions where it is not already present.

(ii) Local **eradication** of *H. amplexicaulis*. This objective assumes that eradication at the national scale is not possible in the foreseeable future, but that 'local' eradication is possible where infestations are accessible and limited in number and extent.

(iii) **Containment** of populations of *H. amplexicaulis*. It is important to apply a rigorous definition of containment. Here, containment is defined as prevention of spread from a property or part of a property to other properties or parts of a property that are free from *H. amplexicaulis*. The intention is to focus on individual infestations rather than district or regional populations.

(iv) **Asset protection** (Downey *et al.* 2010). In many catchments in north eastern Queensland and the Northern Territory, *H. amplexicaulis* is already widespread and abundant, but even here there are still environmentally (as well as economically and socially) significant areas that have little or none of the species. In these regions a feasible objective is to prevent areas that are free from *H. amplexicaulis* from being invaded or to undertake control works to remove plants before an infestation becomes established.

Delimitation of strategic management zones

We divided the Australian mainland and relevant offshore islands into 21 discrete zones (Figure 1) using river basins. The boundaries between zones align with watersheds between basins (Geoscience Australia 2004). In some cases, a river basin was sub-divided because abundance varied across the basin in such a way as to suggest a different strategic objective was appropriate for different sections.

The use of catchment boundaries to delimit management zones is especially relevant to the management of *H. amplexicaulis* because of the species' preference for freshwater aquatic and semi-aquatic habitats. Watersheds constitute partial barriers to the dispersal of this species, although there are dispersal mechanisms whereby the species can cross from one catchment to another. However, in general, the alignment of boundaries between management zones with watersheds is based on the assumption that the probability of dispersal over any given distance between catchments is lower than the probability of dispersal over the same distance within catchments.

Assignment of objectives to management zones

One of the four strategic objectives was assigned to each of the 21 management zones (Figure 1). Zones are labelled according to the strategic objective assigned to them (P = Prevention; E = Eradication; C = Containment; A = Asset protection).

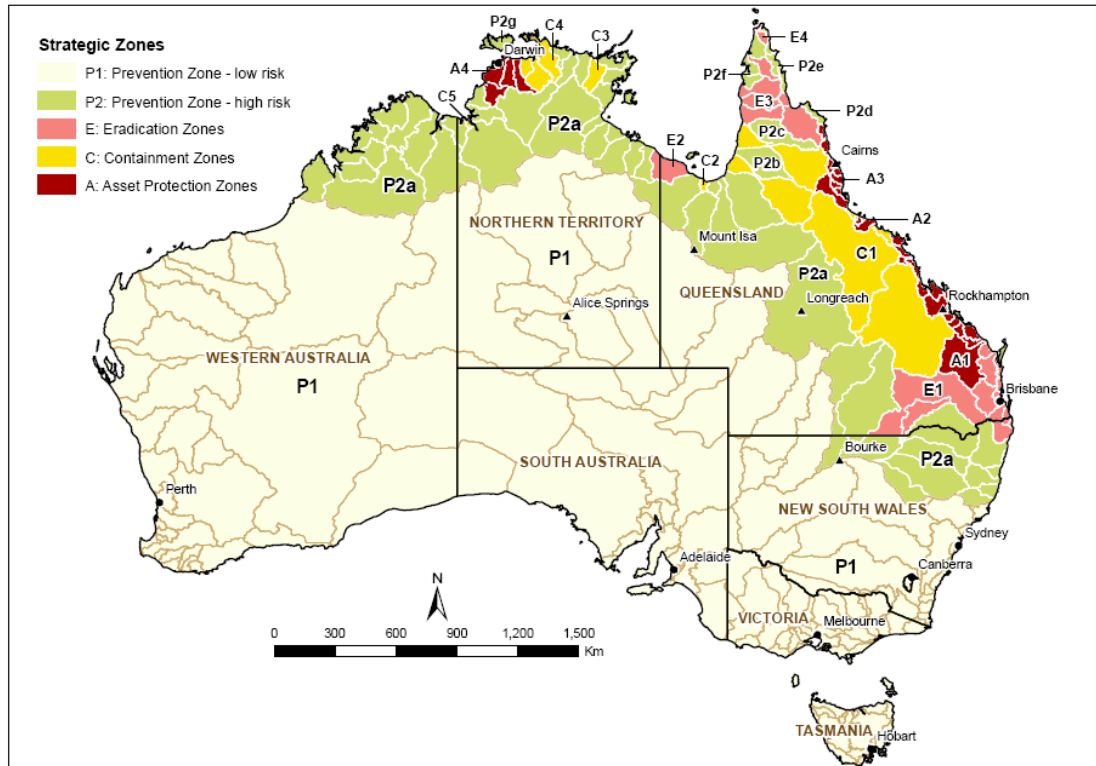


Figure 1

DISCUSSION

The strategy proposed here is designed to address problems associated with *H. amplexicaulis* on a continental scale, namely the whole of Australia. It is consistent with the fact that this species is a declared pest plant in all mainland Australian states with state-level declarations variously imposing one or more legislative restrictions and obligations relating to trade, planting, cultivation, movement and/or control of the species. The strategy also acknowledges that: (i) *H. amplexicaulis* will spread unless action is taken to prevent it from doing so; (ii) the risks posed by *H. amplexicaulis*, in terms of both the probability of spread and the assets that are threatened, differ across its potential range in Australia; (iii) the control/management options for *H. amplexicaulis* differ from region to region depending on how abundant and widespread the species is and on climatic conditions; (iv) in spite of its status as a declared pest plant, *H. amplexicaulis* is valued as a forage species by some pastoralists; (v) even where it is present and valued, *H. amplexicaulis* is not used in the same way by all pastoralists and its productivity and usefulness vary from property to property and from region to region.

These factors elicit a strategy in which the objectives differ from one region to another. It is logical to define regions for the management of *H. amplexicaulis* using catchment boundaries. This is because catchment boundaries (watersheds) present dispersal barriers that can be exploited by managers. They also differ in terms of the current and potential abundance of *H. amplexicaulis* due to differences in the amount and quality of habitat available and the probability of colonisation. These differences influence what constitutes realistic objectives for management of the species.

The success of the strategy proposed for *H. amplexicaulis* is largely dependant on

developing practical means of achieving the four objectives assigned to each of the zones and on the goodwill and cooperation of landholders. It is especially important to consider interactions between zones because a failure to achieve an objective set for one zone may jeopardise progress in other zones.

Prevention relies on identifying routes of dispersal and eliminating them. This means that the sources of propagules most likely to give rise to a new incursion would have to be identified. Failure to eliminate dispersal routes into a prevention zone would invoke a need to eliminate new infestations that arise. This requires a capacity to detect new infestations very early in the invasion process and eradicate them. Deliberate planting of *H. amplexicaulis*, and transporting it for that purpose, are prohibited under state and territory legislation.

Eradication requires that all live plants and all seeds are removed from the target area. Established plants can be dealt with chemically, manually/mechanically or by burning, though some chemical treatment will almost inevitably be necessary. Mechanical and manual techniques carry the risk that they themselves spread viable vegetative material. It is unlikely that all established plants can be found, treated and killed in a single exercise. Repeated treatments would be required. A critical requirement would be to curtail seed production and vegetative spread. Current knowledge indicates that it takes at least eight years to exhaust the seed-bank once input has ceased (Wearne *et al* 2010). Thus, eradication of individual populations probably requires a diligently executed plan extending over a minimum of ten years. Any seeding that occurs during the eradication program will extend the time required, though if all goes well the effort required on an annual basis would diminish as the program proceeded.

Containment involves either preventing spread from existing infestations or, where seeds or other viable plant parts do spread, eliminating, before they reproduce, any plants that arise from them (Grice *et al.* 2010). The intention would be to contain the individual clearly delimited populations rather than simply contain the species to the zone. This means that there would be neither expansion of existing infestations nor development of new ones.

Containment could involve preventing or reducing seed production, preventing or minimising the spread of seeds, preventing or minimising the movement of vegetative material and detecting and killing new plants arising from seeds or vegetative materials that are dispersed outside of a containment area.

In some circumstances it may be possible to reduce seed production by heavy grazing. When an infestation is inundated it is unlikely that cattle will graze it heavily enough to eliminate seed production. If a sward is grazed very heavily and then inundated, seed production may be reduced. This means that the circumstances under which an infestation is growing will influence the effectiveness of grazing in reducing seed production.

H. amplexicaulis can spread both by seed and vegetative material that can be moved by water, deliberate or accidental transport by people (e.g. on motor vehicles, boats and machinery), and by animals (e.g. waterbirds). Some of these mechanisms can be

addressed more readily than others. Probably the most important means of dispersal, involving flowing water, cannot be controlled.

To target an infestation for containment, appropriate boundaries must be established. Containment will be more feasible when boundaries are placed where detection of *H. amplexicaulis* is relatively easy, the likelihood of spread across the boundary is relatively low and the environment immediately outside the area to which it is to be contained is not ideal for *H. amplexicaulis*. Containment will also be more economic when the boundary of the containment area is short and simple.

Areas immediately outside of containment areas should be searched and treated as soon as possible after vegetative dispersal is likely to have occurred. The optimum time to search may be later in the case of seed dispersal to allow for germination. Significant flood events are likely to disperse seeds and vegetative material. Schedules and locations of search and treatment activities must take into account the pathways along which individual infestations are likely to spread and the fact that seed may survive in the soil for at least eight years. In the main, the proposed management zones are arranged to minimise the risks posed by down-stream spread.

Asset protection would rely on vigilance to detect incursions into areas that have been free of *H. amplexicaulis*. If incursions are detected, effort would be required to minimise seed production and spread. Knowledge of routes of dispersal would be important. Any measures that reduced the abundance of *H. amplexicaulis* would reduce the impact that it has on the assets being protected. It would be essential to have a quantitative understanding of the relationship between the abundance and impact of *H. amplexicaulis* in different situations and prioritise efforts according to the value of assets to be protected (Downey *et al.* 2010). Having quantitative information on the value of assets in advance of an invasion occurring would be of value.

Interactions between zones would be crucial to the success of the approach advocated here. Failure to eradicate or contain the species in one zone would increase the likelihood that it would invade adjacent zones where prevention is the objective. Efforts to prevent would have to contend with higher propagule pressure from those adjacent zones (Richardson *et al.* 2000). Perhaps the greatest inter-zone threat would be from asset protection zones. Upstream areas were never assigned as asset protection zones. Unmanaged infestations in asset protection zones are likely to expand and give rise to new infestations. Buffers of unsuitable habitat are probably the most cost effective defence against this risk. The proposed asset protection zones in eastern Queensland (A1, A2 and A3) are bounded to the west by the hilly terrain of coastal ranges or the Great Dividing Range where there is little suitable habitat for *H. amplexicaulis*. The containment zone to the west (C1) is also upstream of the asset protection zones, removing the risk of incursion into C1 by water flows. The risks of deliberate or accidental spread by human activity or movement of seeds on waterbirds would remain. The asset protection zone in the Northern Territory (A4) is not surrounded by unsuitable habitat as the watersheds between catchments are often very low-lying. Moreover, A4 catchments support large numbers of highly mobile waterbirds that could move seeds to adjacent containment and prevention zones.

Since *H. amplexicaulis* was listed as a WONS and declared under state level pest plant legislation, there has been considerable effort directed at the control of the species. Some of this activity has been effective; some less so. A number of the location-specific actions that have been and are being conducted are consistent with the strategy proposed here. In New South Wales, *H. amplexicaulis* is being targeted for eradication. Comparable efforts in southeast Queensland would facilitate this effort and put into effect a single eradication zone (E1). Likewise, Western Australian policy is to keep the species out of that state so that large sections of prevention zones P1 and P2a are already in place.

Progress against *H. amplexicaulis* is dependent on reliable information on the status of individual infestations and it is important that the status of known and suspected infestations is reviewed regularly. Information on many known or suspected infestations in eradication and containment zones is currently inadequate. Eradication targets must be delineated reliably as early in the process as possible so as to ensure targets are accurately defined and avoid attempting eradication of populations for which the prospects of success are poor. Likewise, containment targets must be delineated as tightly as possible; that is, their boundaries must be clearly determined. On grazing properties where the *H. amplexicaulis* has been planted and makes a significant contribution to productivity, the aim should be to contain the species to paddocks where it was planted and is intensively managed. Spread beyond these paddocks should be prevented and dealt with if it occurs. Knowledge of the landscapes in which each infestation occurs can be used to identify breakpoint or points of confinement around which to design a containment unit and so increase the efficiency of the containment exercise (Grice *et al* 2010). Whatever the objective for a particular infestation, the approach to achieving that objective should be tailored to suit its peculiar circumstances.

The plan must be flexible in order to respond to new information on the distribution, abundance and ecology of *H. amplexicaulis* and on further development of control techniques.

Subdivision of the potential range of an invasive species should be based on its biology. Whereas in the case of the *H. amplexicaulis*, a wetland species, watersheds are the most appropriate boundaries, in the case of strictly terrestrial species, the most appropriate boundaries may be major rivers. As a generalisation, subdivision should be based on habitat suitability and dispersal mechanisms.

It is important to assess the effectiveness of any strategy for managing invasive species and adjust it on the basis of that assessment. A spatially differentiated strategy provides a more explicit basis for assessment and adjustment and there may be value in supporting spatially differentiated strategies with appropriate legislation and policies.

This paper is an abridged version of:

A.C. Grice, J.R. Clarkson and M. Calvert. 2011. Geographic differentiation of management objectives for invasive species: a case study of *Hymenachne amplexicaulis* in Australia. Environmental Science and Policy (submitted for publication, under review).

*Please contact the speaker at craig.magnussen@deedi.qld.gov.au for complete copies of the paper.

References

ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand), ANZECC (Australian and New Zealand Environment & Conservation Council) and Forestry Ministers), 1997. The National Weeds Strategy. Commonwealth of Australia, Canberra. NRMCC 2006

ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand), ANZECC (Australian and New Zealand Environment & Conservation Council) and Forestry Ministers), 2000a. Weeds of National Significance. Rubber vine (*Cryptostegia grandiflora*) Strategic Plan. National Weeds Strategy Executive Committee, Launceston, Tasmania. ARMCANZ 2000b

ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand), ANZECC (Australian and New Zealand Environment & Conservation Council) and Forestry Ministers), 2000c. Weeds of National Significance. Hymenachne (*Hymenachne amplexicaulis*) Strategic Plan. National Weeds Strategy Executive Committee, Launceston, Tasmania.

Cherry, H., Willsher, L., Whyte, B., 2008. Bitou bush and boneseed eradication and containment in Australia. *Plant Protection Quarterly* 23:38-40.

Downey, P.O, Johnson, S.B., Virtue, J.G. and Williams, P.A., 2010. Assessing risk across the spectrum of weed management. *Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 5, No. 038.

Geoscience Australia, 2004. Australia's River Basins 1997: Product User guide, National Mapping division, Geoscience Australia, Canberra.
https://www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=42343
(Accessed 30 April 2010).

Grice, A.C., 2000. Weed management in Australian rangelands, in: Sindel, B.M. (Ed.) *Australian Weed Management Systems*. R.G and F.J. Richardson, Melbourne, pp. 431-458.

Grice, A.C., 2006. Commercially valuable weeds: can we eat our cake without choking on it? *Ecological Management and Restoration* 7:40-44.

Grice, A.C., 2009. Principles of containment and control of invasive species, in Clout, M.N. and Williams, P.A. *Invasive Species Management: A Handbook of Principles and Techniques*. Oxford University Press, pp. 61-76.

Grice, A.C., Clarkson, J. and Spafford, H., 2008. Commercial weeds: roles, responsibilities and innovations. *Plant Protection Quarterly* 23:58-64.

Grice, A.C., Clarkson, J.C., Friedel, M.H., Ferdinands, K. and Setterfield, S., 2010. Containment as a strategy for tackling contentious plants, in: Zydenbos, S.M. (Ed.) *Proceedings of the 17th Australasian Weeds Conference*. New Zealand Plant Protection Society, pp. 486-489.

Panetta, F.D., 2007. Evaluation of weed eradication programs: containment and extirpation. *Diversity and Distributions* 13:33-41.

Richardson, D.M., Pyšek, P., Rejmánek, M., Barbour, M.G., Panetta, F.D. and West, C.J., 2000. Naturalisation and invasion of alien plants: concepts and definitions. *Diversity and Distributions* 6:93-107.

Thorp, J.R. and Lynch, R., 2000. The Determination of Weeds of National Significance. National Weeds Strategy Executive Committee, Launceston.

Wearne, L.J., Clarkson, J., Grice, A.C., van Klinken, R.D. and Vitelli, J.S., 2010. The biology of Australian weeds. 56. *Hymenachne amplexicaulis* (Rudge) Nees. *Plant Protection Quarterly* 25(4):146-161.

**ERADICATING BONESEED (*CHRYSANTHEMOIDES MONILIFERA* SUBSP
MONILIFERA) IN NSW: HOW GRASS ROOTS INITIATIVES BECOME
NATIONAL PROGRAMS**

Hillary Cherry¹, Stephen Johnson², David Pomery³ and Paula Bosse⁴

**¹National Coordinator Bitou Bush & Boneseed
Pest Management Unit, Office of Environment & Heritage
PO Box 1967, Hurstville NSW 1481
T: +61 2 95856587 | E: hillary.cherry@environment.nsw.gov.au**

**² Weed Ecologist
NSW Department of Primary Industries
Locked Bag 21, Orange NSW 2800**

**³ Chief Weeds Officer
Illawarra District Noxious Weeds Authority
PO Box 148, Kiama NSW 2533**

**⁴ Riverina Noxious Weeds Project Officer
PO Box 382, Jindera NSW 2642**

ABSTRACT

Actions are underway to eradicate boneseed in New South Wales (NSW). Boneseed poses a major threat to NSW biodiversity because it has the potential to reduce the abundance and diversity of native species and adversely impact natural ecosystems. Potential distribution maps created in 2006 revealed that boneseed could invade most of southern, central and western NSW, however very few infestations currently exist. In response to this threat, NSW regional Noxious Weeds Advisory Groups, including Eastern/Western Riverina and South Coast/Southern Tablelands, have recognised boneseed as an emerging threat and developed management strategies to encourage eradication. These groups are also pursuing a more stringent legislative listing for boneseed across NSW. Weed risk assessments for boneseed performed by regional groups support eradication and weed officers have submitted declaration requests to the New South Wales Department of Primary Industries (NSW DPI). As a result, NSW DPI have recommended that boneseed be listed as a Class 1 (State Prohibited) weed under the NSW *Noxious Weed Act 1993*, and be eradicated across the state. Increased focus and resourcing of boneseed from national, state and local authorities will help achieve eradication of any remaining boneseed infestations. In the long term, these efforts will ensure boneseed does not threaten NSW and will encourage establishment of national boneseed containment lines at the NSW-Victoria border. The Boneseed Weeds of National Significance program will continue to support efforts by regional groups and NSW DPI to work toward these goals, and garner support from neighbouring regions in Australian Capital Territory (ACT) and Victoria to ensure coordinated action continues to protect NSW from boneseed.

INTRODUCTION

Boneseed (*Chrysanthemoides monilifera* ssp. *monilifera* (L.) Norlindh) is a Weed of National Significance (WoNS) that threatens biodiversity in New South Wales (NSW). It is widespread in parts of South Australia, Tasmania and Victoria, where it causes extreme environmental impacts. Like its close relative bitou bush (*C. monilifera* ssp. *rotundata* (DC.) T. Norl.), boneseed aggressively invades native coastal areas, where it can form dense thickets and impact native biodiversity. However boneseed poses an additional threat because, unlike bitou bush, it readily invades inland and upland regions from the mallee to the mountains.

The WoNS bitou bush and boneseed program began in 2005 and a priority action for the program was to undertake detailed mapping for both subspecies. Previous to 2005, bitou bush and boneseed were mapped together (as one species), and this method did not relay the true threat or direction of spread for boneseed in NSW. When the two subspecies were mapped separately, maps showed that boneseed was far more widely distributed in NSW than previously thought. Records of boneseed exist from as far inland as Broken Hill, Griffith, Tumbarumba and Dareton, as well as north to the Blue Mountains. Boneseed is also interspersed with coastal infestations of bitou bush on the NSW south coast and Sydney regions, especially on headlands and cliffs, and as far north as Cessnock. In addition, potential distribution maps, also created in 2006, revealed that boneseed has potential to invade most of southern, central and western NSW, either from existing infestations or via spread from neighbouring infestations in Victoria and South Australia.

In response to this threat, the National Boneseed Coordinator began working with NSW regional Noxious Weeds Advisory Groups (NWAGs) to focus on eradicating outlier populations of boneseed in NSW. The national coordinator attended regional NWAG meetings and met with weeds officers in key areas to provide information on this relatively new weed and determine the true extent of infestations. This included an investigation of all NSW herbarium records, which led to the discovery of five existing infestations. The national program also developed identification and awareness materials for boneseed, which was not well-known in many regions. Because bitou bush and boneseed were treated as one species in the past, many land managers and weeds officers thought boneseed would only invade coastal areas, and so were not on the lookout for it in their regions. Thus, creating and widely distributing identification materials was critical to finding new infestations.

Following intensive search efforts, groups across the southern and western parts of NSW, such as the Eastern and Western Riverina and South Coast and Southern Tablelands NWAGs, recognised boneseed as an emerging threat and began to develop management strategies to encourage eradication. For example, the Southern Rivers Catchment Management Authority's regional weed management strategy and the South Coast Bitou bush and Boneseed Taskforce's boneseed management plan (SCBBBTF, 2007) require complete removal of boneseed in all coastal councils south from Wollongong to the Victorian border. Similar plans were also developed for the eastern and western Riverina regions (Bosse, 2011). Concurrently, at the state level, the national coordinator began discussions

with NSW Department of Primary Industries (NSW DPI) to relay the revised distribution information for boneseed and bitou bush and work towards ensuring more appropriate legislative listings for the two subspecies. Bitou bush and boneseed were listed as individual subspecies in 2006 under the NSW *Noxious Weeds Act 1993*. This split has allowed Local Control Areas (LCAs) to address these two weeds separately when deciding on the correct noxious weed classification for their LCA.

Weeds officers in the NWAGs had previously recognised the value of eradicating boneseed, and subsequent weed risk assessments for boneseed by regional groups supported eradication in all LCAs. Following the listing of boneseed as a subspecies, weed officers across southern and western NSW lobbied their individual LCA to change the declaration status of boneseed to Class 2 (*The plant must be eradicated from the land and the land must be kept free of the plant.*). This took place across at least 85 LCAs, in conjunction with five NWAGs, over a three year period from 2007-2010.

Once all LCAs within each NWAG area had agreed to a Class 2 listing, the NWAGs then requested the change of legislation directly with NSW DPI, with support from the national boneseed coordinator. Upon assessment of the LCA requests above, NSW DPI recommended to the Minister for Primary Industries that boneseed should be declared across the state as a Class 1 weed (*Plants that pose a potentially serious threat to primary production or the environment and are not present in the State or are present only to a limited extent.*), rather than a Class 2 listing. This is because the distribution boneseed is very limited in the south and west of NSW and is absent from other regions of the state. This will allow greater focus on boneseed statewide, which will raise awareness and, in turn, prevent further incursions. This recommendation will be considered by the Minister's Noxious Weeds Advisory Committee, and if progressed, will undergo public consultation and gazettal prior to 1 September 2011.

DISCUSSION

In 2005, WoNS boneseed mapping highlighted the possibility of boneseed eradication in NSW. Weeds officers from around the state rallied together through the NWAGs and lobbied at the grass roots level to gain support for eradication. Six years later, this has culminated in a request for permanent legislative change that will prompt eradication of this environmentally damaging weed from NSW. While it has been a long process, it is worthwhile because it embeds the eradication goal in legislation and ensures the legacy of hard work by weed officers and land managers to control this nationally significant weed.

Partnerships are already in place to assist with eradication: The existing structure of LCAs and NWAGs, supported by NSW DPI and other state government agencies, allows information sharing and effective management statewide. Additional infestations may be found as land managers become more aware of boneseed, however control and eradication will be supported by strong legislation and access to a range of best practice management information. For example, the WoNS Boneseed Program has produced the *Boneseed Management Manual* (Brougham et al, 2006), which is a one-stop-shop for best practice advice. In addition, increased focus and resourcing of boneseed from national, state and local

authorities will help achieve eradication of any remaining infestations. The recently revised *draft National Bitou bush and Boneseed Strategic Plan* (NRMCANZ, 2011) recognises the importance of NSW eradication efforts and recommends continued eradication and ongoing surveillance of boneseed.

In the long term, eradication efforts will ensure boneseed does not threaten the NSW environment. In addition, statewide eradication in NSW may also encourage establishment of national boneseed containment lines at the NSW-Victoria border, reducing the threat of further spread. The Boneseed Weeds of National Significance program will continue to support efforts by regional groups and NSW DPI to work toward these goals and garner support from neighbouring regions in ACT and Victoria to ensure coordinated action continues to protect NSW from boneseed.

ACKNOWLEDGMENTS

These achievements were made possible by weeds officers, land managers and regional weeds advisory groups across NSW. This work was partially funded by the Australian Government's Caring for our Country.

REFERENCES AND FURTHER INFORMATION

Bosse, P. 2011. draft *New Incursion Plan – Boneseed and Bitou bush 2011-2016*. Eastern and Western Riverina Noxious Weeds Advisory Group, Jindera, New South Wales. Available on www.riverinaweeds.org.au

Brougham, KJ, Cherry, H and Downey, PO, eds. 2006. *Boneseed Management Manual: current management and control options for boneseed (Chrysanthemoides monilifera ssp. monilifera) in Australia*. Department of Environment and Conservation (NSW), Sydney. Available on www.weeds.org.au/wons/bitoubush

Cherry H., Willsher L. & Whyte B. 2008. Bitou bush and boneseed eradication and containment in Australia. *Plant Protection Quarterly*, 23, 38-40.

NRMCANZ (Natural Resource Ministerial Council of Australia & New Zealand). 2011. draft *Weeds of National Significance Bitou bush and Boneseed (Chrysanthemoides monilifera ssp. rotundata and monilifera) Strategic Plan*. Australian Weeds Committee, Launceston. Available on www.weeds.org.au/wons

SCBBBTF (South Coast Bitou bush and Boneseed Taskforce). 2007. *South Coast Bitou Bush and Boneseed Management Plan 2007-2012*. SCBBBTF, Illawarra District Noxious Weeds Authority, Kiama, New South Wales. Available on www.southerncouncils.nsw.gov.au

Eradication: Lessons learnt from the National Siam and Four Tropical Weeds Eradication Programs

Mick Jeffery
Project Coordinator
Biosecurity Queensland, Far North Queensland

Biosecurity Queensland, a business group within the Department of Employment, Economic Development and Innovation, is responsible for managing two nationally cost-share funded weed eradication programs: the Siam Weed Eradication Program which commenced in 1994, and the Four Tropical Weeds Eradication Program which commenced in 2003. Together these programs are tasked to eradicate seven species of weeds from mainland Australia: *Chromolaena odorata*, *Mikania micrantha*, *Limnocharis flava*, *Clidemia hirta*, *Miconia calvescens*, *Miconia nervosa* and *Miconia racemosa*.

These species have been chosen as eradication targets due to their very restricted distribution in Australia, proven invasiveness in several other countries and the potential to impact agriculture and the environment across tropical and sub-tropical Australia if allowed to expand their full potential ranges.

Over the past seventeen years, a number of lessons have been learnt which could inform other eradication programs. With very few examples of successful weed eradication in the global literature, there is yet to be a definitive 'How to guide' to achieve the desired endpoint. The North Queensland programs have been guided by eradication theory and informed by practices from other eradication programs, but further in-house adaptive management is required to maintain the upper hand over the target species.

Delimitation

This is probably the most difficult yet fundamental component of any eradication program. Setting the boundaries of the weed incursion needs to be achieved as early as possible. This will provide clarity on the scale of the task ahead, and the resources required to survey and control the infestation. The spread of an incursion should be halted once all the infestations have been identified and are being effectively managed.

Determining the extent of a weed incursion is much easier in theory than to achieve on the ground. Depending on the length of time between the introduction of the weed into Australia and its detection, a weed incursion may have had many opportunities to disperse across the landscape. This could be via a range of dispersal mechanisms including wind, water, wildlife, vehicles or humans (eg moving or selling garden plants or vehicle contamination). Detecting all plants that result from all of these pathways is the eradication challenge, especially the accidental or deliberate human mediated dispersal.

Whereas wind, water and animal dispersal can be modelled and predicted to a certain degree of confidence, the capacity of people to move weed material across the landscape is enormous, random and difficult to model. To maintain a high level of confidence that Siam weed is contained within North Queensland, the program has had to regularly undertake broadscale media campaigns, including television and radio advertisements, across northern Australia to encourage people to report Siam weed.

The take home message is that it is vitally important to maintain ongoing delimitation activities and to remain vigilant. Never presume to think that you know where all the locations of your target weed are. The Siam weed program spent nine years eradicating within two adjoining catchments. In 2003, a TV infomercial resulted in detections of two further infestations, one 150km south and one 125km north of the core infestations. Without the broader media campaign, the Siam weed program would have continued to eradicate in the Tully and Johnstone River catchments, oblivious to the fact that other infestations existed and were expanding in Australia.

At a more targeted level, the North Queensland eradication programs have also invested heavily in weed identification workshops/toolbox talks for a wide variety of organisations that employ field staff who may encounter eradication target weeds during their day to day activities. This has included the obvious targets such as Local Government and National Parks staff, but also workers involved in road maintenance, mosquito control, irrigation management and earthworks. This has provided hundreds of extra eyes looking for our weeds across North Queensland, and is evidenced by most of our positive detections being reported by field officers going about other business (Brooks and Galway 2008).

Concurrent with delimitation is the need to contain the spread of the target species. Most of these species have been declared as eradication targets in other relevant states and territories, providing legislative restrictions on growing, sale and movement. The programs have compliance officers who prepare spread prevention plans with all impacted property owners to ensure managed infestations are contained. Also, at an operational level, all field staff and other agencies who participate in survey and control activities follow stringent weed spread prevention protocols.

Know your enemy

Scientific research is crucial to understanding the weeds you are trying to eradicate. Critical weed biology questions that need answering include: How long does the seed remain viable in the soil? How long does a plant take to germinate and produce the next generation of seed? What dispersal mechanisms does the plant use? Answers to all of these questions will inform the length of time it take to eradicate the weeds, how often you need to survey and control the weeds, and where you should be searching. The eradication programs must be able to implement effective control measures for the entire population, so cost effective and alternative herbicide treatments and applications methods are also investigated.

Often, answers to these fundamental weed biology questions are not available for species which are new to Australia. A search of the literature can highlight the paucity of weed biology research into even the most widespread invasive species. Often these weeds are such widespread problems overseas that eradication is not contemplated and research is focussed on weed suppression, damage or use. Furthermore, the way a weed behaves in its native range may be different to how it will grow in Australia, where it could be exposed to different environmental conditions and be free from predators that could keep it in check. Both the Siam and Four Tropical Weeds programs have had to invest in research programs and partner with CSIRO to address research gaps. A strong scientific basis is necessary to make sound operational decisions. Although the Siam weed program has been running for

17 years, Siam weed research is ongoing, ensuring the program is constantly improving and adapting.

Resources

Estimating the resources required to achieve eradication is a bean counters nightmare! Modellers and statisticians continue to build trends and projections, but the ability of invasive species to confound the experts often appears to be unlimited. Build in the vagaries of climatic conditions and the consequent impact on operations, and the end result is a crystal ball gazing exercise. Nonetheless, within this environment of multiple, ever changing variables, estimates of the annual cost to achieve eradication objectives are necessary. It is also much easier to estimate resources for a known (delimited) static surveillance area. In reality, discovery of new or outlying infestations do occur, and need resourcing to rapidly delimit and control.

Both eradication programs have found that the ongoing detection of new infestations continues to put pressure on budgeted expenditure. The national cost-share funding environment normally requests three-year budgets which are agreed to at Ministerial Council level. The process of reaching this agreement can take up to nine months. The ability to modify these budgets during the three-year cycle, as new infestations have been detected, has also been problematic. To avoid this cyclical shortfall in funding, the latest funding proposal for the Four Tropical Weeds Eradication Program has budgeted in a small contingency component to allow the program to rapidly respond to new detections while still maintaining strict survey and control timelines for previously known infestations. As new discoveries decline over time, this contingency fund will become redundant.

Another important resourcing lesson is that the budget needs to be sufficient to meet the stringent infestation revisit timetables required for eradication. The ultimate aim is to sterilise infestations by not allowing seeding events to occur. Any seeding event can provide further dispersal opportunities and lengthen the life of the eradication program, which will continually test the resolve of the funding parties. It is better to allow for frequent and thorough searches of infestations rather than budget for 'just enough'.

Data, the key to it all

Eradication programs are often very expensive and require a continuous funding commitment for a prolonged period to achieve the desired outcome. A high standard of very detailed data needs to be recorded to track progress, analyse trends and to feedback into resourcing decisions and budget approvals. Both eradication programs have a purpose built Access® database, a very strong GPS-GIS integration, and receive technical support from Biosecurity Science to analyse the data on an annual basis for reporting purposes.

The Siam weed program is a good example of how data collection has evolved over time. For the first few years, no data was collected. After four years, a data recording system and database was developed, but nil records were often not entered. By 2006, locational data was collected on a much more thorough spatial basis, which then fed into the first attempt to coarsely analyse the data in 2007, 13 years after the program had begun. More serious trend analysis did not occur until 2008, and an even more detailed spatial recording system based on one hectare grid squares was rolled out in 2010.

The data standard we have today allows program staff, external parties and funding bodies transparency in how we track and report progress towards eradication. It would have assisted the Siam weed program enormously to measure trends and retire sites more quickly if we had been accurately and consistently recording data from day one. Records showing the continual absence of plants, especially reproductive plants from previously controlled areas, provide the most compelling evidence of progress towards eradication. The take home message is that the highest standard of data collection, storage and analysis should be utilised from the outset of any serious eradication program.

Belief

Finally, once the nuts and bolts are in place, a culture of eradication needs to be instilled at all staff levels. There needs to be a belief by the field teams undertaking the grunt work that eradication is possible so that they conduct their surveillance to the highest possible standard. Without this internal drive, the goal of eradication will fall at the first hurdle. In support of the field teams, supervisors and managers must also be fully committed and convinced of the eradication aim. This includes supporting field staff in being adequately remunerated for the stringent standards required of eradication, and providing the best possible technology and equipment to undertake survey and control efficiently and effectively.

Both the Siam and Four Tropical Weeds Programs have been plagued by high staff turnover due to poor remuneration and short-term employment contracts. Poor recognition and recompense of the skills required to conduct eradication is being addressed institutionally, but will take some time to change. In the meantime, we will continue to rely on the dedication and passion of our field staff.

ACKNOWLEDGEMENTS

I would to acknowledge Simon Brooks for his ongoing scientific input into the eradication programs (and this paper), and to all the eradication program staff that work enormously hard to achieve the ultimate goal.

REFERENCES

Brooks, S.J. and K.E. Galway. 2008. Processes leading to the detection of tropical weed infestations during an eradication program. In: Proceedings of the 16th Australian Weeds Conference. R.D. van Klinken, V.A. Osten, F.D. Panetta and J.C. Scanlan eds. Queensland Weeds Society, Brisbane.p424-426.

THE CHALLENGES OF WEED MANAGEMENT IN NATIVE PASTURES.

**Jo Powells
Acting District Agronomist
NSW DPI Goulburn**

The Monaro region of the Southern Tablelands, NSW is renowned for its fine wool production. This grazing system is driven by native pastures which represent 60% of the agricultural landscape (Ayres & Arnott 1999). The region has been in drought for 10 of the last 11 years with close to average rainfall patterns returning in 2010.

The native pastures of the region are made up of both temperate and summer active perennial grasses along with many native forbs including both locally common and threatened species. While there are both annual and perennial weeds, broadleaf and grass weeds it is the perennial grass weeds that pose the biggest threat to the production and sustainability of pasture systems across the region. These weeds are Serrated Tussock (*Nassella trichotoma*) and African Lovegrass (*Eragrostis curvula*).

Serrated tussock is a temperate (C3) perennial grass native to South America (Auld, B.A. & Medd, R.W. 1992) which is widespread across the Monaro region. African lovegrass is a summer active (C4) perennial grass native to South Africa (Auld, B.A. & Medd, R.W. 1992) and is more dominant on less fertile, granite and slate derived soils however is now spreading further into the more fertile, basalt derived soil region of the Monaro.

The native grass paddocks across the region are generally large in size (100ha plus) and are generally seen as nil to low input pastures. These paddocks often have little potential for pasture improvement due to unfavourable soil type, non-arable land, limited rainfall and short growth seasons.

Because the target plants are perennial grass weeds, ones that are perfectly adapted for survival, well camouflaged and could potentially dominate a native pasture the control options need to be carefully considered. Chemical and physical control, addressing soil nutrition and pasture and grazing management are all tools that should be considered when building a weed control program for these weeds.

Chemical control

There are two commonly used herbicides that are registered for the control of both serrated tussock and African lovegrass. Glyphosate and Flupropanate based herbicides are both generally used for control of these weeds across the region but both can have devastating effects on native pastures when poorly applied.

Spot spraying activities using either herbicide are often poorly performed by over application (drowning the plant in herbicide), poor nozzle selection (wide spraying field) and through poor targeting (large off-target damage) (figure 1).



Figure 1. The over-spraying of one African lovegrass plant with Flupropanate, the surrounding native grasses have been destroyed, only small broadleaf weeds remain. Photo J. Powells.



Figure 2. The marked area showing the recovery of an over-sprayed area 2 years after herbicide application. The effected area of over 2m² contains broadleaf weeds, native forbs and annual grasses. Photo J. Powells.

Native pastures are very susceptible to off target spray or spray drift. This type of damage can have serious consequences for native pastures, with the effects often persisting for several years in the form of bare ground, broadleaf weed infestation, and potential re-infestation of the perennial grass weed (figure 2).

Whilst spot spraying is a viable option with the right equipment and application, locating the plants can be very challenging, especially in overgrown native pastures (Figure 3). If infestations of large mature plants are not removed, control of these weeds will never be achieved. The use of a marker dye when spraying can also help prevent the unnecessary re-spraying of target plants.

Herbicide choice combined with careful application using calibrated equipment can greatly reduce the weed population whilst limiting the affect the on non-target plants and the long

term health of the surviving pasture. Herbicides should still be considered as valuable tools but must be used with care and according to the product label.



Figure 3. The circled seed heads of African lovegrass sitting just above the seed heads of the corkscrew (*Austrostipa scabra*) native pasture. Photo J. Powells.

Physical control

As both serrated tussock and African lovegrass are perennial in growth, chipping out of the plant can be difficult. If this method is to be used, care needs to be taken to ensure the entire plant, including root stock is fully removed. However, the bare and disturbed ground that remains after chipping offers a perfect seedbed for the next generation of serrated tussock or lovegrass plant to germinate.

Some success has been achieved using chipping followed by the introduction of a handful of seed mix (usually phalaris/ cocksfoot and subterranean clover) onto the disturbed ground to promote revegetation with a useful pasture plant (figure 4.). This has only been done when the infestations and areas of disturbance from chipping are small and sporadic.



Figure 4. The foreground of the photo shows successfully established phalaris and sub clover growing in place of serrated tussock in a native pasture. Photo J. Powells.

Soil Nutrition

Promoting pasture health through addressing nutrient deficiencies can be a very effective way of limiting the further spread of invasive weeds. Whilst most native pastures are well adapted to low nutrient soils, many respond favourably to improved soil fertility.

Research work carried out by NSW DPI over the past 15 years has highlighted positive responses to increased fertility in native pastures containing weeping grass (*Microlaena stipoides*), wallaby grass (*Austrodanthonia* sp.), speargrass (*Austrostipa* sp.), poa tussock (*Poa* sp.) and nineawn grass (*Enneapogon nigricans*).

Trial work carried out on native pastures near Cooma investigated the effects of addressing soil phosphorus and sulphur deficiencies and showed increased native pasture growth and no increase in the populations of either serrated tussock or African lovegrass. Through improving soil fertility, higher stocking rates could be run to utilise the additional growth and increased quality of the pasture (1.8 DSE on unfertilised pasture to 3.3 - 4.5 DSE on fertilised granite derived soil; 3 DSE on unfertilised pasture to 5 DSE - 11 DSE on fertilised basalt derived soil).

The simplest method of weed control is prevention. If serrated tussock and African lovegrass germination could be prevented or even minimised through a more competitive native pasture, population spread of these weeds would be restricted further. Maintenance of high levels of ground cover (70-80 %) limits the space for these weeds to germinate. The native pasture research at Cooma highlighted the additional benefits of higher groundcover in fertilised paddocks (5-12% higher groundcover) as well as the pasture growth, quality and stocking rate benefits.

Pasture & Grazing management

Native pastures can have a highly variable growth cycle. Unlike the improved pastures such phalaris and cocksfoot, the length and timing of reproduction and seed-set in most native pastures can last from one to several months. This timing also varies between native grass species as well as seasonally. To be able to manage a native pasture successfully, knowledge of each species and their growth, reproductive and seeding times is required.

Grazing these species at the most appropriate time to maximise livestock production can be done in conjunction with resting the pasture during grass flowering and seed-set. This can help promote healthy native grassland that can recruit and sustain itself whilst gaining the best quality feed for livestock.

Introduction of subterranean clover into native pastures can assist in increasing overall pasture quality but the clover can also assist grass production through nitrogen fixation. Subterranean clover can be established by broadcasting inoculated seed over the pasture along with the appropriate fertiliser.

Greater control over livestock grazing especially during drought can help prevent the over-grazing of native pastures and loss of groundcover which can often lead to an outbreak of weeds post-drought. Normally groundcover can be managed through simple paddock rotations based on pasture and groundcover benchmarks. However, during times of drought, the removal of livestock from a paddock when it reaches a predetermined

groundcover benchmark and feeding in a sacrifice paddock or livestock containment area is required to ensure long term pasture health and weed management.

The importance and value of maintaining groundcover in agricultural farming systems is now well acknowledged by farmers, the local community as well as the broader water catchment community. Local Catchment Management Authorities on the Monaro have helped subsidise the construction of livestock containment areas on farms in a move to conserve groundcover in paddocks within their catchments during times of drought.

Tactical pasture and grazing management are both vitally important for long term control of weeds. It is essential to have knowledge of your pasture plants, their lifecycle and grazing preference. By combining this information with the appropriate livestock enterprise you can assist with the suppression of weed germination allowing for a reduction in overall weed population over time with removal of parent plants.

For successful weed management in native pastures to be achieved you will need to utilise several, if not all of the tools in your weed management tool box. You will also need plenty of patience, persistence and perseverance!

ACKNOWLEDGMENTS

The Monaro Grasslands Research & Demonstration Project was run by NSW DPI, Cooma from 2004 to 2011. Funding support for this project came from Southern Rivers CMA, Natural Heritage Trust and NSW Department of Environment and Climate Change.

The project team would like to thank our landholders, the Sherlock family and the McGufficke family who hosted the 2 research sites mentioned in this paper.

REFERENCES AND FURTHER INFORMATION

Auld, B.A. & Medd, R.W. (1992) Weeds – An illustrated botanical guide to the weeds of Australia, p. 47, 49. Inkata Press, Melbourne.

Ayres, L. & Arnott, R. (1999) The Monaro District, NSW Agriculture

“Farming Native Pastures” is a 3 session workshop developed and run by NSW DPI which can assist producers in building native pasture management skills.

Pasture & grazing management skills can be developed through the NSW DPI PROGRAZE™ course.

Sustainable landscape management and soil nutrition skills can be developed through the NSW DPI Landscan™ course.

Further information on managing native pastures, Serrated Tussock, African Lovegrass and herbicide use can be found on the NSW Department of Primary Industries website www.dpi.nsw.gov.au or through your local district office.

Strategic Implementation of Weeds of National Significance Containment Lines and Outlier Infestation Control Programs

James Browning
Senior Weeds Officer
New England Weed Authority
ARMIDALE NSW 2350

Jonathan Lawson
Invasive Species Catchment Officer
Border Rivers Gwydir Catchment Management Authority
Glen Innes NSW 2370

Overview

A successful funding application was secured through the Commonwealth Governments Caring for Our Country program: Reducing the Impact of Weeds of National Significance (WONS) and is being delivered through the Border Rivers Gwydir Catchment Management Authority (BR-G CMA) regional base line funding. The project is a two year project 2009/2010 & 2010/2011, with a continuation into 2011/12 & 2012/2013.

The objective of the project is to reduce the impact of WONS over the next two years within the BRG Catchment with a focus on Serrated Tussock (*Nassella trichotoma*), Gorse (*Ulex europaeus*), Chilean Needle Grass (*Nassella neesiana*) and Bridal Creeper (*Asparagus asparagoides*), through the strategic placement of containment lines, eradication of outlier infestations and the management of core areas.

The project concentrates on eradicating outlying communities of **Serrated Tussock**, implementing on ground management of two core infestations, the strategic placement of containment lines to contain this spread south, west and north of the core infestations on the New England Tablelands and the eastern section of the Slopes within the Inverell Shire.

Chilean Needle Grass has a large hold within the slopes and tablelands of the catchment. The project promotes grazing management techniques through workshops to landholders to increase their knowledge of Chilean Needle Grass and promotes the use of grazing management as a tool for reducing the impact of this species through strategic grazing to stop seed set and dispersal while encouraging greater competition of desirable pasture species.

Gorse is located along Boorolong Creek at Armidale and a herbicide eradication program was proposed in year one of the project with landowners carrying out the second pass.

The distribution of **Bridal Creeper** is largely unknown. NIWAC is aware of at least 3 infestations within the New England Tablelands. As part of this contract, those known infestations will be managed through on ground works. Awareness raising activities

will raise the capacity of both the community and weed authority personnel to recognise the species.

All of the programs will result in the long term decrease in the extent and impacts caused by WONS within the BRG catchment.

Project Stakeholders

The project is a partnership between the Northern Inland Weeds Advisory Committee (NIWAC) and the BR-G CMA. The project is jointly managed by Jonathan Lawson BR-G CMA and James Browning New England Weeds Authority on behalf of NIWAC. A Steering Committee was established to develop the on ground strategy, allocate tasks and to develop media and educational opportunities.

Stakeholders include:

- Border Rivers Gwydir Catchment Management Authority,
- Northern Inland Weeds Advisory Committee,
- New England Weeds Authority, Glen Innes Severn Council, Tenterfield Shire Council, Inverell Shire Council, Southern New England Landcare, Glen Innes Natural Resource Advisory Committee, Granite Borders Landcare Committee.

Media and Education

The Landcare network was utilized to assist in delivering an awareness and education package throughout the region. This involved media releases, field days at key sites, display stands at local shows, live displays at local libraries, rural outlets and council offices. Perspex display cabinets were developed that provided interactive displays for the project.

Television advertisements were developed for Serrated Tussock and Chilean Needle Grass and existing advertisements for Bridal Creeper were utilized through partnerships with the Namoi Catchment Management Authority. These were broadcasted at key times throughout the region at times when the species targeted were easy to identify.

On Ground Works

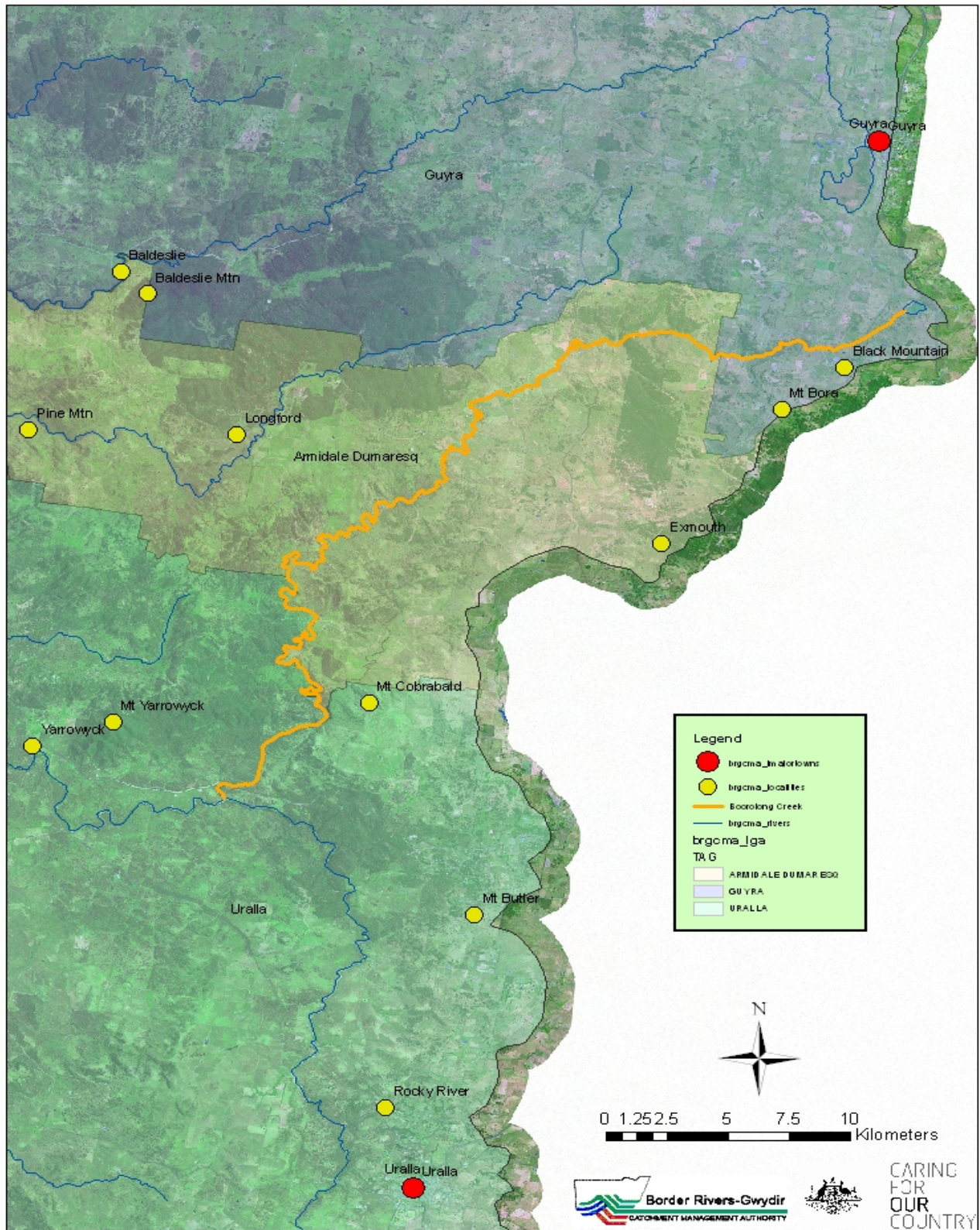
Gorse

Gorse was originally planted as an ornamental garden plant adjacent to the Boorolong River. Once established on the riverbanks it spread over 21kms of the river system through open grazing land and gorge country. Landowners had commenced a spray program in areas that were easy to access and where making solid progress.

On ground works were carried out by New England Weeds Authority (NEWA) staff in Autumn 2010 and follow up work was completed along the length of the infestation concentrating on the hard to access areas where control had not been possible.

Affected landowners carried out a second pass in spring 2010 reducing the infestation to light levels with the New England Weeds Authority carrying out regular inspections to ensure that the infestation remains suppressed.

Boorolong Creek Gorse Location



Bridal Creeper

Education and awareness programs were carried out in the first year of the project with no new infestations reported or discovered. Awareness raising activities will continue during the life of the project to ensure Bridal Creeper does not establish in the region.

Chilean Needle Grass

Education and awareness raising programs were carried out in the targeted areas to promote identification and management techniques. On ground works are set to commence in the second year of the project targeting isolated infestations.

Serrated tussock

Representatives from Inverell, Glen Innes and Tenterfield Shire Councils and the New England Weeds Authority met prior to commencement to formulate an investigation process to determine locations and densities of infestations within their shire boundaries. Infestation locations were recorded by GPS and Tr@cer Weeds. These locations were then exported into the BR-G CMA Geographical Information System to create spatial maps. Though the inspected by ground to determine the extent of infestation, a control program was introduced at a property level as required.

Aerial inspections were carried out in September 2010 and January 2011 to detect new infestations with one small infestation being discovered.

Increased landowner contact combined with education and awareness activities resulted in another two small infestations being detected.

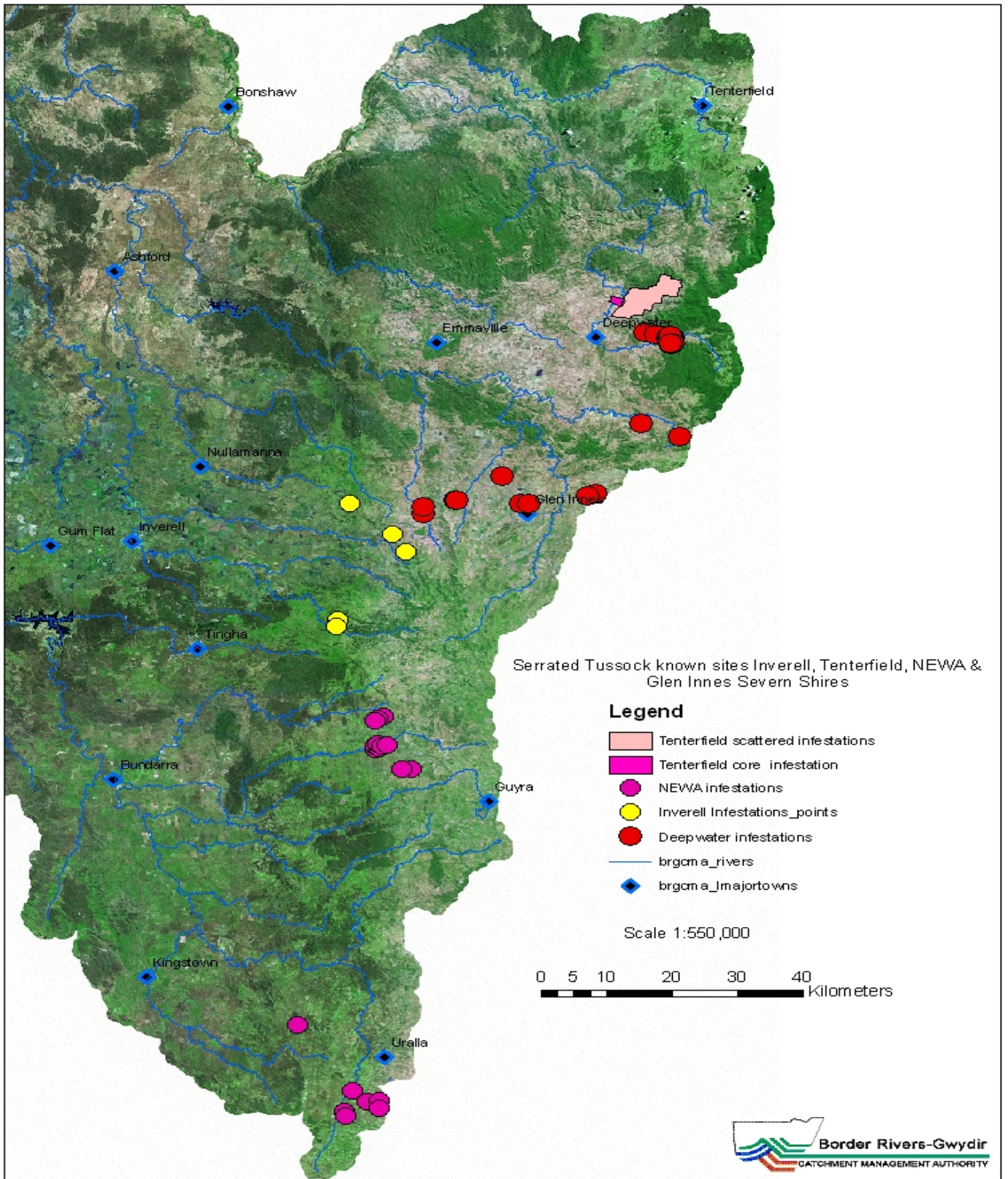
All but two of the sites were able to be treated by hand removal or spot spray methods and will be monitored by the respective weeds officers during the next two seasons to further reduce infestation levels.

Two sites, one at Deepwater and the second at Glen Innes were found to contain significant levels of Serrated Tussock, mainly due to difficult terrain involved. A three year management plan was developed, for each site, in conjunction with landowner consultation and assistance from a local agronomist. On ground works involved short term cropping phases in arable areas and long term pasture programs in difficult to access areas.

Paddocks were boom sprayed by helicopter and pasture improvement carried out by rock drilling or sown by aerial application in April 2011. As part of the land owners' contribution to the project paddocks were subdivided and control in lightly infested areas was carried out.

Results at this stage are promising with only the first stage of the three year program complete.

Map shows known sites of Serrated Tussock within Inverell, Glen Innes, Tenterfield Shire Councils and New England Weeds Authority.



Conclusion

Overall the project has been highly successful and created regional partnerships and awareness of Weeds of National Significance throughout the region.

The Commonwealth Governments Caring for Our Country investment in reducing the impact of WONS and BR-G CMA commitment to the Caring for Our Countries targets have enabled the introduction of containment lines. Active control programs and regular monitoring are being carried out in lightly infested areas and core infestations of Serrated Tussock are now under active management.

The project will continue to maintain the Serrated Tussock program for the next two years and will focus on Chilean Needle Grass and Bridal Creeper in the coming season.

Acknowledgements

Matt Foster
Grazag
Armidale NSW 2350

Border Rivers Gwydir Catchment Management Authority,
Northern Inland Weeds Advisory Committee,
New England Weeds Authority, Glen Innes Severn Council, Tenterfield Shire Council, Inverell Shire Council, Southern New England Landcare, Glen Innes Natural Resource Advisory Committee, Granite Borders Landcare Committee

References

Cowan, TF., Sindel BM., Jessop RS., Browning JE. The Distribution and Spread of *Nassella trichotoma* (Serrated Tussock) With A View To Improving Detectability, Containment And Eradication

Campbell M.B. Only Well Managed Sown Pastures Provide Permanent Serrated Tussock Control 1960

Trotter T.F The Ecology and Management of *Nassella trichotoma* on the Northern Tablelands of New South Wales

BUILDING LASTING NATIONWIDE GORSE MANAGEMENT PARTNERSHIPS USING MEMORANDA OF UNDERSTANDING (MOU)

Michael Noble
Weeds of National Significance Coordinator – Gorse
Tasmanian Government Department of Primary Industries, Parks, Water &
Environment
PO Box 303
Devonport TAS 7310

INTRODUCTION

Gorse (*Ulex europaeus*), a prickly shrub weed with yellow pea flowers, originates in Western Europe and the British Isles, and was introduced to Australia in the early 1800s. It now occupies extensive areas of southern Australia, and is one of Australia's Weeds of National Significance (WoNS).

A feature of gorse critical for consideration in weed management is its remarkable seed viability time span. Gorse seed is potentially viable in the soil for many decades. To strategically eradicate gorse in key parts of Australia, efforts must continue in a regular manner for up to several decades or more.

The National Gorse Taskforce in 2007 initiated the signing of 25-year memoranda of understanding (MOUs) with key partners, as a mechanism to achieve strategic eradication. 25-year gorse eradication MOUs have now been signed with 19 local governments, regional authorities and other organisations across Australia. This initiative has proven very successful thus far, and additional community inclusion and recognition initiatives have been implemented to build on this.

GORSE – A LONG TERM CHALLENGE FOR SOUTHERN AUSTRALIA

Gorse (*Ulex europaeus*) is a medium to tall perennial, leguminous, prickly shrub (growing to 4m, but usually less than 2.5m). It has bright yellow pea flowers appearing primarily in autumn and spring. Please refer to Figure 1.

Originating in Western Europe and the British Isles, gorse grows as a component of heath lands (e.g. in England), occupies neglected lands and is used as an ornamental plant and forage crop (Panetta *et al* 1998).

The species “was introduced to Australia during the early 1800s as a hedge and ornamental plant” (Gouldthorpe *et al* 2009, p.14). Gorse now inhabits 23 million hectares of the Australian continent and infests up to one million hectares. Its potential range in Australia is 87 million hectares (Gouldthorpe *et al* 2009). Gorse is extensively established in southern states (particularly Tasmania and Victoria), but has potential for spread through much more of southern Australia.

In NSW, core gorse infestations are found in the Southern Tablelands, South East, Blue Mountains and Lithgow areas in particular. However, outlying infestations are found as far north as the New England Tablelands. The potential range of gorse in NSW extends significantly beyond its current distribution.



Figure 1.

Gorse (Ulex europaeus)

In the Australian environment, gorse presents a broad range of issues and impacts, both environmental and economic in nature.

Extensive areas of agricultural and forestry lands in southern Australia are compromised or effectively rendered unavailable for use, due to the presence of gorse and gorse infestations. For example, heavy gorse covers 30 000ha of the Tasmanian Midlands (sheep country) and annual production losses were at least \$1 million in 2002 here alone (Gouldthorpe *et al* 2009).

Primary control of gorse infestations is expensive, and a program of follow-up lasting at least 25 years is required for successful management of infestations. Gorse seed has been found to retain 85% viability for up to 26 years (Panetta *et al* 1998). Follow-up actions are not usually as expensive, but require long term, regular commitment.

Gorse infestations reduce the financial value of agricultural lands. For example, in 1999 agricultural lands in the Victorian Central Highlands were considered to be reduced in value by \$220/ha, due to the presence of gorse (Gouldthorpe *et al* 2009).

Gorse invades native vegetation where it reduces native floral diversity and alters fire behaviour (Gouldthorpe *et al* 2009). Gorse is highly flammable and burns with intense heat. It provides ready ignition points for fires, and when it burns can cause and/or exacerbate damage to infrastructure and native vegetation.

Another major problem with gorse is that it harbours feral and pest animals. Gorse thickets provide habitat for rabbits, feral cats, house mice and foxes (Gouldthorpe *et al* 2009).

Gorse is a declared weed (or equivalent) in each state and territory in Australia. In NSW, gorse is declared under the *Noxious Weeds Act 1993*.

Weeds of National Significance Status for Gorse

In 1999, gorse was selected as one of 20 initial Weeds of National Significance (WoNS). This selection was made due to “its invasiveness, potential for spread and economic and environmental impacts” (CRC for Australian Weed Management 2003, p.1).

In 2003, a WoNS Gorse National Strategy was published. The National Strategy directed the national gorse program be focussed on five key areas. These are:

- Best practice management of established infestations implemented across Australia
- Prevent spread from established infestations
- Eradication of isolated and scattered infestations
- Management of at-risk areas to maintain them free of gorse
- National Gorse Taskforce (NGT) – be formed so that the strategy for gorse control is effectively managed at the national level

In 2004, a National Gorse Coordinator was appointed and National Gorse Taskforce formed.

In 2006, the WoNS Gorse National Best Practice Manual was produced. This was revised and reprinted in 2009.

LASTING PARTNERSHIPS - 25-YEAR GORSE ERADICATION MOU

The longevity of gorse seed (remaining viable for 25 years or more), and requirement of staged management and monitoring over time, are primary considerations with regard to gorse management programs. These are key reasons for the National Gorse Coordinator and Taskforce recognising the need for a lasting legacy from the gorse WoNS program. Gorse management efforts initiated during national coordination period (which is set to largely conclude by 2012), must receive ongoing attention well into the future, otherwise the on ground results will not be sustained.

In 2007, the initiative was taken to develop and sign 25-year memoranda of understanding (MOU) with local government, regional bodies and other relevant organisations (e.g. Tasmanian Parks and Wildlife Service). This mechanism morally (though in no way legally) binds relevant authorities to eradicate gorse from specified areas.

The MOU document provides background and scope with regard to gorse eradication to be achieved. Commitments by both the National Gorse Taskforce and the other signatory or signatories are outlined in the document. Typically, the NGT will:

- Provide best practice advice to ensure that the management approach of the infestations will lead to eradication
- Provide coordination and facilitation when requested to assist in the eradication project
- Promote and highlight the eradication project in the media for the benefit of both/all MOU parties

- Contact the other MOU signatory/signatories annually to seek an update on the eradication of infestations

Typically, the other signatory or signatories commit to:

- Facilitate eradication of all living gorse and the seed banks at the infestation sites
- Map the infestations to the National Mapping Standard as developed by the Bureau of Rural Science
- Ensure that gorse seed from infestations is not moved to infest other areas of the jurisdiction, chiefly through ensuring that hygiene measures are adequate in regard to preventing seed being moved
- Undertake annual inspections and destroy any regrowth or seedling germination to ensure that infestations do not produce any further seed
- Report annually to the National Gorse Taskforce

The first MOU was signed between the National Gorse Taskforce and the Kangaroo Island Natural Resource Management Board in SA during May 2007. Nineteen MOUs have now been signed across the nation. In NSW, the National Gorse Taskforce has signed gorse eradication MOUs with:

- Orange City Council
- Albury City Council
- Tumut Shire Council
- Bega Valley Shire Council
- Greater Hume Shire Council
- Kempsey Shire Council
- Glenn Innes Severn Shire Council
- Tenterfield Shire Council
- New England Weeds Authority
- Eurobodalla Shire Council
- Wellington Shire Council
- Cessnock Shire Council

Building on the MOU Initiative – Bright Yellow Gorse Batons

Building on the success of the MOU initiative, the National Gorse Taskforce in 2009 introduced a specially developed bright yellow gorse baton. Each new MOU signatory is allocated a baton containing a copy of the signed MOU, gorse mapping and other information. Also, a prominent local community member (community champion) is given an additional (smaller) baton and a copy of the MOU. This serves to involve the community directly and assists corporate memory within signatory organisations, to help ensure consistent and ongoing work to eradicate gorse in the agreed area.

The first combined MOU signing and baton handover was undertaken in Western Australia during 2009 between the National Gorse Taskforce and South Coast Natural Resource Management Inc. The relevant Australian Government Minister Tony Burke attended this event in Albany. Please refer to Figure 2.



Figure 2. Signing of the South Coast NRM Inc. MOU and presentation of the gorse baton. From left, Chair of the National Gorse Taskforce Ian Sauer, South Coast NRM Chair Alex Campbell, Minister Tony Burke and Community Champion Chris Gilmour.

The relevant Australian Government minister (currently Senator Joe Ludwig), retains a baton with copies of all MOUs signed nationwide. The Minister is sent additions to go in their baton as new MOUs are signed. Whilst he was Minister, Tony Burke notified the NGT that the baton had pride of place in his Canberra office.

The use of MOUs has provided important leverage for local weed management staff in jurisdictions throughout Australia. MOUs have provided a beneficial support in obtaining funding for gorse management exercises.

A CASE STUDY – RESULTS IN WESTERN AUSTRALIA

Gorse in Western Australia is restricted to the south of the state. Gorse in WA is within the South Coast Natural Resource Management Inc. region. In 2009, the National Gorse Taskforce and South Coast Natural Resource Management Inc. signed an MOU for “eradication of gorse in Western Australia”. This is a realistic goal as gorse infestations cover

less than 100ha in Western Australia, and are restricted primarily to an area within 50km of Albany (Moore and Kennewell 2010).

The National Gorse Taskforce and South Coast NRM sought and gained funding from the Australian Government Defeating the Weed Menace program to undertake a project which has seen the bulk of primary gorse control in WA completed. At least 95% of the gorse in WA has now received primary control, and the focus is now very much on ways to increase the speed of seed bank depletion.

Recognising nationally outstanding gorse management achievers

In 2010, the National Gorse Taskforce decided to launch a further initiative with the introduction of Nationally Outstanding Gorse Management Achievers Recognition. So far two people – Margaret Hatton of Kilmore (Vic) and Anton Kurray of Mt Gambier (SA) – have been recognised by the Taskforce for their nationally outstanding efforts in managing gorse in their areas. They have been presented with a certificate of recognition contained in a bright yellow gorse baton.

The National Gorse Taskforce hopes to recognise other nationally outstanding gorse management achievers in 2011, and continues to seek worthy nominees.

CONCLUSION

The National Gorse Taskforce recognises the need for consistent and ongoing efforts by governments and community if eradication of gorse in key areas is to be achieved. The short term nature of natural resource management funding cycles and staff turnover, necessitate additional mechanisms if targeted eradication of persistent weed species is to be achieved.

The National Gorse Taskforce recognised this, and introduced MOUs. The gorse baton and national recognition for individuals have built on this foundation. These measures will continue the work toward nationally targeted gorse eradication well into the future.

ACKNOWLEDGEMENTS

Michael Noble is the fourth WoNS National Gorse Coordinator, and substantially benefits in the role from the work done before him by Sandy Leighton, Dean Vincent and Michael Rowland.

BIBLIOGRAPHY

CRC Weed Management, 2003, *Weeds of National Significance Weed Management Guide Gorse – Ulex europaeus*, Department of the Environment and Heritage and the CRC for Australian Weed Management

Gouldthorpe, J. *et al*, 2009, *Weeds of National Significance Gorse Best Practice Manual*, Department of Primary Industries and Water, Hobart, Tasmania.

Moore, J. H. and Kennewell, M., 2010, The gorse (*Ulex europaeus*) eradication programme in Western Australia, In: S.M. Zydenbos, ed. *Proceedings of the Seventeenth Australasian Weeds Conference*, 26-30 September 2010 Christchurch. Christchurch, N.Z: New Zealand Plant Protection Society, pp. 107-110.

Moore, J.H., Sandiford, L., Austen, L., and Poulish, G., 2006, Controlling gorse seedbanks, In: C. Preston, J.H. Watts and N.D. Crossman, eds. *Proceedings of the Fifteenth Australasian Weeds Conference*, 24-28 September 2006 Adelaide. Adelaide, S.A: Weed Management Society of South Australia Inc., pp. 283-286.

Panetta, F.D., Groves R.H. and Shepherd, R.C.H., eds., 1998, *The Biology of Australian Weeds Volume 2*,
Meredith, Victoria : R.G and F.J. Richardson.

A Strategic Approach to Athel Pine Management in NSW

From National to Local

Kay Bailey
National Athel Pine Coordinator
NRETAS, Alice Springs

(Co-authors: Don Mackenzie
Bourke Shire Council
Andrew Cosier
Wellington Council)

INTRODUCTION

Athel pine (*Tamarix aphylla*) is a Weed of National Significance (WoNS) that in the past was widely planted throughout arid and semi-arid Australia as a shade tree and for wind protection. It is an evergreen tree that grows to 18m and tolerates saline and drought conditions. It was introduced to the Whyalla area in the 1930s. Cuttings were then widely spread around Australia at homesteads, bores and communities until the 1970s. More recently athel pine was planted to remediate mine sites and areas affected by soil salinity. It has thrived in coastal, riparian, sand dune, rocky and clay areas.

Athel pine was a classic ‘sleeper weed’, planted throughout Australia until conditions became right for it to spread. It was first identified as a major problem after the 1974, 1988 and 1997 exceptionally wet years in central Australia when 600kms of the Finke River became infested (Gouldthorpe, 2008). An extensive control program has since lessened the issue in the upper Finke but the lower Finke River south of Alice Springs remains severely infested. Inland water systems and environments in New South Wales, Queensland, South Australia, Western Australia and Victoria also have weedy populations. The planted range of athel pine in Australia is much larger than its naturalised, or wild, range. On this basis, the potential for spread or expansion or range remains high.

THE NATIONAL STRATEGY

Australia spends considerable time and money each year in combating weed problems and protecting ecosystems and primary production public land. Weed problems are complex, with multiple causes, and reducing their impacts needs to be coordinated. It was this knowledge that led to the development of the Australian Weeds Strategy (Natural Resource Ministerial Council, 2007), which provides a framework and identifies priorities for weed management across Australia including established weeds of national significance. One of the goals of the strategy is to restrict the spread and/or eradicate established weeds and the WoNS initiative was established in 1999 as a component to implement this goal.

Declaration of athel pine as a WoNS also occurred in 1999. Two years later a national strategy was published (ARMCANZ, ANZECC & FM, 2001) that aimed to prevent further infestations and to minimise the impact of current athel pine infestations on industry and the environment. It was recognised that athel pine occurs across the majority of borders in

Australia and that a national approach was required to provide successful and integrated management.

In 2006 the first National Athel Pine Coordinator was appointed by the Northern Territory government with financial support from the Australian Government through the Defeating the Weeds Menace Program. The role of the national coordinator is to facilitate actions identified in the 2001 national strategy. A management committee with representatives from all affected jurisdictions as well as community members was set up to coordinate the implementation of the national strategy, identify research priorities, monitor and report on progress and to maintain a national focus. The Australian Government continues to provide on-ground funding support through the Caring for Our Country program.

Key goals of the national athel pine program were to prevent spread of the weed into clean areas and to reduce impacts in areas where it already exists. This is consistent with the Australian Weed Strategy goals to reduce spread and eradicate where possible. Achievement of these goals was dependent on a strategic approach that identifies priority actions and geographic or ecological areas. Components of such a strategy included surveying and mapping of priority areas; awareness raising; determining high risk areas; on ground control of high risk amenity plantings and weedy infestations; recording treatment and results; and review of the program.

Such an approach recognises that control of small infestations through cost effective, proven, best practice techniques will prevent larger infestations in the future that require extensive resources in order to control. It also incorporates designation of larger infestations as control zones where the aim is to prevent further spread and reduce adverse impacts over time.

Mapping of both planted and naturalised athel pine has been undertaken at a national level. This has led to determination of priority high risk areas for both awareness raising and control work in all states where it occurs as well as the Northern Territory. The lower Finke River has been designated a control zone. Eradication targets have been set in Queensland, the Northern Territory and Western Australia and outlier infestations identified for further treatment and control in New South Wales, South Australia, Western Australia and Victoria. These targeted management actions have directed priorities for Caring for Our Country and other funding opportunities for control work.

The national program has brought together the results of research and trials into the best methods for treating athel pine and produced a best practice manual. This manual has been used as a key resource during workshops that have been run in the identified high risk areas thus improving recognition of athel pine, the impacts it causes and the potential for further spread.

An essential element of a strategic approach is review, evaluation and feedback. The Australian Weeds Committee undertook a review of progress toward implementation of the national strategies for all WoNS, including athel pine, in 2009. Recommendations have been incorporated into a revised National Athel Pine Strategic Plan for the next five years (National Athel Pine Management Committee, 2011). To encourage ongoing commitment and ownership by stakeholders, public consultation on the revised plan was sought. The aim is to maintain ongoing strategic programs and address critical management and research needs for the next five years.

Assessment of progress with the national athel pine program has determined that this weed will become a Phase 3 WoNS on 1 July 2012. Systematic, strategic planning and implementation has enabled this progress to be achieved.

NSW STATEWIDE APPROACH

The management of invasive species including WoNS in NSW is directed by the 2008 New South Wales Invasive Species Plan (NSW Department of Primary Industries, 2008). This Plan uses a risk-based approach to outline a coordinated response by stakeholders and guides investment through the Weeds Action Program.

Athel Pine is a Class 5 restricted plant under the *Noxious Weeds Act 1993* and thus no sale, trade or movement of any athel pine material is permitted. There is no legislative requirement in NSW to undertake control of athel pine.

In 2010 a Weed Risk Management assessment for athel pine in NSW was undertaken in accordance with the State Weed Risk Management System. This system is consistent with the National Post-Border Weed Risk Management Protocol and provides a standard, nationally accepted process to help make decisions about declaration and prioritisation of weed species.

Athel pine distribution and abundance information was provided by local government noxious weeds officers in 2007 and again in 2010 to develop a state athel pine presence map (NSW Government: Industry & Investment, 2008). However there are some key infestation locations not identified on that map. The national mapping process has commenced recording the actual point locations of both planted and naturalised athel pine throughout NSW. The risk of spread status of each recorded site is also noted in order to identify high risk sites that are close to watercourses. This mapping has generally been opportunistic but has also utilised surveys in some local government areas and an aerial survey in the Western Catchment Management Authority (CMA) region adjacent to the SA border. This information could assist in the determination of priority sites for protection of key assets from current infestations and from where future spread might occur.

Awareness raising in some areas through the Regional Weeds Advisory Committees has been productive in ensuring that athel pine is identified as an issue, that mapping has occurred and management action plans developed. The two local government case studies discussed later for the Shire of Bourke and Wellington Council illustrate the strategic response that is feasible in these regions. However there is a need to extend this approach to other regions.

NSW has had a state representative on the National Athel Pine Management Committee (NAPMC) since its inception. In 2010 it was suggested by the State representative and the National Coordinator, that a stakeholder forum be held of those interested, or involved, in athel pine management in NSW to develop a strategic, prioritised approach towards management of athel pine. This follows the approach in South Australia and Western Australia where such forums developed Action Plans that distinguished high priority sites and actions; and ensured review and evaluation of the extent of implementation of the management actions over time. The Athel Pine Forum being run at the conclusion of the 16th NSW Weeds Conference aims to develop an agreed action plan for this state.

LOCAL CONTROL AUTHORITY: SHIRE OF BOURKE

In NSW, local government has been responsible for implementation of noxious weed management since 1906 and plays a major role in reducing the impact of declared weeds in their area. Not only are Councils responsible for controlling weeds on land that they own or control, but also for ensuring that all land owners or occupiers of private land fulfil their obligations under the *Noxious Weeds Act 1993*.

In 2006 Bourke Shire Council developed a five year management plan aimed at removing all 498 known athel pines from inside the levy bank around the town. Athel pine was identified as a potential issue for the Shire after Weeds Officer, Don Mackenzie, visited the infestations along the Finke River earlier that year as an inaugural member of the NAPMC. Gaining agreement for the 5 year Management Plan was assisted by memories of a naturalised infestation of athel pines occurring on the town levy banks after the 1974 flooding of the Darling River. These plants had been successfully removed.

Gaining acceptance that athel pine control was an issue and developing the Council management plan were the first, and essential, steps in the Council's strategic approach to this WoNS. In Don's words the biggest challenges since have been the high cost of removal, getting other stakeholders to recognise the issue and act, and the lack of management plans for this WoNS in NSW.

Don approached the task of getting other stakeholders on board by proposing to the Macquarie Valley Regional Weeds Advisory Committee (MVRWC) that a Regional Weed Management Plan be developed. Approval led to the development and adoption of a 5 year Plan for Bourke, Cobar and Dubbo LCAs from 1 July 2007 (NSW Department of Primary Industries, 2007). Other Councils have since become part of this Plan. The objectives of this Plan have influenced actions throughout the Macquarie Valley Region and cover identification of infestations; management of all core infestations on Livestock Health and Pest Authority (LHPA) and Council land; containing all isolated infestations on LHPA and Council land; managing all infestations on private land; and implementing a community awareness program. All Objectives have been progressed within Bourke Shire Council.

Partnerships with other stakeholders have assisted resourcing, including funding. The Western CMA has funded athel pine removal projects in 2007 (91 trees) and 2010 (60 trees). Koinonia Christian Academy in Bourke, the Bourke Golf Club and Bourke Shire Council have all contributed financially and/or in kind to remove a total of 195 of the highest priority trees. The Bourke Shire Council has now made an annual allocation for athel pine control work as part of the Macquarie Invasive Species Project under the NSW Weed Action Program. Having both Shire and the Regional athel pine management plans assists in gaining support for mapping, treatment and awareness activities.

Trials of different herbicide and application rates were undertaken by Don, with results taken on board and techniques modified over time. Cut stump, painting with Grazon Extra and stump grinding about 2 months after treatment has proved to be the most effective technique. Costs have been calculated for chemical use (\$4.31 per tree) and for the stump grinding (\$130.00 per tree).

Displays on the impacts of and identification of athel pine have been presented at a number of local shows and other events since 2006 to increase the community awareness of athel pine. The National Athel Pine Coordinator was invited to Bourke to talk to the MVRWC meeting in 2009. Field inspections of the treatment work around the Bourke township and the provision of identification and best practice information provided has led to identification and mapping of athel pine in other Shires.

The Bourke Shire Council 5 year Athel Pine Management Plan is due for review. Whilst the goal of all 498 trees has not been met with 303 remaining, a planned approach according to identified priorities allows for an ongoing progress to achieve a common goal as resources are available.

LOCAL CONTROL AUTHORITY: WELLINGTON COUNCIL

Wellington Council is part of the Macquarie Valley Weeds Advisory Committee (MVWAC). Although not one of the original Councils signatories to the 2007 MVWAC Athel Pine Regional Management Plan, the Council has since adopted this Plan and is implementing all five of its objectives.

In 2009, the Wellington Council Weeds Officers were made aware of athel pine as a Weed of National Significance and shown how to identify it at a MVWAC meeting in Bourke. Subsequent surveying located 33 trees which were mapped and a specimen sent to the NSW Herbarium for formal identification.

A Management Plan for Athel Pine in the Wellington Council area was developed allocating the highest priority for treatment or action to trees within the riparian zone of the Macquarie and Bell Rivers. This recognised that the greatest risk of spread of seed and vegetative material of athel pine occurs via watercourses.

Education of private landowners was included in the Management Plan and has occurred with contact made and information regarding the legislative status of athel pine provided along with encouragement to remove the trees.

Council officers undertook treatment of the high priority sites including one possibly weedy athel pine on private land and one on Council land, using methods recommended in the National Athel Pine Best Practice Management Manual (Gouldthorpe, 2008). Follow up of these sites in April 2011 resulted in a small amount of regrowth being treated.

Mapping of any further sightings has continued, as has publicity and landholder notifications.

A review of the Management Plan early in 2011 showed that capacity to identify athel pine and knowledge about the potential impact was needed as many of the landowners had not responded to the inspection reports. Consequently, information days are planned for the Wellington Show, Central West CMA field days and local area field days with the Central West Health and Pest Authority.

The Council has also commenced discussions with landowners where the larger numbers of athel pine trees are located to seek funding for removal.

The Weeds Officers in the Wellington Council have undertaken and continued all elements of a strategic approach to athel pine management within their area. In the long term, whilst athel pine may not be the highest priority weed for this Council, developing a Plan, implementing it, reviewing results and modifying key actions has led to improvements that may prevent a much bigger weed control problem.

CONCLUSION

The case studies outlined in this paper from the national, NSW state and local level showcase the transition towards strategic programs for management of athel pine and the progress that can be made when such an approach is adopted. Strategic elements necessary, and included, in these case studies are surveying and mapping of priority areas; awareness raising; determining high risk areas; on ground control of high risk amenity plantings and weedy infestations; recording treatment and results; and review of the program. Further implementation of this approach elsewhere would be beneficial for management of this Weed of National Significance.

ACKNOWLEDGEMENTS

The Australian Government *Caring for Our Country* program funds the National WoNS Coordinator for *Mimosa pigra* and Athel Pine position whilst the Northern Territory Department of Natural Resources, Environment, The Arts and Sport hosts the position.

The principal author would like in particular to thank Don Mackenzie and Andrew Cosier, not only for their contribution to this paper, but also their commitment to ensuring that athel pine control is undertaken in the respective areas in a professional and planned manner.

REFERENCES

- ARMCANZ, ANZECC & FM (2001), *Weeds of National Significance National Athel Pine Strategic Plan*. National Weeds Strategy Executive Committee, Launceston.
- Gouldthorpe, Jonah (2008), *Athel Pine National Best Practice Management Manual*, National Athel Pine Management Committee, Northern Territory Government.
- Natural Resource Management Ministerial Council (2007), *The Australian Weeds Strategy: A national strategy for weed management in Australia*, Commonwealth of Australia.
- NSW Department of Primary Industries (2007), *Athel Pine Regional Management Plan*, Macquarie Valley Weeds Advisory Committee.
- NSW Department of Primary Industries (2008), *New South Wales Invasive Species Plan 2008-2015*, Orange.
- NSW Government: Industry and Investment (2010), *Tamarix spp athel pine*, map available at http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/339059/Tamarix-spp.pdf

PARTHENIUM WEED IN NSW

– a model for continuing success

Philip J. Blackmore
Invasive Species Officer (Weeds)
Department of Primary Industries
Armidale NSW

INTRODUCTION

Parthenium weed is a Weed of National Significance in Australia and has been one of the highest priority species in NSW since 1976. The weed is widely established throughout central Queensland (Parsons and Cuthbertson, 2001) where it causes significant production losses (Chippendale and Panetta, 1994) and human health problems (Navie *et al.*, 1998). Despite ongoing incursions since 1982, Parthenium weed has been prevented from establishing in NSW (Blackmore and Johnson, 2010) through the commitment to implement an ongoing strategy. The success of this program can provide a model for control of new weed incursions.

BACKGROUND

Parthenium weed is a fast growing annual with prolific seed production. Once established, it quickly builds a huge seed bank in the soil (Navie *et al.*, 1997) that makes eradication difficult and expensive. Parthenium weed contains powerful allergens that cause a range of human health problems, including asthma (Mitchell, 1981) and severe contact dermatitis (Towers, 1981).

Parthenium weed was introduced into Queensland as a contaminant of pasture seed in 1958 (Everist, 1976). It became naturalised in the Central Highlands region of that state where spread was aided by land clearing operations during the Brigalow Scheme (Holman, 1981). The impact of Parthenium weed was not appreciated until a series of favourable seasons commencing in 1973 promoted an alarming increase in spread and density (Haseler, 1976). It is now endemic throughout the Central Highlands area and regular isolated outbreaks occur in all surrounding areas.

ANTICIPATING THE THREAT

Preparation for the anticipated onslaught from Parthenium has been a key reason for the success of the NSW Parthenium Weed Program. The NSW Department of Agriculture became aware of the threat posed by Parthenium weed in 1976 (Mears, 1976). Work to develop a strategic response to Parthenium weed incursion commenced in 1978 (Brown, 1978), four years before the first discovery of an infestation in NSW. The response identified potential invasion pathways and methods to intercept those pathways using existing resources.

PLANNING AND COORDINATION

Detailed planning involving all stakeholders and effective coordination has been essential to the success of the Parthenium weed program. Responsibility for the program rested with the Weeds Unit of the Department of Agriculture and the program coordinator was the Noxious Plants Advisory Officer based at Tamworth. Once Parthenium weed had been discovered in NSW a major planning meeting was held annually, prior to the start of the

winter cereal harvest. From the start, the aim of the program was “to prevent Parthenium weed from establishing in NSW” (Brown, 1983). This continued until 1993. For a period between 1993 and 1996 coordination was carried out from head office in Orange. During this time, although good work was done, contact was lost with some stakeholders due to the distance from the state border.

Commencing in 1996, the NSW Parthenium Weed Taskforce became the coordinating group for the NSW Parthenium Weed Strategy. The taskforce has had a single convenor based in Armidale from the start to the present. It has established representation from the Queensland Government, has re-established representation from the important industry stakeholders; NSW Farmers and the Australian Grain Harvesters Association and a NSW government stakeholder, the Cattle Tick Unit of the Department of Primary Industries. This unit operates the border crossings. New representation has been welcomed from the Border Rivers-Gwydir Catchment Management Authority. Representation from local control authorities has been continuous and committed. The taskforce meets biannually.

Weed of National Significance status has meant national coordination to implement the National Parthenium Weed Strategy through the National Parthenium Management Group. NSW is represented on this group. The major outcome from the national strategy has been containment of the core infested area to central Queensland. This has greatly assisted the NSW Parthenium program to meet its aim to prevent Parthenium weed from establishing in NSW.

The WoNS Parthenium weed program is now winding down and it is anticipated that the Parthenium weed Taskforce will continue the role of building interstate cooperation to control the spread of Parthenium weed.

COMMITMENT

The NSW Government has remained committed to the Parthenium weed program from its inception. This support has been critical to the success of the program.

RELATIONSHIP OF THE PARTHENIUM WEED PROGRAM TO THE INVASIVE SPECIES PLAN

The Parthenium weed program links directly to the NSW Invasive Species Plan under Goal 1: “*Prevent the Establishment of New Invasive Species*” and Goal2: “*Eliminate, or Prevent the Spread of New Invasive Species.*”

HISTORY OF INCURSIONS INTO NSW

Parthenium weed was first discovered in NSW in 1982 (Blackmore, 1997). Almost 800 infestations have been discovered in NSW between 1982 and 2010, the greater majority being in Moree Plains Shire (Blackmore and Johnson, 2010). The number of new infestations peaked in 1989 (figure 1.). All infestations have been eradicated or fully suppressed. Most infestations have occurred on roadsides and have consisted of less than 10 plants. A much smaller proportion of infestations have occurred on private property. 51 infestations on farmland have been discovered between 1983 and 2010 (Blackmore and Johnson, 2010). Most infestations have occurred in the north of the state to the west of the Great Dividing Range but infestations have also occurred in the central west plains and the Riverina (figure 2.).

New Parthenium Incursions in NSW

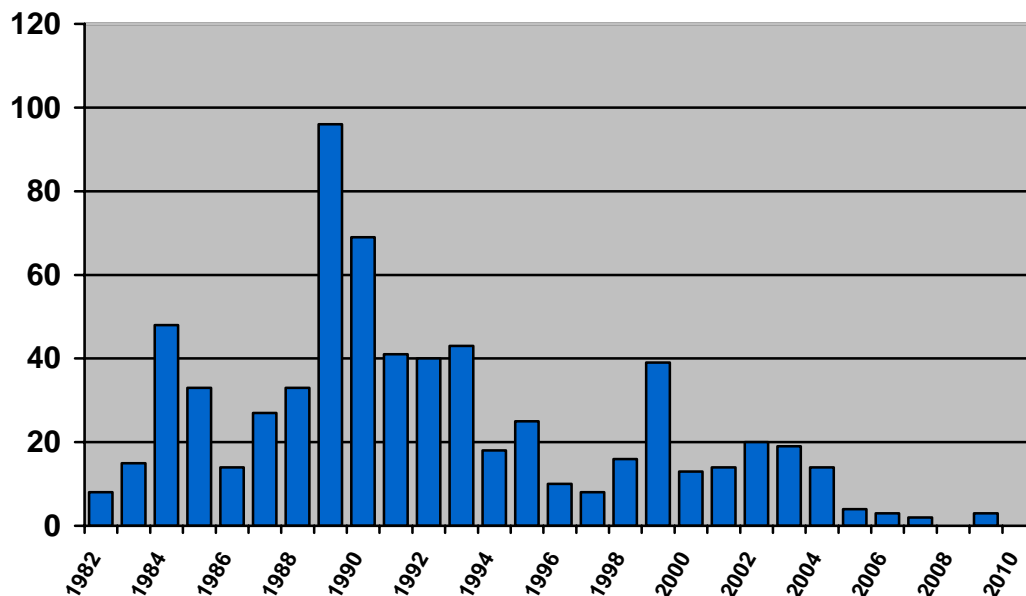


Figure 1. New Parthenium weed infestations in NSW 1982 - 2010

DISPERSAL

Parthenium weed reproduces only by seed (Navie *et al.*, 1998). Its seed is adapted to spread in high flows along streams and waterways (Auld *et al.*, 1983). Seed can spread locally by whirlwinds (Haseler, 1976) and by wild and feral animals but long distance spread (jump dispersal) is solely through unintentional human agency. Vectors include; contaminated harvesting and earth moving machinery, vehicles, seed and produce (Haseler, 1976; Auld *et al.*, 1983). This type of dispersal provides significant opportunity for invasion pathway interception.

PATHWAY IDENTIFICATION AND INTERCEPTION

The core areas of Parthenium weed infestation in the late 1970's were outside the Murray-Darling Basin (Haseler, 1976). This meant that the threat of spread by natural forces into NSW could be discounted. The pathways that needed to be considered and that were most readily managed, were those that involved human activity.

The eastern Australian winter cereal harvest commences in central Queensland in late September and concludes in South Australia in January. Approximately 600 headers enter NSW from Queensland each year but this can vary between 100 and 850 depending on the size of the Queensland wheat crop. This seasonal shift of grain harvesting machinery was recognised as a major potential carrier of Parthenium weed seed before the first outbreak was discovered in NSW (Brown, 1978). Unregulated movement of harvesting machinery in NSW caused several outbreaks on farming land before it was accepted that cleaning requirements should be imposed at the state border (Brown, 1986). Legislation imposing this interstate quarantine restriction was introduced in 1984. Inspection was carried out by existing stock inspectors at the cattle tick inspection stations already in place.

Three clean-down sites at the main border crossing points of Goondiwindi, Mungindi and Hebel have been established by NSW Department of Primary Industries with support from the Natural Heritage Trust and Border Rivers-Gwydir CMA. These sites are each equipped with a large air compressor for cleaning headers. Wash down pads have been built at Goondiwindi and Mungindi.

New legislation covering the movement of harvesting machinery into NSW from Queensland was introduced in 1997 (*Noxious Weeds Amendment Act 1997* and *Noxious Weeds Regulation 1997*). Inspection procedures were upgraded in accordance with the new requirements. Since 1997, the number of new outbreaks of Parthenium weed that have been linked to grain harvesters has declined significantly (Blackmore and Johnson, 2010). In turn, this has meant a decline in all outbreaks on private property.

Other pathways have been assessed several times during the life of the program including; cotton harvesting machinery, hay and silage making machinery, earthmoving machinery, mining and mineral exploration machinery, livestock and livestock transports, cars and caravans, hay, grain and seed. All of these pathways fall within the group of human assisted spread. None has been considered sufficiently high risk to be actively regulated despite a small number of infestations that have been linked to some of them (Blackmore and Johnson, 2010).

Much of the machinery and some of the vehicles in this group are cleaned in south-central Queensland either voluntarily or in accordance with industry codes of practice before entering NSW. End point inspection has been a valuable interception tool for pathways including livestock transports and mineral exploration machinery, while cotton harvesting machinery is self regulating due to the threat of transmitting the root disease Fusarium wilt (Cotton CRC Extension Team, 2009).

By 2009 it had become evident that established infestations of Parthenium weed in the upper reaches of Maranoa and Balonne Rivers, northern tributaries of the Darling River, have created a pathway for spread to NSW by natural forces. To date no infestations have reached NSW by this route but local control authorities remain vigilant in regularly inspecting the waterways.

ACTIVE INSPECTION - SEARCH AND DESTROY

Local government is responsible for inspecting roadsides and private property and for controlling any new infestations of Parthenium weed on roadsides. Local government weeds officers have been very effective in finding and destroying new infestations of Parthenium weed on roadsides (Blackmore and Johnson, 2010). All known infestations on roadsides have been eradicated. The NSW Weeds Action Program supports these activities.

The greatest proportion of roadside infestations has occurred along the Newell Highway between Goondiwindi and Narrabri. Many of these infestations have been linked to deliveries of Queensland oilseeds to a crushing plant in Moree and to the sale of by-products as stockfeed (Brown, 1986). The plant was closed in 2001 and since then, roadside infestations in Moree Plains Shire have fallen almost to zero (Blackmore and Johnson, 2010). Numerous incursions have been discovered on other roads leading into NSW from Queensland.

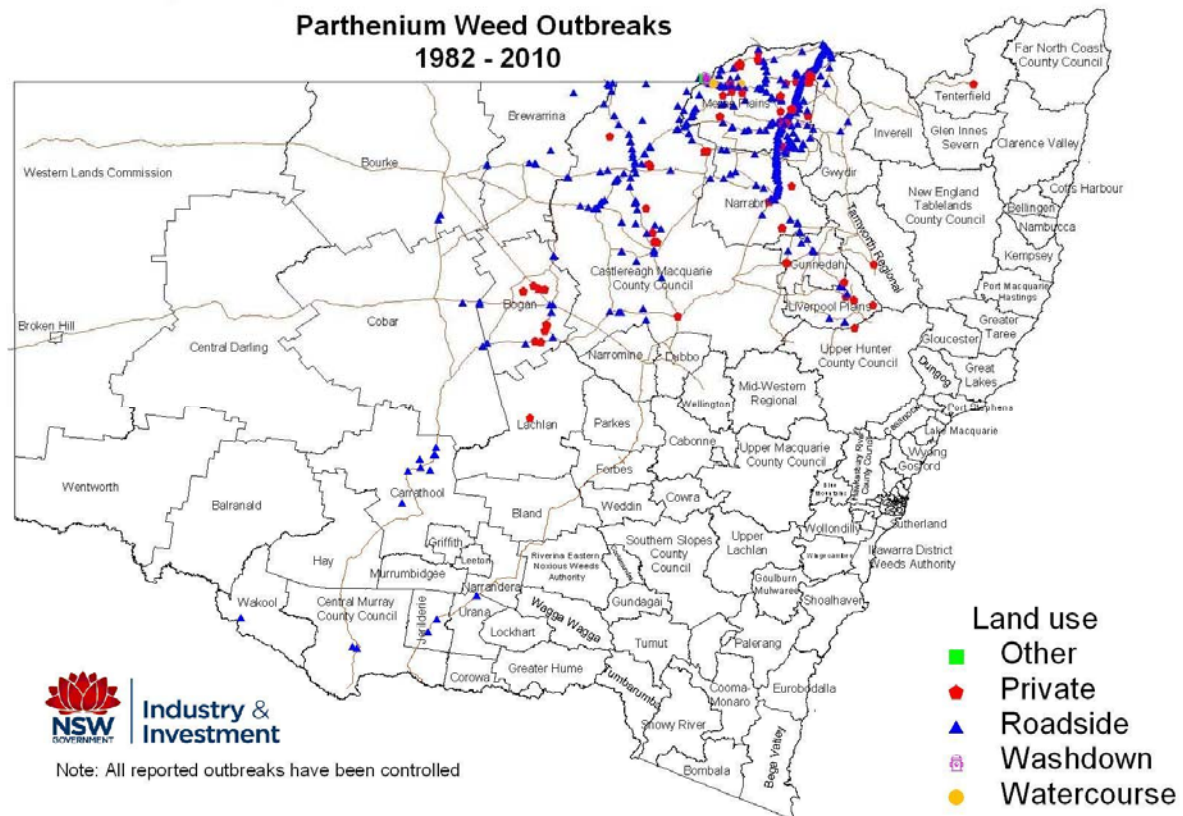


Figure 2. Parthenium weed infestations in NSW 1982 - 2010

Infestations of Parthenium weed on private property and particularly on farmland are much more difficult to find than roadside infestations and in the early stages of the program were more established when found. Discovery of these infestations has often been by a report from the landholder. It is mandatory for occupiers to report infestations of Parthenium weed. The Parthenium Weed Taskforce considered that incursion of Parthenium weed onto farmland by unintentional human agency was the most likely scenario for establishing a permanent population in NSW (Tanner 1995).

The increasing number and size of private property infestations in the late 1980's led Brown (1989) to consider that the fight to prevent Parthenium weed establishing in NSW may have been lost. However, the storm has been weathered. In the 5 year period 2001-2006 only 8 private property infestations were discovered and no private property infestations were discovered in the 4 years 2007-2010. (figure 1.)

PASSIVE INSPECTION THROUGH EXTENSION

Passive inspection occurs and is made by three groups from the community:

1. council outdoor staff such as grader and slasher drivers, and
2. agency staff from NSW DPI, Catchment Management Authorities and Livestock Health and Pest Authorities, and
3. rural landholders and the general community.

Council outdoor staff have been considered a valuable component of the control program since its inception (Brown, 1978). Annual training is recommended (Spinks, 2004).

Agency staff have regular contact with farmers and graziers and may observe or become aware of new infestations. Training is also recommended.

The recruitment of rural landholders and the general community to passive Parthenium weed surveillance has been considered of high importance to the success of the control program (Brown, 1983). Extension material including Agfacts, posters, slide shows and live plant displays, combined with media publicity of new infestations was developed and delivered (Brown, 1989).

However, by 1995, the Parthenium Weed Taskforce perceived that the success of the control program had created a lack of recognition and awareness of Parthenium weed due to its rarity in the field. The Taskforce considered that this lack of awareness may allow an ineradicable population to become established (Tanner, 1995). To reinvigorate the extension program, a campaign of television commercials and community service announcements was initiated, supported by new identification pamphlets and cards, refrigerator magnets, stickers and posters. Field days at outbreak sites and displays continued. A project officer was employed in 2000 to co-ordinate delivery of this campaign.

The television campaign commenced in 1996 and was still running in 2010. Four different television commercials have been developed and aired since the campaign commenced. Three of the commercials have focused on the Parthenium weed awareness and identification, while the fourth commercial focused on the importance of landholders reporting suspect infestations.

To measure the impact of the extension campaign a large scale mail out survey of rural landholders in the North West Livestock Health and Pest Authority district of NSW was conducted (Blackmore, 2009). This survey attracted 761 responses from 1990 surveys mailed.

Analysis of the survey revealed that:

1. Parthenium weed is a topical issue in north-western NSW.
2. Awareness of Parthenium weed by respondents in north western NSW is very high. The level of awareness is not correlated to proximity to infestations.
3. Newspapers and television commercials are the best media for building awareness of new weeds. The internet is not an effective method for the dissemination of news about weeds.
4. 50% of respondents in north western NSW have at least a reasonable level of confidence in their ability to identify Parthenium weed.
5. Among respondents, farmers are slightly more confident in their ability to identify Parthenium weed than graziers or absentee landowners.
6. Most respondents in north western NSW would report a Parthenium weed infestation on their property, although graziers were slightly more reluctant than farmers. Those who were not sure or would not report an infestation would mainly do this because they would not recognise Parthenium weed. A very slight antagonism to weeds officers was identified.

7. Respondents considered a fact sheet or ute guide to be the preferred tool for identifying Parthenium weed. The internet was not highly regarded as an identification tool.

CONCURRENCE WITH WEED SPREAD THEORY

The strategic approach taken by the Parthenium weed program is supported by weed spread theory. Auld *et al.* (1978/79) found that the faster the rate of spread of a weed, the stronger the rationale for government intervention to control the rate of spread. Parthenium weed had spread across central Queensland at an alarming rate and there was strong reason to presume that it would continue its spread into southern Queensland and NSW. Auld *et al.* (1978/79) were of the opinion that interception of weed seed carriers was at least as important as control of infestations in a rapidly spreading weed population. Compulsory hygiene inspection for grain harvesting machinery entering NSW from Queensland has been in place since 1984.

Moody and Mack (1988) determined that weeds that establish satellite infestations spread at a faster rate than weeds that spread from an invasion front. They also concluded that control of the satellites is a far more effective method to reduce the rate of spread than only controlling the parent infestation. As Parthenium weed spreads much greater distances and at a greater rate through human agency (jump dispersal) than through natural forces, discovery and control of satellite infestations has been essential to the campaign to prevent its establishment in NSW.

In their review of the weed spread theory as it applies to official weed control programs, Panetta and Scanlan (1995) critiqued work by Auld and Coote (1980) to model a spreading plant population. They observed that of the 4 factors described, the potential to manipulate:

- i. the proportion of annual seed increase that is dispersed beyond the core infestation and
- ii. the area over which this seed is dispersed,

is central to our ability to regulate weed spread. This approach has been the basis for the Parthenium weed program through the border quarantine for grain harvesting machinery and through containment of Parthenium weed in central Queensland by construction and use of public washdown facilities.

Panetta and Scanlan (1995) concluded that noxious weed legislation is most effective at an early stage of invasion and that the interception of the human assisted carriers of weed seeds should be officially regulated. The NSW Parthenium weed program commenced before this weed was discovered in NSW and the most important carriers of Parthenium weed seed, grain harvesting machinery, is intercepted at the Queensland border by statute.

NEW PROBLEMS

Parthenium weed is spreading into southern Queensland along several rivers and streams (Graham Hardwick, pers.com.). These rivers are the headwaters of the Murray-Darling Basin and flow directly into NSW. Prior to floods in early 2011, the infestations were upstream from St George Irrigation Area. This is closely managed agricultural country that should provide at least a temporary barrier to downstream spread. However, it is inevitable that further downstream spread will occur. Until now NSW has only needed to manage the spread of Parthenium weed through human agency. NSW must now plan for spread by natural forces.

The current mining boom has seen a greatly increased movement of mining exploration machinery and mine vehicles between central Queensland and NSW. Much of this traffic has been operating in areas of heavy *Parthenium* weed infestation.

CONCLUSIONS

The success to date of the NSW *Parthenium* weed program can be attributed to a number of factors:

- Preparedness,
- Early detection,
- Knowledge of dispersal mechanisms,
- Ability and willingness and to intercept invasion pathways,
- SMART planning,
- Effective coordination involving relevant stakeholders,
- Containment of the core infestation,
- Active inspection and destruction of new incursions,
- Passive inspection by the community promoted by extension,
- Commitment to implementing and resourcing the program.

Not all weed management programs will enjoy the ability to apply all these factors. Clearly the greater the number of factors that can be applied, the more successful the program will be. However, early detection is the key factor (Panetta and Scanlan, 1995).

REFERENCES

- Auld, B.A., Menz, K.M. and Monaghan, N.M. (1978/79). Dynamics of weed spread: implications for policies of public control. *Protection Ecology*, 1: 141-8.
- Auld, B.A., Coote, B.G. (1980). A model of a spreading plant population. *OIKOS*. 34: 287-92.
- Auld, B.A., Hosking, J. and McFadyen, R.E. (1983). Analysis of the spread of tiger pear and parthenium weed in Australia. *Australian Weeds*. 2, 56-60.
- Blackmore, P.J. (1997). *Parthenium Weed Update*. Proceedings of the 9th Biennial Noxious Weeds Conference. pp. 18-23. NSW Department of Agriculture, Dubbo.
- Blackmore, P.J. (2009). Survey of awareness and attitudes to *Parthenium* weed in north western NSW. Unpublished report. NSW Dept. of Industry and Investment. Armidale NSW. 17 pp.
- Blackmore, P.J. and Johnson, S.B. (2010). Continuing successful eradication of *Parthenium* weed (*Parthenium hysterophorus*) from New South Wales, Australia. Proceedings of the 17th Australasian Weeds Conference, Christchurch, New Zealand. Ed. S.M. Zydenbos. New Zealand Plant Protection Society. Christchurch, New Zealand. pp 382-5
- Brown, D. (1978). *Parthenium* weed survey, Goondiwindi May 1978. Unpublished report. NSW Dept. of Agriculture. Tamworth NSW. 3 pp.
- Brown, D. (1983). *Parthenium* weed programme. Unpublished report. NSW Dept. of Agriculture. Tamworth NSW. 4 pp.
- Brown, D. (1986). *Parthenium* weed in NSW – An overview. Unpublished report. NSW Dept. of Agriculture. Tamworth NSW. 6 pp.

- Brown, D. (1989). Discussion paper on Parthenium weed in NSW – Control and awareness programme. Unpublished report. NSW Dept. of Agriculture. Tamworth NSW. 15 pp.
- Chippendale, J.F. and Panetta, F.D. (1994). The cost of parthenium weed to the Queensland cattle industry. *Plant Protection Quarterly* 9, 73-6.
- Cotton CRC Extension Team. (2009). Cotton Pest Management Guide 2009/10, NSW Department of Industry and Investment, Orange, NSW. 144 pp.
- Everist, S.L. (1976). Parthenium weed. *Queensland Agricultural Journal*. 102: 2.
- Haseler, W.H. (1976). Parthenium hysterophorus L. in Australia. *PANS* 22 (4): 515-7.
- Holman, D.J. (1981). Parthenium weed threatens Bowen Shire. *Queensland Agricultural Journal*, 107, 57-60.
- Mears, A.D. (1976). Parthenium weed – will it cross the border? *Agnote* Unpublished report. NSW Department of Agriculture. Sydney. 2 pp.
- Mitchell, C. (1981). Aeroallergens and the respiratory tract. Proceedings of the 6th Australian Weeds Conference, Gold Coast, Queensland. Eds. B.J. Wilson and J.T. Swarbrick pp. 2:115-23. Queensland Weed Society, Broadbeach.
- Moody, M.E. and Mack, R.N. (1988). Controlling the spread of plant invasions: the importance of nascent foci. *Journal of Applied Ecology*, 25: 1009-21.
- Navie, S.C., McFadyen, R.E., Panetta, F.D. and Adkins, S.W. (1997). A study of the soil seed bank of parthenium weed in central Queensland. Proceedings of the Sixteenth Asian-Pacific Weeds Science Society Conference, Kuala Lumpur. Ed. A Rajan, pp. 74-8. Malaysian Plant Protection Society, Kuala Lumpur.
- Navie, S.C., McFadyen, R.E., Panetta, F.D. and Adkins, S.W. (1998). *Parthenium hysterophorus* L. in 'Biology of Australian Weeds, Volume 2'. pp. 157-76. R.G and F.J. Richardson, Melbourne.
- Panetta, F.D. and Scanlan, J.C. (1995). Human involvement in the spread of noxious weeds: what plants should be declared and when should control be enforced? *Plant Protection Quarterly*, 10(2): 69-74.
- Parsons, W.T. and Cuthbertson, E.G. (2001). Parthenium Weed in 'Noxious Weeds of Australia, Second Edition' pp. 292-6. CSIRO Publishing, Melbourne, Australia.
- Spinks, R. (2004). Parthenium weed training kit. Northern Inland Weeds Advisory Committee, Narrabri. NSW 98 pp.
- Tanner, L.R. (1995). Parthenium Weed Taskforce Report, Update 15th September 1995. NSW Department of Agriculture, Orange, Australia.
- Towers, G.H.N. (1981). Allergic exzematous contact dermatitis from parthenium weed (*Parthenium hysterophorus*). Proceedings of the 6th Australian Weeds Conference, Gold Coast, Queensland. Eds. B.J. Wilson and J.T. Swarbrick pp. 143-50. Queensland Weed Society, Broadbeach.

WEEDS IN PARADISE !
ERADICATION VERSUS CONTROL - AN 'ISLAND WIDE' LANDSCAPE
APPROACH TO WEED MANAGEMENT ON LORD HOWE ISLAND

Hank Bower
Manager Environment World Heritage
Lord Howe Island Board

Sue Bower
Flora Manager Officer
Lord Howe Island Board

Background

Lord Howe Island World Heritage Area is renowned for its spectacular scenery, biological diversity and the most southern true coral reef system in the world. With over 85% of the island vegetated, at first glance it is difficult to imagine this island paradise being threatened by weed species. As with any island ecosystem, Lord Howe Island (LHI) is vulnerable to the threat of invasive species, however its isolation also provides an opportunity to achieve complete eradication.

To protect the island's unique biological diversity, the Lord Howe Island Board (LHIB) is embarking on an ambitious programme to eradicate priority weeds. Eradication targets are set over a 30 year period, pending resourcing. Since the formal commencement of the program in late 2004 significant inroads have been achieved in reducing the spread and density of widespread weed invasions and removal of isolated weed outbreaks in the settlement. To date at least 3 species have been eradicated, Cat's-Claw Creeper *Macfadyena unguis-cati*, Bamboo *Arundinaria simonii* and African Rosewood *Tipuana tipu*.

Location and plant species diversity

Lord Howe Island (LHI) is part of New South Wales and is located about 760 km north east of Sydney. The island is approximately 11km long and up to 2.8km wide, rising to the south with Mt Lidgbird (777m) and Mt Gower (875m) at its highest point. LHI was inscribed as a World Heritage Property in 1982 and over 70% of the island is protected as a formal conservation reserve (the Permanent Park Preserve (PPP) under the *Lord Howe Island Act 1953*).

LHI supports a diverse array of habitats with many unique flora and fauna assemblages, exhibiting a high level of endemism. There are 239 native vascular plant species with over 45% endemic (113 species) with 5 endemic genera. Up to 34 vegetation communities are described for the LHIG with 18 of these of concern, due to threatening processes and/or very restricted distributions (e.g. gnarled mossy cloud forest and mangrove communities).

Weed Threat

The Lord Howe Island Biodiversity Management Plan (2007) identifies weed invasions as one of the main threats to the Islands biodiversity. Introduced plants greatly out-number native plant species with over 271 exotic species defined as weeds and a further 400 species found in cultivation. At least 50 exotic species have escaped into natural areas of the island.

Weed invasions can potentially impact all vegetation communities across the island. Several weed species have a wide environmental tolerance and exhibit ecosystem changing characteristics (with the ability to invade intact shaded habitats and dominate lower to mid stratum to the extent of inhibiting native recruitment). Detailed weed mapping undertaken in 2002/03 of the key weed species (Bridal Creeper *Asparagus asparagoides*, Cherry Guava *Psidium cattlianum* var. *cattleianum*, Climbing Asparagus *Asparagus plumosus*, Ground Asparagus *Asparagus aethiopicus*, Ochna *Ochna serrulata* and Sweet Pittosporum *Pittosporum undulatum*) revealed densities and distribution of weeds within the Permanent Park Preserve (PPP) being far greater than had been expected. See Figure 1 & 2 for spread of Cherry Guava and Ground Asparagus.



Photo 1. Former LHIB employee Lani Thompson, displays a Cherry Guava removed from weed mgt block LN-021 (west side Mt Lidgbird at 450m). Over 206 mature Cherry Guava's and 3 mature Ground Asparagus have been removed from LN-021. Caring for our Country has funded further high elevation guava work on LHI.

On LHI the most serious weed species are either fleshy fruited (and are dispersed by birds) or are wind dispersed. The main vectors of fleshy fruited plants are the Lord Howe Island Silvereye (*Zosterops lateralis* subsp. *tephropleura*), LHI Currawong *Strepera graculina crissalis* and Black Bird *Turdus merrula* (in the settlement).

Cherry Guava has proven to be a highly aggressive invader, having established from the Northern Hills through the Settlement and into the Southern Mountains as high as 650m elevation on the northern flanks of Mt Gower. To date over 632,471 individuals have been removed (Table 1) including over 1000 on Mt Gower requiring helicopter winch access. Cherry Guava is one of the top 100 invasive species on the Global Species Database (IUCN

Invasive Species Specialist Group (ISSG). LeCussan (2004) confirmed the invasive capacity of this species through research on the impacts and management of Cherry Guava on Pacific Islands in the USA, New Zealand and Mauritius & Ile deLa Reunion.

Legislation

The LHIB restricts plant imports through the *LHI Regulation* 2004 and strict Plant Importation Policies. The LHI Regulation prohibits the importation of any plant without prior approval from the Lord Howe Island Board (LHIB). The Policy details which plants are prohibited for import and other prescriptions. For example any new species not recorded on the Island must undergo a Weed Risk Assessment to determine their risk of invasiveness. Species that exhibit weedy characteristics are then prohibited from import.

At least 89 plants are declared noxious for LHI under the *Noxious Weed Act* 1993 (with 20 known to occur on island). Fifteen of these (including 3 *Asparagus* species) are now targeted for total eradication on all land tenures. Two noxious weed species, Tiger Lily *Lilium formosanum* and Crofton *Ageratina adenophora* are so widespread and found in inaccessible areas, that targeted management, not eradication is currently planned for these species. Research into the biological control of Crofton is underway. Three Weeds of National Significance (WONS) also occur on the island including Bridal Creeper, Bitou Bush *Chrysanthemoides monilifera* ssp. *rotundata* and Lantana *Lantana camara* (which is the least abundant of the three).

Noxious weed inspections are conducted across leases to ensure priority weeds are removed from the settlement area. These inspections provide a valuable opportunity to educate leaseholders on best practice control measures, identification of plants and to maintain an inventory of introduced flora. Inspections have identified the presence of serious weeds including Leaf Cactus *Pereskia aculeata*, Scotch Broom *Genista monspessulana*, Black Locust *Robinia pseudoacacia*, Climbing Nightshade *Solanum seaforthianum* and Cocos Palm *Syagrus romanzoffianum*. Early detection and control of known and potential weeds is essential to prevent their spread and reduce costs for control in the future.

An island wide approach to weed control

To achieve eradication requires a landscape 'Island wide' approach and reliable long term funding. In contrast to the mainland where eradication is often not feasible due to reinvasion. The chance of re-infestation on an island following eradication of target species is very low due to the distance from mainland Australia and provided effective quarantine is maintained.

The 'Island Wide/Landscape Approach' to weed eradication has been adopted from the New Zealand Department of Conservation Raoul Island Weed Eradication Project in the Kermadec Group. The approach aims to systematically grid search and control key invasive weeds from across the entire Island every two years (half the Island per year pending resourcing). However, blocks with vigorous weeds such as Madeira Vine *Anredera cordifolia*, Glory Lily *Gloriosa superba*, Climbing Asparagus and Ground Asparagus require more frequent treatment. As the weed density and distribution decreases, the time taken to treat weeds across the extent of the Island should also decrease, enabling all blocks to then be searched annually. It is important that the control of all mature fruiting plants is achieved in the early stages of the program to remove seed source and prevent replenishment of soil seed banks. A consistent downward trend in populations of all targeted weed species should be experienced over time; this can only be achieved through a consistent, timely and long term approach to on ground weed control.

LHI is mapped into 414 weed management blocks over 9 main landscape units (Figure 1 and 2). Weed control blocks are prioritised to achieve best control outcomes by taking advantage of weed species seasonal growth periods; to avoid active seabird breeding grounds and to control weeds before they set fruit. A team of bush regenerators (locally referred to as 'weeder's') systematically grid search and control target weeds from each block using a survey string line/hip chain to delineate areas treated. Isolated infestations/locations of priority weeds are recorded on GPS and labeled with tape on a nearby tree as an 'INF' (Infestation) which enables priority weeds to be revisited and seedling regeneration or missed plants controlled.

All weeds controlled from a block are recorded, according to size class (seedling, juvenile, mature or kilograms of corm removed) including person hours worked, area treated by spray methods etc and this is then entered onto a database to monitor weed control targets and effort per block. A trend towards a reduction in weed numbers and hours should be observed over time. We are still however at a stage where high numbers of juvenile and seedlings are being removed hence labour inputs are still high. A total of priority weeds treated since 2004 is listed in Table 1.

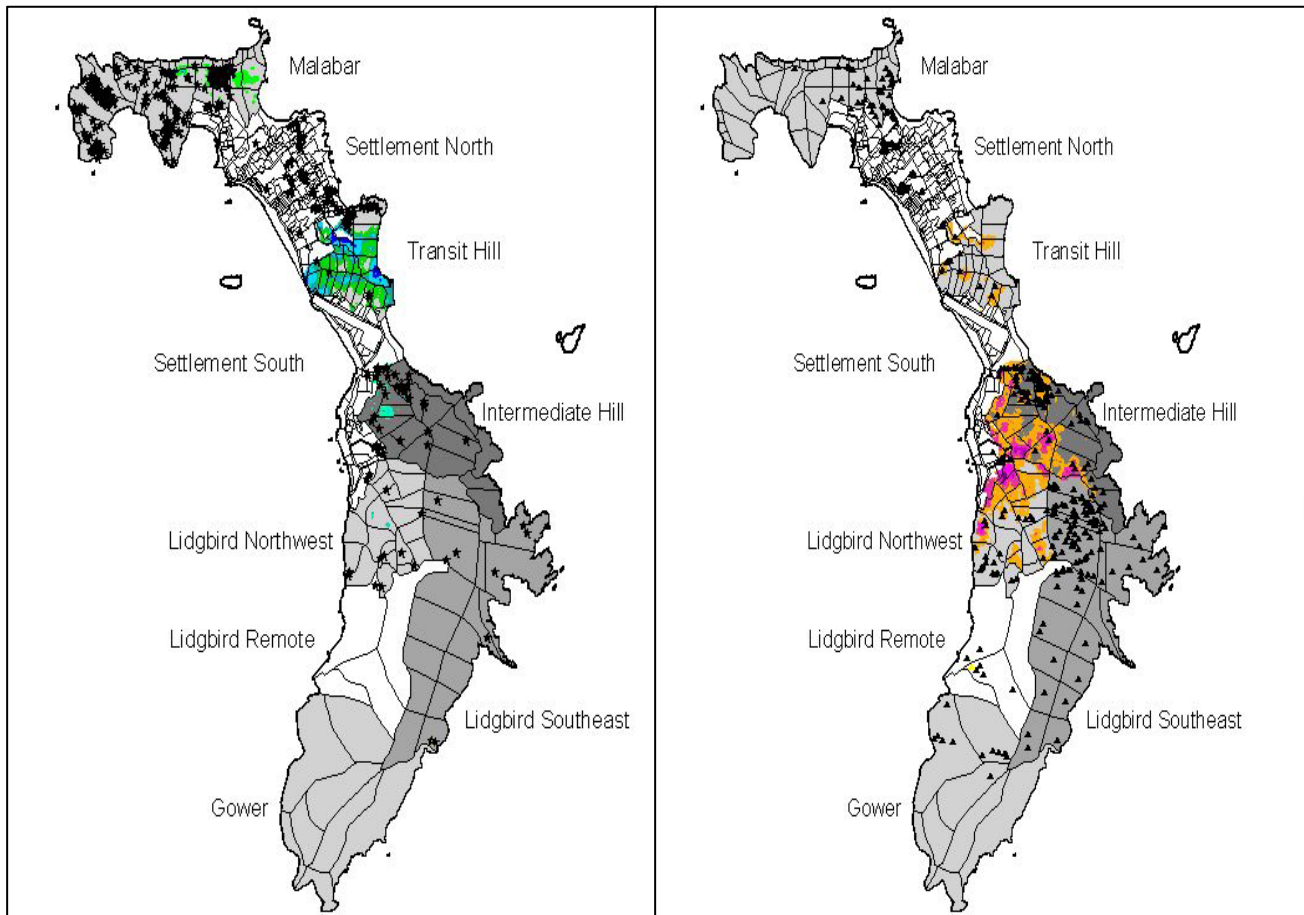


Figure 1: LHI weed management blocks showing distribution of Ground Asparagus. Green/blue areas indicate density mapping in 2002/3; black markers – indicated infestations controlled outside of these areas.

Figure 2: LHI weed management blocks showing distribution of Cherry Guava. Orange/pink areas indicate density mapping in 2002/3; black markers indicated infestations controlled outside of these areas.

Weed Control Techniques

Weed control techniques used on LHI have been tried and tested on the Island to ensure techniques are effective in the local, highly maritime environment. The island supports a variety of sub tropical and temperate weeds, which require different seasonal approaches to maximise control results. Other seasonal constraints include a dry hot summer, increased incidence of wind and rain in winter and influx of large numbers of migratory nesting seabirds

at different locations and times. Timing of control is important to ensure the most effective control technique is applied to each weed and to reduce impact to seabird colonies.



Photo 2. Preparation of Ground Asparagus for spraying at Transit Hill. Recent investment by the Environment Trust has secured the primary control across 10ha on the north east of Transit Hill. This work is continuing. Ground Asparagus smothers bird burrows and the leaf litter layer which is important feeding stratum for species such as the LHI Woodhen and Placostylus.

A range of weed control techniques are applied to control a variety of weed species. Woody weeds in bushland areas are treated by cut & paint using Metsulfuron methyl® 1g/L diluted in a solution of Glyphosate® 1:1 with water, and Cherry Guava with 100% Triclopyr® (Garlon 600™) under a APVMA off label permit. In paddock situations Cherry Guava has been treated by basal bark spray using Starane Advanced™ (Fluroxpyr 333g/L) and diesel. Madeira Vine is treated by hand removal or scrape & paint using 100% Glyphosate when not affected by drought or cold.

Crowning or ‘Snip & drip’ (Metsulfuron methyl® 1g/L diluted in a solution of Glyphosate® 1:1 with water) is used for Ground and Climbing Asparagus where spraying is not feasible.

Accessible cliff line infestations are treated by splatter gun and accessible dense infestations of Asparagus species are foliar sprayed using Glyphosate® 10mls/L, Metsulfuron methyl® 1gm/10L with surfactant and dye. Prior to broad scale spray and/or splatter treatments, sites are ‘prepared’ to minimise off target impacts. This involves treatment of all woody weeds coincident with carefully pulling back decumbent foliage of Asparagus species off native plants, trimming lower branches of native plants, hand weeding around clumps of sensitive ground flora and cutting back ferns amongst dense weeds just prior to spraying. Once dense scrambler infestations are sufficiently decreased following 2 to 3 spray treatments and the weed seed bank is depleted, a hand based approach will be deployed. Technical approaches such as helicopter aerial spot spray or abseiling is used for weeds on inaccessible cliffs lines to target control Bitou Bush, Ground Asparagus and Box Thorn *Lycium ferocissimum*.

All high elevation blocks need to be systematically searched and controlled of weeds to ensure eradication. A remote high elevation infestation of Cherry Guava was recently detected (at 650m elevation) on the northern slopes of Mount Gower and helicopter based winch was used to gain access to the location. This enabled staff to undertake systematic grid search over a successive number of work days. Over 1000 Cherry Guavas were removed over a linear area of 15 ha with plants distributed in two main patches or broadly scattered. Winch access enables staff to undertake a whole day of high elevation work as opposed to a 6 hour return hike, which only allows for 2 hours on-ground work. It also reduces fatigue, enables successive days of work and reduces risk of accidents. Heli-surveillance identified additional weeds from high elevation blocks including a large infestation of Tobacco Bush *Solanum mauritianum* at the Big Pocket on Mt Gower.

Cliff line environments are a common feature of LHI and require innovative approaches to facilitate eradication of target weeds. The weed eradication program needs to remain adaptive, trial new techniques that will improve efficiency and maintain links with mainland restoration practitioners and island eradication programs.

Community Awareness

It is important to ensure that the community remains aware of the impacts that weeds pose to biodiversity, tourism, lifestyle and the Islands World Heritage values. Some weeds were highly valued (e.g. Cherry Guava) and their eradication was not initially supported. Regular provision of information on how such weeds impact the environment has been vital in gaining ongoing support for the weed eradication project. Community awareness and capacity is delivered through articles in newsletters, noxious weeds inspections; promoting volunteer based activities, field visits, school activities, training in weed control techniques and engaging external volunteers (who also assist with weed control on leases).

Volunteers helping to eradicate weeds from LHI

Volunteers make a valuable contribution toward the weed eradication program. They provide value for money in delivering on-ground outcomes and increase motivation for local staff (that works each day eradicating weeds from LHI). There are two volunteer programs run on LHI; the LHIB supported program and the Friends of Lord Howe Island (FLHI) program. The LHIB volunteer program provides up to 10 volunteer positions per year with additional positions funded externally. Persons engaged are required to formally apply with preference to those with experience in bush regeneration, a very high level of fitness and capacity to work 5 days per week 8hrs per day in steep and rugged terrain for a minimum of 3 weeks. The program provides airfares, a food allowance and basic accommodation.

The FLHI offer several one-week programs each year, where groups of up to 20 people contribute 4 hours each morning to weeding activities primarily targeting Asparagus species on Transit Hill. FLHI volunteers pay to come and weed on LHI, are taken on natural history tours each day and stay at a local lodge. This group has contributed significant input to the management of weeds on LHI over the years. Volunteer and community input are vital in helping to lever funds through State and Federal Government grants. To date over 30,000 hours of volunteer input has been generated by the LHIB supported and FLHI volunteers toward the eradication of weeds from LHI.



Photo 3. The Malabar cliffs on the Northern Hills of Lord Howe Island. The NRCMA has improved habitats in the Northern Hills through funding the removal of Bridal Creeper, Ground Asparagus and Bitou Bush. LHIB employees, contractors and volunteers have undertaken this important project work.

Outcomes to date

Over \$3.5 million of external grants has been invested towards the eradication of weeds from LHI since the formal commencement of the program. Grants through Caring for our Country, the Northern Rivers Catchment Management Authority and NSW Environmental Trust have built on the commitment of the LHIB, which has contributed three permanent bush regeneration positions since 2009 and a Flora Management Officer to manage the project.

Since 2004, over 80% of the island has received primary weed control with over 70% receiving 2 or more follow-up treatments. Mature infestations of Cherry Guava are no longer commonly encountered after seven years of sustained effort. Advances have been made in reducing the density and spread of a widespread Ground Asparagus infestation from Transit Hill. Widespread Ground Asparagus and Bridal Creeper infestations being treated with foliar spray methods (approx 30 ha) have only received one primary treatment and require successive follow up to reduce regrowth and seed banks. Bitou Bush is reduced to scattered infestations on cliff lines and adjacent bushland edges and Lantana is now only found as isolated plants.

Remote areas such the upper slopes, ridges and plateau of Mt Gower and Mt Lidgbird have not received systematic search and control. Weeds from these areas are incidentally surveyed commensurate with targeted threatened species surveys including the LHIB annual Woodhen *Gallirallus sylvestris* census. Recent threatened species survey for *Calystegia affinis* across the Big Slope (covering 51ha on Mt Gower's south east) has also failed to unearth target weeds. However, this doesn't dismiss that weeds could be present.

Further commitment by the community, the LHIB and State and Federal Governments is required to continue to progress the eradication of weeds from LHI. Weed eradication will protect the islands unique biological wealth through improving its resilience to future threats including the projected impacts of climate change.

References

Department of Environment and Climate Change (NSW), 2007, *Lord Howe Island Biodiversity Management Plan*, Department of Environment and Climate Change (NSW), Sydney.

Lord Howe Island Board, 2006, *Lord Howe Island Weed Management Strategy*. Report to the Lord Howe Island Board, prepared by J. LeCussan .

LeCussan, J, 2004, *Investigating the Management, Control and Monitoring of the Invasive Woody Weed Species, Psidium cattleianum in National Park areas in USA, New Zealand, Mauritius & Ile deLa Reunion*. Unpublished report prepared for The Winston Churchill Memorial Trust, The Swire Group Churchill Fellowship 2004, Lord Howe Island (NSW)

www.lhib.nsw.gov.au (note web site currently under construction)

http://www.environment.nsw.gov.au/resources/parks/LHI_bmp.pdf

Table 1. Totals of individual weeds removed between 01/01/2004 and 17/06/2011

Botanical Name	Seedlings	Juveniles	Mature	Total	kgs
<i>Acokanthera oblongifolia</i> (Bushman poison/Septic tree)	360	4	2	366	0
<i>Anredera cordifolia</i> (Madeira vine)	157	85	40	282	3939.66
<i>Arundinaria simonii</i> (Bamboo)	0	0	484	484	0
<i>Arundo donax</i> (Giant Reed/Elephant Grass)	0	0	27	27	0
<i>Asparagus aethiopicus</i> (Ground Asparagus)	360221	59837	59692	479750	7390.9
<i>Asparagus asparagoides</i> (Bridal Creeper)	30492	14858	11190	56540	3263.65
<i>Asparagus plumosus</i> (Climbing Asparagus)	24693	5166	10247	40106	292.75
<i>Brachychiton acerifolius</i> (Flame Tree)	29	38	4	71	0
<i>Chrysanthemoides monolifera</i> ssp. <i>rotundata</i> (Bitou Bush)	1193	830	625	2648	0
<i>Cestrum nocturnum</i> (Night Cestrum)	1157	817	830	2804	0
<i>Cinnamomum camphora</i> (Camphor Laurel)	18	34	11	63	0
<i>Coffea arabica</i> (Coffee)	91	108	64	263	0
<i>Cortadeira selloana</i> (Pampas Grass)	1	0	11	12	0
<i>Cotoneaster glaucophyllus</i> (Cotoneaster)	13152	10244	1917	25313	0
<i>Gloriosa superba</i> (Glory lily)	439	1732	7	2178	0
<i>Grevillea robusta</i> (Silky Oak)	43	38	40	121	0
<i>Hedychium gardnerianum</i> (Ginger lily)	54	16	19	89	12
<i>Ipomoea indica</i> (Morning Glory)	0	0	170	170	0
<i>Lantana camara</i> (Lantana)	125	98	94	317	0
<i>Leptospermum laevigatum</i> (Coastal Tea Tree)	0	3	1	4	0
<i>Ligustrum lucidum</i> (Large-leaved Privet)	0	0	3	3	0
<i>Ligustrum sinense</i> (Small-leaved Privet)	390	268	205	863	0
<i>Lycium ferocissium</i> (African Boxthorn)	16	159	212	387	0
<i>Macfadyena unguis-catii</i> (Cats Claw Creeper)	15	5	5	25	0
<i>Macroptilium atropurpureum</i> (Siratro)	10	20	5	35	0
<i>Melia azedarach</i> (White Cedar)	78	136	10	224	0
<i>Murraya paniculata</i> (Orange Jessamine)	0	0	1	1	0
<i>Ochna serrulata</i> (Ochna)	342091	77939	14007	434037	0
<i>Olea europea</i> (African Olive)	0	1	0	1	0
<i>Passiflora edulis</i> (Black Passionfruit)	29	66	90	185	0
<i>Phanerophlebia falcata</i> (Holly fern)	0	0	7	7	0
<i>Pittosporum undulatum</i> (Sweet Pittosporum)	26846	34330	11015	72191	0
<i>Psidium cattleianum</i> (Cherry Guava)	248524	192411	191536	632471	2541
<i>Psidium guajava</i> (Yellow Guava)	2665	2723	1145	6533	0
<i>Rhaphiolepis umbellata</i> (Hawthorn)	60	22	33	115	0
<i>Ricinus communis</i> (Castor Oil Plant)	170	205	401	776	0
<i>Schefflera actinophylla</i> (Umbrella Tree)	222	269	73	564	0
<i>Senna septemtrionalis</i> (Senna_winter)	20	30	112	162	0
<i>Tetrapanax papyrifer</i> (Rice Paper (Aralia))	47	438	210	695	0
<i>Toxicodendron succedaneum</i> (Rhus Tree)	12	10	4	26	0
<i>Ulmus parviflora</i> (Chinese Elm)	0	0	1	1	0

TROPICAL SODA APPLE HERBICIDE TRIAL AND HERBICIDE RESISTANCE.

Tony Cook
Technical Specialist Weeds
Department of Primary Industries
Tamworth Agricultural Institute 4 Marsden Park Road, Calala, N.S.W. 2340

INTRODUCTION

This paper is split into two separate topics. The first part briefly outlines recent herbicide trial work on Tropical Soda Apple (*Solanum viarum*) and the second section highlights the increasing threat of herbicide resistance in the non-cropping regions of NSW.

TROPICAL SODA APPLE HERBICIDE TRIAL

Background

The recent discovery of Tropical Soda Apple (TSA) along the Macleay River will test the resolve of the control authorities and the effectiveness of the treatments used. In response to this new threat, Department of Primary Industries staff from Tamworth conducted an experiment that investigated a range of chemical treatments. Some of these are listed under an environmental weeds permit and the remainder are potentially better treatments that may offer more effective, longer term and selective control of Tropical Soda Apple.

Classic nationwide weed management starts with an effective quarantine program. The best return on investment is spent prevent new weed incursions into Australia. However, despite the excellent efforts of quarantine authorities, new species enter this country. The introduction of TSA is one example of a weed that has eluded the first goal of the NSW Invasive Species Plan (NSW ISP). Furthermore, the NSW Invasive Species Plan has as its first specific objective, Goal 1, to exclude or prevent the establishment of new invasive species. However, the second objective of the plan is to eradicate or contain new species. An excerpt from the NSW ISP species for this scenario is 'Invasive species have the ability to establish in new areas rapidly and successful control often corresponds directly with timely and rapid response. The challenge is to develop and deploy effective and efficient ways to eradicate or contain an introduced species before it becomes widespread.'

Containment or eradication of the TSA infestations in the northern coastal region of NSW is perfectly aligned to this goal of the NSW ISP. Since the early 1980's our department employed Weeds Research & Demonstration Units that were ideally equipped to undertake rapid response 'applied research'. Essentially they undertook research on weeds that commercial companies could not see an economic benefit. Therefore the aim of this work was two-fold; to verify suitable treatments for the control of TSA and to demonstrate the need for a dedicated tactical response team that will support the second objective of the NSW Invasive Species Plan.

The choice of legal treatments for TSA control was limited. As no research had been conducted on the weed, treatments listed in Pesticide Permit 9907 were the only options. This Permit is a generic environmental permit that allows the use of metsulfuron, glyphosate or fluroxypyr based products on environmental weeds (Table 1). Other application techniques are described on the permit, but are not suitable for TSA's growth

habit (eg, wipe onto leaves, cut & paint, stem injection etc). This permit expires on 31 March 2012.

Table 1. Examples of foliar (spot spray) treatments applicable for TSA control using Permit 9907.

Active Ingredient	Weed	Rate of product
glyphosate 360 g a.i./L	Environmental weed	2L per 100L water
metsulfuron 600 g a.i./L	Environmental weed	10 to 20 g per 100L water
fluroxypyr 200 g a.i./L	Woody weeds, vines & trees	500mL per 100L water
glyphosate 835 g a.i./L + metsulfuron 10 g a.i./L	Environmental weed	173g pack of product per 100L water
glyphosate 360 g a.i./L + metsulfuron 600 g a.i./L	Environmental weed	2L glyphosate & 15g metsulfuron per 100L water

Source: Aust. Pesticides & Veterinary Medicines Authority website (www.apvma.gov.au)

Note: Definition of environmental weeds on the permit is weeds are defined here as those introduced terrestrial and aquatic plant species that pose a threat to natural ecosystems, some of which are declared noxious under the NSW *Noxious Weeds Act 1993*.

After consultation with experts from private and government agencies it was decided to use fluroxypyr products for the first year of an eradication campaign. The decision was based on likely high levels of efficacy and pasture selectivity of the treatment. Despite this decision, there was some degree of doubt that fluroxypyr would be the best treatment if compared to a broader range of options. Therefore, a preliminary experiment was commenced in October 2010 to determine if there were better treatments than those listed on Pesticide Permit 9907.

TRIAL METHODS

An experimental area was located at Lagoon Creek adjacent to the Macleay River, approximately 15km west of Bellbrook. Treatments were sprayed on 29th October 2010 to actively growing TSA. The summarised experimental details are listed below in Table 2.

Table 2. Details of TSA experiment.

Site Detail	Comments
TSA growth stages at spraying	Two stages: Early flowering regenerating plants (actively growing) with senescing older plants in the middle of clumps with ripe fruit. Both approximately 1 metre tall.
Weather	At 2:45pm: 27°C, 41% rel. humidity, moderate to light easterly breeze, and 65% cloud cover
Soil conditions	Deep alluvial loam with an excellent moisture profile
Spray equipment	Knapsack spray with variable cone
Spray water volume	1,000 L/ha
Treatments	12 treatments including the untreated control
Adjuvants	Uptake spray oil added to all herbicide treatments at 0.5% v/v (500mL per 100L water)
Special note	One treatment (Hotshot) was sprayed on 15 th November 2010
Pasture species	Mainly kikuyu and Bahia grass

RESULTS

Assessments consisted of near monthly visual ratings of control scores (zero to five scale), biomass reduction estimates (not presented) and pasture damage ratings. Last assessments were made on 9th March 2011, approximately 4 ½ months after treatment (MAT), allowing enough time for TSA to exhibit longer term treatment effects. One assessment of seedling recruitment was made on 17th December 2010, with only a few seedlings occurring in the glyphosate only treatments. Subsequent assessments of these plants revealed that trampling and grazing from stock killed these plants.

TSA control

Only a few treatments were able to completely kill all TSA up to a period of 4 ½ MAT (Table 3). They were Grazon[®] DS + metsulfuron (350mL + 10g/100L water) or Grazon[®] Extra (350mL/100L water). At this stage in the trial it was decided that there was little chance of TSA recovery as all the stems of the sprayed bushes were dead. Time for complete control was approximately 1 ½ MAT and excellent brownout at 17 days after treatment which is ideal for follow-up spraying, allowing easy discrimination between previously treated plants.

Table 3. TSA control scores* (zero to five) at four times after spraying.

Herbicide(s)	Rate per 100L water	15.11.2010 17 DAT	17.12.2010 1 ½ MAT	12.1.2011 2 ½ MAT	9.3.2011 4½MAT
<i>metsulfuron</i>	<i>10g</i>	<i>2.4</i>	<i>2.1</i>	<i>0.3</i>	<i>0.0</i>
2,4-D amine 625 + metsulfuron	500mL + 10g	2.5	1.8	1.1	0.0
<i>fluroxypyr 200</i>	<i>500mL</i>	<i>3.6</i>	<i>4.6</i>	<i>3.8</i>	<i>2.3</i>
fluroxypyr 200 + metsulfuron	500mL + 10g	3.8	4.5	2.8	1.4
Grazon [®] DS + metsulfuron	350mL + 10g	4.5	5.0	5.0	5.0
<i>glyphosate 360 + metsulfuron</i>	<i>2L + 10g</i>	<i>4.8</i>	<i>5.0</i>	<i>4.6</i>	<i>4.4</i>
<i>Glyphosate 360</i>	<i>2L</i>	<i>4.9</i>	<i>4.7</i>	<i>3.1</i>	<i>0.3</i>
Grazon [®] DS	350mL	3.7	4.8	4.7	4.3
Grazon [®] Extra	350mL	3.9	4.9	5.0	5.0
2,4-D amine 625	500mL	1.9	2.0	1.1	0.4
Untreated		0.0	0.0	0.0	0.0
Hotshot - sprayed 15.11.10	700mL	N/A	3.9	4.7	3.7

* Control scores: 0 = no kill, 1 = herbicide symptoms present with little biomass reduction, 2 = moderate (50%) biomass reduction, 3 = marginal control, 80% biomass reduction, 4 = excellent control, 95% biomass reduction and 5 = all plants dead

Treatments in bold italics font are those described in Pesticide Permit 9907. The glyphosate + metsulfuron treatment was slightly different to the permit treatment as a lower rate (10g/ha) of metsulfuron was used.

The preferred permit treatment (fluroxypyr 200 at 500mL/100L) demonstrated promising results 1 ½ MAT. However, later assessments revealed rapid recovery of plants from basal tissue. A combination of glyphosate and metsulfuron was the best Pesticide Permit

treatment; however it led to unacceptable periods of pasture damage (Table 4). A similar treatment (Hotshot) performed similarly to the fluroxypyr although sprayed 17 days later.

There appears to be some benefit of using Grazon[®] Extra over the older Grazon[®] DS formulations, with occasional plants (approx 1 in 20) showing signs of recovery after Grazon[®] DS applications.

Metsulfuron or 2,4-D amine applied by itself were very ineffective treatments. However metsulfuron appears to be a good tank mix partner with Grazon[®] DS or glyphosate and not with fluroxypyr or 2,4-D amine.

Table 4. Pasture damage ratings* (zero to five) of TSA treatments.

Herbicide(s)	Rate per 100L water	17.12.2010 1 ½ MAT	12.1.2011 2 ½ MAT	9.3.2011 4 ½ MAT
<i>metsulfuron</i>	<i>10g</i>	<i>0.0</i>	<i>0.7</i>	<i>0.0</i>
2,4-D amine 625 + metsulfuron	500mL + 10g	0.1	0.1	0.0
<i>fluroxypyr 200</i>	<i>500mL</i>	<i>0.9</i>	<i>0.7</i>	<i>0.0</i>
fluroxypyr 200 + metsulfuron	500mL + 10g	1.1	0.7	0.0
Grazon [®] DS + metsulfuron	350mL + 10g	0.8	0.7	0.0
<i>glyphosate 360 + metsulfuron</i>	<i>2L + 10g</i>	<i>4.4</i>	<i>2.7</i>	<i>1.3</i>
<i>Glyphosate 360</i>	<i>2L</i>	<i>4.3</i>	<i>2.2</i>	<i>0.7</i>
Grazon [®] DS	350mL	0.6	0.2	0.1
Grazon [®] Extra	350mL	0.6	0.0	0.0
2,4-D amine 625	500mL	0.0	0.0	0.0
Untreated		0.0	0.0	0.0
Hotshot - sprayed 15.11.10	700mL	1.3	1.1	0.0

* Pasture damage scores: 0 = no kill, 1 = herbicide symptoms present with little biomass reduction, 2 = marginal pasture damage (30%) biomass reduction, 3 = moderate damage, 80% biomass reduction, 4 = extreme damage, 95% biomass reduction and 5 = all plants dead

Treatments in bold italics font are those described in Pesticide Permit 9907. The glyphosate + metsulfuron treatment was slightly different to the permit treatment as a lower rate (10g/ha) of metsulfuron was used.

Pasture damage

All treatments except those containing glyphosate exhibited commercially acceptable levels of pasture safety. Plots treated with glyphosate had little competitive pasture species 1 ½ MAT. This may be an opportunity for seedling TSA or other weeds to establish.

DISCUSSION

The need of a rapid response research approach for new weed infestations is paramount. This case highlights the value of getting more accurate answers to problems in the earlier

stages of the establishment phase. Increasingly, economic approaches are being considered in weed management and weed evaluation decisions (Panetta *et al.* 2002, Cacho *et al.* 2003 and Odom *et al.* 2003). In addition, economic returns are much greater at this stage. A common measure of this is the cost to benefit ratio. It is estimated that this ratio is approximately 1:100 for a quarantine/prevention program, 1:25 for an eradication of pest, 1:5-10 for containment and 1:1-5 for control of weeds that have reached their full geographical spread (Anon, 2010a). Therefore an eradication program is worth pursuing, despite there being few successful examples. The chances of success will significantly improve if the treatments used are proven to be highly effective.

Highly effective treatments such as Grazon[®] based treatments (picloram and triclopyr), are likely to assist in an eradication program due to;

- Their high levels of efficacy, reducing re-treatment time.
- Selective attributes, maintaining a competitive pasture that will reduce seedling establishment.
- Residual activity in the soil resulting in control of seedling TSA.

Where to from now?

Results from this experiment will be supporting evidence for a minor use permit application sent to the Australian Pesticides & Veterinary Medicines Authority. The application will request that the permit be valid for a period of 5 years and can be renewed upon request of the permit holder. A selection of herbicide treatments will be on this permit to allow flexibility under certain circumstances. The following treatments are those being put forward in the application to the APVMA:

Grazon[®] Extra (350 to 500mL/100L): Superior control over Grazon[®] DS and resulted in 100% control.

Grazon[®] DS + metsulfuron (350 to 500mL/100L + 10g/100L): Also resulted in 100% control. This treatment may have a broader weed spectrum due to the metsulfuron component.

Glyphosate 360 + metsulfuron (2L + 10g/100L): Should be used near water bodies as Grazon[®] products have no registered use patterns near water. Only glyphosate products that have a registered aquatic use can be used. There are several minor use Pesticide Permits that allow the use of metsulfuron near or on waterways, therefore the APVMA should approve the use of such products near water.

REFERENCES

Anon. (2010a). Goulburn Broken Invasive Plants and Animals Strategy 2010-2015, Executive Summary. www.gbcma.vic.gov.au/downloads/PestPlantsAnimals/IPAS_ExecutiveSummary_Web.pdf. Accessed 16 May 2011.

Cacho, O.J., Spring, D. and Sinden, J. (2003). Benefit cost analysis of responses to weed incursions: Year 1 Report to AFFA and CRC Weed Management (Scholl of Economics, University of New England, Armidale).

Odom, D.I.S., Hester, S., Sinden, J. and Cacho, O.J. (2003). Benefit-cost analysis of weed management: issues and potential. (Report presented at CRC for Australian Weeds Management Workshop on Incursion Response, Brisbane).

Panetta, F.D., Pheloung, P.C., Hosking, J., Weiss, J., Virtue, J.G. and Randall, R. (2002). Principles to be utilised in determining when an exotic plant incursion warrants a nationally coordinated response with cost-sharing. www.weeds.org.au/docs/costsharing.pdf. Accessed 16 May 2011.

ACKNOWLEDGMENTS:

Special mention and gratitude go to James Browning (New England Weeds Authority) and Terry Schmitzer (Mid North Coast Weeds) for organising the trial site. The excellent photography of TSA plants used in the verbal presentation and the valuable assistance with trial assessments was courtesy of Rebecca Leigh Miller.

HERBICIDE RESISTANCE IN NON-CROPPING AREAS

Background

Since the first reported case of herbicide resistance in 1982, there are now 35 weed species confirmed resistant to as many as 11 mode of action herbicide groups. The overwhelming majority of these cases occur in cropping regions. However, in the past 5 years there has been a noticeable increase in the number of new cases of herbicide resistant weeds in non-crop situations. Pastures, roadsides, fence-lines, irrigation channels, driveways, railways and airstrips are some of the examples where resistant weeds have been found. The majority of cases occur along fence-lines and irrigation channels. However, the number of roadside resistant weeds is likely to increase rapidly in coming years. Resistance to glyphosate, flupropanate and 2,2-DPA are the herbicides that certain weeds species have developed resistance to. Confirmed cases of glyphosate resistance leads the list as it is most commonly used herbicide in Australia. It is estimated that the annual consumption rate of glyphosate is 15,000 tonnes (ATSE, 2002).

It appears that cases of glyphosate, 2,2-DPA and flupropanate resistant weeds have occurred due to several applications of the same herbicide, generally without implementation of alternative control tactics. To emphasise the significance of our potential problems, a recent media release from the Australian Glyphosate Sustainability Working Group stated there are roadside weeds resistant to glyphosate (Storrie, 2010).

The key to preserving our herbicides requires a new approach. It requires the use of integrated weed management tactics, increased monitoring, a better understanding of how resistance develops and the willpower from weed managers to be flexible with their weed management strategies.

FREQUENTLY ASKED QUESTIONS

What is the different between herbicide resistance and tolerance?

Herbicide resistance: Herbicide resistance is the ability of a weed to survive a rate of herbicide which would normally give control.

Resistance is not survival due to:

- Shading from other weeds or structures
- Poor spraying (blocked nozzles, clumsy spot treatment techniques)
- Spraying stressed plants (drought, frost, disease, heavily grazed/slashed)
- Incompatibilities with the spray mixture
- Wheel tracking, dust on plants
- Applying sub-lethal doses
- Herbicide tolerance (see definition below)

Herbicide tolerance: Species that were never controlled by that herbicide, for example, trying to control a grass weed with a hormonal herbicide.

What is the current herbicide resistance status in non-cropping areas?

Herbicide resistant weeds of non-cropping areas have resistance to glyphosate, flupropanate or 2,2-DPA. The most common resistance is to glyphosate as it is the most widely used herbicide. Recent data from the Australian Glyphosate Sustainability Working Group states that is 74 confirmed cases of glyphosate resistance in non-broad acre situations. Some of these non-cropping uses include driveways, fence lines, irrigation channels, railways and roadsides.

There are six cases of Giant Parramatta Grass (*Sporobolus fertilis*) resistant to flupropanate or 2,2-DPA (Anon, 2010b; Ramasamy *et al.*, 2008a) while there are two confirmed cases of serrated tussock (*Nassella trichotoma*) resistance to flupropanate (Noble *et al.*, 2005; Ramasamy *et al.*, 2008b).

What is herbicide resistance and how does it occur?

Herbicide resistance develops after repeated use of herbicides usually without the use of other alternative control tactics. If a range of herbicides are used that act on the same biological process in the weed the chances of developing resistance increase. In any weed population there are likely to be a small number of individuals that are naturally resistant to herbicides due to genetic diversity, even before the herbicides are used. When a herbicide is used, these individuals survive and set seed whereas the majority of susceptible plants are killed. Continued use of a herbicide or herbicide group will eventually result in a significant fraction of the weed population with resistance. There are four main factors that influence the evolution of resistance. These are:

- **The intensity of selection pressure.**

This refers to how many weeds are killed by the herbicide. It is good practice to use robust labelled rates of herbicides to control weeds, as this will lead to the highest and most consistent levels of weed control. Failure to control weeds adequately will lead to increases in weed populations and put pressure on all herbicides used.

- **The frequency of use of a herbicide or mode of action group.**

For most weeds and herbicides, the number of years of herbicide use is a good measure of selection intensity. The more often a herbicide is applied the higher the selection pressure and the higher the risk of herbicide resistance developing.

- **The frequency of resistance present in untreated populations.**

If the frequency of resistant genes in a population is relatively high, such as with Group B (Brush-off® - metsulfuron) herbicides, resistance will occur quickly. If the frequency is low, such as with Group M (glyphosate) herbicides, resistance will occur more slowly.

- **The biology and density of the weed.**

Weed species that produce large numbers of seed and have a short seed bank life in the soil will evolve resistance faster than weed species with long seed bank lives. Weed species with greater genetic diversity are more likely to evolve resistance. Resistance is also more likely to be detected in larger weed populations.

What does mode of action for herbicide groups mean?

The mode of action is the overall manner in which a herbicide affects a plant at the tissue or cellular level. Herbicides with the same mode of action will have the same translocation (movement) pattern and produce similar injury symptoms. In order to facilitate management of herbicide resistant weeds, all herbicides sold in Australia are grouped by mode of action. The mode of action is indicated by a letter code on the product label. Letters used range from A to Z with the exception of letters S through to Y, this equates to 19 separate herbicide groups (Anon, 2008). The mode of action labelling is based on the resistance risk of each group of herbicides. Australia was the first country to introduce compulsory mode of action labelling on products. The letters and codes used in Australia are unique because they were the first, they are compulsory and they reflect the relative risk of resistance evolving in each group.

Farmers and weed managers are now better aided to understand the huge array of herbicide products in the marketplace in terms of mode of action grouping and resistance risk by reference to the mode of action chart. All herbicide labels now carry the mode of action group clearly displayed such as: -

Products represented in Group A (mostly targeted at annual ryegrass and wild oats) and Group B (broadleaf and grass weeds) are HIGH RESISTANCE RISK herbicides and specific guidelines are written for use of these products in winter cropping systems, and some of these principles may be used for other agricultural enterprises (Anon, 2010c). Specific guidelines also follow for the MODERATE RESISTANCE RISK herbicides, for example Group I (wild radish), Group J (serrated tussock and giant Parramatta grass), Group L (annual broadleaf weeds and grasses) and Group M (many perennial and annual weedy grasses and broadleaf weeds).

What are some high risk weeds/practices under threat?

Some high risk non-cropping practices have already been exposed by the presence of herbicide resistance. However, there are many examples of similar weeds/scenarios that have not developed herbicide resistance or may have some resistance but not yet confirmed.

Perennial Grass Weeds:

Since we have two weed species already resistant to Group J herbicides (flupropanate/2,2-DPA), there is strong chance that other perennial grass weeds will get resistance to these herbicides. Therefore weeds such as Chilean needle grass, Coolatai grass, other *Sporobolus* species, African Lovegrass and other stipoid grasses are likely candidates to get resistance to Group J herbicides. Although these Group J herbicides were the most commonly used herbicides, the use of glyphosate on perennial grass weeds will steadily increase due to cost competitiveness of glyphosate and the development of resistance to Group J. It must also be stated that the chances of developing Group M (glyphosate) resistance is moderate to high. These two herbicides are the only effective herbicides on

many perennial grass weeds. If weed managers lose one due to herbicide resistance greater selection pressure is likely to be placed on the remaining herbicide. If both herbicide groups are lost due to resistance, management of multiple resistant perennial grass weeds will be extremely difficult.

Annual grass and broad leaf weeds:

The herbicide of choice to control annual weeds is glyphosate. This choice is only suitable for non-selective situations. However, if selective control of annual grasses is needed Group A herbicides (e.g. Verdict[®], Fusilade[®], Select[®]) are likely to be used. Where selective control of annual broad leaf weeds is required the use of Group I herbicides (hormonal herbicides) is likely. All these scenarios should be considered moderate to high risk because repeated glyphosate or hormonal herbicide use is likely or herbicides from high resistance risk (Group A) are used. There are some cases of glyphosate (Group M) resistant annual weeds on roadsides in Australia and multitudes of cases of Group A resistant weeds in crop. A few weed have also developed resistance to hormonal herbicides in crop, therefore all the above mentioned resistance risks should be noticed.

Perennial broad leaf weeds (non-woody):

Weeds such as St John's Wort, Blue Heliotrope, Silver Leaf Nightshade and Galenia are excellent examples of weeds that heavily rely upon the use of hormonal herbicides (Group I) for their management. Although no resistance to Group I herbicides have been found in Australia for this category of weeds, there are cases of resistance in perennial weeds overseas.

Woody weeds:

This category of weeds is at least risk of developing herbicide resistance. However, it does not mean resistance will not occur. Woody weeds including blackberries, lantana, bitou bush and gorse have a range of herbicides registered for use. These are glyphosate, metsulfuron and hormonal herbicides (Groups M, B and I), which offers weed managers an option to rotate herbicide groups. Unfortunately, from experience, most people rely upon the one herbicide each time and rarely rotate herbicide groups to prevent resistance. As yet there are no cases of herbicide resistant woody weeds internationally.

Integrated Weed Management: What examples can we use?

Integrated weed management (IWM) is the complementary use of a range of suitable chemical and non-chemical control methods. The aim is to include an assortment of control tactics and reduce the reliance on herbicides and therefore reduce the likelihood of developing herbicide resistance. Successful IWM programs are underpinned by long-term planning, selecting suitable control techniques and understanding of the weed's ecology.

An ideal example of excellent integrated management is the control of nodding thistles in terrain that limits the use of herbicides.

A suggested control program could be: treat rosette stage nodding thistles in accessible areas with hormonal herbicide at low rates then use the spray graze technique (heavy grazing pressure with sheep – 7 days after herbicide application). Follow-up applications of hormonal herbicide at robust rates are required to control any survivors (standard practice). Pasture improvement should be employed that will promote competitive pastures and the pastures should be rested in periods when nodding thistles are likely to germinate

(autumn). Biological control programs should be targeted in inaccessible areas where herbicide application is not possible. If thistles are not being controlled effectively by bio-agents, goats can be used to selectively graze them.

Many strategies can be designed to prevent and/or reduce the occurrence of resistance by adopting IWM strategies. Do not rely on a single strategy to keep resistance at bay.

Examples of useful strategies include:

- If a failure is suspected do not use the same product or product from the same mode of action group.
- If in doubt always use herbicide resistance testing to confirm that resistance exists.
- Control weed escapes before the weeds set and shed viable seed.
- Rotation of herbicide mode of action groups within and across years.
- Ask for advice from local experts in weed management.
- Always monitor your post-spraying weed areas to check for surviving weed populations and determine whether these survivors are due to resistance. Keep good records of weed populations.
- Additional cultural weed control techniques to reduce seed banks, eg. burning, cultivation, slashing prior to seed set, competitive pastures, grazing and biological control.
- Heed guidelines for each herbicide mode of action group.
- Maintain accurate records of your herbicide applications on a paddock basis.
- Read the herbicide product label and literature carefully and follow the instructions.
- Always use effective label rates.
- Do not introduce or spread weeds by contaminated seed, grain or hay.
- Consider pasture topping.
- Attend educational courses, eg. GRDC IWM course, *SMARTtrain* and field days.

What should you do if you think you have resistance?

When resistance is first suspected, we recommend that growers contact their local agronomist or local weed authority. The following actions are recommended:

Consider the possibility of other common causes of herbicide failure by asking:

Was the herbicide applied in conditions and at a rate that should kill the target weed?

Did the suspect plants avoid herbicide contact or emerge after herbicide application?

Does the pattern of surviving plants suggest a spray miss or other application problem?

If resistance is still suspected, please check the following questions:

Has the same herbicide or herbicides with the same mode of action been used in the same field or in the general area for several years?

Has the uncontrolled species been successfully controlled in the past by the herbicide in question or by the current treatment?

Has a decline in the control been noticed in recent years?

Is the level of weed control generally good on the other susceptible species?

If resistance is still suspected:

Contact NSW DPI staff for advice on sampling suspect plants for testing of resistance status. Otherwise use the following services listed in Table 5:

Table 5. Information about each herbicide resistance testing provider

Information	Plant Science Consulting	Charles Sturt Uni – Herbicide Resistance
--------------------	---------------------------------	---

		Testing Service
Office number	(08) 8342 4606 – fax	(02) 6933 4001 (02) 6933 2924 - fax
Mobile number	0400 664 460	N/A
Email	info@plantscienceconsulting.com	N/A
Postal Address	22 Linley Av, PROSPECT SA 5082	Herbicide Resistance Testing, School of Agricultural and Wine Sciences, Charles Sturt University, Locked Bag 588, WAGGA WAGGA, NSW, 2678
Webpage	www.plantscienceconsulting.com	N/A

Ensure all suspect plants do not set any seed, unless the testing service requests a sample of seed. In this case ensure enough plants survive to produce seed for testing and hand-weed plants after the seed is harvested.

If resistance is confirmed, develop a management plan using sound principles of IWM for future years to reduce the impact of resistance and likelihood of further spread.

Where to go for more information?

The following websites are excellent sources of information:

www.croplifeaustralia.org.au

www.glyphosateresistance.org.au

www.grdc.com.au/director/events/linkpages/weedlinks?shortcut=1

www.weedscience.org/In.asp

REFERENCES

Anon. (2008). Herbicide Resistance: Mode of Action Groups. Produced by Grains Research and Development Corporation (GRDC) and CropLife Australia.

http://www.grdc.com.au/uploads/documents/GRDC_HerbicideCard.pdf. Accessed 25 May 2011.

Anon. (2010b). List of Herbicide Resistant Weeds in Australia.

<http://www.croplifeaustralia.org.au/files/resistancemanagemen/herbicides/2010%20Herbicide%20Resistant%20Weeds%20List.pdf>. Accessed 20 May 2011.

Anon. (2010c). Herbicide Resistant Management Strategies. Developed by the CropLife Australia Herbicide Resistance Management Review Group and industry researchers.

<http://www.croplifeaustralia.org.au/files/resistancemanagemen/herbicides/2010%20Herbicide%20Resistance%20Management%20Strategies.pdf>. Accessed 25 May 2011.

ATSE. (2002). Pesticide use in Australia. A review undertaken by the Australian Academy of Technological Sciences and Engineering. (<http://www.atse.org.au/resource-centre/func-startdown/217/>). Accessed 20 May 2011.

Noble, S., Pritchard, G., Casonato, S.G., McLaren, D.A. and Lawrie, A.C. (2005). Resistance to flupropanate in serrated tussock (*Nassella trichotoma* (Nees) Hack. ex Arechav.) in Victoria. Proceedings of the 2nd Victorian Weeds Conference, Bendigo, Vic. p. 125.

Ramasamy, S., McLaren, D.A., Pritchard, G., Officer, D., Bonilla, J., Preston, C. and Lawrie, A.C. (2008a). 2,2-DPA resistance in giant Parramatta grass (*Sporobolus fertilis*). Proceedings of the 16th Australian Weeds Conference. Weed management 2008: hot topics in the tropics. R.D. van Klinken, V.A. Osten, F.D. Panetta and J.C. Scanlan (eds.), 18-22 May, 2008: pp.71-3.

Ramasamy, S., Pritchard, G., McLaren, D.A., Bonilla, J., Preston, C. and Lawrie, A.C. (2008b). Field survey of flupropanate-resistant *Nassella trichotoma* in Victoria. Proceedings of the 16th Australian Weeds Conference. Weed management 2008: hot topics in the tropics. R.D. van Klinken, V.A. Osten, F.D. Panetta and J.C. Scanlan (eds.), 18-22 May, 2008: pp.98-100.

Storrie, A. (2010). Local roadsides the next frontier for glyphosate resistant weeds. A press release on behalf of the Australian Glyphosate Sustainability Working Group. June 2010.

http://www.glyphosateresistance.org.au/media%20releases/mr_100623_roadsides_next_frontier.pdf.

Accessed 30 May 2011.

Glyphosate resistance is threatening Australian weed management

Andrew Storrie^{1,2}, Christopher Preston^{1,3} and John Cameron^{1,4}

¹ Australian Glyphosate Sustainability Working Group
<http://www.glyphosateresistance.org.au>

² Agronomo, PO Box 5944, Albany WA 6332

³ School of Agriculture, Food & Wine, The University of Adelaide, PMB 1, Glen Osmond
SA 5064

⁴ ICAN Pty Ltd, PO Box 718 Hornsby NSW 1630

ABSTRACT

The development of resistance in weed populations to the world's most widely used herbicide, glyphosate, is threatening weed management across the Australian landscape. Glyphosate is used for weed control in all sectors including native vegetation, backyards, parks and gardens, roadsides, rail lines and all agricultural sectors. Glyphosate is widely used, because it is highly efficacious on a wide range of species, cheap, and relatively benign to the user and the environment. In many sectors it is the only herbicide used. The world's first case of glyphosate resistance was recorded in Australia in annual ryegrass (*Lolium rigidum* Gaudin) in 1996. By late 2010 another 4 species, awnless barnyard grass (*Echinochloa colona* (L) Link), liverseed grass (*Urochloa panicoides* P. Beauv.), windmill grass (*Chloris truncata* R.Br.) and flaxleaf fleabane (*Conyza bonariensis* (L.) Cronquist) were resistant to glyphosate in Australia.

In 2004 the Australian Glyphosate Sustainability Working Group (AGSWG) was formed with support from the Grains Research and Development Corporation and industry partners to promote better use and management of glyphosate and increase collaboration and consistency amongst the glyphosate research and extension activities of key research, extension and industry groups.

This paper outlines the current state of glyphosate resistance in the world and how the AGSWG plans to engage with the non-cropping sectors of the weed management community to develop the necessary expertise, resources and tactics to promote responsible use of glyphosate and to sustain it as a highly effective herbicide.

Key words: glyphosate resistance, annual ryegrass, flaxleaf fleabane, windmill grass

INTRODUCTION

Glyphosate is the most widely used and therefore the most important herbicide in world agriculture (Duke and Powles 2008). In Australia, glyphosate is also used for weed control in other sectors including native vegetation areas, residential yards, parks and gardens, industrial premises, roadsides, rail lines and forestry. Currently in Australia there are 225 registered products that contain glyphosate with nearly 365,000 registered uses and 515 plant species labelled for control (Infopest 2011).

Glyphosate is popular because it kills a wide range of annual and perennial weed species, has low mammalian and environmental toxicity and little soil activity (Duke and Powles 2008).

The heavy reliance on glyphosate for weed control across such a wide range of situations leads to weed species shifts toward harder-to-kill species followed by the evolution of glyphosate resistant weed populations (Shaner 2000). This in turn leads to the development of hard-to-kill weed populations that ultimately increase weed management costs, seriously impacting on the profitability of agriculture. In many areas such as riparian and wetland areas suitable alternatives to glyphosate are not available and unlikely to become available. The mobility of glyphosate resistant weeds through pollen and seed means that glyphosate resistance that develops in one land management unit can easily spread to other areas.

This paper will review the systems where glyphosate resistance has developed around the world and how the Australian Glyphosate Resistance Working Group (AGSWG) will develop strategies to reduce the risks of glyphosate resistance occurring on land managed by local councils, railways, transport authorities and water authorities in Australia.

CURRENT STATE OF GLYPHOSATE RESISTANCE IN THE WORLD

Glyphosate resistance is currently found in 14 countries (Table 1) (Heap 2011).

Table 1. Number of glyphosate resistant weed species present in each country (adapted from Heap 2011).

Country	Number of species	Country	Number of species
Canada	1	Italy	1
USA	11	Czech Republic	1
Brazil	5	Israel	1
Argentina	3	South Africa	3
Chile	1	China	1
Spain	5	Malaysia	1
France	1	Australia	5

The majority of cases in the USA are in glyphosate resistant soybean, maize and cotton production systems. Palmer amaranth (*Amaranthus palmeri* S. Wats.), Italian ryegrass (*L. multiflorum* Lam.) and annual ryegrass also infest orchards, while flaxleaf fleabane and horseweed (*Conyza canadensis* (L.) Cronquist) are found in vineyards, plant nurseries and along roadsides. Winter grass (*Poa annua* L.) has recently been collected from a golf course.

Brazil and Argentina have over 25 million hectares of glyphosate resistant crops (James 2007), so most of their glyphosate resistant weeds are found in broadacre cropping. Brazil also has flaxleaf fleabane, horseweed, sourgrass (*Digitaria insularis* (L.) Mez ex ekman) and Italian ryegrass in orchards. Colombia has crowfoot grass (*Eleusine indica* (L.) Gaertn.) in coffee and Chile has Italian ryegrass in orchards.

By contrast glyphosate resistance in Europe, Israel, South Africa, China and Malaysia has predominately developed in vineyards, orchards and roadsides. These differences are closely linked to the farming systems practiced.

CURRENT STATE OF GLYPHOSATE RESISTANCE IN AUSTRALIA

The world's first glyphosate resistant weed was annual ryegrass (*L. rigidum*) found in Echuca, Victoria in 1996 (Powles *et al.* 1998, Pratley *et al.* 1999). Since then another 4 glyphosate resistant weed species – awnless barnyard grass, liverseed grass, windmill grass and flaxleaf fleabane have been confirmed. There are now 134 confirmed populations of glyphosate resistant ryegrass (Table 2). There are 18 glyphosate resistant barnyard grass populations, two liverseed grass, two windmill grass and eight fleabane populations.

Table 2. Land uses reporting glyphosate resistant annual ryegrass in Australia (from Preston 2010).

Situation		Number of sites	States
Broadacre cropping	Chemical fallow	29	NSW
	Winter grains	32	Vic, SA, WA
	Irrigated crops	1	SA
Horticulture	Tree crops	4	NSW
	Vine crops	17	SA, WA
Other	Driveway	2	NSW, Vic
	Fence line /Firebreak	36	NSW, SA, Vic, WA
	Irrigation channel	10	NSW
	Airstrip	1	SA
	Railway	1	WA
	Roadside	1	SA

The first case of annual ryegrass to evolve on roadsides was confirmed in 2010 with a second case yet to be confirmed in southern NSW. Fallows, fence lines, under-vine and under-tree areas may be sprayed from one to five times a season to maintain weed-free areas. Despite this variation in application intensity per season, glyphosate resistance commonly appears after 12-15 years of use (Powles *et al.* 2008, Pratley *et al.* 1999, Neve *et al.* 2004, Preston *et al.* 2009).

THREAT OF SPREADING GLYPHOSATE RESISTANT WEEDS

While the frequency of genes in a weed population conferring resistance to glyphosate are lower than for many other herbicides, it has evolved in situations where there has been an over-reliance on glyphosate for weed control. Surveys of farmers have shown that 70% believe that resistance often comes from an external source as seed or pollen, rather than evolving as a result of their management (Llewellyn and Allen 2006). Unfortunately this perception potentially reduces landholders' responsibility for managing glyphosate resistance (Marsh *et al.* 2006). In reality, glyphosate resistance has been shown to evolve in-situ and not be introduced from external sources. Glyphosate resistance introduced in

weed seed and pollen will shorten the time for the problem to develop (Thill and Mallory-Smith 1997).

Seed

Seed can be transported by wind, water, machinery, livestock and fodder. Weeds that have a pappus attached to their seeds are able to be blown considerable distances by the wind. Fleabane has been found to spread between 500 and 1,800 metres from the parent plant (Shields *et al.* 2006, Borger *et al.* 2010) with seeds being collected 140 m above the ground (Shields *et al.* 2006). Fleabane is a common roadside and fence line weed with the potential to rapidly invade adjacent areas. Some species detach from the root system and tumble across the landscape, dropping seeds as they roll. In the USA *Salsola iberica* L. has been measured travelling up to 4000 m in the direction of the prevailing wind (Stallings *et al.* 1995). It is common for weeds such as *Brassica tournifortii* Gouan and *Raphanus raphanistrum* L. to break off at ground level on maturation and roll downwind. Many grasses, including windmill grass, have seed heads that detach and blow in the wind, often accumulating on fences.

Contaminated crop seed is also a common avenue for weed spread (Moerkerk 2002, Nickam *et al.* 2002). In a survey of Western Australian farmer saved crop seed, Michael *et al.* (2010) found that three quarters of samples contained weed seed and most of that was resistant to one or more herbicide mode-of-actions, although no glyphosate resistance was found. A survey of drought fodder in NSW in 1981 found grain and hay highly contaminated with weed seeds (Thomas *et al.* 1984) and this should be seen as a warning for spreading weeds through urban areas where hay is used as mulch. In 2011, Western Australian gardeners found new weed species where they had used sugar cane 'hay' as garden mulch which had been imported from Queensland and distributed by a major hardware retail chain (Peltzer pers. comm. 2011).

Pollen

Genes carrying herbicide resistance can be spread in pollen by weeds that are obligate out-crossers. Of the current glyphosate resistant weeds in Australia only annual ryegrass is an out-crossing species, although glyphosate resistant canola is also an out-crossing species. Reiger *et al.* (2001) showed that fertile hybrids between canola and *Raphanus raphanistrum* are possible, albeit at very low frequencies. Researchers in the USA found that by modelling the flow of *Amaranthus tuberculatus* pollen, glyphosate resistance has the potential spread over 4000 m per year (Hartzler 2011).

THE AUSTRALIAN GLYPHOSATE SUSTAINABILITY WORKING GROUP

The Australian Glyphosate Sustainability Working Group (AGSWG) was first established in 2004 by the Grains Research and Development Corporation (GRDC) and the Cooperative Research Centre for Australian Weed Management to develop strategies to combat the increase in glyphosate-resistant weeds. The participants in the AGSWG include public sector researchers, agricultural industry and representatives from the herbicide industry. The AGSWG is a globally unique organisation whose role it is to identify and develop key extension messages for delivery to all Australian glyphosate users.

The AGSWG, in partnership with other public sector weed experts, have procured Rural Industries Research and Development Corporation funding to develop strategies to reduce the risk of glyphosate resistance occurring on land managed by local councils, railways, transport authorities and water authorities in Australia. The project will identify the key

decision makers, existing knowledge, benchmark the extent of glyphosate resistance in these sectors and identify and deliver alternatives to glyphosate use in these areas.

CONCLUSION

Glyphosate plays a critical role in all sectors of weed management in Australia. Despite glyphosate resistance being relatively rare, the number of species developing resistance is accelerating at an alarming rate. Four new species have been identified in Australia in the past four years with two of those in 2010. Glyphosate resistant ryegrass was also confirmed to have evolved on roadsides in 2010.

The genes for glyphosate resistance are mobile and can readily spread by seed and pollen movement. Non-broadacre cropping areas of fences, tree crops, vines and roadsides are the new growth areas for glyphosate resistance. The AGSWG and co-operators are commencing a project in 2011 to benchmark glyphosate resistance risks in non crop areas and develop industry relevant tactics and extension materials to combat this expanding threat.

ACKNOWLEDGEMENTS

This project is supported by the Rural Industries Research and Development Corporation. The Australian Glyphosate Sustainability Working Group is supported by the Grains Research and Development Corporation and by industry participants.

REFERENCES

- Duke, S.O. and Powles, S.B. (2008) Glyphosate: a once-in-a-century herbicide. *Pesticide Management Science* **64**, 319-325.
- Hartzler, R. (2011) Spread of Glyphosate-Resistant Weeds. AGPROFESSIONAL Online. Available. <http://www.agprofessional.com/cornrc.php?id=1301821&page=5> (accessed 2 April, 2011)
- Heap, I. The International Survey of Herbicide Resistant Weeds. Online. Available www.weedscience.com (accessed 30 March, 2011).
- Infopest (2011) Queensland Department of Employment, Economic Development and Innovation.
- James, C (2007). International Service for the Acquisition for Agri-biotech Applications Brief 37-2007: Executive Summary Online. Available <http://www.isaaa.org/resources/publications/briefs/37/executivesummary/default.html> (accessed 5 April, 2011).
- Llewellyn, R.S., and Allen, D.M. (2006) Expected mobility of herbicide resistance via weed seeds and pollen in a Western Australian cropping region. *Crop Protection* **25**, 520-526.
- Marsh, S.P., Pannell, D.J., and Llewellyn, R.S. (2006) Weed and pollen mobility and social costs of herbicide resistance. In '15th Australian Weeds Conference'. Adelaide, South Australia pp. 495-498.
- Michael, P.J., Owen, M.J. and Powles, S.B. (2010) Herbicide-resistant weed seeds contaminate grain sown in the Western Australian grainbelt. In '17th Australasian Weeds Conference'. Christchurch, New Zealand pp. 285-286.
- Moerkerk, M.R. (2002) Seed box survey of field crops in Victoria during 1996 and 1997. In '13th Australian Weeds Conference', Perth, Western Australia pp. 55-58.
- Niknam, S.R., Moerkerk, M., and Cousens, R. (2002) Weed seed contamination in cereal and pulse crops. In '13th Australian Weeds Conference', Perth, Western Australia pp. 59-61.

- Neve, P., Diggle, A.J., Smith, F.P. and Powles, S.B. (2003). Simulating evolution of glyphosate resistance in *Lolium rigidum*. II. Past, present and future glyphosate use in Australian cropping. *Weed Research* **43**, 418-27.
- Pratley, J., Urwin, N., Stanton, R., Baines, P., Broster, J., Cullis, K., Schafer, D., Bohn, J., Krueger, R. (1999) Resistance to glyphosate in *Lolium rigidum*. I. Bioevaluation. *Weed Science* **47**, 405-411.
- Preston, C. (2010) Australian Glyphosate Resistance Register. Australian Glyphosate Sustainability Working Group. Online. Available www.glyphosateresistance.org.au (accessed 30 March 2010).
- Preston, C., Wakelin, A.M., Dolman, F.C., Bostamam, Y., Boutsalis, P. (2009) A decade of glyphosate-resistant *Lolium* around the world: mechanisms, genes, fitness, and agronomic management. *Weed Science* **57**, 435-441.
- Rieger, M.A., Potter, T.D., Preston, C., and Powles, S.B. (2001) Hybridisation between *Brassica napus* L. and *Raphanus raphanistrum* L. under agronomic field conditions. *Theoretical and Applied Genetics* **103**, 555-560.
- Thill, D.C. and Mallory-Smith, C.A. (1997) The nature and consequence of weed spread in cropping systems. *Weed Science* **45**, 337-342.
- Thomas, A.G., Gill, A.M., Moore, P.H.R., and Forcella, F. (1984) Drought feeding and the dispersal of weeds. *Journal of the Australian Institute of Agricultural Science* **50**, 103-107.
- Shaner, D.L. (2000) The impact of glyphosate-tolerant crops on the use of other herbicides and on resistance management. *Pest Management Science* **56**, 320-326.
- Shields, E.J., Dauer, J.T., VanGessel, M.J., and Neumann, G. (2006) Horseweed (*Conyza canadensis*) seed collected in the planetary boundary layer. *Weed Science* **54**, 1063-1067.
- Stallings, G.P., Thill, D.C., Mallory-Smith, C.A. and Lass, L.W. (1995) Plant movement and seed dispersal of Russian thistle (*Salsola iberica*). *Weed Science* **43** 63-69.

FLAMING FIREWEED

Brian Sindel¹, Andy Sheppard², Phoebe Barnes¹ and Michael Coleman³

University of New England, ¹Department of Agronomy and Soil Science, ³Institute for Rural Futures, Armidale, NSW 2351

²CSIRO, Ecosystem Sciences, GPO Box 1700, Canberra, ACT 2601

ABSTRACT

Fireweed (*Senecio madagascariensis*) continues to spread in coastal pastures in south eastern Australia, as well as onto the Northern and Southern Tablelands of NSW and in far north Queensland on the Atherton Tablelands. Wherever it spreads it is causing considerable angst amongst farming communities. Recognising the impact and spread of fireweed, and as a result of landholder lobbying, particularly by the Bega Valley Fireweed Association, the Australian Government funded a 2 year research project through the University of New England and CSIRO in 2010 to examine ways to better control this weed and fully assess prospects for biological control. Field sites were established at Dorrigo and Armidale in northern NSW to collect data on survival of fireweed seeds in the soil, impact of fireweed on pasture production and availability, and fireweed seedling emergence times. Initial results indicate that pasture availability to livestock is reduced where fireweed plants are growing close to one another but that seed longevity can be relatively short in the soil seed bank under high rainfall conditions. Where pasture growth is weakened e.g. through herbicide application, fireweed seedlings may germinate in large numbers out of season. An application was submitted to the Australian Weeds Committee (AWC) in September 2010 on behalf of the Australian Government to have fireweed listed as a Weed of National Significance (WoNS), but this application is still under consideration. Twelve natural enemies have been identified in initial surveys across five populations of fireweed in the Kwa-Zulu Natal Province of South Africa, including three stem borers, four flower feeders, two sap suckers, and three plant pathogens. A postdoctoral research fellow and Masters student at the University of Kwa-Zulu Natal will examine what factors keep fireweed in check in South Africa and continue quantitative studies of the weed's natural enemies including attempts to rear the species and make more specific identification.

INTRODUCTION

Fireweed (*Senecio madagascariensis* Poir.) is an invasive weed with wind-blown seed that commonly occurs in temperate and subtropical pastures along the south east coast of Australia. Containing pyrrolizidine alkaloids, it is poisonous to livestock, particularly cattle. However, once cattle are familiar with the weed, they tend to avoid it, which allows it to compete more vigorously with pastures and reduce their productivity. Poisoning is more likely to occur where other feed is limited, when plants are young and not easily differentiated from the rest of the pasture, when contaminated hay is consumed or when stock are newly introduced to the weed (Sindel *et al.* 1998). While herbicides are available that effectively kill fireweed, year-long management is made difficult because of the ability of the weed to germinate and flower throughout much of the year (Sindel and Michael 1996).

In Australia fireweed was introduced to the Hunter Valley around 1918 (Sindel 1986), probably through shipping. By the 1980s the weed had spread north and south in coastal New South Wales and southern Queensland in similar climatic regions to where it originated in southern Africa and also where it is found in Argentina (Sindel and Michael 1992).

Fireweed continues to spread in coastal pastures in south eastern Australia, as well as onto the Northern and Southern Tablelands of NSW and in far north Queensland on the Atherton Tablelands. Wherever it spreads it is causing considerable angst amongst farming communities and has led to debate as to whether the weed should or should not be declared noxious in certain areas. Recognising the impact and spread of fireweed, and as a result of landholder lobbying, particularly by the Bega Valley Fireweed Association, the Australian Government through the Department of Agriculture, Forestry and Fisheries (DAFF) funded a 2 year research project through the University of New England (UNE) and CSIRO in 2010 to examine ways to better control this weed and fully assess prospects for biological control. In this paper we report on some of the current issues surrounding fireweed and some early results of the *Fireweed Control Research* project.

RECENT SPREAD

In the late 1980s fireweed was restricted principally to coastal pastures from north of Brisbane to Nowra with small infestations near Bega on the south coast of NSW (Sindel and Michael 1988) and isolated plants further inland, particularly at Dubbo on the Central Western Plains of NSW within the confines of the Western Plains Zoo (Sindel and Michael 1992). Based on the then distributions in Australia and overseas, Sindel and Michael (1992) predicted that fireweed could well spread further north in eastern Queensland, further south through coastal Victoria, and into higher altitude areas in tropical Queensland, though areas with heavy frosts may have reduced the 'weediness' of the species, since young seedlings were shown to be somewhat sensitive to frost (Sindel and Michael 1989).

Fireweed is now widespread in the Bega area where once it occurred only in isolated patches, and reports of it spreading in the Dorrigo and Tenterfield areas on the Northern Tablelands and in the Monaro region on the Southern Tablelands of NSW indicate that this invasive pasture weed has not yet reached its potential distribution in Australia. In 2007 the weed was found growing on the Atherton Tablelands in far north Queensland, in line with predictions by Sindel and Michael (1992).

If as predicted, climate is indeed changing and becoming warmer and drier in many parts of Australia, this will affect the continued spread of fireweed and its potential distribution. The movement of the weed into cooler highland areas, as is occurring now in NSW and Queensland, may increase in the future. Likewise, cooler southern Australian areas may become more susceptible to invasion.

The realized distribution of a weed is often tempered by factors in addition to climatic suitability or by factors that interact with climate. For example, the rust fungus *Puccinia lagenophorae* that commonly infects fireweed in Australia in wet weather may become less of a constraint on growth and reproduction of the weed if there are drier times ahead, though increasing temperatures may

be of benefit. The extent to which this pathogen constrains fireweed in Australia is largely unknown.

FIREWEED CONTROL RESEARCH PROJECT

There are four major aims of the *Fireweed Control Research* project being undertaken by UNE and CSIRO: 1) to compile data for a fireweed application under the Weeds of National Significance (WoNS) nomination process; 2) to conduct research to fill gaps in our current knowledge of fireweed ecology and impacts; 3) to undertake initial investigation of potential biological control agents for fireweed in South Africa; and 4) to identify current best practice management strategies for fireweed, and work with industry and community groups to extend these findings to agricultural landholders.

WONS Application

An application was submitted to the Australian Weeds Committee (AWC) in September 2010 on behalf of the Australian Government to have fireweed listed as a WoNS, but this application is still under consideration and is being compared against applications for a range of other environmental and agricultural weeds. Listing of fireweed as a WoNS would recognize its impact on communities, agriculture and the environment and lead to additional resources being devoted to research and extension, but it is not clear whether fireweed will be rated highly enough in the current prioritization process.

Ecology and Impact Studies

Field sites were established at Dorrigo and Armidale in northern NSW to collect data on survival of fireweed seeds in the soil, impact of fireweed on pasture production and availability, and fireweed seedling emergence times. Initial results indicate that pasture availability to livestock is reduced where fireweed plants are growing close to one another but that seed longevity can be relatively short in the soil seed bank under high rainfall conditions. Where pasture growth is weakened e.g. through herbicide application, fireweed seedlings may germinate in large numbers out of season, e.g. over summer.

Biocontrol Progress

Contracts were recently established between CSIRO and the University of Kwa-Zulu Natal in South Africa to undertake the biological control component of this research. Twelve natural enemies have been identified in initial surveys across five populations of fireweed in the Kwa-Zulu Natal Province, where Australian fireweed is thought to have originated, including three stem borers, four flower feeders, two sap suckers, and three plant pathogens. A postdoctoral research fellow and Masters student at the University of Kwa-Zulu Natal will examine what factors keep fireweed in check in South Africa and continue quantitative studies of the weed's natural enemies including attempts to rear the species and make more specific identification.

While Sindel *et al.* (2008) have argued strongly that the potential for biological control of fireweed in Australia should be fully investigated based on the invasiveness of fireweed in Australia, lack of weediness in South Africa and identification of the area of origin, the chances of finding one or more agents that suppress the growth of fireweed without damaging a range of closely related native *Senecio* species in Australia is low. In Hawaii, where the moth *Secusio extensa* (Lepidoptera: Arctiidae) has recently been evaluated for biological control of fireweed and proven to cause high levels of feeding damage on potted plants (Ramadan *et al.* 2011), all species of Senecioneae are non-native and weedy. While the results indicate that *S. extensa* is sufficiently host-specific for introduction for biological control to Hawaii, that is unlikely to be the case in Australia where the chances of the moth attacking Australian native *Senecio* species is high. A fireweed biocontrol workshop is being conducted with representatives from Australia, Colombia, Argentina, Brazil and Japan in association with the XIIIth International Symposium on Biological Control of Weeds in Hawaii this September.

Best Practice Management

A summary of current best management practices for fireweed has been drafted as a booklet 'Fireweed: a Best Practice Management Guide for Landholders' and this is currently out for review and comment. Aimed at farmers and hobby farmers and written in an easy going style, the booklet is designed to complement existing more technical publications produced by state departments. It will initially be published on the web in pdf form and then towards the end of the *Fireweed Control Research* project in mid 2012, hard copies of the booklet will be published and printed for distribution to landholders. This finalized version of the booklet will be revised on the basis of information that is to be collected on best practice management (BPM) from a survey of graziers along the NSW/Queensland coast to be undertaken by UNE in spring 2011. This survey will replicate a survey undertaken throughout these districts over 20 years ago by Sindel and Michael (1988) and allow us to see how the fireweed situation and management practices have changed over that period with directly comparable data. The current Guide can be found at www.ruralfutures.une.edu.au/fireweed/fireweed.htm on the UNE website. We welcome comments and suggested improvements.

CONCLUSION

Although competitive pastures suppress fireweed growth, fireweed is not simply a management problem for individual landholders. In continuing drought times, which are likely to increase with climate change, and in drier environments such as the far south coast of NSW, it is difficult to maintain high pasture cover and there are few other economic options available for fireweed control. It is also probable that fireweed management will become more difficult in the future because of greater restrictions being placed on fireweed-effective herbicides such as bromoxynil.

Weeds such as fireweed can create considerable consternation within communities, often because of their invasiveness and impact on the social and financial wellbeing of the landholders concerned, and the failure of management strategies to halt the invasion of the weed. Fireweed in Australia is rightly considered to be a 'flaming' nuisance. An integrated approach to weed management requires utilization of a range of techniques. Given the continued spread of fireweed

both in Australia and overseas, the prospect of climate change leading to further spread, and its origin having been identified, a sound case has been made for further investigation of the potential for biological control of fireweed in Australia. This work is now in progress. We suggest that further research is also required into a range of other techniques, such as the utilization of livestock types other than cattle, novel physical techniques and wick wiping of non-selective herbicides for fireweed control.

ACKNOWLEDGMENTS

We acknowledge the provision of funding for this fireweed research from the Australian Government via DAFF through the National Weeds and Productivity Research Program and are grateful to the Bega Valley Fireweed Association, Dorrigo Community Weed Action and the many other landholders, researchers and advisors who are contributing to a better understanding of fireweed and its control, including those on the Steering Committee of the *Fireweed Control Research* project – Clare Edwards, Noel Watson, Barry Powells, Bill Palmer, Craig Muir, Berte Hennecke and Rowley Beckett.

REFERENCES AND FURTHER INFORMATION

- Ramadan, M.M., Murai, K.T. and Johnson, T. (2011). Host range of *Secusio extensa* (Lepidoptera: Arctiidae), and potential for biological control of *Senecio madagascariensis* (Asteraceae). *Journal of Applied Entomology* 135, 269-84.
- Sindel, B.M. (1986). The ecology and control of fireweed (*Senecio madagascariensis* Poir.). *Plant Protection Quarterly*, 1, 163-72.
- Sindel, B.M. and Michael, P.W. (1988). Survey of the impact and control of fireweed (*Senecio madagascariensis* Poir.) in New South Wales. *Plant Protection Quarterly* 3, 22-8.
- Sindel, B.M. and Michael, P.W. (1989). Frost as a limiting factor in the distribution of *Senecio madagascariensis* Poir. (fireweed) in Australia. Proceedings of the 12th Asian-Pacific Weed Science Society Conference, Taegu, Republic of Korea, pp. 453-9. Asian-Pacific Weed Science Society.
- Sindel, B.M. and Michael, P.W. (1992). Spread and potential distribution of *Senecio madagascariensis* Poir. (fireweed) in Australia. *Australian Journal of Ecology* 17, 21-6.
- Sindel, B.M. and Michael, P.W. (1996). Seedling emergence and longevity of *Senecio madagascariensis* Poir. (fireweed) in coastal south-eastern Australia. *Plant Protection Quarterly* 11, 14-9.
- Sindel, B.M., Michael, P.W., McFadyen, R.E. and Carthew, J. (2008). The continuing spread of fireweed (*Senecio madagascariensis*) – the hottest of topics. Proceedings of the 16th Australian Weeds Conference, Cairns, 2008, eds R.D. van Klinken, V.A. Osten, F.D. Panetta and J.C. Scanlan, pp. 47-9, The Weed Society of Queensland Inc., Brisbane.
- Sindel, B.M., Radford, I.J., Holtkamp, R.H. and Michael, P.W. (1998). The biology of Australian weeds. 33. *Senecio madagascariensis* Poir. *Plant Protection Quarterly* 13, 2-15.
- Updates on fireweed research can be found at <http://www.ruralfutures.une.edu.au/fireweed/fireweed.htm> on the UNE website where you can also register to be placed on a mailing list for such updates.

STRATEGIC USE OF WEED LEGISLATION TO LIMIT THE SPREAD OF WEEDS IN NEW SOUTH WALES

Dr Stephen B. Johnson¹ and Ass. Prof. Paul O. Downey^{2,3}

¹Invasive Species Unit, Biosecurity, New South Wales Department of Primary Industries,
Locked Bag 21, ORANGE, NSW 2800

²Pest Management Unit, Parks and Wildlife Division, New South Wales Department of
Environment, Climate Change and Water, PO Box 1967, HURSTVILLE, NSW 1481

³Current address: Institute of Applied Ecology, University of Canberra, CANBERRA,
ACT 2601

SUMMARY

Although the NSW *Noxious Weeds Act 1993* (NW Act) outlines a list of noxious weed species for the State, these listings have seldom been used strategically to manage individual weed species, or weeds more generally from a statewide perspective, for example to contain the spread of listed weed species. This paper outlines how the listings under the NW Act could be used to manage weeds more strategically, and recent progress on declarations to achieve this outcome.

Using the following four weed species listed under the NW Act as **theoretical examples**: (1) cats claw creeper, (2) bridal creeper, (3) African olive and (4) fireweed, we illustrate how the declaration process, being a combination of the declared control areas (DCAs) and Control Classes (CCs) for individual species, can be used strategically to establish state-wide containment zones. Firstly, we overlaid the current distribution pattern for each weed with the current DCA listings to highlight the degree of mismatch. Then we assigned each of the 'unlisted' DCAs in the state for each taxa with one of three CCs, being (i) eradication; (ii) suppression (containment), and; (iii) asset protection, or left them as 'unlisted' for DCAs that are unlikely to be invaded. The selection of the CC for each DCA was based on its proximity to the current infestation, with DCAs covering core infestations assigned an asset-protection class. A containment CC was assigned to those DCAs along the edge of the taxa's distribution, that is with low density or scattered infestations, and an eradication CC to all adjoining DCAs currently without the listed taxa or where it is scarce.

Following, a recent five-year statutory review of all weed species originally declared in Weed Control Order 20, using the NSW Weed Risk Management system to determine the weed risk and feasibility of control, the proposed process outlined above was applied to all Class 1-4 listed weed species. In order to obtain support for these proposed changes, a series of targeted stakeholder consultations were undertaken for the regions and areas affected, as well as statutory public consultation in accordance with the NW Act. The targeted consultation process has, to date, resulted in widespread support among local control authorities for the proposed strategic changes to the way weeds are managed under the NW Act.

The proposed changes aim to strategically limit the spread of listed weed species without the need for significant additional resources, simply by (i) raising awareness of the weed species with local stakeholders in areas where it is absent or scarce, and (ii) ensuring that suppression

and monitoring occurs in areas with low densities. This more comprehensive and strategic approach will have direct benefits for all stakeholders.

INTRODUCTION

The management of weeds can be split into four strategic activities, prevention, eradication, containment and asset-protection (Charlton *et al.*, 2009). Whilst significant emphasis has been placed on prevention and/or early intervention as the most cost effective management approach, all four areas/activities are important for weed management. This emphasis is the basis for many of the weed declarations in New South Wales (NSW) and across Australia.

A total of 181 taxa are presently declared as noxious under the NW Act, in one of five Control Classes (CC). Control Classes 1 and 5 encompass the whole state, being essentially state-wide eradication targets, and imposing restrictions on sale and movement, respectively. There are 27 taxa in CC1 and 30 in CC5. The remaining 124 weed taxa are listed in one or more of the three remaining CCs based on their status (i.e. density and impacts) in each of the 123 Local Control Authorities (LCAs) in NSW. These listings are derived from requests either from individual control authorities, or from collective weed committees encompassing a number of LCAs in a region. This localised approach to listings and declarations has rarely resulted in the strategic management of noxious weeds on a state-wide basis: (bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) is the notable exception). For example, the listings and declarations have not been used to limit the spread of emerging species or establish containment zones for significant weeds, e.g. the Weeds of National Significance (WoNS).

Irrespective, strategic weed management of some declared taxa under the NW Act does occur to some extent in the following instances:

- CC1 taxa (state-wide prevention and eradication);
- CC5 taxa (i.e. state-wide restrictions on sale and movement) – to a lesser extent than CC1;
- for Weeds of National Significance not listed as CC1 or CC5, which are listed strategically, e.g. alligator weed (*Alternanthera philoxeroides*) and salvinia (*Salvinia molesta*) both declared as CC2 and CC3 in different declared control areas (DCAs), and serrated tussock (*Nassella trichotoma*) as CC3 and CC4; and,
- other important weeds within NSW, e.g. water hyacinth (*Eichhornia crassipes*), declared as CC2, CC3 and CC4, and the Pampas grasses (*Cortaderia* spp.), as CC3 and CC4 in different DCAs.

In order to enhance weed management outcomes, we set out to develop a way of making noxious weed declarations more strategic, once a weed was declared as noxious. As a result of this process, we propose the use of strategic declarations for listed species to deliver state-wide as well as regional outcomes, and thereby illustrate how the Act and declarations can be used more strategically to deliver on the objectives of the Act, as well as to limit the spread of listed noxious weeds in NSW. Lastly we assessed the level of stakeholder acceptance for these proposed changes. This paper is an expansion of Downey and Johnson (2010) who initially proposed these changes.

METHODS

The development of a new system for strategically managing noxious weeds

Initially, we selected four noxious weed species to use as **theoretical examples** to illustrate how the process may work: (1) cats claw creeper (*Macfadyena unguis-cati*); (2) bridal creeper (*Asparagus asparagoides*); (3) African olive (*Olea europaea* subsp. *cuspidata*) and (4) fireweed (*Senecio madagascariensis*). For each of the four weed species we examined each of the 123 LCAs in NSW to determine their current declaration status in each, that is, not listed or CC1-5 (I&I NSW, 2010a), the distribution of the weed based on records held in PlantNet (BGT, 2010) and the authors' knowledge. We also made a qualitative assessment of their potential spread based on known invasion pathways and habitat preferences to determine those LCAs that may become invaded in the future. We then allocated each LCA with a proposed CC based around strategically controlling and containing the species, using the existing CCs, these being: CC2 (prevention and eradication), CC3 (containment and suppression) and CC4 (asset protection). Areas that were unlikely to be invaded, and where the species/taxa was not present, were not allocated a CC (i.e. not listed). It should be noted that a number of LCAs already had declarations listed (DCAs).

Assessing the feasibility of implementing the proposed changes

The proposed changes or system based on these four examples, was examined for its potential use and implementation during the recent review of Weed Control Orders under the NW Act, which occurs every five years. For example all declarations made under Order 20 (declared in 2006) were reviewed before they expired on 30 August 2011. A review of all declarations since Order 20 using the NSW Weed Risk Management (WRM) system (Johnson 2009a, b), has assessed 27 CC1, 12 CC2 and 36 CC3 weeds (see Johnson and Lisle (2009) and Johnson and Charlton (2010) for further information). Because CC4 weeds are declared at a variety of scales from one local government area to the whole State, Industry and Investment (I&I) NSW (now NSW Department of Primary Industries, DPI) invited local government stakeholders to review and submit their CC4 weed declarations. Over 70% of LCAs returned their assessments within the 21 day timeframe, and this number was increased to 93% after a further 21 day grace period. The CC5 species were previously assessed using a separate desktop review method.

This review also examined the potential for including/introducing the new strategic system proposed here, because it would require the listing of some noxious weeds in new LCAs, which would potentially result in new declarations. Given the potential number of new declarations (i.e. new LCAs and CCs for already listed weeds) it is advisable to add them during a strategic review of all declarations.

Assessing the level of stakeholder support for the proposed changes

As LCAs are primarily responsible for implementing the NW Act, I&I NSW (the agency primarily responsible for the Act) needed to consult with LCAs in order to achieve any mutually agreeable changes. Consultation with both key stakeholders (informal), and more broadly with the public (a statutory obligation), is an important part of the process of assessing new weed declarations and changes to the way weeds are declared. The various levels of consultation undertaken are outlined below (as outlined above, the CC5 review occurred through a different process).

Control Class 1 weeds (CC1) – are declared across the state and are generally either the subject of State and/or National eradication campaigns, or are not yet found in NSW. Consultation on new CC1 weeds was conducted with key stakeholders, such as those represented on the Noxious Weeds Advisory Committee.

Control Class 2 weeds (CC2) – are regional targets for eradication in NSW. Consultation with key stakeholders (as above) and affected LCAs occurred for all new or revised CC2 listings.

Control Class 3 weeds (CC3) – are subject to regional containment. As for CC2 weeds, consultation with key stakeholders and affected LCAs occurred for new or revised CC3 listings.

Control Class 4 weeds (CC4) – it was assumed that LCAs had initiated some form of consultation with their stakeholder for all requested changes submitted. Any declaration changes that did not arise specifically from the LCAs (i.e. like those proposed here), were the subject of specific consultation with LCAs directly affected.

Statutory Public Consultation – An additional period of consultation on all proposed changes to a weed control order is legislated, this being statutory public consultation. This process includes public advertisement, accepting public submissions, and consideration of those submissions. This consultation takes place prior to gazettal of any new weed control order.

RESULTS AND DISCUSSION

Strategic management of noxious weeds: establishing containment zones

A large majority of the control declarations, that is DCA and CCs under the NW Act are not strategic from a state-wide perspective, based on the spatial assessments of the four weeds undertaken here (Figure 1). This assessment indicated that the NW Act could be used more strategically to contain the spread of listed weed species in NSW, through the establishment of state-wide containment zones based on the spatial aggregation of DCAs and the level of CC assigned. Whilst this process may not be applicable for all declared weed taxa in NSW (i.e. those weeds that are already widespread across the state), our results illustrate that this approach has significant benefits in helping to reduce the spread of many noxious weeds.

Improving strategic management under the NW Act

The strategic management of a number of weeds could be improved by the approach outlined here (i.e. to limit spread). To illustrate this point, there are a large number of listed weeds identified in several recent reports as posing an impact to threatened species in NSW (Coutts-Smith and Downey, 2006; Downey *et al.*, 2010), whose management could benefit from such strategic management. In addition this approach could be modified to have direct benefits to the biodiversity at risk, especially if those DCAs (and surrounding ones) with the worst impacts were given 'higher' CC classes. Those weed species indentified as posing an impact

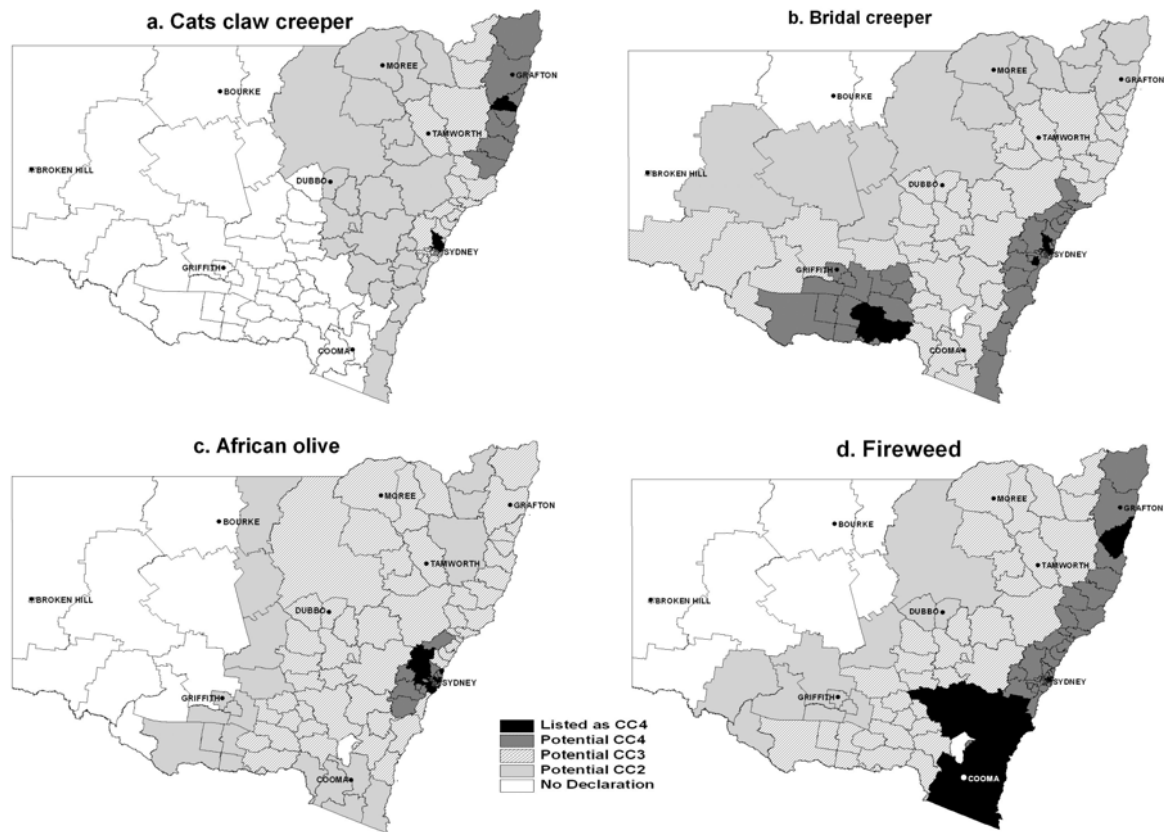


Figure 1. Current (listed) and proposed (potential) declarations of (a) cats claw creeper, (b) bridal creeper, (c) African olive and (d) fireweed, which illustrate how the *Noxious Weeds Act 1993* in New South Wales can be used more strategically to contain and manage the spread of listed weeds, using the weed’s distribution and the legislative control classes (CC).

whose management would benefit from this approach include bridal creeper (Figure 1b), lantana (*Lantana camara*), Madeira vine (*Anredera cordifolia*), cat’s claw creeper (Figure 1c), asparagus fern (*A. aethiopicus*), Scotch broom (*Cytisus scoparius*), Japanese honeysuckle (*Lonicera japonica*), the privet species (*Ligustrum lucidum* and *L. sinense*) and gorse (*Ulex europaeus*).

Increase in the number of weed declarations

In order to implement the proposed changes from these (and other similar) strategic assessments (Figure 1), each proposed addition or change (i.e. LCA/DCA and CC) would need to be enacted. Based on these four examples, the number of LCAs in which each weed could be potentially listed would increase significantly (Table 1).

The level of stakeholder support for the proposed changes

The consultation process to align weed declarations with the weed species distribution and level of control with respect to the establishment of containment strategies, has, to date, resulted in approximately 74% of the Local Control Authorities agreeing with the proposed

amendments recommended by NSW DPI. In a further 19% of cases a mutual agreement was negotiated between the both parties. In less than 1% of cases, agreement was not reached between LCAs and NSW DPI and the proposed amendments recommended by NSW DPI were used (Table 2).

Table 1. Summary of the number of Local Control Authorities (LCAs) in which cats claw creeper, bridal creeper, African olive and fireweed are declared in NSW and the number of declarations proposed to deliver strategic management (see also Figure 1). Note: CC = Control Class, and the total number of LCAs is 123.

Declared weed taxa	LCAs with current declarations (all CC4)		LCAs actually invaded by weed		Proposed declarations			
	No.	% of total	No.	% of total	CC2	CC3	CC4	all
					No. of LCAs	No. of LCAs	No. of LCAs	% of total
cats claw creeper	12	10	10	8	24	39	7	57
bridal creeper	10	8	66	54	13	42	56	90
African olive	7	6	47	38	20	55	33	88
fireweed	14	11	68	55	12	35	54	82

Table 2. The outcomes, to date from the consultation process involving the proposed changes to the noxious weeds listings in NSW (see text for further details). Data represents a combination of 42 Local Control Authorities (LCAs) responses to the proposed changes in declaration for 20 weeds, all in Control Class 3. Many LCAs were consulted on more than one species.

Consultation outcome	Details of consultations/negotiations	Number of LCAs consulted	Percentage
General agreement – no changes needed	LCA agrees with NSW DPI proposed recommendations	123	73.7
Changes required	LCA/NSW DPI mutually negotiated an agreeable outcome	31	18.6
Consultation failed – no changes recommended	LCA disagrees with NSW DPI recommendations. After consideration NSW DPI kept it's original recommendations	1	0.6
Consultation unsuccessful – no change recommended	LCA not yet contacted/ contactable. Proposed NSW DPI outcome recommended	12	7.2
	Total	167	100

The outcomes of the consultation, to date, from a combination of 42 LCAs (out of 123, 34%) and 20 CC3 weeds (18 existing species and two new species, out of 36 existing species, 50%) are reported (Table 2). Local Control Authorities agreed with NSW DPI recommendations nearly 74% of the time while mutual agreement was negotiated in nearly 19% of other cases. In less than 1% of cases, agreement was not reached between LCAs NSW DPI and the proposed recommendation of NSW DPI was recommended.

Why was there such a positive response rate?

Operationally, the large number of proposed new declarations (for example, for cat's claw creeper the proposed recommendation would lead to 70 additional LCA/CC declarations, see Table 1) will impose extra responsibilities on many individual LCAs. In saying this, most of the proposed new declarations, will pose little or minimal changes to the current approach because they cover areas [LCAs] that are currently free of the declared weed species (i.e. if listed as CC2 – also see Figure 1). Whilst there are awareness raising costs associated with educating stakeholders in these LCAs and small monitoring costs, control costs would be non-existent or very low (i.e. once an infestation was detected). These costs would however, be substantially offset by future savings, because any infestation should be detected and treated early and thus prevented from establishing; something that may have happened only sporadically under the previous declaration approach. In addition this system enables individual LCAs to be more strategic in their control of their declared weeds, as well as monitoring for future weeds; which are now identified in a robust manner for them. This increased strategic guidance and support should aid implementation of the NW Act; we conclude this from the high level of support for the proposed changes.

Managing small weed outbreaks is consistent with the cost-effective basis of managing new weed incursions, and stopping weed spread. Where the costs will be incurred is in the DCAs/LCAs that adjoin core infestations of declared weeds in which the weed is not currently declared, but require management from a strategic state-wide perspective. These DCAs would then be declared CC3 (containment and suppression), which requires active suppression. The number of LCAs affected is dependent on the weed species, the current declarations, current and potential distribution and how manageable the weed is within the LCA. In some instances, some core infestation areas without a current declaration will need to be listed as CC4, which would also incur management costs. However as all new CC4 listing require the development of a management plan under the NW Act, the costs and scale of control can be clearly articulated before work commences.

It is probable that the extra costs (control and awareness) involved can be accounted for by changes in government funding (I&I, 2010b) which will be increasingly directed towards early detection and eradication, or containment, complementary to the approaches contained in the NSW Invasive Species Plan 2008-2015 (NSW DPI, 2008).

Broader outcomes

As part of the WoNS initiative, a series of nationally strategic containment zones has recently been proposed, some of which occur in NSW (Weeds Australia, 2010). The NW Act has been used to support some these containment zones in the past. For example, the NW Act supports strategic containment to (i) prevent the spread of lantana further south in coastal NSW, (ii) containment and eradication of boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*) in the Sydney basin and north, and (iii) reduce infestations of bitou bush from the Illawarra south of Sydney to the Victorian border. It also helps ensure the eradication and surveillance of incursions of Hymenachne (*Hymenachne amplexicaulis*) and Parthenium weed (*Parthenium hysterophorus*) into NSW (both CC1 species), and alligator weed and salvinia from coastal NSW, while supporting the containment of serrated tussock and Chilean needle grass (*Nassella neesiana*). The proposed changes would make adoption of these broader outcomes

easier, and in many instances, establish such outcomes, through strategic listings based on the weeds distribution and controllability.

Future directions

This study has highlighted the value in looking at noxious weeds legislation and the declaration process for individual taxa in a more strategic way from a state-wide and legislative perspective. Once adopted, the process will greatly strengthen our ability to manage key weed species and reduce the costs long-term, by helping to contain species and limit their spread in a strategic manner, as well as to detect and treat new outbreaks of such species. This has not occurred uniformly in the past with some weeds species invading large areas before detection or strategic management has been applied, and usually long before any declarations are made; especially considering the protracted declaration process. Whilst this approach is significant for weed management in NSW, the same or a similar approach could be applied in other jurisdictions to achieve the same outcome.

ACKNOWLEDGMENTS

Alan Maguire (NSW DPI), kindly produced the figures while Adjunct Professor Bruce Auld did the majority of Class 1, 2 and 3 NSW WRM system assessments.

DISCLAIMER

The species discussed in this paper are used as theoretical examples and recommended declarations are subject to negotiation between NSW DPI and relevant stakeholders.

REFERENCES

- BGT (2010). PlantNET. Botanic Gardens Trust, Sydney, Australia. plantnet.rbgsyd.nsw.gov.au
- Charlton, S.A., Downey, P.O. and Johnson, S.B. (2009). Weed categorisation – applying the ‘PECA code’ in NSW. In ‘Proceedings of the 15th Biennial NSW weeds conference’, Narrabri, pages unnumbered. (I&I NSW, Orange).
- Coutts-Smith, A.J. and Downey, P.O. (2006). ‘The impact of weeds on threatened biodiversity in New South Wales’. Technical Series 11. (CRC for Australian Weed Management, Adelaide).
- Downey, P.O. and Johnson, S.B. (2010). Strategic use of weed legislation to limit the spread of weeds in NSW. In Zydembos, S.M. (Ed.) ‘17th Australasian Weeds Conference’, Christchurch, pp. 478-481. (New Zealand Plant Protection Society, Christchurch).
- Downey, P.O., Scanlan, T.J and Hosking, J.R. (2010). Prioritizing weed species based on their threat and ability to impact on biodiversity: a case study from New South Wales. *Plant Protection Quarterly* 25(3), 111-126.
- I&I (2010a). Noxious weed declarations. (Industry and Investment NSW, Orange). www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds
- I&I (2010b). ‘NSW Weeds Action Program. Guidelines for Applicants for 2010-2011’. (Industry and Investment NSW, Orange).
- Johnson, S. B. (2009a). New South Wales Weed Risk Management System. Background Information. Industry and Investment New South Wales, Orange. 54 pp.
- Johnson, S. B. (2009b). New South Wales Weed Risk Management System. Instruction Book. Industry and Investment New South Wales, Orange. 90 pp.

Johnson, S.B. and Charlton, S.A. (2010). Evolution, not revolution. Getting stakeholders on board with the roll out of the National Post-Border Weed Risk Management protocols in New South Wales. *In* Zydenbos, S.M. (Ed.) '17th Australasian Weeds Conference', Christchurch, pp. 493-496. (New Zealand Plant Protection Society, Christchurch).

Johnson, S.B. and Lisle, S.D. (2009). The noxious weeds declaration process and the NSW Weed Risk Management System. What does this mean for you? *In* 'Proceedings of the 15th Biennial NSW weeds conference', Narrabri, pages unnumbered. (I&I NSW, Orange).

NSW DPI (2008). 'NSW Invasive Species Plan 2008-2015'. (NSW Government, Sydney). [available from: www.dpi.nsw.gov.au/agriculture/pests-weeds/nsw-invasive-species-plan].

Weeds Australia (2010). Weeds of National Significance. (Weeds Australia, Launceston). [available from: www.weeds.org.au/natsig]

ALLIGATOR WEED IN AN URBAN ENVIRONMENT

**Barry Powells
Chief Weeds Officer
Coffs Harbour City
Council**

Introduction

Alligator Weed (*Alternanthera philoxeroides*) represents one of the greatest threats to waterways, wetlands and irrigation systems in Australia. It is a very versatile weed, capable of growing on both land and water. It can tolerate a range of control methods, is tolerant of most herbicides and any effective control program can take several years. It is a Weed of National Significance and a Class 2 noxious weed in northern NSW

Alligator Weed is a perennial stoloniferous herb capable of producing monocultures of creeping and upright stems.

The main identifying features are a hollow stem, spear shaped leaves arranged in opposite pairs along the stem and papery white ball-like flowers on stalks.

The Coffs Harbour infestation was positively identified in February 2010 on land south of the City owned by the Bundagen Cooperative. This land covers 313ha, is owned by 170 shareholders with approximately 100 living on this land. This co-operative was formed in 1981 by a group of like minded people, principally from the Bellingen area with the aim of preserving the land in its natural state and free from development. An additional aim was to provide low cost housing for members on pre-determined parts of the property.

The coastal strip has been sand mined in the past and has now been returned to its natural state. Bundagen has Bongil Bongil National Park as its northern and southern neighbor.

This group also strongly opposes the use of pesticides on their land!

The Alligator Weed was first noticed growing in the lawn of one residence. Early control advice from non-professionals at Bundagen was to keep mowing it and/or dig it out. After two years of this approach the weed continued to spread at an alarming rate, moving from the lawn to garden and vegetable growing areas and climbing up fruit trees.

The Bundagen Cooperative has a very energetic weeding group who meet regularly to control noxious and environmental weeds on the property. They finally suggested to get this weed properly identified which they did at the herbarium of the Coffs Harbour Botanic Gardens. At this point they contacted Council. In turn NSW DPI at Grafton was advised of this new infestation of Alligator Weed.

This is the first infestation of Alligator weed found between Port Macquarie and Lismore and therefore a significant regional site. The Bundagen community has a fairly transient population and many visitors to the area, so it is critical to maintain the weed awareness and then contain and manage the site. Many of the alternate lifestyle community in the Bellingen and Coffs areas also visit the site regularly.

An Eradication program

Its origin is unknown but thought to have been brought in by an earthmoving contractor. Unfortunately he has no recollection of where he worked before Bundagen.

Before work started there were some obstacles to overcome, the principle one being the aversion to the use of herbicides. After a meeting between council and concerned residents stressing the significance of the infestation, the difficulty of achieving effective control without herbicides and the impossibility of physical removal, Metsulfuron methyl was allowed to be used.

This herbicide was applied to actively growing plants on several occasions and within six months the level of infestation decreased by approximately 75%. However, fresh shoots kept on reappearing to remind us that the job was far from done.

Summer 2010-2011 created another problem. Being wet and hot, the grasses, particularly Paspalum grew very quickly and made the spraying of the Alligator Weed almost impossible. A solution had to be reached.

A further meeting was arranged between Bundagen residents, NSW DPI and Council to discuss solutions to the grass problem. Some Bundagen residents, particularly a close neighbour to the infested site were strongly opposed to the use of Glyphosate. Various solutions were put forward, including steam weeders, manual removal and digging but none were achievable. An agreement was reached to use Glyphosate once. Following death of the grass the area was brush cut and all material stored in black plastic.

Further Metsulfuron spraying occurred during summer/autumn further reducing the weeds viability.

As a longer term solution to the long grass problem the property owner mulched the site, against recommendations from Council and NSW DPI. Our fear is the Alligator Weed stolons will grow under the mulch undetected until stems appear making further control much less effective.

Overall the program has been successful but far from complete. We are looking at least a five year monitoring and control program before we can hopefully have this weed eradicated from the site.

Education and Awareness

All decisions to be made are discussed at community meetings for resolution. Before any control work commenced a series of meetings were held in conjunction with Council and NSW DPI. Alligator Weed brochures and the control manual were provided.

Regular updates on spraying and progress made were provided to the community.

The wider community was made aware of Alligator Weed by press releases and media interviews.

The Primary School where most Bundagen children attend was also contacted and Alligator Weed information was distributed in their school Newsletter.

Bellingen Council Weed Officers were made aware of the problem and media outlets advised as there are strong links between Bundagen and Bellingen.

Conclusion

The success of this program depends on many factors including:

- Early identification
- Follow up on any possible spread to other sites
- Gaining landowners cooperation
- Regular meetings with landowners to discuss program, problems etc
- Provide landowners with all necessary information about the weed and control options available
- Provide support
- Develop management plans in conjunction with landowner
- Community and Media made aware of the problem



**BATTLING BITOU BUSH FOR BIODIVERSITY: SUCCESSFUL
PARTNERSHIPS AND INTEGRATED MANAGEMENT FOR EFFECTIVE
OUTCOMES IN THE NORTHERN RIVERS**

Nicole Strehling¹, Melinda Fletcher², Hillary Cherry³, Reece Luxton⁴ and Rhonda James⁵

¹Catchment Coordinator (Southern)
Northern Rivers Catchment Management Authority, Kempsey

²Catchment Officer (Incentives)
Northern Rivers Catchment Management Authority, Alstonville

³National Coordinator Bitou Bush & Boneseed
Pest Management Unit, Office of Environment & Heritage, Hurstville

⁴Reece Luxton
Senior Environmental Officer (Weed Management)
Clarence Valley Council, Grafton

⁵Rhonda James
Director
Bushland Restoration Services, Cudgera

ABSTRACT

Bitou bush poses a significant threat to fragile coastal ecosystems in New South Wales (NSW). Bitou bush has impacted over 80% of the coastline, with at least 158 native plant species and 26 ecological communities at risk. The listing of bitou bush as a noxious weed under the NSW *Noxious Weeds Act 1993*, a Key Threatening Process under the NSW *Threatened Species Conservation Act 1995*, and as a Weed of National Significance, recognises the severity of its impact.

Partners in the Northern Rivers region are reducing the impact of bitou bush on biodiversity, utilising a dual approach of biodiversity asset protection and strategic containment. A national northern containment zone was established on the north coast of NSW at the Queensland (QLD) border. Consistent eradication efforts in QLD have prevented bitou bush spreading north. Partners in the Tweed are working to drive bitou bush south from the border and reduce its national distribution. Efforts are underway to strengthen the control requirements for bitou bush in the Tweed under the NSW Noxious Weeds Act.

The NSW Bitou Bush Threat Abatement Plan (Bitou TAP) prioritises 169 sites where bitou bush control can achieve the best possible biodiversity outcomes. The Northern Rivers Catchment Management Authority is implementing the Bitou TAP with nine land managers and over 15 community groups at 25 priority sites to protect biodiversity assets. This includes strategic, best-practice control to protect and recover native plant species at risk. Partners are also supporting community groups and schools to rear and release the

leaf roller moth (*Tortrix* sp) biological control agent on bitou bush. These programs rely on strong partnerships, collaboration across all land tenures and integrated weed management techniques. The success of the bitou bush program is made possible due to support from the community, land managers, and the NSW, QLD and Australian Governments.

INTRODUCTION

Bitou bush poses a significant threat to fragile coastal ecosystems in NSW. The Northern Rivers Catchment Management Authority is working with partners across the region to reduce the impact of bitou bush on biodiversity, utilising an integrated approach of containment, biodiversity asset protection, community engagement and biological control.

The bitou bush threat

Bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata* (DC.) T. Norl.) is a widespread environmental weed introduced from South Africa. It poses a significant threat to coastal ecosystems in the Northern Rivers region and the majority of Australia's east coast. Approximately 80% of the NSW coastal zone has been impacted by bitou bush and over 158 native plant species and 26 ecological communities are identified as at risk. Infestations result in changes to the diversity of birds, native mammals and ground-dwelling insects (French *et al* 2008), and reduce cultural and recreational access to coastal landscapes and their aesthetic appeal. Bitou bush is listed as a Key Threatening Process and noxious weed in NSW, and is a Weed of National Significance (WoNS).

The Northern Rivers Catchment Management Authority

The Northern Rivers Catchment Management Authority (NRCMA) is the regional body responsible for guiding natural resource management (NRM) in the Northern Rivers region. The region extends from the Camden Haven catchment in the south, north to the Queensland border, west to the New England Tablelands, and includes marine waters to three nautical miles and the Lord Howe Island group. With much of the Northern Rivers coastal zone under threat by bitou bush, management to protect and recover native plant species is an important issue for coastal land managers and communities.

Policy framework

Management of bitou bush is guided by numerous national, state, regional and local plans and strategies. Key strategies that guide NRCMA's bitou bush programs include:

- National Bitou Bush and Boneseed Strategic Plan (ARMCANZ, 2000)
- NSW State-wide targets for natural resource management (Premier's Department 2006)
- The NSW Bitou Bush Threat Abatement Plan (DEC, 2006)
- The NSW Threatened Species Priorities Action Statement (PAS) (DECC, 2007)
- Northern Rivers Catchment Action Plan (CAP) (NRCMA, 2005)

Management of widespread environmental weeds

Environmental weed management in NSW is undertaken according to four approaches (DPI 2008):

- 1) Prevention – actions to prevent new weed species from arriving,
- 2) Eradication – actions to remove newly arrived and naturalised weeds where eradication is an achievable goal,
- 3) Containment – actions to reduce the spread and/or severity of established weed infestations using defined geographic boundaries where eradication is no longer feasible, and
- 4) Asset protection – actions to protect environmental assets from the impacts of established weed species.

The NRCMA's bitou bush program uses a combined approach of containment and biodiversity asset protection. Because bitou bush is not limited to certain land tenures, effective management actions can only be delivered through strong, cross-tenure partnerships and community engagement.

ACTION

Containment - Control of bitou bush in the National Northern Containment Zone

The potential distribution of bitou bush ranges north to the coast of central QLD. However, consistent eradication efforts in QLD since 1980 have reduced bitou bush infestations to a surveillance level (Cherry *et. al.*, 2008). To support QLD efforts, a National Northern Containment Zone (NNCZ) for bitou bush was established on the NSW/QLD border in 1995 (Cherry *et. al.*, 2008). Control in the NNCZ is essential to prevent spread and reduce the northern distribution of bitou bush in Australia. The NRCMA has been working with Tweed Byron Local Aboriginal Land Council, Tweed Shire Council, NSW National Parks and Wildlife Service, Far North Coast Weeds, the NSW Land and Property Management Authority and Tweed coast Dunecare groups to develop and implement a plan to drive bitou bush south from the QLD border.

Since 2007, the NRCMA has delivered \$100,000 from NSW Environmental Trust and \$75,000 from its own investment program to:

- 1) map the extent and density of bitou bush in the NNCZ
- 2) develop a Bitou Bush National Northern Containment Zone Management Plan (BRS, 2009), and
- 3) undertake strategic best-practice control of bitou bush and secondary weed species to maximise natural regeneration.

On-ground works have been coordinated by Bushland Restoration Services (BRS) and implemented in partnership with land managers and the local Madhima Gulgan indigenous bush regeneration team. A further \$110,000 from the Australian Government's Caring for our Country will support extension of the NNCZ to include the whole Tweed Shire by June 2013. This investment has been complemented by significant cash and in-kind contributions from Tweed Shire Council, Far North Coast Weeds, the National Parks and Wildlife Service, and the Tweed coast Dunecare groups.

A monitoring program has been established in accordance with the Monitoring Manual for Bitou Bush Control and Native Plant Recovery (DECCW, 2009), including photopoints, mapping and observational data. Monitoring will be repeated after each year to ensure on-ground actions are effective and inform adaptive management.

To support on-ground works, NNCZ partners submitted a proposal to upgrade the classification of bitou bush under the NSW *Noxious Weeds Act 1993* from a Class 4 to a Class 3 noxious weed in the Tweed Shire. Under the current Class 4 classification, control requirements for bitou bush are ‘*Numbers and distribution reduced and prevented from flowering and spreading. The species must not be sold, propagated or knowingly distributed.*’ An upgrade to a Class 3 noxious weed would strengthen control requirements to ‘*The plant must be continuously suppressed and destroyed. The plant may not be sold, propagated or knowingly distributed.*’

Asset Protection - Implementation of the NSW Bitou Bush Threat Abatement Plan

The Bitou TAP uses a biodiversity asset protection approach to manage bitou bush. The approach identifies priority assets threatened by bitou bush and sites where control will have the greatest biodiversity outcomes. The Bitou TAP identifies 158 native plant species, 3 endangered plant populations and 26 ecological communities at risk from bitou bush in NSW and lists 169 high priority sites for control to benefit biodiversity (DEC 2006). Over half of the high priority sites listed in the Bitou TAP are located within the Northern Rivers region.

Since 2007, the NRCMA has worked with the NSW Office of Environment and Heritage, coastal Catchment Management Authorities, NSW Land and Property Management Authority, Community Reserve Trusts, Local Councils and coastal community groups to implement the Bitou TAP at 25 priority sites across over 309 hectares of land outside of National Park estate. The National Parks and Wildlife Service is implementing the TAP at a further 28 sites.

Bitou TAP implementation involves a number of consistent activities at each priority site, including:

- Preparation of a five-year site management plan using a standard proforma
- Staged control to protect priority native species using best-practice management techniques
- Monitoring in accordance with the Monitoring Manual for Bitou Bush Control and Native Plant Recovery

Table 1: NRCMA funded Bitou TAP sites

Land manager	Partners	Sites	Biodiversity at risk
Tweed Shire Council	Fingal Head Coastcare, Tweed Landcare, Bushland Restoration Services, DECCW	SEPP 26 No 2a Fingal Head	<i>Archidendron henderonii</i> , <i>Celtis paniculata</i> , <i>Caelospermum paniculatum</i> , <i>Cordyline congesta</i> , <i>Cryptocarya foetida</i> , <i>Cryptocarya triplinervis</i> var. <i>triplinervis</i> , <i>Glochidion sumatranum</i> , <i>Hibiscus tiliaceus</i> , Littoral Rainforest, <i>Pandanus tectorius</i> var. <i>australianus</i> , <i>Polyalthia nitidissima</i> , <i>Syzygium moorei</i>
		Wooyung Nature Reserve	Coastal Saltmarsh, Coastal Wetlands (SEPP 14), <i>Cryptocarya foetida</i> , <i>Geodorum densiflorum</i> , Littoral Rainforest, <i>Pandanus tectorius</i> var. <i>australianus</i> , <i>Polyalthia nitidissima</i> , Swamp Oak Floodplain, Swamp Sclerophyll Forest on Coastal Floodplains
Byron Shire Council	New Brighton Dunecare, South Golden Beach Dunecare, 7 Mile Beach	Fern Beach – South Golden Beach	<i>Acronychia littoralis</i> , <i>Cryptocarya foetida</i> , Littoral Rainforest
		Belongil Beach	<i>Cordyline congesta</i> , <i>Cryptocarya foetida</i> , Littoral Rainforest
		Seven Mile Beach North – 1km south of Jews Point	<i>Cordyline congesta</i> , <i>Cryptocarya foetida</i> , <i>Ischaemum triticeum</i> , Littoral Rainforest

	Dunecare	(SEPP 26 no. 34)	
North Coast Holiday Parks Reserve Trust	Byron Clean and Green, Bushland Restoration Services	Clarkes Beach Caravan Park	<i>Acmena hemilampra</i> , Byron Bay Dwarf Gramminoid Clay Heath, <i>Cryptocarya foetida</i> , Littoral Rainforest, <i>Pandanus tectorius var. australianus</i>
	Nambucca Shire Council, Nambucca Valley Landcare	Scotts Head	<i>Vigna marina</i> , <i>Glycine clandestina</i> (blf), <i>Chamaecrista maritima</i> , <i>Plectranthus cremnus</i> , Themeda Grassland, Littoral Rainforest, <i>Acronychia littoralis</i>
Ballina Shire Council	Lighthouse Beach Dunecare, Ballina Coastcare (Angels Beach Dunecare & East Ballina Landcare), Lennox Head Landcare, Lennox Head Residents Association, EnviTE	Lennox Head (headland)	<i>Plectranthus cremnus</i> , Themeda Grassland
		Boulder Beach, Ballina (including SEPP26 No 38 – Boulder Beach south)	<i>Arthraxon hispidus</i> , Freshwater Wetlands on Coastal Floodplains, Littoral Rainforest, <i>Plectranthus cremnus</i> , Swamp Sclerophyll Forest on Coastal Floodplains, <i>Syzygium hodgkinsoniae</i>
		Sharps Beach Ballina (Whites Head)	<i>Plectranthus cremnus</i> , Themeda Grassland
		Sharps Beach, Ballina	<i>Cryptocarya foetida</i> , Freshwater Wetlands on Coastal Floodplains, Littoral Rainforest, Swamp Sclerophyll Forest on Coastal Floodplains
		Angels Beach Ballina	<i>Acronychia littoralis</i> , <i>Archidendron hendersonii</i> , <i>Cryptocarya foetida</i> , Freshwater Wetlands on Coastal Floodplains, Littoral Rainforest, Swamp Sclerophyll Forest on Coastal Floodplains
		Shelly Beach Ballina	Freshwater Wetlands on Coastal Floodplains, Littoral Rainforest
		Shaws Bay, Ballina	<i>Acronychia littoralis</i> , <i>Cryptocarya foetida</i> , Littoral Rainforest
		Lighthouse Beach Ballina	Littoral Rainforest
Dirawong Reserve Trust	Evans Head Living Museum & Community Technology Centre, Bandjalang Aboriginal Corporation, E White & Associates	Dirawong Reserve	<i>Acronychia imperforata</i> , <i>Acmena hemilampra</i> , <i>Acronychia littoralis</i> , <i>Casuarina equisetifolia</i> , Coastal Banksia Woodlands, Coastal Sand Dune Complex, <i>Cupaniopsis anacardioides</i> , Dune Grasslands, Frontal Dune Vegetation Complex, <i>Geodorum densiflorum</i> , <i>Gleichenia mendellii</i> , <i>Hibiscus tiliaceus</i> , <i>Ischaemum triticeum</i> , Littoral Rainforest, <i>Lygodium microphyllum</i> , <i>Macarthuria neocambrica</i> , <i>Pandanus tectorius var. australianus</i> , <i>Pultenaea maritima</i> , <i>Stackhousia spathulata</i> , Themeda Grassland, <i>Vigna marina</i>
Clarence Valley Council	Angourie Dunecare	Angourie Reserve	Coastal Sand Dune Complex, Coastal Scrub, Coastal Wetlands (SEPP 14), Frontal Dune Vegetation Complex, <i>Ischaemum triticeum</i> , Littoral Rainforest, Themeda Grassland
		Wooli River	Coastal Banksia Woodlands, Coastal Saltmarsh, Coastal Sand Dune Complex, <i>Sophora tomentosa</i>
Kempsey Shire Council	Mid North Coast Weeds Advisory Committee, Macleay Landcare	Crescent Head	<i>Acalypha nemorum</i> (prostrate form), <i>Casuarina equisetifolia</i> , <i>Pandanus tectorius var. australianus</i> , <i>Pelargonium australe</i> , <i>Pultenaea maritima</i> , <i>Sarcostemma brunonianum</i> , <i>Stackhousia spathulata</i> , <i>Thesium australe</i> , <i>Thysanotus juncifolius</i> , <i>Viminaria juncea</i> (prostrate form)
Land and Property Management Authority – Goolawah State Park (Now managed by National Parks & Wildlife Service)	Goolawah Dunecare, Macleay Landcare, DECCW	Racecourse Headland (including SEPP 26 No 104A, 105, 105A, 106)	Littoral Rainforest, <i>Marsdenia liisae</i>
		Delicate Nobby Headland - 1.5km north of Limeburners Creek NR (SEPP 26 no 105B)	Littoral Rainforest
Port Macquarie-	Port Macquarie Landcare,	Flynn's Beach & Shelly Beach	<i>Sophora tomentosa</i>

Hastings Council	Lighthouse Beach Dunecare Bonny Hills Landcare	SEPP 26 113 – Miner’s Beach, South of Sea Acres NR	Littoral Rainforest
		Grants Head	<i>Casuarina equisetifolia</i> , <i>Comesperma sphaerocarpum</i> , <i>Isopogon anemonifolius</i> , <i>Leucopogon esquamatus</i> , <i>Pandanus tectorius var. australianus</i> , <i>Persoonia linearis</i> , <i>Thesium australe</i> , <i>Viminaria juncea</i> (prostrate form), <i>Zieria smithii</i>
		Googleys Lagoon – Camden Head – West of Kattang NR (SEPP 26 no 122)	Littoral Rainforest

Work underway on priority TAP sites is complemented by the tireless efforts of over 50 coastal community volunteer groups throughout the Northern Rivers region. The Bitou Bush Weeds of National Significance Program, NRCMA, National Parks and Wildlife Service and Local Councils support these groups to manage bitou bush and environmental weeds on the coastline. The significant achievements of coastal community groups are helping to protect and recover local biodiversity, prevent further bitou bush spread and increase broader community awareness of the value of healthy coastal ecosystems.

Community Engagement in Biological Control

Bitou bush programs integrate a range of weed management actions, including biological control. When employed correctly, biological control can be an effective, low risk, long term tool to manage weeds. The leaf roller moth (*Tortrix* sp.) has been shown to negatively impact bitou bush. Moth larvae feed directly on bitou bush foliage leading to the death of shoots. This can result in severe defoliation and weakening of the plant. Unfortunately, the leaf roller moth does not spread rapidly of its own accord, so can benefit from community assistance.

To tackle bitou bush in core infestations outside of Bitou TAP sites and encourage the community to become actively involved in bitou bush management, the Bitou Bush Weeds of National Significance Program, NSW Department of Primary Industries and NRCMA are supporting the community to implement biological control programs. In 2010, the Australian Government’s Caring for our Country supported a number of community workshops across NSW to build community capacity in rearing and release of the leaf roller moth and provide incentives to develop local rearing facilities (see Sullivan *et. al.* these proceedings). As a result, a number of community nurseries are now established throughout the Northern Rivers region, and Local Councils, schools and community groups are engaged in rearing, releasing and monitoring the moth on bitou bush. It is hoped that this will enable the moth to spread into dense infestations of bitou bush and reduce the flowering and seed-set, in conjunction with other agents such as the bitou tip moth.

CONCLUSION

While the threat posed by bitou bush can seem overwhelming, the NRCMA is working with partners in the region to prioritise the limited resources available to reduce the national distribution of bitou bush and protect environmental assets at risk. Just as the bitou bush threat is not constrained by land tenure, a consistent approach across our coastline is essential to meet the bitou bush challenge. While the problem is still immense, strong, cross-tenure and community partnerships are achieving positive biodiversity outcomes.

ACKNOWLEDGEMENTS

This work would not be possible without the support and hard work of Local Government, coastal community volunteer groups and bush regeneration contractors. This project is partially funded through the NSW Government's Environmental Trust and the Australian Government's Caring for our Country.

REFERENCES

- Agriculture & Resource Management Council of Australia & New Zealand, Australian & New Zealand Environment & Conservation Council and Forestry Ministers, (2000) *Weeds of National Significance Bitou Bush and Boneseed (Chrysanthemoides monilifera ssp. rotundata and monilifera) Strategic Plan*. National Weeds Strategy Executive Committee, Launceston.
- BRS (Bushland Restoration Services) (2009) *Bitou Bush National Northern Containment Zone Management Plan*. Northern Rivers Catchment Management Authority, Grafton.
- Cherry H., Willsher L. & Whyte B. (2008). Bitou bush and boneseed eradication and containment in Australia. *Plant Protection Quarterly*, 23, 38-40.
- DEC (Department of Environment and Conservation) (2006) *NSW Threat Abatement Plan – Invasion of native plant communities by Chrysanthemoides monilifera (bitou bush and boneseed)*. Department of Environment and Conservation (NSW), Hurstville.
- DECC (Department of Environment and Climate Change) (2007) *NSW Threatened Species Priorities Action Statement*. Department of Environment and Climate Change (NSW), Hurstville.
- DECC (Department of Environment and Climate Change) (2008) *Bitou Bush Management Manual: current management and control options for bitou bush (Chrysanthemoides monilifera ssp rotundata) in Australia*. Department of Environment and Climate Change (NSW), Sydney.
- DECC (Department of Environment and Climate Change) (2009) *Draft regional weed management priorities for biodiversity conservation: a site based assessment for the 13 Catchment Management Authorities in NSW to guide investment until 2015*. NSW Department of Environment and Climate Change, Hurstville.
- DECCW (2009) *Monitoring manual for bitou bush control and native plant recovery*. Department of Environment and Climate Change (NSW), Hurstville.
- French K., Ens E., Gosper C.R., Lindsay E., Mason T., Owers B. & Sullivan N. (2008). Management implications of recent research into the effect of bitou bush invasion. *Plant Protection Quarterly*, 23, 24-28.
- NRCMA (2005) *Northern Rivers Catchment Action Plan*. Northern Rivers Catchment Management Authority, Grafton.
- Premier's Department (2006) *A new direction for NSW – State Plan*. NSW Government, Sydney.
- Sullivan, P., Postle, L., Cherry, H., and A. Petroschevsky. (2011) Promoting biological control and weed warriors in the community. In: NSW Weeds Conference (these proceedings).

“DARRUNDAR WAJAAR” REPAIR TO COUNTRY GREEN TEAM

Tim Scanlon
Senior Ranger (Pests)
NPWS North Coast Region
P.O Box 170 Dorrigo NSW 2453

ABSTRACT

The “Darrundar Wajaar” Repair to Country Team story is a success story. And it can be a model for other communities to follow.

The Coffs Coast Repair to Country team has undertaken bush regeneration / weed control at very high profile sites supporting 5 endangered ecological communities since January 2008. During this time, 5 trainees have obtained both on-ground experience and qualifications in bush regeneration; up to Cert. 4 level for 2 participants. But more than this, it has transformed the lives of whole families and their communities, provided mentors, increased links to country and uncovered new talent that has impressed those that have come in contact with them.

One of the keys to the Repair to Country team’s success is that they are employed by Coffs Harbour Local Aboriginal Lands Council (CHLALC) but overseen by a local steering committee comprising National Parks and Wildlife Service, Northern Rivers Catchment Management Authority, Coffs Harbour City Council, DECCW Northern Aboriginal Heritage Unit, Coffs Harbour Regional Landcare and community members. The Steering Committee has sourced over \$500,000 in funding for the project and enabled the project to be fully supported and closely coordinated with other works.

The team initially worked on the highest priority significant Aboriginal sites in the Coffs Harbour area as selected by Aboriginal elders and leading bush regenerators. The team now undertake follow up work at these sites but a large proportion of their time is now spent on private contract work.

It is hoped that the project will be ongoing. New trainees are currently being employed to continue and expand on-ground works, training and the important social outcomes already achieved.

BACKGROUND

Australian Aboriginal culture is most probably the oldest living culture in the world. “Country” – the land and the sea – is a vital component of that culture, providing the core of spirituality. Maintaining connection to “country” is therefore important in keeping Aboriginal culture alive and strong.

The weeds and bush regeneration industry is increasingly becoming more skilled and the jobs market more competitive. For Aboriginal people, with many suffering several generations of oppression, with life expectancy 17 years lower, workforce participation 10% lower and median gross weekly income 59% of non-indigenous Australians, it can be extremely hard to break into the industry (Australian Human Rights Commission, 2008).

The positive effect that education has on an individual’s economic outcomes, particularly employment and income, has been well established. Educational attainment has been positively associated with health status. With higher levels of schooling there is a decreased engagement in health risk behaviours. Education level has also been shown to be positively associated with

reductions in the rates of long-term health conditions, particularly heart disease and diet-related illnesses (Australian Human Rights Commission, 2008 and Australian government, 2011).

One of the key elements in tackling disadvantage in Aboriginal communities is promotion of positive mentors. It has been recognised that positive local mentors can improve health and wellbeing statistics throughout the community.

STRUCTURE / MODEL

The “Darrundar Wajaar” Repair to Country team, or “blue” team, as they’ve liked to be known, have been established and overseen by a steering committee comprising:

- Coffs Harbour Local Aboriginal Lands Council (LALC);
- National Parks and Wildlife Service (NPWS);
- Coffs Harbour City Council (CHCC);
- Northern Rivers Catchment Management Authority (NRCMA);
- Dept. Premier and Cabinet Coastal Branch Aboriginal Heritage Unit; and,
- Coffs Harbour Regional Landcare.

And previously also:

- Coffs Harbour Enterprise and Training Company (ETC); and,
- Aboriginal Corporation of Education and Training (ACET)

Initially, the team were administered by ETC and received payment for the trainees two days per week from ACET through the former CDEP Federal government funding program. Administration fees by ETC were \$2 / hour / trainee.

Since October 2009 the team has been administered by Coffs Harbour Local Aboriginal Lands Council, with no administration fees.

The team has generally comprised one supervisor and up to 4 trainees. They were employed following advertising in local newspapers, job agencies and through the local Aboriginal community networks.

It was compulsory that the trainees were Aboriginal but not for the supervisor. The supervisor is not Aboriginal. She has been extremely successful in all aspects of the position.

A second hand car and tool cabinets were purchased for the team. Additional more recently purchased team resources include a laptop computer and mobile phone.

FUNDING AND SUPPORT

To date, the project has received funding of approximately \$536,110. This figure includes grants through Envirofund, Protecting our places, Elsa Dixon Aboriginal Employment Program, Northern Rivers Catchment Management Authority, Coffs Harbour City Council Environmental Levy and National Australian Apprenticeships.

In addition, the team has attracted over \$150,000 in private contracts and this figure continues to rise as the good name of the team spreads.

The team work out of Coffs Harbour City Council works depot and have use of the Council’s herbicide storage facilities.

Both NPWS and CHCC employ a team of full-time bush regenerators. The support given by these highly experienced staff has been an important component in the success of the team and has included:

- Induction to sites including OH&S;
- Training in bush regeneration and weed control techniques;
- Native and weed species identification; and,
- Provision of additional tools and on-ground site support.

The initial work sites for the team were selected by Aboriginal Elders, NPWS and CHCC bush regenerators. These 16 significant Aboriginal areas are located on lands managed by NPWS, CHCC, Crown Lands (Land and Property Management Authority) and Coffs Harbour Local Aboriginal Lands Council. These sites also support:

- 5 Endangered Ecological Communities (EECs);
- 10 threatened plant species; and,
- an endangered plant population.

Aboriginal Elders have spent time with the team discussing site induction and cultural importance of the sites.

NPWS have provided the team with several internal training courses such as Four wheel driving, Aboriginal artifact identification and Aboriginal cultural awareness.

RESULTS

The 16 work sites initially selected, covering an area of 93.6ha, have been transformed following three and a half years of regular on-ground works. Major infestations of bitou bush, lantana, madeira vine, balloon vine, winter senna, groundsel bush, morning glories and introduced grasses have been controlled and regularly followed up.

The initial team had what it takes to be excellent bush regenerators: excellent skills, a lot of pride, huge amounts of energy and sensitivity when required.

All of the 16 work sites are high profile areas and hence the work has had many social / tourist / aesthetic benefits for the local community.

Other contract works undertaken by the team include restoration of Coffs Harbour airport swamp oak forest and swamp forest EECs, Bellingen Island lowland rainforest on floodplain EEC, the Bellinger coastline littoral rainforest EEC, vine weed control at Woolgoolga Creek lowland rainforest on floodplain EEC and planting of a bush tucker garden at Coffs Harbour Base Hospital.

The trainees played a part in the development of the team logo and badge design, which now forms part of their work uniform.

A work site and contract planning spreadsheet was developed by the supervisor and team to help manage the various projects.

The team found several important Aboriginal artifacts that have been catalogued and protected.

Qualifications obtained by the team in Conservation and Land Management are:

- two completed Certificate 4;
- one completed Certificate 3; and,
- one completed Certificate 2.

Three of the trainees have obtained Basic Fire Fighting qualifications through NSW Rural Fire Service. Two of the trainees undertook temporary work with NPWS as Field Officers over the last year. One of the trainees is now employed full time as a Field Officer for NPWS Toormina.

PROBLEMS ENCOUNTERED

Initially the team was employed two days per week by ACET and three days per week (including the TAFE training day) by ETC and at times there was a lack of communication between the employers. This meant that a true picture of the team's attendance was not known and it was found that some of the team members had missed a lot of days without the steering committee knowing. This was resolved by the employers tabling all missed days at Steering committee meetings.

Pre employment medical checks to screen applicants for physical / health suitability for bush regeneration work was not undertaken when the first team commenced but is now an important prerequisite before new trainees commence work. Although initially told, the team needed to have it in writing that if a team member suffers an injury they must immediately inform the employer and fill out the appropriate paperwork. There was an injury to one of the former team members and an ongoing dispute with regards to when the injury occurred.

It is beneficial to employ both male and female trainees so that significant male and female Aboriginal sites can be worked on. When the trainees work on known female sites or male sites the team need to then split up and work with staff from other organisations (unless of course you have both a male and female supervisor!).

Full monitoring including transects were not established at every work site before on-ground works commenced. This would have been a very useful exercise for the team to do; increasing their knowledge of the sites and the plant species present, and of course would be very useful to help promote the good work that the team have done.

Not all bush regenerators wish to be supervisors. Future trainees will not be initially offered Certificate 4 in Conservation Land Management. Potential leaders may be offered Cert. 4 on completion of their Cert. 3.

FUTURE

The initial trainees finish the program in June this year and the new team commence in time to start at TAFE in July.

The initial aim of the program was for it to be self-sustaining; with trainees obtaining qualifications and on-ground experience in weed control, bush regeneration and a range of other skills then moving on. With the current team budget and commitments there is ample funding to employ team members for at least another 12 months, before any additional contract and external grant funding is received.

One of the benefits of the team having a close working relationship with local stakeholders and the steering committee is that each of the trainees, and their skills and work performance, is well known. This can help reduce shyness that some of the team members have, and is a huge benefit when jobs with any of the stakeholders come up.

It is hoped that each of the previous trainees will obtain on-going work in the industry and continue their association with future teams through mentoring.

TAKE HOME MESSAGES

Aboriginal traineeships in weed management and bush regeneration can provide many benefits to the participants, their families and the community. The ownership of the sites that can be achieved by involving Aboriginal people working on “country” can be significant.

The success of the project can mainly be attributed to:

- Employment of a small manageable team;
- Very close links with key stakeholders at the LOCAL LEVEL;
- Application writing and internal funding / support from the steering committee, including significant on-ground support from bush regeneration field staff;
- A thorough application process which increases the chances of employing a good team / supervisor and hence development of a good name which means contract work – we’ve had to distance ourselves from other projects / teams that have come and gone – all of these teams did not have the above mentioned process or support;
- Employment for enough time (3.5 years in the case of initial trainees) to obtain good on-ground experience and hence good further employment opportunities; and,
- No administration fees or commissions by the employer.

Weed management and bush regeneration is not for everyone. Do not expect that all initial team members will complete their qualifications and wish to continue in the industry. For example, one initial Repair to Country team member left to become a hair dresser.

Many significant Aboriginal sites also support Endangered Ecological Communities and / or have other values which can certainly help when writing funding applications.

ACKNOWLEDGEMENTS

Thankyou to Lisa White, the supervisor of the Repair to Country team. She has been a tireless worker and source of inspiration for the team. She has been able to work with and supervise 3-4 very energetic young men while at the same time plan future work programs, undertake excellent work in sometimes very fragile environments and work well with the various employers, Steering Committee, stakeholder organisations and the Aboriginal community.

The Repair to Country project has been a true joint venture between all of the different present and past members of the Steering Committee and the project’s success has been partly due to the work of each of the members.

But planning can only go so far! The biggest thankyou must go to the current team who have undertaken some excellent on-ground work and been good to work with. We got lucky!

REFERENCES AND FURTHER INFORMATION

Australian Human Rights Commission. 2008. A statistical overview of Aboriginal and Torres Strait Islander peoples in Australia. http://www.hreoc.gov.au/social_justice/statistics/index.html

Australian Government. 2011. Australian Indigenous cultural heritage. <http://www.cultureandrecreation.gov.au/articles/indigenous/>

WEED AWARENESS – WHY BOTHER?

Jessica Grantley
Communications Officer
NSW Department of Industry & Investment

Roger Smith
Natural Resources Coordinator
Orange City Council

Weed awareness can involve activities like a story in the local newspaper, an ad on the local television or a display stand at a field day. But why bother setting up displays and activities? Why have an information display at your local shopping centre? Why run a television campaign about weeds? Do these activities make a difference?

NSW *no space for weeds* (NS4W) is the statewide weed awareness program coordinated by Department of Industry & Investment that highlights weeds are everyone's problem and provides opportunity for the community of NSW to become part of the solution. The NS4W brand was developed to clearly identify and brand weed awareness resources, activities and events to the community. NS4W has appeared in numerous publications and media, on promotional merchandise and operational equipment, and has reached thousands of people across the state.

Weed officers can't be everywhere all the time! Raising awareness is an essential activity for improved weed control and weed management. A phone inquiry requesting more information, an interested community member starting a conversation about weeds at a field day or the opportunity to explain the identification features of a particular weed are all awareness raising activities that engage the community - they start the community thinking about weeds and they help get our messages and our information out. Weed awareness is a cost effective way to support the management of weeds.

Orange City Council prides itself in its endeavour to promote weed management via awareness campaigns. Awareness activities include the local TV, radio and newspapers, roadside signage and electronic display boards, field days, local schools visiting Council reserves, magnetic vehicle signs, clothing embroidery and correspondence logos. Woody the Weed has made several appearances over the years and proved to be quite an attraction! From Orange City Council's perspective, *awareness is worth it.*

What is it?

Weed awareness campaigns are all about getting our message across, raising the profile of weed management, providing information, and engaging and educating the public with the ultimate goal of changing behaviour.

Weed awareness campaigns can involve a wide range of activities including; a story in the local newspaper, an ad on the local television, a display stand at a field day, an information table at a local shopping centre, a television campaign, a letterbox drop, a visit to a local school or a radio interview.

Why bother?

Weed officers can't be everywhere all the time. We don't have sufficient resources now and it is unlikely that we will have sufficient in the future and so the community is an essential partner with

huge potential. It is critical to change the behaviour of the community and the first step to changing behaviour is raising awareness. Behaviour change is a slow process but it does happen. Anti-littering campaigns have made positive changes in the reduction of litter thrown from vehicles and motivated community involvement in events such as *Clean Up Australia Day!*

Raising weed awareness is an essential activity for improved weed control and weed management. If weeds were a high profile for everybody in the community, - if everybody managed weeds on their own property appropriately and promptly, - if everybody volunteered some time and energy to weed control activities, - we would see a difference! There would be a reduction in weed infestations, a reduction in weed spread and a reduction in the introduction of new weed species. Overall weed management would be a much easier job!

The challenges

Maintaining the energy for weed awareness campaigns is a huge challenge for professionals. Campaigns often appear to have limited or no effect. There are frequently financial constraints and extension and awareness activities are often not given a high management priority. Motivating the community about weed awareness is a challenge because there is often not a direct benefit to the individual. For farmers there is a financial and time saving benefit of a reduction in the efforts required to control weeds in the following year if efforts are expended this year. For other community members the benefits have to be presented as a 'social good' and appeal to their lifestyle. Activities that offer a sense of community, a sense of belonging and a sense of purpose and contribution may then motivate them to become involved.

Children are a very important audience. They have a power of influence over their parents and are generally motivated by social approval and acknowledgement. Awareness activities that include school campaigns easily target this audience.

Measuring the success of an awareness campaign is very challenging and it is impossible to engage all the people all the time through one simple weed awareness activity - there is no silver bullet for achieving weed awareness!

One bite at a time – making it count

Q: How do you eat an elephant? A: One bite at a time!

For weed professionals awareness activities often come last on the list. Being effective in awareness activities in a busy working life is a huge challenge. Things to think about:

- Be realistic about the scope and extent of your activity
- Do your chosen activity well
- Keep the negatives in perspective and focus on the positives.
- Acknowledge those already engaged with the weed message as very important allies. They need support and recognition to encourage them to persevere; they are advocates for the cause.
- Make use of existing networks to spread your message, utilise existing newsletters and communication channels.
- Identify your audience and deliver the message in an engaging way, make it relevant and interesting.

Stay on the track/keep the big picture in mind

It is important to keep the big picture in mind but to remain focused on the small successes; the micro effects of the awareness raising campaign. Use the brand 'NS4W', share resources, support local groups, utilise existing local networks, use existing information dispersal mechanisms for example group newsletters (hard copy and email), notice boards, council and tourist building foyers or group meetings. Focus on the successes of small local events and activities.

Use what will work in your community - be innovative if you can

Weed awareness activities will not fit into a "one size fits all" campaign. One method of engagement will not work for everybody. Changing activities can help keep the worker engaged and motivated and also increases the chance of engaging larger numbers of the community over a longer timeframe.

Effective awareness campaigns often include product branding (utilise the 'NS4W' brand), use of a variety of media including posters, flyers, stickers, brochures, magnets, lollypops, interactive games, presentations, TV advertisements, radio interviews, media stories in newspapers, special interest magazines, internet sites, competitions, displays at field days, shows and community events. Try using a range of styles such as cartoons, factual text and photographic images.

Celebrate the positives/record your progress

Celebrating the successes of any campaign is essential. Focus on the positives and the achievements regardless of how small they are and keep a record of all the campaign details, costs and results. Weeds have to compete with a range of other community concerns including housing, financial, health and education issues. Where would weeds rate on a daily basis in many households? Any small success of a weeds awareness campaign is a success.

Working with the community's ability to change and consider new issues is a challenge. Research indicates that only 2.5% of people are innovators who immediately embrace and act on new ideas and no more than 13.5% are early adopters who are accepting and willing to take on new ideas. The remaining 84% of the population are very slow to take on new ideas and to change behaviours (Rogers, 1962).

The ideas presented in this paper have been demonstrated through the effective campaign developed by Orange City Council to deliver weed awareness activities in their area. Orange City Council is a local council with typical weed management resources. The committed staff and the energy spent on awareness activities continue to make their campaigns successful which motivate them to continue their efforts.

Weed Awareness by Orange City Council - Is it worth it?

Weed awareness is a cost effective way to aid in the management of weeds. Over the past decade weed management staff have found they are spending more and more time chained to their desks rather than being at the coal face carrying out property inspections. This is where awareness becomes a great getting the word out that noxious weeds are a threat to agriculture, the environment and human health. In an attempt to promote weed management Orange City Council actively participates in various awareness campaigns utilising the local media, roadside signage and electronic display boards, field days, school visits or local schools visiting Council reserves, magnetic vehicle signs, clothing embroidery and correspondence logos (No Space 4 Weeds). Woody the Weed has also been a great ambassador for Orange City Council over the years.

Modes of Awareness

Orange City Council has been the organiser for a noxious weeds television campaign taking in members of the Macquarie and Lachlan Valleys for the past 10 years. The campaign runs approximately 600 ads over the months of October, November and January each season on the three local stations. Initially the campaign was run on two of the three local commercial stations but for the past two years the Macquarie Valley Weeds Advisory Committee has contributed significant funds toward the campaign to enable it to be run on all three local stations. The campaign is extremely economical with each ad costing participating agencies less than one dollar. As well as local LCAs several government agencies including the Central West CMA and the Department of Lands also participate in the campaign. Local weed officers have been involved with the production of the ads giving them ownership and elevating their profile at the local level.

The local print media also play an important role in assisting with raising the profile of weeds. The local newspaper, the Central Western Daily is only too happy to run articles on a regular basis. During the growing season between 6 to 10 stories are run in the local paper usually on a Saturday when locals are more inclined to purchase it.

Radio interviews are a quick and effective means of spreading the word about weeds regionally. The local ABC radio presenters usually have an affinity with the locals and local area issues as well. Questions asked during an interview are very down to earth but informative at the same time.

Roadside signage is another means by which Orange City Council endeavours to raise the profile of noxious weeds. The free standing metal signs are 900 x 900mm in size attached to a metal frame. The signs ask the question "Have You Sprayed Your St John's Wort Yet", (or whatever weed you like) with an enquiries telephone number. The signs are placed along roadsides where properties have weed infestations and serve as a prompt for landholders to take some action regarding specific weeds or weeds in general.

Electronic display boards are also used to raise the general profile of weeds. These electronic boards display the phrase "Got Weed Problems? Phone 63938025". It is surprising the amount of passing traffic that ring the number on the display board to make enquiries or talk about weeds in their own area. Of course not every LCA has access to these display boards but for those who do they are an effective mode of awareness.

Field days are another great way to make personal contact with the general community and talk at a "grass roots" level about weeds. The Australia National Field Days, (ANFD) have become an integral means of informing people about weeds. In 2009 the weeds stand at the ANFD received 770 enquiries over the three days. In 2010 the stand received 634 enquiries - a fantastic result. Neighbouring LCA's assisted with staffing the stand which also allowed fellow weed officers time to network and share ideas.

Creating working relations with local schools and their students is another great method to raise weed awareness. Up until recently Council staff would visit local schools to talk about various issues including weeds. Schools are now encouraged to visit Council-managed reserves to see weed and other conservation issues first hand. Between 5 and 10 schools visit these sites annually with the site visits forming part of their yearly curriculum. If you have a range of activities, such as tree planting or bug surveys, student interest is easily maintained.

Finally Orange City Council Weed Management staff have adopted the NSW I & I "No Space 4 Weeds" logo. The logo is embroidered onto staff uniforms, used on all correspondence and has been

reproduced onto magnetic vehicle signs. The logo is becoming well known and is a simple but effective tool for weed management.

Measuring Awareness

How does one measure awareness and whether the target audience has been reached? Do surveys prove awareness campaigns are worth it? Who has the time to organise surveys and does the general community take the time to fill out survey forms? Do you? How many phone calls do you receive after a story in the local paper or a weed campaign on television? I'm sure you can count the number of phone calls on your fingers and toes.

Orange City Council and several neighbouring councils recently ran a campaign on Chilean Needle Grass. The campaign screened on the three local commercial channels and ran over 600 ads over three months. Orange City Council received less than 10 local enquiries! Due to cool, moist conditions, the timing was probably out as the Chilean Needle Grass seeded very late, but was the campaign worth it or does it simply allow one to "tick the box" and report it as successful in your Weed Control Coordination Report?!!!!!!!!!!!!

An LCA in the Macquarie Valley recently implemented an urban campaign on Green Cestrum. 2000 flyers were distributed to local householders offering a free eradication service. The LCA only had one response. Was the campaign worth it? Realistically, if the campaign prevented one infestation from establishing *it was worth it*. A recent weed awareness display at the Orange National Field Days received 634 weed enquiries. That definitely gets a tick.

Unless one has data to back up awareness campaigns it may be difficult to convince managers to run with the campaigns. It is very easy to record field day enquiries or numbers of school students visiting a reserve but not so easy to measure the success of a newspaper article or television campaign. This is why an integrated approach to weed awareness is useful. Use a few different angles - one of them will get the word out there.

REFERENCES AND FURTHER INFORMATION

Rogers, E. M. (1962). *Diffusion of innovations*. New York: Free Press.

Grantley, J. (2010) '*Make a difference*' Weed Awareness Resource Kit, Orange, Industry & Investment NSW.

Kit contents: CD (with all kit components on), Power point presentation, Promotional postcards, Promotional posters, Display ideas information sheet, Kid's activity sheets x8, NSW no space 4 weeds merchandise samples: lollipops, tattoos, magnets, stickers, car air fresheners.
www.extranet.dpi.nsw.gov.au/weeds/ns4w/resources#Make-a-Difference-campaign-resources

'NS4W' resources: www.extranet.dpi.nsw.gov.au/weeds/ns4w

Weed resources: www.dpi.nsw.gov.au/weeds

CAN'T SEE THE FISH THROUGH THE WEEDS.

Charlie Mifsud
Aquatic Weeds Project Officer
NSW Department of Primary Industries

Abstract

Within New South Wales (NSW) some recreational water users such as fishers and boaters are unaware of water weeds and the threat they pose to the environmental, recreational and economic value of our water bodies. These groups were highlighted within Australia and overseas as often responsible for the unintentional spread of water weeds. However they also have a capacity to aid in early detection of water weeds. An awareness campaign was initiated by NSW Department of Primary Industries (NSW DPI) to highlight the threat posed by water weeds to fishers and boaters in NSW. This paper will provide an overview of this campaign.

Introduction

A state wide awareness campaign targeting fishing and boating enthusiasts in NSW aims to reduce the risk of spreading water weeds and increase their capacity to report new incursions. Surveys undertaken during 2001 and 2009 estimated there were approximately 1 million recreational fishers and 215,000 registered watercraft in NSW (NSW DPI 2001, NSW Maritime 2010). Therefore they are an ideal target group to increase their awareness of water weeds, their mechanisms of spread and the impact they can have on water bodies. Previous evidence indicates that fishers and boaters are being unintentionally responsible for the spread of water weeds from infested water bodies to non infested ones.

The awareness campaign commenced in 2010 and focuses on highlighting the impact of water weeds on fishers and boaters, defines what water weeds are and explains how fishers and boaters might help in preventing the spread of water weeds.

How can water weeds affect fishers and boaters?

It is likely that many recreational fishers and boaters have a limited understanding of water weeds and the potential impacts they have on both water bodies and their recreational activities. The key points highlighted in the awareness campaign are detailed below.

Heavy infestations of water weeds can:

- restrict watercraft navigation
- reduce access to fishing sites
- foul fishing gear
- make it difficult to land fish
- reduce sunlight penetration which can shade out native plants
- lower the temperature and oxygen content of water
- affect diversity and abundance of fish and other aquatic organisms due to reduced water quality
- reduce fish and bird habitat and access to water bodies for wildlife
- damage boat motors by blocking the water intakes
- reduce the area of open water available for swimming

Water weeds can form thick floating mats, submerged thickets or dense stands along the banks of waterways. Water weeds can spread by seed and fragments and a single plant fragment can start a new infestation and some plants can survive considerable time out of water. Water weeds can be spread by the following

- hitchhiking on watercraft, trailers and equipment, such as fishing gear
- propellers and anchors can cut plants into fragments facilitating spread
- plant fragments can be found in the bilge, live wells and in bait containers
- attached to clothing and foot wear
- in mud attached to clothing and equipment
- attached to the fur of pets and wildlife
- attached to vehicles and earthmoving equipment
- on fishing nets and traps
- deliberate releases from aquariums into water bodies
- deliberate plantings by aquarium plant enthusiasts
- water movement through irrigation channels and during floods

Which weeds are considered a problem?

Water weeds are invasive plants that interfere with the normal functions of our water bodies. Within NSW there are numerous water weeds that potentially could affect our water bodies and their recreational use, table 1 highlights these and lists those declared under the NSW Noxious Weed Act 1993.

Table 1

Water Weed	Latin name	NSW Declaration	Other status
Alligator weed	<i>Alternanthera philoxeroides</i>	Classes 2 & 3	WONS
Cabomba	<i>Cabomba caroliniana</i>	Class 5	WONS
Dense waterweed	<i>Egeria densa</i>	Class 4	
Elodea	<i>Elodea Canadensis</i>	Not declared in NSW	
Hydrocotyl	<i>Hydrocotyl ranunculoides</i>	Not declared in NSW, proposed Class 1	
Hygrophila	<i>Hygrophila costata</i>	Class 2	NSW weed alert
Lagarosiphon	<i>Lagarosiphon major</i>	Class 1	NSW weed alert
Parrots feather	<i>Myriophyllum aquaticum</i>	Not declared in NSW	
Sagittaria	<i>Sagittaria platyphylla</i>	Class 5	Proposed WONS
Salvinia	<i>Salvinia molesta</i>	Classes 2 & 3	WONS
Senegal tea	<i>Gymnocoronis spilanthoides</i>	Class 1	
Water hyacinth	<i>Eichhonia crassipes</i>	Classes 2, 3 & 4	Proposed WONS
Water lettuce	<i>Pistia stratiotes</i>	Class 1	

Much of the awareness material highlighted five water weeds in particular, three of these are declared Weeds of National Significance (WONS) due to their highly invasive nature. Salvinia (*Salvinia molesta*), cabomba (*Cabomba caroliniana*) and alligator weed (*Alternanthera philoxeroides*). The other two water weeds highlighted were water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*). Recent outbreaks of water hyacinth near the Murray river at Albury and water lettuce on the Dumaresq and Warrego rivers on the NSW/Queensland border, makes them high priority species to control in NSW.

How can fishers and boaters help?

There is a high potential for the spread of water weeds from infested sites to non infested sites due to the large numbers of watercraft and fishers within NSW and those visiting from interstate. Therefore increased knowledge of the problem and what can be done by fishers and boaters can contribute significantly to reducing the spread of water weeds and also aid in the early detection of new incursions

The awareness message was designed around encouraging the audience to follow some simple procedures to help in preventing the spread but also to aid in detection. These include.

- inspecting and removing any plant material from watercraft, trailers and all equipment before leaving a site or launching at a new site
- learning to recognise water weeds and being observant for new or unusual weeds
- avoiding infested water bodies and if in an infested area avoid running the engine through or anchoring up in weed beds.
- reporting infestations to your local council weed officer or NSW DPI

Resources used to highlight the awareness message

After consultation with members of the fishing and boating industry it was decided to use a variety of promotional resources to present the awareness message to this target audience. These resources included.

- Signage erected at boat ramps in fresh and brackish water areas across the state. The signs entitled Protect our Waterways encourage boaters to remove plant material from watercraft, trailers and equipment before launching and leaving. It also provides advice on whom to contact if a suspicious water weed is found.
- A brochure highlighting the impacts water weeds can have on water bodies and fish habitat. This brochure targets fishers and was distributed through fishing clubs and angling stores. It contains the key messages on water weeds, their impacts on fishing and boating and hygiene of watercraft, trailers and equipment. The brochure also includes information on freshwater fish to make it more appealing to fishers.
- Articles and advertisements have been placed in fishing and boating magazines and in newsletters of angling associations. These articles and advertisements relate to the water weed awareness message and the boating hygiene signs.
- Fish measuring mats containing the key awareness and hygiene messages and some fish information have been distributed through fishing clubs and via fishery education officers.

- Posters and postcards highlighting boating and fishing hygiene and a brochure on water weeds have been distributed to fishery education officers who attend events throughout the state and departmental fish hatcheries that are open to the public.
- A roadside billboard campaign across the major highways in regional NSW promoting a prevent the spread; clean your equipment message.
- Water weed identification training has been provided to fishery compliance officers and conservation staff to aid in identification of target waterweeds.

What has been done elsewhere and what worked?

Australia is not alone in the threat posed by invasive water weeds. Other countries are affected and have developed awareness campaigns to educate the public about water weeds with the aim of reducing the spread.

In the United States of America (USA) a number of states have regional awareness campaigns on invasive species including water weeds. There is also a national program entitled Protect Your Waters (<http://protectyourwaters.net>).

The Texas Parks and Wildlife Department (TPWD) coordinates an awareness campaign on giant salvinia (*Salvinia molesta*), which includes a web page (TPWD 2011) containing an online reporting form for people to report sightings; videos; brochures; and posters that highlight the impacts of salvinia on recreation. Other awareness material incorporating the awareness message include a fish measuring device, radio sound bites, television and magazine advertisements and press releases. The key points highlighted in the campaign include.

- to report sightings of invasive species and anyone transporting them
- descriptions of invasive species to aid in identification
- hygiene of boats, trailers and equipment
- the impacts of invasive species on recreation, water quality, aquatic life and habitat

The states of Wisconsin and Michigan, in the Great Lakes region of the USA, also coordinate awareness campaigns on invasive species aimed at recreational users of their water bodies (UWSP 2011). These campaigns present their message via inclusion on the following resources; brochures, fact sheets, dvds, shirts, hats, aprons, posters, signs, stickers, cards and inserts. Workshops on invasive species identification and how to organise a volunteer watercraft inspection program also occur.

The messages presented in the awareness campaigns by these States is similar to that undertaken in Texas with an emphasise on hygiene of boats, trailers and equipment with a slogan of “Clean Boats Clean Waters”, identification of invasive species, reporting sightings and consulting government agencies.

The Protect Your Waters” national campaign website has links to other groups and organisations involved in invasive species. The website provides information on invasive species, their impacts and hygiene practices. Awareness information is also distributed via brochures, posters and stickers.

Biosecurity New Zealand a department of the Ministry of Agriculture and Forestry (MAF) has awareness information focused on invasive species including the water

weeds lagarosiphon (*Lagarosiphon major*), salvinia and the algae didymo (*Didymosphenia geminata*). The theme for their awareness campaign is “Check Clean Dry” (MAF 2011). Checking involves removing all unwanted material from anything that has been in contact with the water. Clean, encompasses cleaning all equipment and in the case of possible contact with didymo use of a detergent. Drying all equipment for at least 48 hours is recommended. This awareness message is incorporated on posters, leaflets, brochures, bumper stickers, banners, pocket guides, signs, and advertisements and on lollipop wrappers.

Follow up surveys on the awareness campaigns undertaken in Texas, Wisconsin and Michigan show that such campaigns do highlight the issue of invasive species including water weeds with fishers and boaters and that it can make a difference.

A survey of boaters in the Great Lakes region showed that 87% of respondents reported always removing aquatic plants that they noticed attached to their boat or trailer (Rothlisberger et al 2010).

In Texas surveys undertaken after the awareness campaign on giant salvinia with boaters who live around the lakes where the campaign was focussed showed that 51% of the boaters in the region saw the campaign materials and 96% said that they are more likely to clean their boat, trailer or equipment as a result of seeing information or advertising (Carly Montez personal communication 19.4.11).

Conclusion

Awareness campaigns on water weeds that have been undertaken in other countries have proven successful in raising public awareness. The campaign initiated by NSW DPI also aims at increasing the level of awareness within the target audience of fishers and boaters and help to reduce the spread of and early detection of new water weed incursions. As part of the boat ramp sign campaign GPS locations and photographs were taken of each sign to assist in recognising any future trends that emerge in relation to new weed incursions that may link to the presence of the signs. An increase in water weed reports to the Weed Hotline will also be used as an indication that public awareness on water weeds is increasing. Water weeds will continue to affect recreational use of our water bodies and therefore engaging with this audience of fishers and boaters will assist managers in the battle against these invasive species.

References

Rothlisberger, J. D., Chadderton, W.L., McNulty, J. and D. M (2010). Aquatic Invasive Species Transport via Trailered Boats: What Is Being Moved, Who Is Moving It, and What Can Be Done. Fisheries vol 35 no 3 March 2010: 121-132.

NSW Maritime July 2010. NSW Boat Ownership and Storage: Growth Forecasts to 2026.
http://www.maritime.nsw.gov.au/docs/wh/boat_storage.pdf

Department of Primary Industries 2001. Survey of Recreational Fishing in New South Wales.
http://www.dpi.gov.au/data/assets/pdf_file/0020/171209/Survey-of-Recreational-Fishing-in-New-South-Wales.pdf

TPWD 2011, Texas Parks and Wildlife Department, Texasinvasives. org, accessed 10th April 2011 from <http://www.texasinvasives.org>

UWSP 2011, University of Wisconsin- Stevens Point, Lakes: Clean Boats Clean Waters, accessed 10th April 2011 from <http://www.uwsp.edu/cnr/uwexlakes/cbcw>
MAF 2011, Ministry of Agriculture and Forestry, Biosecurity New Zealand, Pests and Diseases: Didymo, accessed 15th April 2011 from <http://www.biosecurity.govt.nz/pests/didymo/media>

PADDOCK PLANTS – GRASSES, LEGUMES AND HERBS

**Carol Rose¹ (Extension Agronomist),
Harry Rose¹ (Education Officer)
Clare Edwards² (Extension Agronomist),
Department of Primary Industries, ¹Kempsey & ²Armidale**

ABSTRACT

Most pastures on the North Coast contain a large number of grasses and other herbaceous species. The composition of a pasture can vary from year to year depending on climate, grazing and fertiliser, and other factors. Different species can also be indicators of changes in these factors and enable landholders to better read the land. However, this is only possible if the individual species can be recognised. The Paddock Plants workshop has been developed by NSW Department of Primary Industry (NSW DPI) agronomists to enhance landholders' skills in recognizing the diversity of plants within pastures.

BACKGROUND

A survey of landholders was conducted in Scone area in 2000 (Rose & Rose, 2001) which showed low levels of recognition of a number of native species. This gap in knowledge is commonly encountered by agronomists across the state with both inexperienced and experienced landholders. This work stimulated the development of native grass recognition workshops, which were run in the Hunter; Northern, Central and Southern Tablelands; and Mid North Coast. Other courses, such as Prograze and Landscan, also highlighted the need for development of landholders' skills in species recognition and what different species could indicate about landscape factors and land management. Sharing these experiences and utilizing the feedback supplied by participants across the state sparked the development of a new workshop called Paddock Plants.

PADDOCK PLANTS CONTENT

A team from the NSW DPI pasture section developed Paddock Plants as a whole of landscape course. The primary aim is to increase landholders' skill to recognise the diversity of pasture species and their role as indicators of landscape features (e.g. slope, aspect and water table) and land management (e.g. grazing, soil disturbance and chemical use) or both. A secondary benefit of the course is to increase awareness of biodiversity and its role in the farming system.

Paddock Plants workshops consists of one or more paddock walks over a half to full day. The format is flexible so that the interests of different groups can be catered for. Hence, where landholders are interested in biodiversity, suitable natural sites are used and discussions revolve around the importance and maintenance of biodiversity. Where days are run in conjunction with weed officers, weed species and indicator plants that signal the weakness of a landscape to weed invasion are often highlighted (e.g. an increasing proportion of carpet grass in a kikuyu pasture can indicate declining soil fertility and pasture competitiveness).

Paddock Plants has proved popular, with over 2800 people attending workshops in NSW between 2006 and 2010 and 42 workshops being run on the North Coast alone. Feed back

from these days indicated that 90% of the respondents found the course very useful to extremely useful.

Paddock Plants Resources

The Paddock Plants workshops not only involve hands-on interactive learning, but also provide information sheets that act as a long-term reference. Each information sheet provides summary data for an individual species on recognition, distribution, management and similar species.

Paddock Plants Modified 24 April 2010

COMMON NAME
FORAGE PEANUT

SCIENTIFIC NAME *Arachis pintoii*
FAMILY FABACEAE
CATEGORY INTRODUCED LEGUME

WHAT IT LOOKS LIKE:

- Warm-season, perennial, low-growing herb, which forms a strong taproot and mats of stolons. Stems can ascend up to 50cm high
- Leaves have 4 obovate leaflets up to 4.5cm long
- Flowerheads are racemes of yellow pea-like flowers in the leaf axils; producing 1-3 pods that are pushed into the soil on "pegs"
- Flowers from spring to autumn

WHERE IT GROWS & WHY:

- Sown on the north coast for grazing, agro forestry & horticultural tree-crop groundcover
- Best suited to >1000mm rainfall on free-draining soils. Shade tolerant, but frost sensitive


MANAGEMENT:

- Amarillo and Bolton are the only cultivars suited to seed sowing; other cultivars planted by sprigs
- Has high seed costs and requires high sowing rates. Seeds must be sown at 2-6cm deep
- Provides a moderate yielding, non-bloating and high quality forage
- Slow to establish, but is highly persistent and produces large amounts of seed
- Highly drought tolerant, but loses leaves and is slow to recover. Requires high humidity & good soil moisture for best growth
- Grows on low to high fertility soils and is very efficient at utilising native P

- Persistent under heavy grazing and shade; maximum production if rotationally grazed
- Don't let tall grasses dominate

SIMILAR PLANTS:

- Round-leaved Cassia (*Chamaecrista rotundifolia*) leaves have 2 leaflets



Flowering plants in a Kyogle trial and Amarillo peanut with *Higane puspahum*: K Moore


 NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Fig. 1 Example of a Paddock Plants information sheet

The number of information sheets is ever expanding, with agronomists and project officers writing new sheets as species are included in workshops for the first time. At present there are 417 information sheets on native and introduced; grasses, legumes, herbs, shrubs and trees.

PADDOCK PLANTS DIVERSIFICATION AND FUTURE

Paddock Plants is ongoing throughout the state, covering areas such as wetlands, acid sulphate soils, cropping, salinity, biodiversity, animal production and weed management.

Other Projects have now adapted and utilised the Paddock Plant workshop format, including:

- Box Gum Grassy Woodlands project;
- Native Grass project on the Monaro;
- Prograze;
- Landscan;
- NSW Weeds Training Program.

Plans are also in the pipeline to adapt Paddock Plants for trees, diseases and pests.

As a result of feedback from landholders, a series of books based on the Paddock Plants sheets have been written for the North Coast. The first book 'Grasses of the North Coast' was funded by the Northern Rivers Catchment Authority (NRCMA), National Heritage Trust and NSW DPI. This book proved so popular that there have been 3 reprints (approximately 8000 books). The last print run of 4000 copies (of the 2nd addition) was funded jointly by the NRCMA, Far North Coast Weeds, North Coast Weeds, Mid North Coast Weeds Authorities and various North Coast Landcare groups. The joint funding was in recognition of the contribution that this resource and the Paddock Plants workshops have made to a range of outcomes on the North Coast and is a prime example of how organizations working together can support those outcomes.

Further funding was supplied for a book based on the Paddock Plants sheets called 'Legumes and Herbs of the North Coast of NSW'. This funding was by the Landcare Northern Rivers Network through the Commonwealth program 'Caring for Our Country'. The book has now been expanded to include the whole of the NSW coastal area ('Legumes and Herbs of Coastal NSW') and has been published by NSW DPI through Tocal College.

Tocal is sponsoring books to cover grasses, legumes and herbs, weeds and wetland plants, with hopefully a series for each portion of the state (coast, tablelands and upper slopes, and lower slopes and plains). It is hoped that weeds officers and other weed professionals will form the major authors of the weed books.

Paddock Plants also formed the basis of the book 'Glove Box Guide to Plants of the Gwydir Wetlands & Macquarie Marshes, which formed part of the NSW DPIs' Best Management Practice for Grazing in Wetlands project.

CONCLUSION

The Paddock Plants workshop is a whole of landscape course which increases landholder and land managers' and advisors' skills in plant recognition and landscape interpretation. The resources developed from this project will be a long term testament to the value of Paddock Plants. It is a highly adaptable course that can act as a stand alone course or be combined into other learning experiences. It's development and on going evolution is a tribute to the contribution of a wide range of organizations and landholders.

ACKNOWLEDGMENTS

The authors would like to thank all the DPI agronomists and project officers who have contributed to the Paddock Plant project by producing information sheets, running field days and contributing to further developments.

REFERERENCES AND FURTHER INFORMATION

Rose, C. & Rose, H. 2001, 'Native and natural pasture; perceptions in the Upper Hunter', *Proceedings of the 2nd National conference*, STIPA Native Grasses Association, University of Melbourne, Dookie Vic.

Rose, H., Rose, C. & Campbell, T. 2008, *Legumes and Herbs of the North Coast NSW*, NSW Department of Primary Industries.

Rose, H., Rose, C. & Rose, T. 2010, *Legumes and Herbs of the North Coast of NSW*, 2nd edition, Industry and Investment NSW.

Rose, H., Rose, C. & Rose, T. 2011, *Legumes and Herbs of Coastal NSW*, Industry and Investment NSW.

Rose, H., Rose, C., & Campbell, T. in press, *Grasses of Coastal NSW*, NSW Department Of Primary Industries.

PROMOTING BIOLOGICAL CONTROL AND WEED WARRIORS IN THE COMMUNITY

Paul Sullivan¹, Lesley Postle², Hillary Cherry³ and Andrew Petroeschevsky⁴

¹Invasive Species Officer
Biosecurity Branch, NSW Department of Primary Industries,
Tamworth Agricultural Institute, 4 Marsden Park Rd, Calala NSW 2340
T: +61 2 6763 1175 | E: paul.sullivan@industry.nsw.gov.au

²Project Officer
Biosecurity Branch, NSW Department of Primary Industries
Locked Bag 4, Richmond, NSW 2753
T: +61 2 4588 2113 | E: lesley.postle@industry.nsw.gov.au

³National Coordinator Bitou Bush & Boneseed
Pest Management Unit, Office of Environment & Heritage
PO Box 1967, Hurstville NSW 1481
T: +61 2 95856587 | E: hillary.cherry@environment.nsw.gov.au

⁴National Aquatic Weeds Coordinator
Biosecurity Branch, NSW Department of Primary Industries
Grafton Primary Industries Institute, PMB 2, Grafton NSW 2460
T: +61 2 6640 1618 | E: andrew.petroeschevsky@industry.nsw.gov.au

Key words: biological control, community engagement, Weed Warriors, *Chrysanthemoides monilifera*, bitou bush, bridal creeper, *Asparagus asparagoides*, *Salvinia molesta*, Weeds of National Significance

ABSTRACT

A national community biological control initiative has improved the ability of weed managers and community members to implement biological control programs, and has expanded the distribution of a number of biological control agents for three Weeds of National Significance along the east coast of NSW. An extension strategy was used to devolve ownership of biological control programs to local weed professionals and community groups. Through training courses and follow up advice, land managers and community members are now equipped with the skills to rear, release and monitor agents for bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*), salvinia (*Salvinia molesta*) and bridal creeper (*Asparagus asparagoides*).

Over 250 participants have been trained, via a series of workshops and hands-on field days, to use biological control as part of their integrated weed management programs. Some participants also achieved accredited qualifications in using biological control. Twelve community nurseries were established that provide sustainable breeding facilities for biological control agents over the long-term. Land managers and community groups are now releasing and monitoring agents in major weed infestations and supplying schools with agents for the *Weed Warriors* program.

The project has also promoted expansion of the *Weed Warriors* program in NSW, which is being implemented in tandem with extension workshops and establishment of community nurseries. The *Weed Warriors* program empowers students to get involved in weed management by learning about biological control and by rearing, releasing and monitoring agents as part of their classroom studies. *Weed Warriors* depends on key contacts in the community, such as weed professionals, educators, or volunteers, who work directly with students and teachers. Key contacts were recruited via the extension workshops and have formed networks to provide agents that are reared in community nurseries for local schools.

The community implementation approach allows biological control and *Weed Warriors* programs to continue into the future without extensive support from state/federal government agencies which traditionally have provided resources for such activities. This paper explores the benefits and challenges of the community approach being implemented by this project.

INTRODUCTION

Weeds have significant economic, environmental and social impacts in Australia. They cost an estimated \$4 billion to Australian agriculture (Sinden *et al.*, 2004) and to that must be added the massive costs imposed by weeds on the environment. In New South Wales, over \$3.5M was invested in 2009/10 to manage bitou bush, just one of the many widespread weeds that cause significant environmental damage. Thus, it is critical to engage all members of the community in reducing the impact of weeds.

Widespread weeds that are too abundant to be eradicated can be managed in many ways. Biological control is often considered to be an excellent option, if agents are available, as biological control can decrease the weed to acceptable levels and reduce further spread.

Australian biological control programs are economically advantageous, providing very high rates of return on investment, estimated to be in the order of 23:1 (Page and Lacey, 2006). They are also environmentally friendly because biological control agents are target-specific (*i.e.*, less risk of off-target damage), with only the target weed being affected. Biological control is non-toxic and non-polluting when compared to chemical control and biological control does not create erosion and physical degradation to the soil in the same way that physical control can. Once agents are established, they can suppress weed infestations over the long term. The agents then naturally disperse further afield and thus land tenure arrangements impose few problems. Agents can be used in remote or difficult to access areas, making biological control a desirable tool for the management of established weeds in ecologically sensitive natural habitats. There is also a low risk of missing weed control opportunities because agent activity is linked to the weed's lifecycle.

Despite the above benefits, adoption of biological control by the community and weed managers has often been limited. For example, use of the salvinia weevil by weed managers in the Sydney and Hunter regions of NSW was low, despite recent research demonstrating that the weevil is more effective in temperate climates than previously thought (Sullivan *et al.*, 2011). In response, the National Aquatic Weeds Management Group sought to increase use of the weevil in these regions by building the capacity of weed control authorities to implement salvinia biological control programs. There was a similar need to increase participation in redistributing agents for bitou bush. Thus, this

project was developed to increase uptake and use of biological control as an integrated weed management tool in NSW.

METHODS

In an effort to address the strategic management of both bitou and salvinia, NSW partners collaborated in a multi-state project in conjunction with the Australian Government's Caring for Our Country program. The project, *Community implementation of biocontrol of weeds across south-eastern Australia*, combined efforts across four states (Victoria, New South Wales, Tasmania and South Australia) over two years from 2009 to 2011. The project employed the previously tried and proven method of community participation in biological control programs to speed up their delivery. Weed professionals, government agency staff, land managers, volunteers and school students were trained and joined forces to release agents targeting Weeds of National Significance (WONS), (salvinia (*Salvinia molesta*), bitou bush (*Chrysanthemoides monilifera* ssp. *rotundata*) and bridal creeper (*Asparagus asparagoides*)). Agent releases were also made for other invasive weeds such as English broom (*Cytisus scoparius*) and Cape broom (*Genista monspessulana*) that have a significant impact on key environmentally sensitive World Heritage areas such as Australian Alps National Park and Barrington Tops National Park.

The project partners worked to improve the community's skills, knowledge and engagement in biological control programs and empower the community to reduce the impact of nationally significant weeds that threaten biodiversity and natural icons, coastal environments and critical aquatic habitats.

In NSW, the project focused mainly on bitou bush and salvinia. Contributing partners included NSW Government agencies with additional support from Catchment Management Authorities (CMAs), local governments, weed professionals and community groups. Specific goals for NSW included:

1. Increasing the capacity of weed professionals and community members to release and monitor biological control agents,
2. Establishing 50 salvinia biological control release sites,
3. Releasing the leaf-roller moth (*Tortrix* sp.) at 25 new bitou bush sites,
4. Establishing the cape broom psyllid (*Arytinnis hakani*) at 1 new site,
5. Establishing the broom gall mite (*Aceria genistae*) at 1 new site,
6. Training weed professionals and community members through 4 accredited salvinia biological control workshops and 1 field day,
7. Training weed professionals and community members through 11 bitou bush workshops and 5 field days,
8. Engaging 20 community groups in biological control, and
9. Engaging 28 schools in the *Weed Warriors* program.

To deliver these objectives, a project officer was employed and a steering committee was formed whose members included biological control researchers, WONS coordinators, CMA and local government members. The steering committee provided project direction and suggestions, as well as links to an excellent network that allowed the project officer to reach a broad range of community and local government members.

This program focused on giving inspired volunteers and weed professionals tools, in the form of training and resources, so that they would have both the competency and capacity

to lead biological control programs independently. A series of introductory workshops were held throughout the geographic range of the various target weeds. Workshops and field days were held to provide integrated technical information combined with hands-on field demonstrations. Follow up communication and on-going support was provided.

Biological control theory and realistic expectations were explained at workshops and field days together with information on: the weed, the agents, agent sourcing, agent rearing skills, selection of release sites, agent release technologies, management of release sites, monitoring guidelines and redistribution of agents. Participants were also given practical and hands-on demonstrations of release and monitoring techniques.

In addition, participants were provided with opportunities to receive qualifications at accredited biological control courses. These courses examined the general principles and practicalities of biological control and integrated weed management. The courses also examined, in greater detail, issues involved in rearing and releasing agents and followed up with specific weed examples, such as biological control for salvinia or bitou bush.

Following the workshops, weed professionals and volunteers were invited to submit proposals to establish agent rearing nurseries at strategic sites along the NSW coastline near widespread bitou bush and salvinia infestations. Weed professionals and volunteer groups often collaborated to create nurseries which allowed local communities to rear a constant source of agents. In many cases, the nurseries were incorporated into existing community nurseries. Funding and agents were provided to set up 12 community nurseries to ensure a future supply of agents for release either directly or through the *Weed Warriors* program.

Many members of the nursery teams have also volunteered to run *Weed Warriors* programs in conjunction with neighbouring schools. This is a national program designed for schools to educate students about the impact of weeds and involve them in local weed management using biological control. Weeds professionals and/or volunteers act as key contacts and assist teachers to run programs and form networks with local community weed managers.

During the program, students are given a unique opportunity to work with key contacts to implement a biological control program for a regional priority weed. Students breed the agents, release them at a local infestation and monitor their progress. The *Weed Warriors* program in NSW has further developed teachers' resources for 9 weeds (bitou bush, blue heliotrope (*Heliotropium ampexicaule*), bridal creeper, cat's claw creeper (*Macfadyena unguis-cati*), gorse (*Ulex europaeus*), horehound (*Marrubium vulgare*), lantana (*Lantana camara*), Paterson's curse (*Echium plantagineum*) and salvinia). The focus of the current *Weed Warriors* project was to promote bitou bush, salvinia and bridal creeper biological control programs for schools.

RESULTS

Multiple biological control releases were made during the project, including: 64 releases of the salvinia weevil, 29 releases of the bitou bush leaf roller moth, 6 releases of the bridal creeper leaf hopper, 6 releases of the Scotch broom gall mite, 6 releases of the Cape broom psyllid, 5 releases of the horehound plume moth and one release of the Paterson's curse flea beetle. While the number of releases met the project milestones, the two-year duration of the project was not long enough to determine successful establishment of agent

populations at release sites. With most agents it is necessary to observe an increasing population for at least two generations to determine successful establishment. The majority of agent monitoring will therefore need to be carried out by the community in the future.

The project met or exceeded all goals:

1. Trained more than 250 weed professionals and community members to release and monitor biological control agents,
2. Released the salvinia weevil at 54 new sites,
3. Released the bitou bush leaf-roller moth at 12 rearing nurseries and 17 field sites,
4. Established 6 new cape broom psyllid nursery sites,
5. Established 6 new scotch broom gall mite nursery sites,
6. Trained weed professionals and community members through 5 accredited salvinia biological control workshops and 5 field days,
7. Trained weed professionals and community members through 11 bitou bush workshops and 10 field days,
8. Engaged 130 community groups in biological control, and
9. Engaged 29 schools (97 classes) in the *Weed Warriors* program.

Many of the *Weed Warriors* programs were carried out by experienced weed professionals who had previous experience with the program. However many new key contacts also signed up as a result of attending workshops during the last year, and these new participants are only just beginning to organise their *Weed Warriors* activities. It takes time to approach schools, get commitment from the teachers, get weeds potted up and rear the agents. The full program can take 2 terms to run, so forward planning is essential. In addition, program timing must coincide with the appropriate life-cycles of the target weed and its agent.

To further assist the community, a booklet was produced entitled “*A Community Guide to Implementing Biological Control*” (Jenner *et al.*, 2010). This 16 page booklet summarises the methods and information necessary for community groups to establish biological control nurseries, and release and monitor agents. All participants were provided with the booklets, which supplemented advice given at workshops and field days. It was also distributed to the wider community via the coastal CMAs and at various conferences and forums. The booklet is available in hard copy or for free download from www.weeds.org.au/wons/bitoubush .

DISCUSSION

The aim of the project was to build the capacity of the community to deliver biological control programs for two important WONS weeds, bitou bush and salvinia. This was achieved by providing participants with training and resources so that they would have the competencies and capacity to lead biological control programs.

The project targeted diverse but defined participants, ranging from weed professionals to school children. A broad range of technology transfer strategies were implemented to meet the various needs of different groups and enable them to develop their awareness, understanding and skills. These strategies included accredited training days, educational materials, workshops, field days and hands on experience. Funding and advice was also provided in key locations so that community groups could start their own agent rearing nurseries. Training and resources were developed and delivered through workshops and direct contact, including two accredited AQF III (*Australian Qualifications Framework*)

biological control courses (RTD 3706A Maintain Biological Cultures and RTD3707A Release Biological Cultures) for weed professionals, educational materials for school teachers, and the community biological control booklet.

The success of this project has led to more than 250 adults being trained in biological control, 130 community groups becoming engaged in biological control, 14 people gaining accredited training, 97 school classes participating in a *Weed Warriors* program, and more than 100 new biological control releases being made on seven weeds. Because of this program, many volunteers are now able to rear their own agents, make their own agent releases and monitor the agent's establishment and impact, thus empowering them to take direct action on weeds in their local community. Some workshop participants are now training others in biological control, especially at the school level via the *Weed Warrior* program. In addition to the increased use of biological control, weed professionals and government agency staff are now incorporating the use of biological control into integrated management programs.

Project Challenges

1. Vagaries of breeding biological control agents means that agents are not always readily available or in the numbers that are necessary.
2. Many agents can only be collected from established nursery sites in the field and are not being reared in institutional breeding facilities.
3. Field nursery sites may not be in close proximity to where agents are needed, making it difficult to collect agents.
4. Field nursery sites are not well documented and the current status of agents at each site is not always well-known.
5. The project ended before many rearing nurseries were completely functional, thus necessitating ongoing support.
6. Weed professionals are often reluctant to return monitoring data, and there is no long term plan for collating and using the data. Volunteers usually do not have enough time or confidence to carry out effective monitoring and may need additional training and ongoing support. Effective monitoring may need to be carried out by trained weed professionals.
7. *Weed Warriors* takes time to promote and to recruit schools. It often takes two terms to carry out a complete program, and this needs to be co-ordinated with the agents' life cycles. This means that a long term approach is needed.
8. There is a need for ongoing support and advice.

Project Strengths

1. A broad cross section of the weed management community was engaged in delivering the project.
2. Relationships between volunteers, weed professionals, CMAs and other government agencies have been developed and strengthened.
3. The involvement of community groups ensures that implementation of biological control programs will continue to be effective beyond the life of the project.
4. Community members and weeds professionals now have realistic expectations of the scope of biological control agents and improved competencies to deliver biological control projects.
5. A great deal of enthusiasm and demand for biological control from all sectors of the community has been identified. There is a desire for more information, education, and accessibility of agents.

6. The profile of biological control has been elevated.
7. Community groups are rearing and releasing biological control agents for bitou bush and other weeds in strategic locations all along the NSW coast, thus reducing the impact of these weeds on the environment over the long term.

SUMMARY

By using a community-engagement approach to biological control, this project has developed and strengthened partnerships across a broad spectrum of people dedicated to improving the environment in a sustainable way. The community provided a great deal of enthusiasm throughout the project and a strong demand to run their own programs, and this is now accelerating the delivery of biological control. These community contributions are significant and should not be overlooked because they deliver a large return for a relatively small investment. Ongoing support will be needed at many levels, thus it is critical for regional bodies and local governments, as well as state agencies, to provide support to these volunteer efforts, which will help community groups reduce the impact of weeds into the future.

ACKNOWLEDGEMENTS

We wish to thank steering committee members Royce Holtkamp, Nicole Strehling and Graham Prichard for their suggestions with project direction. We would also like to thank the many weed professionals and community members for assisting with this project and helping to progress biological control across NSW. This project was supported by the NSW Government, with funding provided by the Australian Government's Caring for our Country. Additional support was provided by local governments and volunteer groups.

REFERENCES

- Jenner, J., Cherry, H., Postle L., Holtkamp, R., Sullivan, P., eds. (2010). A community guide to implementing biological control. National Bitou Bush and Boneseed Management Group, Sydney, NSW.
- Page, A. R., and Lacey, K. L. (2006). Economic impact assessment of Australian weed biological control effort. Technical Series No. 10, CRC for Australian Weed Management, Adelaide.
- Sinden, J., Jones, R., Hester, S., Odom, D., Kalisch, C., James, R. and Cacho, (2004). The economic impact of weeds in Australia. Technical Series No. 8, CRC for Australian Weeds Management Systems, Adelaide.
- Sullivan, P.R., Postle, L.A. and Julien, M. (2011). Biological control of *Salvinia molesta* by *Cyrtobagous salviniae* in temperate Australia. *Biological Control* 57: 222 – 228.

TROPICAL SODA APPLE -*Solanum viarum*, A new Incursion (THE PLANT FROM HELL?)

Terry Schmitzer – Regional Weed Management Officer, Mid North Coast Weeds

Greg Egan – Weeds Officer, Kempsey Shire Council

Josh Biddle – Weeds Officer, New England Weeds Authority

World Status

Tropical soda apple is a native of north eastern Argentina, south eastern Brazil, Paraguay and Uruguay. It was first recorded in Florida in 1987 and was known to infest 10,000 ha by 1990 and half a million hectares by 1995. By 2007 it had spread to nine other states in south eastern USA. In the USA it is a Federal Noxious Weed aptly named: "the plant from hell". Tropical soda apple has also naturalised in Africa, India, Nepal, West Indies, Honduras, Mexico and outside its native range in South America.

The Plant

Tropical Soda Apple is an upright but sometimes prostrate much branching perennial shrub. It is an aggressive prickly perennial shrub 1–2 m high and width.

Leaves are broad, 10 – 20 cm long and 6 – 16 cm wide, they are hairy and lobed, resembling fig leaves. The entire plant is armed with straight prickles that can be longer than 2cm. Flowering occurs year round, flowers are white with 5 petals and develop in clusters below the leaves, fruit are 2.5 cm in diameter (golf ball sized) and resemble a watermelon starting from a mottled green maturing to a yellow colour.

The Fruit contains 200-400 small brown seeds about 3mm across. The seeds of the plant are sticky and readily adhere to most surfaces such as animal hooves and coats. It is said a plant can produce around 45,000 seeds. The sweet smell of mature fruit (smells like fizzy apple soda) attracts animals and seeds pass through the digestive system unharmed and will germinate in dung or droppings.

The plant is unpalatable to livestock, thus reducing carrying capacity, however, the fruit is readily eaten by livestock, with major vectors of spread including Cattle, Feral pigs and deer as well as birds, all eating the fruit with movement by water through flood events also contributing to downstream spread.

It invades open to semi shaded areas, including pastures, forests, riparian zones, roadsides, recreational areas, horticultural and cropping areas in a wide variety of soils.

It reduces biodiversity in natural areas by displacing native plants and disrupting ecological processes.

Prickles on this plant restrict native animal and stock grazing and can create a physical barrier to animals preventing movement to shade and water.

The plant is a host for many diseases and pests of cultivated crops and it contains solasodine, which is poisonous to humans.

Australian Infestation

Tropical Soda Apple was first officially identified in Australia in the Upper Macleay Catchment area on the Mid North Coast of New South Wales (NSW) in August 2010.

The plant was observed some eighteen months before this, however, it was misidentified as Devils Apple (*Solanum capsicoides*), a similar plant with white flowers and orange/scarlet coloured fruit.

In May 2010, the plant was brought to the attention of the Mid North Coast Weeds Co-ordinating Committee Inc by Mr Richard Fischer, the community representative on the committee for Kempsey Shire Council, advising that the plant was coming up in flood debris along the Macleay River at Bellbrook.

Several months later Mrs Carolyn Duff, a landholder in the Upper Macleay, arranged an onsite inspection at Lagoon Creek in the Armidale-Dumaresq Shire to discuss the explosion of Tropical Soda Apple plants in that locality with local landholders and representatives from Mid North Coast Weeds Co-ordinating Committee, New England Weeds Authority, NS Primary Industries and Kempsey Shire Council..

From this meeting, samples were sent to the Sydney Royal Botanic Gardens Herbarium by Kempsey Shire Council's Weeds Officer, Mr. Greg Egan for formal identification which proved to be the first naturalised recorded occurrence in Australia.

This weed is believed to have been present in this area for a number of years. Subsequent surveys have identified other smaller infestations in surrounding areas, including Wingham Abattoirs, Saleyards at Kempsey, Grafton and Casino, several properties in the Clarence Valley and Coffs Harbour Council areas, smaller infestations in the Nambucca and Bellingen, Council areas and in southern Queensland. Isolated plants have been identified at Attunga near Tamworth and on roadside near Nymboida in the Clarence catchment.

Survey, Mapping and Strategic Planning

Following formal identification a delimiting survey was conducted by New England Weeds Authority and Kempsey Shire to assist with development of the "Macleay Catchment Tropical Soda Apple Control Plan" giving a framework for strategic tasks required for implementing a control and awareness program and providing the basis for an application for new weed incursion funding assistance.

The plan also highlighted the need for Chemical control trials, due to there being no registered chemicals for Tropical soda Apple, the completion of a Weed Risk Assessment and subsequent declaration of Tropical Soda Apple as a Noxious Weed and the secondment of the "National Livestock Identification System" (NLIS) database to trace cattle movements as the consumption and dispersal of Tropical Soda Apple Fruit by livestock was identified as a major vector of spread. These tasks were undertaken by Mr Tony Cook, Industry & Investment NSW, Tamworth, Dr Stephen Johnson, Industry & Investment NSW, Orange, Mr Peter James Mid Coast Livestock Health & Pest Authority (Kempsey Ranger) and Mr Scott Charlton Industry & Investment NSW respectively.

The Chemical control trials and the cattle trace back are the subject of separate presentations at the 16th NSW Weeds Conference.

The Tropical Soda Apple Taskforce Group was then established comprising stakeholders including Mid North Coast Weeds Co-ordination Committee, New England Weeds Authority, NSW North Coast Weeds Advisory Committee, Livestock Health and Pest Authority and NSW Primary Industries to oversee the program.

An area of land at Lagoon Creek in the more heavily infested areas was secured to enable the commencement of chemical trials by Tony Cook to ascertain the most effective chemicals for control

Landholder consultation regarding the origin and rate of spread of Tropical Soda Apple has not provided any indication of how or where the infestation originated, however, anecdotal information gathered from numerous landholders indicates that the plant was present in the Georges Creek Catchment for possibly fifteen years, following the drought in the mid 90's when agistment cattle and feed were introduced from the Kempsey area.

Little spread was evident until the last two years when mild winters have seen downstream properties plant populations explode from several plants one season to hundreds of plants the next and tens of thousands of plants this year, strongly supporting the “**plant from hell**” label attributed to the plant in the United States of America.

Funding

An early action for the Taskforce was to obtain funding for initial control works. \$30,000 was secured from Industry & Investment NSW, thanks largely to the intervention of Mr Rod Ensbey, Mr Syd Lisle and others within NSW Primary Industries. A further \$15,000 was provided by the Northern Rivers Catchment Management Authority, utilising the “Macleay Catchment Tropical Soda Apple Control Plan” as the basis for the funding applications.

Education and Awareness

Extensive Education and Awareness programs were then put in place by all stakeholders including the development of “Weed Alert” sheets and their mail out through local newsletters (Landcare, LHPA, Machinery dealers, monthly accounts, Dairy Co-operatives and field days),

Articles were prepared for inclusion in local and state newspapers (The Land, Farming Small Acres, and Town & Country magazine, Mid Coast Observer, Macleay Argus and others). Radio interviews and Television news items were also conducted, highlighting Tropical Soda Apple identification and the need for control.

Control Program - Macleay

Round One.

The control program commenced in Georges Creek and upper reaches of the Macleay River catchment in November 2010.

“Bass Lodge” was utilised as base camp with participating organisations including Department of Climate Change and Water (NPWS), New England Livestock Health & Pest Authority, Clarence Valley Council, Gunnedah Shire, Moree Shire, New England weeds Authority, Gloucester Shire, Greater Taree City Council, Port Macquarie – Hastings Council, Great Lakes Council, Kempsey Shire Council, Mid North Coast Weeds Co-ordinating Committee and a significant landholder involvement.

Twenty Three (23) kilometres of one side of the Macleay River and both sides of Georges Creek was treated over three and a half days (rain on Thursday). We were unable to cross the Macleay River due to high water levels and few fish were caught.

Statistics include:

- 45 properties inspected and treated;
- 23km of The Macleay (one side) and 10km of the Georges Creek (both sides) treated;
- 7 landholders assisted (Spraying and navigation of properties) one landholder providing a quickspray and vehicle for two days;
- \$3,000 estimated landholder contribution;
- NPWS walked/Inspected and treated 11km of inaccessible river in one day;
- 8,372ha inspected and treated;
- 80 litres of herbicide used
- Finished 1km short of the Kempsey Shire / Armidale Dumaresq Shire boundary (approximately half way through and including the heaviest infestation)

Round Two.

Round two commenced on the 28th February with base camp being “Bemurrah Homestead” at Pee Dee some 30 kilometres downstream from “Bass Lodge” and situated about halfway through the untreated area. Three and a half days were completed (rain Wednesday) not including follow up inspections of the previously treated area in the weeks leading up to this round.

It was alarming to see that in some areas there were as many Tropical Soda Apple plants growing and having matured to flowering as there was prior to treatment in the November program, this growth occurred in just over three months!

River levels were lower on this visit with access to the southern side of the Macleay River enabling treatment of significant sections of this otherwise inaccessible area. Tuesday saw the team cross the Macleay River at George’s Junction, treating private property, Crown reserve, Thungutti Aboriginal land and Travelling Stock Reserve.

Some landholders had undertaken control work in this section with infestation density being much less below Lagoon Creek than in the upper reaches and confined more to the river. Participating organisations included Gunnedah Shire, Moree Shire, New England Weeds Authority, Greater Taree City Council, Mid North Coast Weeds Co-ordinating Committee, Kempsey Shire and Border Rivers Gwydir Catchment Management Authority.

Accommodation costs were halved this round and more fish were collectively caught.

Statistics include:

- 9 properties in Armidale Dumaresq Shire treated;
- 3 properties in Kempsey Shire treated;
- 2 Travelling Stock Routes in the Armidale LHPA treated;
- 11km of the Macleay river treated;
- 7,100ha in Armidale Dumaresq, 500ha in Kempsey, and 300ha of TSR treated;

- 80 litres of herbicide used;
- Approximately 10km roadway and reserve treated in the Kempsey shire (south side of river above Bellbrook) on Tuesday by Greg Egan and Wendy Bushell.

There are still areas requiring attention, including the “Green Point” Thungutti Aboriginal land and the area above Bellbrook in the Kempsey Shire, these areas will be treated by Kempsey Shire Council and New England weeds Authority with assistance from the Mid North Coast Weeds Committee members.

Coffs Harbour

The Coffs harbour infestation was initially identified by Barry Powells quite by accident on his way to a landowner’s property (west of Coffs Harbour along the Orara River) thanks to the publicity that was given to the Macleay infestation.

Many mature plants were found in a cattle camp with several hundred immature plants growing in the riparian area which had obviously been deposited by a recent flood.

Thirty nine (39) properties were identified as being of interest adjoining the Orara River and its tributaries upstream of Secombe’s to the end of Maston’s Road and downstream from Karangi to Coramba.

The identified properties received a letter describing the weed and requesting entry to their properties. As time was of the essence spraying was completed during the inspection process at no cost to landholders. Almost invariably the plants were located along the riparian zone, occasionally large mats of plants were located, however, generally there were less than 10 plants per holding with an occasional property with plants scattered all over them.

In all 80 properties were inspected due to landholders reporting that they had the weed thanks to a very successful media campaign resulting in many telephone enquiries. Of these 40 or 50 had Tropical Soda Apple with many landholders adamant that that it had been on their land for some years (one fellow suggested over 20 years). Origin of infestations was blamed on stockfeed imports and cattle movement.

Two to three months after treatment with Starane all plants were dead or dying, however, there have been many calls advising of further germination.

Between \$6,000 and \$8,000 has been spent on inspection, mapping and treatment to date with all follow up work being conducted at the landholder’s expense.

Clarence

The Clarence infestations were similarly discovered following the publicity generated from the Macleay infestations. Tropical Soda Apple was identified on many properties in the Tallawudjah Creek catchment in the Glenreagh area and also at Whiteman Creek near Grafton and the Grafton Regional saleyards.

The control program commenced on 6th December 2010, with the aim of containing the spread of Tropical Soda Apple in the catchment, with initial control work being undertaken at no cost to the landholders.

A Field Day was also conducted as part of the control program with good attendance from the local landholders.

Far North Coast

The main infestation on the far north coast is a forty hectare infestation at the Casino saleyards. This site has been treated twice by the council and is now being followed up by the land manager.

There are several other small infestations in the Bonalbo region that have been treated.

Tracking Cattle Movements

Following on from cattle consuming the fruits of Tropical Soda Apple and thus being a major vector of spread and the use of the National Livestock Identification System (NLIS) to trace their movements (see paper by Scott Charlton on this topic).

Lists of first property transfers of cattle from the infestation area were forwarded to the respective councils across the state and interstate with a request for inspection of the subject properties to determine possible new infestations.

At the time of writing this paper, one positive identification of Tropical Soda Apple has been reported.

Conclusion

Following the principles of the Weed Action Program, inspecting “High Risk sites” e.g. saleyards and abattoirs and their paunch disposal sites, Weeds Officers in the region were able to identify and control new outbreaks early, thus greatly assisting control.

Due to the rapid rate of new detections, it is likely that Tropical Soda Apple is already present in other parts of eastern Australia.

In Australia it has the potential to spread in coastal and inland regions of NSW and Queensland.

Landholder reports regarding the **explosive** germination and growth rates of Tropical Soda Apple highlight the potential of this plant to totally dominate coastal landscapes and are reinforced by experience with this plant in the United States of America.

There is an **urgent** need to have a full time officer appointed and funded to facilitate Tropical Soda Apple control programs in NSW.

YOU SHOULD BE FRIGHTENED OF THIS PLANT!

Acknowledgements

The authors would like to acknowledge the information provided by Barry Powells from Coffs Harbour City Council, Reece Luxton from Clarence Valley Council and James Browning from New England Weeds Authority.

References

NSW Industry & Investment, (2010), Tropical Soda Apple, Weed Alert.

van Driesche, R. et al. (2002). Biological control of invasive plants in the eastern United States. USDA Forest Service.

In the footsteps of cows Using technology - and cows - to predict new weed incursions

Mr Scott Charlton – Weeds Strategy & Planning Officer I&I NSW

Ms Robyn Henderson – A/Invasive Species Information Officer I&I NSW

Tropical soda apple, *Solanum viarum* (TSA), is an aggressive prickly perennial shrub 1–2 m high. It invades open to semi-shaded areas, including pastures, forests, riparian zones, roadsides, recreational areas, horticultural and cropping areas. In August 2010 the plant was identified on the NSW Mid North Coast of NSW. It is believed that TSA has been present in this area for a number of years and both systematic and adhoc surveys have found the weed in other satellite locations.

The discovery of TSA at several cattle handling facilities indicates that cattle are a significant vector for the weed. This has presented an opportunity to use the National Livestock Identification System (NLIS) data to trace cattle movements from affected properties throughout Australia. This has proved remarkable as there are few mechanisms to systematically trace weed incursions using such technology.

Through the use of NLIS we have been able to conduct a pathway analysis of where this weed is likely to occur across NSW. Importantly, we can use this information to pinpoint surveillance activities for local managers thus ensuring better use of resources. The data has also allowed us to model the probability of incursions at these sites using statistics gleaned from the NLIS data.

This project has proven to be a successful collaboration between various units of NSW Department of Primary Industries (NSW DPI), Local Government and the LHPA.

Introduction

Tropical soda apple is a native of north eastern Argentina, south eastern Brazil, Paraguay and Uruguay. It was first recorded in Florida in 1987 and was known to infest 10,000 ha by 1990 and half a million hectares by 1995. By 2007 it had spread to nine other states in south eastern USA. In the USA it is a Federal Noxious Weed aptly named: "the plant from hell". Tropical soda apple has also naturalised in Africa, India, Nepal, West Indies, Honduras, Mexico and outside its native range in South America.

Tropical soda apple was first identified in Australia in the Kempsey area on the Mid North Coast of New South Wales (NSW) in August 2010 (*see figure 1*). However, the weed is believed to have been present in this area for a number of years. The extent of the core infestation is about 50 ha. Subsequent surveys have identified other smaller infestations in surrounding areas.

From information available it is likely to have the potential to spread to coastal and sub-tropical regions in NSW and Queensland. However, this does not take into account modified environments such as irrigated agriculture. Further climate modelling is required.

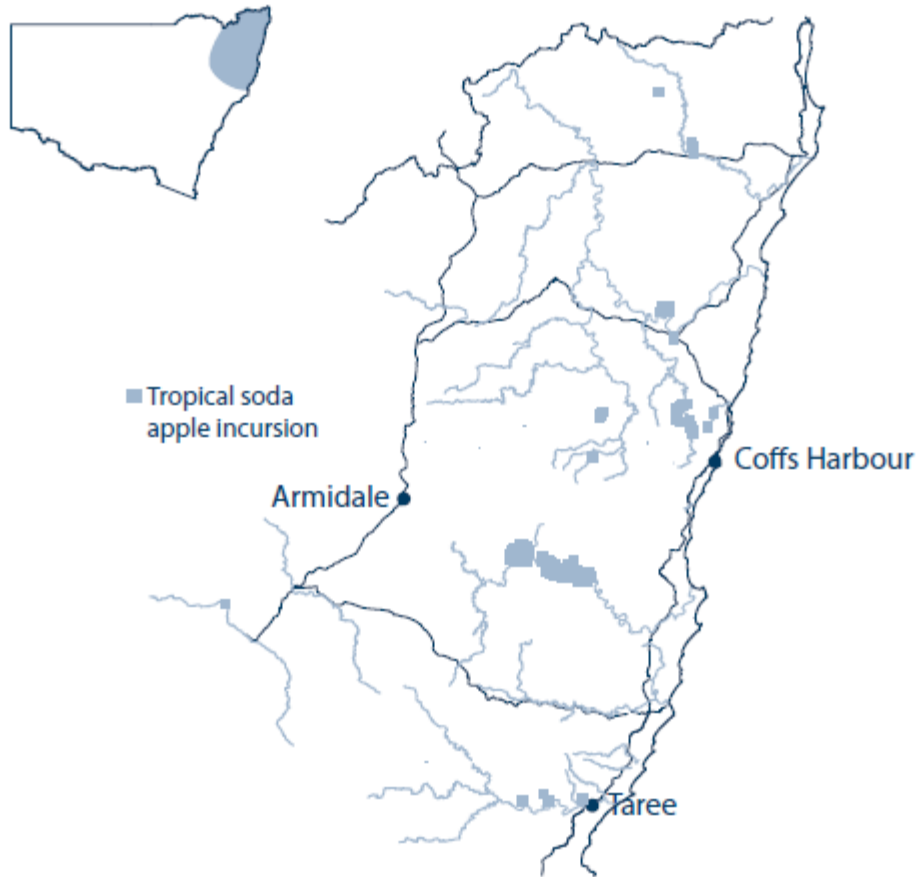


Figure 1. Tropical Soda Apple distribution

Tropical soda apple reproduces via seed and can regenerate from root material. Spread is by stock, feral animals and birds that feed on the fruit, and via water and contaminated produce, equipment, pasture seed, compost and soil. The sweet smell of mature fruit attracts animals and seed passes through the digestive system unharmed and will germinate in dung or droppings. In the USA TSA plants produce an average of 45,000 seeds.

Although TSA was first observed on the Mid North Coast of NSW, it is not known if this is the site of the initial introduction. The weed is believed to have been present in this area for a number of years and only formally identified in August 2010. The source of the original introduction is currently unknown and unlikely to be determined. Evidence from the USA indicates that distribution by animals is likely to be a major vector for this weed. The occurrence of the weed at saleyards where cattle have been transported from infestation sites supports this theory.

There is evidence that stock from one particular property affected by the weed have been dispersed across NSW. Other producers in the area have more than likely transferred stock to other locations in NSW and interstate as well. This dispersal

mechanism indicates that a state-wide management approach is needed in concert with efforts from neighbouring States.

Although the Macleay River may be considered a pathway for the Kempsey incursion, the distribution of the weed along the river suggests that animal movement along the corridor is more likely a factor rather than water transportation.

It is known that both native and feral animals and birds are consuming the fruit. This is also a pathway for spread although this is likely to be more localised than the potential long distance spread via livestock movements.

The invasion process

Invasive species have very real and imminent implications for NSW's economy, environment and social well-being. If a weed is introduced into a new area, infestation will have varying degrees of success. In its most innocuous form, a new plant may struggle to establish and remain undiscovered for a long time. Other plants will establish quickly, colonise an area and quickly spread to another. The invasion process can be represented by a sigmoid curve similar to *figure 2*.

The most effective way to minimise the impact of invasive species is to prevent their initial incursion. This involves identifying species, thoroughly assessing potential invasiveness and implementing effective barriers to prevent their establishment.

Invasive species have the ability to establish in new areas rapidly and successful control often corresponds directly with timely and rapid response. The challenge is to develop and deploy effective ways to eradicate or contain an introduced species before it becomes widespread.

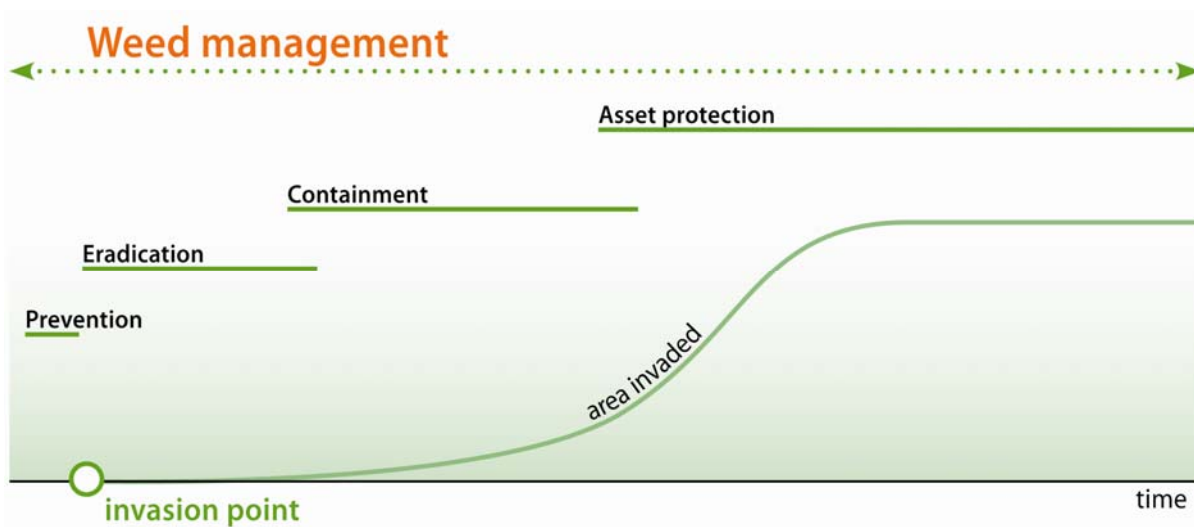


Figure 2. Typical weed invasion process and corresponding management approaches

National Livestock Identification System – NLIS

Livestock movements from tropical soda apple affected areas have been a focus for trace-forward activities. All sheep and cattle movements are currently tracked by the National Livestock Identification Scheme (NLIS). Information from NLIS can be used to target weed identification and extension materials or direct surveillance priorities. The NLIS is Australia's scheme for the identification and tracing of livestock. This system enhances Australia's ability to respond quickly to a major food safety or disease incident in order that access to key export markets is maintained. It is a key industry initiative in partnership with Governments across Australia.

NLIS Cattle was introduced in NSW on 1 July 2004 and involves electronic identification of cattle and centralised recording of movements on a national database. NLIS Cattle uses approved NLIS ear devices or rumen boluses and reporting all movements of cattle between properties with different Property Identification Codes (PICs).

Privacy considerations

The collection and use of information recorded in a stock identification and tracing register is subject to the provisions of the *Privacy and Personal Information Protection Act 1998* (the 'Privacy Act'). The Privacy Act applies to all public sector agencies, including NSW DPI and LHPAs.

When collecting personal information, an agency must take reasonable steps to ensure that landowner privacy is maintained. Personal information must not be used unless it is for a purpose directly related to the reason for which the information was collected. In the "Terms of Use" of NLIS information, a "Permitted Use" (section 13.1) means "*any use which a government participant acting reasonably considers necessary or convenient to comply with the legislative framework within which it operates solely for biosecurity, food safety and market access purposes*".

To abide with these considerations, NSW DPI gave Local Government the minimum amount of required information to enable them to complete their survey. Information regarding the origin of transferred cattle was not required to complete this task.

Pathway analysis

In November 2010 Biosecurity staff at NSW DPI conducted a pathway analysis to model the distribution of TSA based on cattle movements across the State.

The locations of all properties with TSA present were collated and converted to standard GPS coordinates. This process resulted in a list of 756 infested properties (IP). This list was then given to the LHPA who provided NLIS Property Identification codes (PIC) for each IP. The resulting list of PICs was then used to identify 26,762 cattle movements from each IP over a period of time.

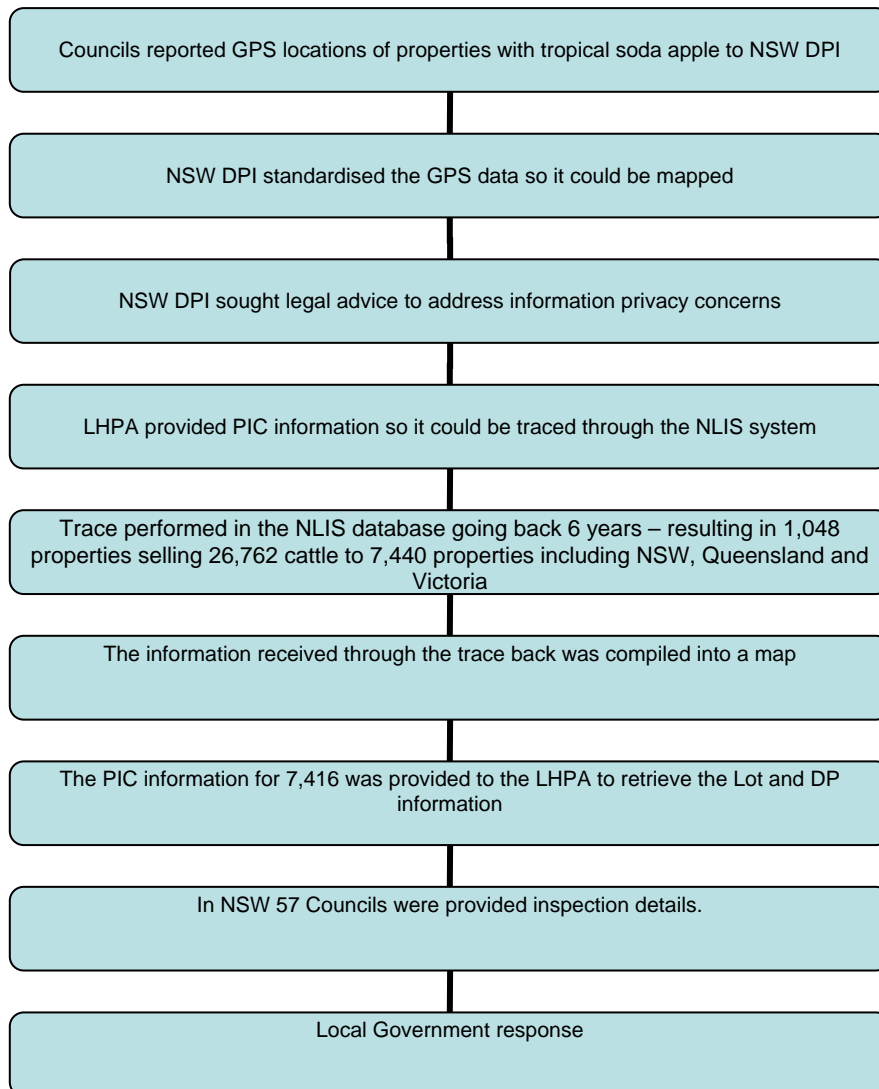


Figure 3. Pathway analysis for tropical soda apple

At this point a decision was made that cattle movements would be analysed for the past six years or the period from which the data was first collected. Consideration was given as to whether the movements should be prioritised based on how long ago the movement took place. It was decided that it would be difficult to get an objective ranking of risk based on this method. Ultimately the risk of spread was based entirely on number of cattle movements.

The NLIS database was interrogated to determine the first movement of individual cattle from each IP. Where cattle were transferred to a cattle handling facility, the following movement was also determined. When an animal went from an IP to an abattoir the trace ended. Abattoirs and other cattle handling facilities have been the focus of Local Government and surveillance activities outside of this process.

The resulting list of 1,048 PICs that received cattle transfers from IPs was submitted to the LHPA for conversion into Lot/DP numbers. The conversion of PICS increased this number again as an individual PIC can have multiple Lot/DP numbers attached to it.

Consequently, over 7,440 Lot/DPs “properties of interest” POI (see *figure 3*) were processed into 57 local government areas and mapped by NSW DPI staff.

This process also identified 9 POIs in Victoria and 25 in Queensland. The appropriate interstate authorities were promptly alerted to the weeds presence.

NSW DPI wrote to 57 local control authorities (LCAs) requesting they inspect the POIs in their area and report the results back to NSW DPI. A template and extension material was also supplied to assist with this process. It was also requested that the identified properties receive follow up surveillance as part of routine weed inspections. This survey is still ongoing.

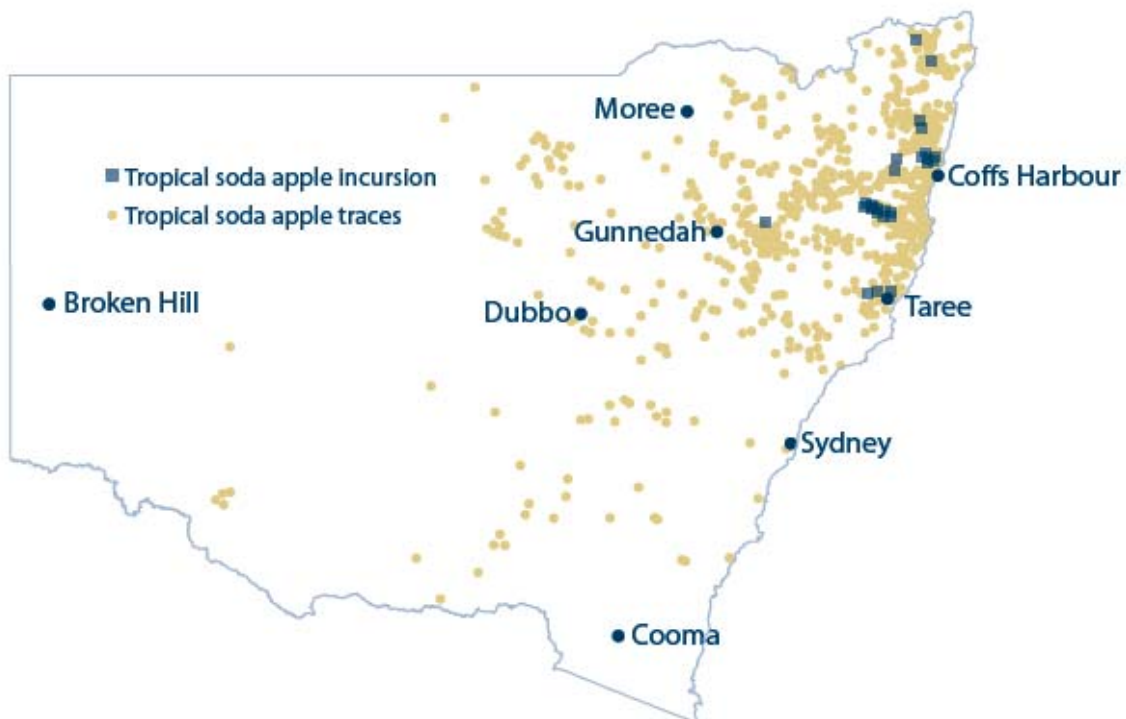


Figure 4. “Properties of interest” derived from NLIS trace

Outcomes

The early identification of 3 separate incursions across the State demonstrates that this is a valuable pathway analysis tool for predicting the movement of some weeds. This ground breaking technique resulted in the discovery of the TSA at Holbrook 1,200km from its original infestation. Subsequent surveys have also found the weed at Tamworth and Inverell. These incursions were able to be eradicated quickly and cheaply. Furthermore, this analysis gives managers valuable information to allow delimitation of the weeds range based on its most common vector.

This program has been very successful in engaging various stakeholders across the State. At the time of writing we have received 18 responses from LCAs while other LCAs are still actively engaged in survey work.

Participation in this tracing activity has also provided weed officers with an opportunity to positively engage with landowners in weeds management where there is a direct benefit for the landowner. This pro-active interaction with landowners has been invaluable in building a rapport with landowners that can be used for broader weed management outcomes.

The identification of specific properties of interest has also enabled local government weed officers to target specific target groups namely the Beef Cattle Industry for the distribution of extension and education material.

Although cattle movements are considered a significant pathway, it was considered important that the Beef Cattle Industry was not unnecessarily impeded. As a result of the trace several hygiene protocols have been promoted to limit the risk of new weed incursions due to cattle movement.

Feedback from local government weed officers has been invaluable in identifying ways that NLIS can be improved. It was commonly reported that some PIC data was incorrect, in many cases owners reported that they had never had cattle on their property or that it was used exclusively for another purpose such as cotton production. It was also established that many cattle buyers purchase bulk lots that are distributed to several other properties without changing transfer details. Other issues included the re-tagging of cattle with incorrect tags when tags are lost in transit, and the ability to trace manure from feedlots.

Since this analysis has been conducted NSW DPI has commenced streamlining the tracing process through its Biosecurity Enhancement Program. These changes will allow officers quicker access to data required for tracing activities.

Conclusion

By manipulating NLIS data normally reserved for managing animal pest and disease, staff were able to identify high risk properties and pathways across NSW, Queensland and Victoria. This result is a tremendous advantage for weed managers and cattle producers allowing them to eradicate outlying populations before they become expensive and impractical to control.

It is important that weed managers think outside of the square when conducting pathway analysis and exploit these types of resources where they are effective.

Although not applicable to all situations this type of approach should be considered in the repertoire of techniques for weed pathway analysis. This particular technique allows weed managers the ability to electronically trace the movements of weeds where the vector is directly related to stock movements recorded on the NLIS database.

This again reinforces the value of tools such as GIS and databases and the importance of accurate recording of information. One caveat should be stated; that the time used to

analyse the pathway should be proportional to the importance of the vector you are analysing. There is not much point spending inordinate amounts of time analysing animal movement if the majority of seed is transported by water. Happy analysing!

ACKNOWLEDGMENTS

The following people have kindly assisted this process.

Robyn Henderson NSW DPI

Marion Bennett NSW DPI

Rod Ensbey NSW DPI

John Tracey NSW DPI

Olga Ozols NSW DPI

Ian McGowan NSW DPI

Cris Ryan LHPA

Various Local Government Staff for providing data and conducting inspection work

MAHONIA

One of the top 5 Plants you Have to Have

Ian Turnbull
Manager Sustainability & Natural Resources
Bellingen Shire Council, Hyde St, Bellingen NSW 2454

BACKGROUND

Mahonia lomariifolia was discovered in August 2009 west of Dorrigo in Bellingen Shire, NSW.

Bellingen Shire Council received a telephone call from concerned landholder on Deervale Rd, approximately 6km west of Dorrigo NSW, regarding a plant that had been spreading from an adjoining landholder's garden and throughout both properties. The caller identified the plant as Mahonia and made reference to p39 of the August 2009 issue of Gardening Australia. The plant referred to in the magazine was *Mahonia japonica* and was given the description of a golden beauty (Gardening Australia, 2009). It has also been described as one of the "top five cool climate plants you have to have".

Shortly after staff visited the property and met with the landholders to take an initial assessment. Four plants (one in seed) were identified within a paddock, adjacent and within some dense wet sclerophyll/ temperate forest. Samples were taken from this site. The inspection then continued a further 250m down the road to another infestation where 3 mature plants (seeding) were found and at least a further 50 seedlings and juvenile plants were located (samples were also taken from this site). A brief drive further down the road located at least 10 more plants.

New Weed Incursion Protocol

Following the process flowchart on p2 of the NSW Primary Industries (formerly NSW Industry & Investment) - New Weed Incursion Plan 2009-2015, the following actions were taken;

1. Ad Hoc Observation

The plant was observed almost concurrently by landholders on Deervale Rd and Rangers from NSW Office of Environment and Heritage (National Parks & Wildlife Service) NPWS.

2. Plant detected

Following the "Field Inspections to Follow up Reported New or Unknown Weed Incursions" NSW Primary Industries, Bellingen Council staff investigated the observations and took samples of the plant for verification by Royal Botanic Gardens in Sydney. NSW Primary Industries advised of the incursion on 14 August 2009.

3. Identification Confirmed

Samples of the plant were pressed and sent to the Royal Botanic Gardens in Sydney for identification. Samples were also taken to Coffs Harbour Botanic gardens and botanist Alex Floyd identified the plant as *Mahonia lomariifolia* – Chinese Holly Grape.

Council received written advice from RBG Sydney dated the stating that the specimen submitted was *Mahonia leschenaultia*. A telephone call to the Gardens requesting clarification saw resubmission of a specimen on the. A response was received identifying the resubmitted specimen as *Mahonia lomariifolia* (Chinese Holly Grape).

Mahonia lomariifolia is not listed as naturalized in NSW on PlantNET (<http://plantnet.rbgsyd.nsw.gov.au/>) nor is it listed as naturalized in Australia according to Australia's Virtual Herbarium (<http://www.anbg.gov.au/avh/>).

Description

Mahonia lomariifolia is a large upright growing shrub or small tree, up to 9 meters high. It is native to the region between Yunnan, Sichuan, northern Burma and east to Taiwan.

The foliage is borne in tufts at the top of the stems. The leaves have more leaflets than most species of Mahonia, usually up to 14-20 pairs of leaflets, with an additional terminal leaflet.

Yellow flowers are borne in racemose upright inflorescences at the tips of the branches, up to 25cm long, in autumn. Between 7 and 20 racemes occur in each cluster. The flowers are bright deep yellow, and are slightly fragrant. Flowers emerge from May to June.

4. Preliminary Assessment

As the plant had not been recorded as naturalized in NSW or Australia it was deemed appropriate to undertake a weed risk assessment.

The plant was assessed using the NSW Primary Industries Weed Risk Management Assessment protocol (NSW I&I , 2009).

There were a number of assumptions which were made on elements of the assessment undertaken by the author. Following an internet and "Enviroweeds" search it has been found that there is a lack of information on the plants biology. Information on related species was provided by Stephen Johnson from NSW Primary Industries.

The results gave a, "very high " reading in both the weed risk and the feasibility of coordinated control categories. The assessment gave a management priority category of eradicate. There was a 14% uncertainty overall in the calculations.

Locations of Infestations

The primary site is on Deervale Rd off Waterfall Way approximately 7km west of Dorrigo. Additional sites on Waterfall Way at Johnsens Rd (11km) and Whites Quarry (18km) were mapped but not delimited. The approximate number of plants at each site have been recorded.

Site 1 - Deervale Rd – area of infestation 37 Ha – Number of Plants ~300

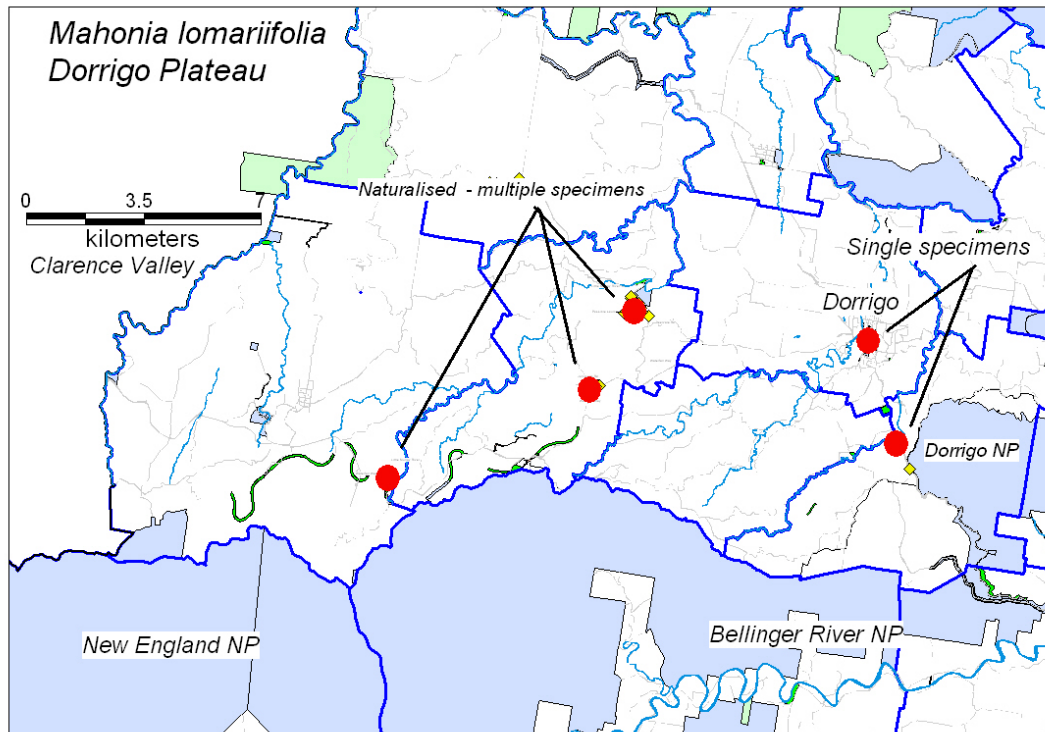
Site 2 – Johnsens Rd – area of infestation 1Ha – Number of plants ~70

Site 3 - Whites Quarry – Area if infestation – 22Ha – Number of Plants ~ 180

The plants on site 1 and 3 were all occurring in gullies in low light conditions. The nature of the terrain is undulating to steep with access only by foot.

Delimiting Survey

A delimiting survey was undertaken on the Deervale infestation . Plants number in excess of 200 were mapped using GPS. It was noted that the plant was restricted to the vegetated areas and not many were found growing in the open. Council prepared a number of media items on the plant in order to seek community advice as to their knowledge of the existence of other plants.



6. Invasive Plants Response Procedures for NSW

Verbal advice from NSW Primary Industries was to develop a Mahonia weed management plan. This was completed and forwarded requesting \$9,600 to implement. This request was approved and Bellingen Council received new incursion funds to undertake a search and destroy program.

Search and Destroy

Bellingen Shire Council engaged a local bush regeneration company to undertake a search and destroy mission on the known sites of Mahonia. The methodology was discussed with weed specialist Dr Paul Downey (who was then with the NSW Department of Environment and Climate Change). Over a period July to November the team undertook search and control activities at the three sites. Extensive data was collected and each location was mapped utilising GPS. The data included location, number of plants, plant stage (Adult, juvenile, seedling), spatial area, flowering status, habitat (in shade/sun), control methods, control time and health of plant.

At the sites surveyed:

Site1. Deervale Rd-1437 plants were destroyed

Ste 2. Johnson Rd-221 plants were destroyed

Site 3. Whites Quarry/5990 Waterfall Way-5535 plants were destroyed

In total in excess of 7,000 individual plants were destroyed. These ranged from seedlings to what may be considered one of the “mother” plants at the Waterfall way site. This plant was 6m high, had a 6m crown and 1 m diameter (multistemmed). Multiple inflorescences, fruit and seed (see picture below). Twelve kilograms of fruit was removed from this plant and bagged.

The activities of the teams who undertook the survey and control activities did so without the need for a weed declaration. Through a range of education and awareness activities and media processes the threat posed by the weed was recognised by the community and the control activities welcomed and assisted by landholders.

A follow up survey of each of the sites will be undertaken in the 2011 spring to control any new seedlings and further review the control undertaken. This activity will be able to be funded through the Weeds Action Program.

Conclusion

The management of new incursions utilising the processes developed and documented by the NSW Primary Industries over the past 5 years can be successful in a new weed incursion situation. Further work on determining a process for delimiting the likely range of a new weed incursion depending on the weed and topographical characteristics requires some further attention. Mahonia species (as members of the Berberidaceae family) should be considered carefully in cooler climates for their weed potential. The experience also clearly illustrated the difference between an estimate of a weed infestation in the early stages and the actual numbers found.

ACKNOWLEDGMENTS

The Author wishes to acknowledge Dr Paul Downey for his assistance in developing the monitoring strategy for the search and destroy process. Thanks also to Kim Cheney from Bellingen Bush Regenerators for following the possibly onerous recording methodology to a tee.

REFERENCES AND FURTHER INFORMATION

Gardening Australia, August 2009 edition.

NSW Government (2009), New South Wales, New Weed Incursion Plan 2009–2015, NSW Government, Sydney.

NSW Industry & Investment, 2009, NSW Weed Risk Management System, NSW Industry & Investment, Orange.

Where might we find invasive alien plants under novel climate regimes?

A case study using the buffer-zone method for selection of pseudo-absence points.

**Rodney H. Jones^a, Franz Mahr^b and Jackie Steel^a
Research Scientist^a, Technical Officer^b**

Biosciences Research Division, Victorian Department of Primary Industries, Frankston

INTRODUCTION

The large number of exotic species in Australia that have become invasive, or may do so in the future (Randall 2007), necessitates a method to determine the potential distribution of hundreds of invasive plant species under current and future climatic conditions. Elith *et al.* (2006), Heikkinen *et al.* (2006) and Hernandez *et al.* (2006) have assessed a range of modelling options available that rapidly produce potential distribution outcomes. An analysis of this literature revealed that the correlative modelling method Maxent (Phillips *et al.* 2006, Phillips and Dudík 2008) was well suited to modelling plant distributions using presence-only data, such as those contained in online databases of collected specimens, e.g. the Global Biodiversity Information Facility (GBIF) and Australia's Virtual Herbarium (AVH).

Maxent statistically compares the climatic conditions at the presence locations of target species with the climatic conditions associated with pseudo-absence locations selected from a set of data designated as the background. However, problems associated with presence locality data (see Araújo and Guisan 2006, Elith *et al.* 2006, Phillips and Dudík 2008, Elith *et al.* 2010) and selection of appropriate pseudo-absence or background points (Chefaoui and Lobo 2008, Phillips and Dudík 2008) are reflected in the varying levels of predictive capacity of model outputs (Phillips *et al.* 2009), and are particularly problematic when applied to invasive species by projecting onto novel geographic areas or climates (Phillips and Dudík 2008, Phillips *et al.* 2009, Thuiller *et al.* 2004, VanDerWal *et al.* 2009).

As most invasive species have not reached the full extent of their potential distribution into suitable habitats there will be areas of suitable habitat that don't have associated presence records. Thus, locations that are climatically suited could be included in the background data from which the pseudo-absences are sampled by Maxent (Chefaoui and Lobo 2008, Engler *et al.* 2004). Of the several methods available to select pseudo-absence data for distribution modelling (see Hirzel *et al.* 2001; Chefaoui and Lobo 2008; Phillips and Dudík 2008), VanDerWal *et al.* (2009) examined the approach of setting spatial constraints on the extent of the background area from which pseudo-absence points are selected. Using a range of well-studied vertebrate species from the Australian Wet Tropics, VanDerWal *et al.* (2009) randomly sampled pseudo-absence points from a background area that was determined by creating buffer zones at a range of incrementally increasing distances from each occurrence point.

In this paper we explore the buffer-zone approach as a method of overcoming problems associated with selection of appropriate pseudo-absence points for invasive species modelling. Following VanDerWal *et al.* (2009), we test the utility of the buffer-zone method by using

distribution data for *Hypericum perforatum* L. (St. John's wort) from its native and overseas invaded ranges to project a potential distribution onto the novel climatic conditions presented by Australia.

METHODS

Case study

From a background study of 20 species of invasive plants occurring in Australia, *Hypericum perforatum* L. (St. John's wort) was selected to present as a case study. *Hypericum perforatum* has a widespread global distribution, being native to Africa, Asia temperate, Asia tropical and Europe; naturalised in broader areas of Africa and temperate Asia, also extended to Australasia, North America, South America and the Pacific region (Germplasm Resources Information Network, GRIN Taxonomy for Plants, <http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl>). The first records of *H. perforatum* in Australia appeared in the mid 19th Century, and rapidly escalated after St John's wort was taken to gold mining areas in north-eastern Victoria in the 1860s (Parsons and Cuthbertson 2001). The plant now occurs in all Australian states with the exception of the Northern Territory.

Maxent

Default settings of the correlative modelling method Maxent, Version 3.3.3e (Phillips and Dudík 2008) were used, with the exception of selecting 'Random Seed' for the 100 replicates of each run, with Bootstrap as the replicated run type. The sample file was generated with location data for *Hypericum perforatum* obtained from the Global Biodiversity Information Facility (GBIF) Portal (www.gbif.org.au). The Environmental Layers used were all nineteen variables of the BioClim dataset downloaded from WorldClim (www.worldclim.org) as 10 Arc-minute ASCII grids for current conditions (1950-2000) and for future climatic conditions (CSIRO-MK 2 A2A scenario at 2080).

Following Broennimann and Guisan (2008), we used data from both native and invaded ranges of *H. perforatum*, and duplicated the method used by VanDerWal *et al.* (2009) to confine the geographic area of background data for each of the 19 current climate BioClim variables. ArcGIS software was used to limit the area from which background data were selected to zones that measured 25, 50, 75, 100, 150, 200, 300, 400 and 500 km radii from each sample-file point in the native and invaded ranges. We also generated a background dataset of the World minus Australia. Each set of these background data were used as sample files to train the model and project the potential distribution of *H. perforatum* onto Australia under both current and future climatic conditions. We present only a representative selection of the results of these projections in this paper.

Allocating cut-off values for climatic suitability

To set a climatic suitability boundary within the Maxent outputs, we devised a method that utilised natural breaks in the output data. Within ArcGIS, the Jenks Natural Breaks Classification method was used to identify 32 natural breaks in the raw Maxent ASCII output file. A polygon containing these natural breaks was then laid over a map of Australia displaying all known distribution points for *H. perforatum* contained in the GBIF database and the Integrated Pest Management System (IPMS) from the Department of Primary Industries, Victoria. A natural break position that covered all known distribution points by one additional

natural-break increment was selected as the cut-off value of climatic suitability for the establishment of *H. perforatum*.

Data analysis

As our measurements related to climatic regions rather than geographic space, we used zones of the Köppen Climate Classification System as units of area upon which to base our calculations. Measures of model accuracy were sensitivity (the ability to predict all of the climatic area in which *H. perforatum* could grow), and specificity (the ability to identify climatic regions that were unsuitable for *H. perforatum*).

The allocation of cut-off values for climatic suitability (see above) provided 100% sensitivity for all Maxent outputs. To calculate specificity, ArcGIS was used to first determine which Köppen zones were identified by Expert Opinion as being suitable for establishment of *H. perforatum* (Fig 1a). We then overlaid the Maxent output map(s) onto the combined map of Köppen zones and Expert Opinion to identify any additional Köppen zones that *weren't* identified in the previous step: these were deemed to be an overestimation of distribution by Maxent. ArcGIS was once again used to then calculate what percentage proportion of each of these additional Köppen zones was occupied by the over-estimate in the Maxent output.

RESULTS and DISCUSSION

Prior to allocating cut-off values for climatic suitability, all model outputs projected a potential distribution that encompassed both known current distribution points and the area designated by Expert Opinion as suitable for establishment of *Hypericum perforatum*. A cut-off value could therefore be assigned that ensured all subsequent model outputs were able to predict suitable climate for the establishment of *H. perforatum* with 100% sensitivity.

Once cut-off values were assigned, however, there were differences in the specificity of model outputs. Whereas the World minus Australia output had sensitivity and specificity levels of 100%, both the 50 km and 200 km outputs predicted Köppen zones 32, 35, 36 & 37 as suitable climatic regions for *H. perforatum* (Figs 1b, c): this did not correlate with the map based on Expert Opinion (Fig. 1a). The size of this discrepancy was measured by calculating the percentage proportion of each of the over-predicted Köppen zones that were occupied by each of the outputs. The proportion of Köppen zones 32, 35, 36 and 37 that was overestimated by the Maxent 50 km output ranged from 0.02% to 13.4%, whereas the 200 km buffer output overestimated three Köppen zones by 0.37% to 1.34% (Table 1). The sum of overestimate percentages for both the 50 km and 200 km outputs provided a comparative measure of the relative imprecision of each output at 17.13% and 2.74% respectively (Table 1).

The relatively slight overestimation for the 200 km buffer output is attributable to the difference in resolution between the Köppen zone map and that of the coarser Maxent output and Expert Opinion maps. It is possible that applying a different resolution to the Maxent output would result in the 200 km output also having 100% precision, making it comparable to the World minus Australia output. Figures for the 50 km output (Table 1) indicate that this was clearly a less accurate projection than either the 200 km output or World minus Australia output for *H. perforatum*.

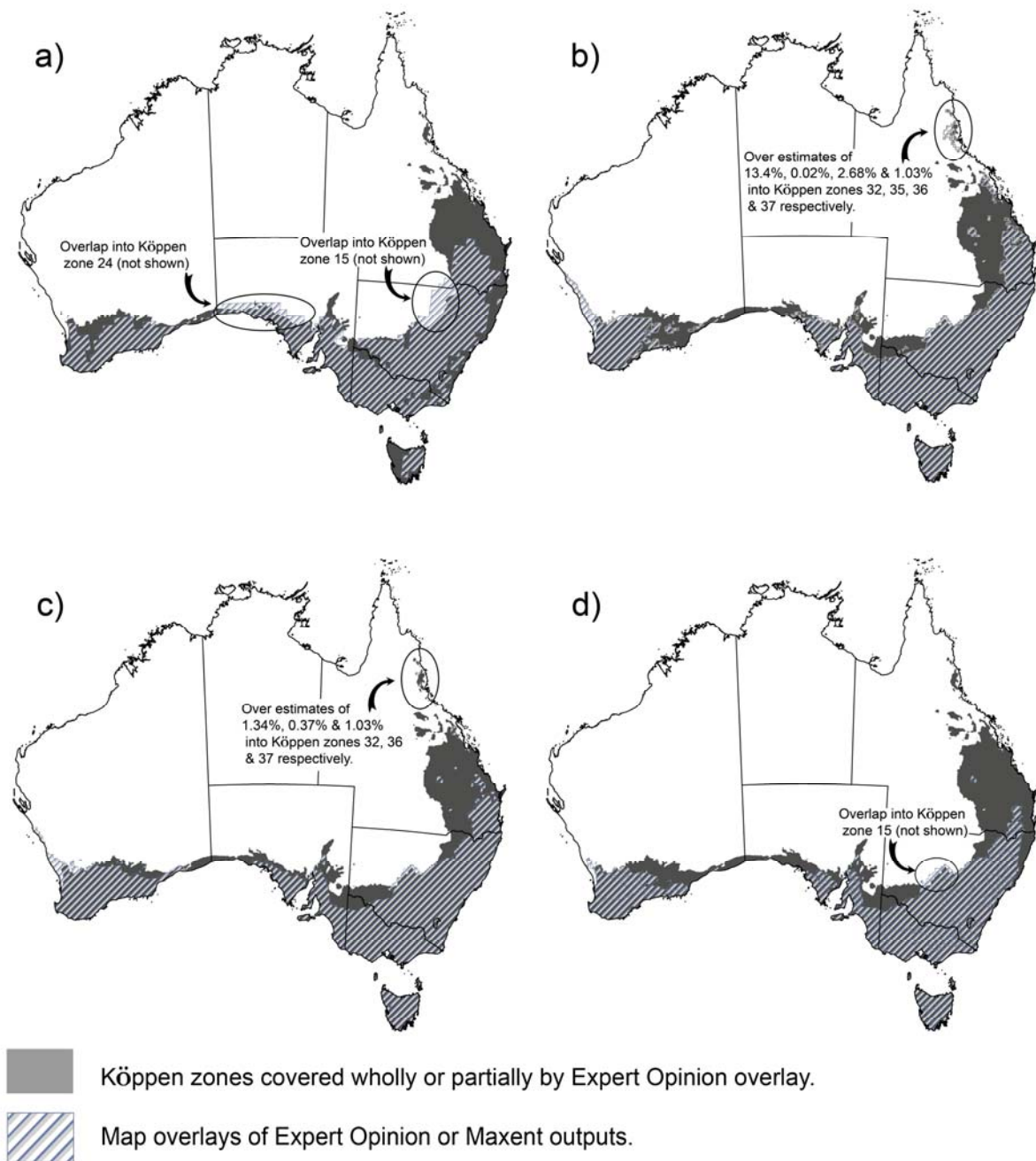


Figure 1. For a case study using *Hypericum perforatum*, maps of Australia showing Köppen Climate Classification System zones that are covered wholly or partially by map overlays of: a) Expert Opinion of distribution; b) Maxent output using pseudo-absence points taken from a 50 km buffer zone around distribution points; c) Maxent output using pseudo-absence points taken from a 200 km buffer zone around distribution points; and d) Maxent output using pseudo-absence points taken from a background of World minus Australia. Areas of relatively slight overestimation due to differences between the resolution of the coarser Maxent output and Expert Opinion maps and that of the Köppen zone map are indicated. Köppen zones 15, 24 and 33 are not shown in order to maintain clarity of map display.

Table 1. Percentage of each Australian Köppen Climate Classification System zone covered by Expert Opinion and Maxent outputs for projections of 50 km, 200 km and World minus Australia.

No.	Köppen Climate Classification Zones	50 km	200 km	World-Aust.	Expert Opinion
1	Temperate no dry season (cool summer)	100.00	100.00	100.00	44.68
2	Temperate distinctly dry (and mild) summer	100.00	100.00	99.92	93.98
3	Temperate no dry season (mild summer)	100.00	100.00	100.00	58.77
4	Temperate distinctly dry (and warm) summer	87.94	100.00	99.11	94.66
5	Temperate moderately dry winter (warm summer)	100.00	100.00	100.00	100.00
6	Temperate no dry season (warm summer)	100.00	100.00	100.00	86.82
7	Temperate distinctly dry (and hot) summer	100.00	100.00	99.72	72.94
8	Temperate moderately dry winter (hot summer)	100.00	99.17	97.83	89.64
9	Temperate no dry season (hot summer)	100.00	100.00	97.37	92.32
11	Grassland warm (summer drought)	63.16	63.79	31.90	67.46
12	Grassland warm (persistently dry)	52.34	60.66	50.72	80.34
13	Grassland hot (winter drought)	0.00	0.00	0.00	0.00
14	Grassland hot (summer drought)	1.39	1.55	0.10	0.46
15	Grassland hot (persistently dry)	0.89	1.14	1.38	7.24
21	Desert warm (persistently dry)	2.65	1.16	0.01	31.59
22	Desert hot (winter drought)	0	0	0	0
23	Desert hot (summer drought)	0	0	0	0
24	Desert hot (persistently dry)	0.00	0.01	0.00	0.82
31	Subtropical moderately dry winter	8.71	3.82	0.64	22.29
32	Subtropical distinctly dry winter	13.40	1.34	0	0
33	Subtropical distinctly dry summer	70.74	54.48	11.01	0.41
34	Subtropical no dry season	0.71	37.88	4.63	43.74
35	Tropical savanna	0.02	0	0	0
36	Tropical rainforest (monsoonal)	2.68	0.37	0	0
37	Tropical rainforest (persistently wet)	1.03	1.03	0	0
41	Equatorial savanna	0	0	0	0
42	Equatorial rainforest (monsoonal)	0	0	0	0

CONCLUSION

Our measure of model performance, utilising map overlays of Maxent outputs (with a cut-off value of climatic suitability applied), Köppen Climate Classification System zones, and a combination of Expert Opinion and known distribution points, allowed detailed and confident comparison of Maxent outputs based on pseudo-absence data selected from a range of backgrounds.

This method of performance measure is also applicable to determining how well the model will project suitable climates for species under climate change. The use of overseas native and invaded ranges to predict suitable climatic regions in the novel geographic space of Australia can be considered analogous with using current climatic conditions to train a model to project onto novel climatic conditions anticipated under future climate scenarios.

For *Hypericum perforatum*, Maxent outputs generated using the buffer-zone approach to select pseudo-absence points from the native and overseas invaded range did not provide a convincingly better outcome than the output based on pseudo-absence points selected from a

background of World minus Australia. Results of this case study, presented from the context of a broader background study, suggest that pseudo-absence points taken from either a buffer zone of 200 km or from a background of World minus Australia may be appropriate for use with Maxent to provide potential distributions for large numbers of invasive species under future climate regimes in Australia.

REFERENCES AND FURTHER INFORMATION

Araújo M.B. and Guisan A. (2006) Five (or so) challenges for species distribution modelling. *Journal of Biogeography* **33**: 1677–1688.

Broennimann O. and Guisan A. (2008) Predicting current and future biological invasions: both native and invaded ranges matter. *Biology Letters* **4**: 585–589.

Chefaoui R.M. and Lobo J.M. (2008) Assessing the effects of pseudo-absences on predictive distribution model performance. *Ecological Modelling* **210**: 478–486.

Elith J., Graham C.H., Anderson R.P., Dudík M., Ferrier S., Guisan A., Hijmans R.J., Huettmann F., Leathwick J.R., Lehmann A., Li J., Lohmann L.G., Loiselle B.A., Manion G., Moritz C., Nakamura M., Nakazawa Y., Overton J.McC., Peterson A. T., Phillips S.J., Richardson K.S., Scachetti-Pereira R., Schapire R.E., Soberón J., Williams S., Wisz M.S. and Zimmermann N.E. (2006) Novel methods improve prediction of species' distributions from occurrence data. *Ecography* **29**: 129–151.

Elith J., Kearney M. and Phillips S. (2010) The art of modelling range-shifting species. *Methods in Ecology and Evolution* **1**: 330–342.

Engler R., Guisan, A. and Rechsteiner, L. (2004) An improved approach for predicting the distribution of rare and endangered species from occurrence and pseudo-absence data. *Journal of Applied Ecology* **41**: 263–274.

Heikkinen R.K., Luoto M., Araújo M.B., Virkkala R., Thuiller W. and Sykes M.T. (2006) Methods and uncertainties in bioclimatic envelope modelling under climate change. *Progress in Physical Geography* **30**: 751–777.

Hernandez P.A., Graham C.H., Master L.L. and Albert D.L. (2006) The effect of sample size and species characteristics on performance of different species distribution modelling methods. *Ecography* **29**: 773–785.

Hirzel A.H., Helfer V. and Metral F. (2001) Assessing habitat-suitability models with a virtual species. *Ecological Modelling* **145**: 111–121.

Parsons W.T. and Cuthbertson E.G. (2001) *Noxious weeds of Australia*, 2nd ed., CSIRO Publishing, Collingwood.

Phillips S.J. and Dudík M. (2008) Modelling of species distributions with Maxent: new extensions and a comprehensive evaluation. *Ecography* **31**: 161–175

Phillips S.J., Anderson R.P., and Schapire R.E. (2006) Maximum entropy modelling of species geographic distributions. *Ecological Modelling* **190**: 231–259.

Phillips S.J., Dudík M., Elith J., Graham C.H., Lehmann A., Leathwick J. and Ferrier S. (2009) Sample selection bias and presence-only distribution models: implications for background and pseudo-absence data. *Ecological Applications* **19**:181–197.

Randall R.P. (2007) *The introduced flora of Australia and its weed status*. CRC for Australian Weed Management, Adelaide, Australia.

Thuiller W., Brotons L., Araújo M.B. and Lavorel S. (2004) Effects of restricting environmental range of data to project current and future species distributions. *Ecography* **27**: 165–172.

VanDerWal J., Shoo L.P., Graham C. and Williams S.E. (2009) Selecting pseudo-absence data for presence-only distribution modelling: How far should you stray from what you know? *Ecological Modelling* **220**: 589–594.



NATURAL RESOURCE MANAGEMENT IN AN AGE OF MOBILE GIS

**Peter Michael
Team Leader – Bush Regeneration
Port Macquarie-Hastings Council
Port Macquarie, NSW**

1. INTRODUCTION

Our presentation shows a step-by-step implementation of our GIS system for reserve management. Choice of software platform or computer hardware is not relevant, but instead this concentrates on the decision making processes which might assist your own organisation or circumstances. Thankfully, we made plenty of mistakes and I'll share those with you too!

The ever-changing focus of NRM organisations is often realised through the application of new technological advancements and capabilities. When applied to the management of invasive species, a large element of this is undoubtedly the capture, manipulation and presentation of bio-spatial data for a whole range of purposes – for example, displaying the current extent of a weed infestation or tracking changes in density over time as a result of non-treatment.

Whereas previously, computer-generated maps were often static, cumbersome or limited in their level of interactivity, present day software and hardware advancements are enabling industry professionals - and the consumer market in general – to interpret and project spatial data in new and innovative ways. Moreover, and with the integration of GPS functionality into portable devices, map-makers and data collectors can quickly and meaningfully capture, manipulate and edit data while working in the field. Relevance meeting functionality is the objective.

2. THE CONCEPT (the 'WHY')

PMHC, like many other Control Authorities, is in its first year of implementing the NSW government's new Invasive Species Plan (ISP), a large component of which is the Weed Action Plan (WAP). I mention the ISP and WAP here specifically because fulfilling the reporting and data format requirements was a significant driver behind our commitment to

this data collection model. In so doing, it has become indispensable to our operations staff and strategic planners on a daily basis. It is often through the simple presentation of spatial data – coupled with real-time GPS navigation - that field staff can, for example, quickly pinpoint a previously ‘tagged’ area for follow-up control in an difficult tract of bushland, or during routine aerial inspections weeds officers can rapidly capture crucial data on new outbreaks of vine weeds in riparian systems or define the outlying extent of a woody weed infestation.

3. DESIGN (the ‘HOW’)

It is worth mentioning here that we expected the first roll-out of the hardware and software to generate lots of grief! Not everyone is – or should have to be – comfortable with getting their head and hands around this kind of change to the way data is recorded. But there was a firm insistence that this was only the first draft and that there would definitely be a few bumps (or derailments) in the early days and time to get everyone up to speed. I firmly believe that in spite of computers being largely obstinate, inflexible, incapable of ‘learning’ and generally disagreeable objects, that people should not feel as though they are the ones failing. In fact, if you take the broad view that if staff can’t work it ‘intuitively’ it’s the *computer’s* fault, then it will help drive the ongoing refinement of the product. So, following are the design steps we took.

Step 1 – Identify what information we need vs. software/hardware capability

Refer to and discuss field officer requirements, reporting requirements of the WAP, acquittals of any other funding providers, information gaps in our existing databases etc, internal reporting requirements and so forth.

Step 2 – Design the data capture architecture

What worked for us was a dendrogram showing broad data categories and the subsets of each. For example, data can be captured in any of three categories; Point (an area less than 10 square metres), Polyline (e.g. fenceline, river bank, etc) or Polygon (greater than 10 square metres, e.g. bushland reserve, farm dam, etc) and each category has a range of feature classes (e.g. weed mapping, human impact, tree planting, weed control). It’s essential to mention here that field operators were consulted in the steps so that they were happy with the display format and informatics. Presently, our range of data capturing categories runs to nearly 30, but is basically 10 different feature classes multiplied by the 3 types of data the software will support. i.e. Point, Polyline or Polygon.

Step 3 - Refine the specific needs of each feature class

For example, when conducting riparian vine weeds aerial inspections, what specific information do we need to capture? Height of infestation? Length of infestation? Age estimate? Previous treatment history? Whose land is it on?

Throughout this process of user interface design, the same questions were repeatedly thrown up – Is this too data heavy? Will our field operators understand and support the requirements? Is there any or too much duplication of data? Is it too restrictive or would it miss the nuances of the situation? The contemporary adage of business franchising “Systemise the routine and humanise the exception” eventually broke down for us as we tried to incorporate too many drop down lists and check-boxes which did not allow for these subtleties. But at the same time, if we moved to too many blank alpha-numeric boxes, we lost greatly the ability – once the data was exported – to sort, collate and “crunch” the figures we needed.

In the end (if ever there is one!) we agreed that the product and process is a dynamic one and we accept and expect changes (‘tweaking’) to be a regular part of using it. As with many endeavours of this kind, the diminishing return becomes more acute the harder you try to perfect it, so simply accepting some degree of imperfection is probably quite healthy! Again, it is pertinent to mention here that the interface design and programming was undertaken by our own GIS analyst at Council as this was clearly a job for a specialist of considerable expertise. Without them, we would still be looking for the ‘ON’ button. They took our draft notes, made suggestions and put up concepts for us to comment on and trial. The whole process - from concept to field operational - took about 2 months and cost our Environmental Services section about five thousand dollars.

4. IMPLEMENTATION

Our Environmental Services section comprises 7 field staff (operating four portable computers) – a Noxious Weeds Officer, two separate vehicle-based operators conducting almost exclusively hand-gun and side-jet operations and a bush regeneration team of four. So, on any given day, we could have: our Noxious Weeds Officer doing property and incursion pathways inspections; vehicle based operators side-jetting rural roadsides then doing knockdown at bushland reserves and the bush regeneration team doing tree-planting then vine weeds.

After collating all of this, you have 60 worked hours, 80 kilometres of incursion pathway inspected, six Bushland Reserves worked in, 30 hectares of rural inspections, six hectares of weed control plus three more hectares of weed mapping. On top of this we have non-WAP data recorded including chemical usage records, 400 trees planted and two green waste dumping encroachments recorded. This entire data recording takes a total of approximately one hour to enter, per day (that is, about 15 minutes per operator) then another hour to do the weekly download onto the system at the office.

Within the ISP, data collection, collation and subsequent reporting requirements can seem quite onerous (!). However, as many of you would have realised by this stage, the data that is routinely plugged into your WAP is exactly that – routine. So it's at this point of the data trail that resource planners and WAP reporters can export information on-demand as required in the reporting framework. Do we need to see how many hectares *in total* have been inspected for Class 4 weeds? How much time has been spent on bitou control across *all* operators? This is done by viewing the data at a desktop level and exporting and manipulating as required.

In rough terms, running a number of basic queries such as these would take an hour or so (in total), and the outputs from the queries can be cut and pasted directly into the WAP pro-forma. Whilst in many instances this does not necessarily lead to faster data entry, it makes the data consistent by systemising its handling. For example, we have been able to calculate how many kilometres of roadside spraying have been done and the number of hectares of High Priority sites have been inspected and/or treated for environmental and Noxious weeds in the financial year-to-date (800+ kilometres and 250+ hectares) (all purely from exported data).

5. ONE YEAR ON – WHAT WORKED AND WHAT DIDN'T

The past 12 months have been a time of immense change and learning within our Environmental Services section in-so-far as the roll-out of the mobile GIS project. As expected, we've had some 'I'm over this!' moments as well as some 'Wow!' moments.

With respect to the former, we ran into some difficulties on a few fronts:

1. Integrating the new software/hardware with our existing GIS network – it was always going to be done, but a lot of 'de-bugging' had to be run;

2. Getting consistency from field staff in everything from standardising projected canopy cover estimates to entering their initials;
3. Learning what the limitations of the software and hardware are versus the capabilities of the staff;
4. Trying to make sense of the exporting of data and the manipulation and (re)projection. i.e. 'I seem to be looking at this screen of numbers a lot but nothing is becoming any clearer. Is this all worth it!?' This was overcome with a combination of perseverance and redefining what we wanted (re-visiting the 'why').

On the up-side (the 'Wow' moments) we've had some fantastic successes:

1. The speed and accuracy which this technology enables has markedly increased our efficiencies and effectiveness. In simple terms, we are spending less time reporting and more time 'doing' – and doing a better job to boot.
2. We have been able to accurately identify our incursion pathways as well as associated behaviours that facilitate weed spread. This then allows us to produce tailored management strategies. This not only identifies the pathway, but also the vector or agent/s that are facilitating the invasion. For example recent target removal of Gloriosa Lily following media work highlighting its toxicity: bulb swapping clubs, horticultural judges awarding it best bloom in show and florists providing it as wedding table settings!
3. Rapid exporting of data and subsequent entry into the ISP reporting proforma (this is the 'flip-side of #4 above);
4. Navigating our way through aerial weed inspections and capturing real-time, accurate geo-spatial data;
5. Rapidly generating suitable weed maps for entire sites and then 'zooming out' to get a landscape/sub-landscape perspective of the threatening processes which often link sites together and where to target control efforts;
6. Expanding the skill-sets of our field staff into the area of GIS;
7. Helping add to the collective knowledge of the organisation by sharing information with other internal stakeholders;

6. CONCLUSION

With only a year under our belts running the mobile GIS program, there is no doubt it has been worth the time and financial investment. We accept that the first year or two will be a time for teething and tweaking but hope that as the program settles down and operators become more adept at the capture and manipulation of the data we gradually build

powerful data sets which will assist us in not only meeting our mandatory reporting requirements, but will also ensure increased effectiveness and efficiency. Whilst technology remains the servant - and meets these aims - time and financial investment in these systems is essential. As mentioned, this is just the first year of utilising this technology, but we feel confident that by 'front-end-loading' our investment, data collection and treatment, we will be returned not only significant baseline data but targeted and meaningful weed management that yields better outcomes for our resource assets and communities alike.

Please feel free to discuss any of the content of our presentation with me as we sincerely hope that it will assist other organisations and individuals in moving down this similar path and make any transition that much easier.

WEED BIOLOGICAL CONTROL IN NEW SOUTH WALES

Past, Present and Future Programs

Royce H Holtkamp
Strategy Leader Invasive Species
Biosecurity Branch
NSW Department of Primary Industries
Tamworth Agricultural Institute
4 Marsden Park Rd
Calala NSW 2340

Biological control of weeds is the use of living organisms such as insects, mites or pathogens to reduce a weed's abundance or to limit a weed's distribution. Biological control will not eradicate a target weed and should always be used as a tool within an integrated weed management strategy. This paper is limited to discussion on classical biological control, which is the use of biological control agents sourced from the target weed's area of origin, and does not cover other forms of biological control such as mycoherbicides.

This paper briefly describes the science underpinning a weed biological control program. Past research programs are described together with an analysis of their success or failure. The status of current programs is also discussed. Possible future programs are outlined including comments on their present status. Potential programs which are likely to produce conflicts of interest are also described.

INTRODUCTION

Biological control of weeds has been carried out in Australia since the early 20th century, commencing with projects on prickly pear (1912) and lantana (1914). Since then 89 plant species have been targeted for biological control. In excess of 40 of these species, both of agricultural and conservation significance, have progressed to a biological control program. Others have never progressed beyond the survey stage.

Some of the weed species listed below affect a variety of ecosystems. Although the rearing and redistribution phases of many of the programs listed below have now finished they continue to be the subject of ongoing interest so information on these programs has been included in this paper.

CLASSICAL BIOLOGICAL CONTROL

Classical biological control involves the introduction of natural enemies (usually insects, mites or plant pathogens) mostly from the native range of the target weed species into areas where their host plant has become a weed. The aim is to reduce the density of the weed to a level that is acceptable and maintain the weed density at that level. There are a number of steps involved in this process which include:

- Identify the native range of a weed and then study its ecology and natural enemies within that range
- Select the most damaging host specific species of insect or pathogen as your potential agent(s)
- Check agents host specificity - it must not cause significant damage to useful or native species
- Import the agent into quarantine and rear it through a number of generations to ensure that it is free of diseases and parasites
- Mass rear and release agents

- Monitor the target weed before and after release of agent to determine agent(s) impact

The advantages of biological control are:

- The long term cost is low with high benefit/cost ratios because the agent is self perpetuating once established
- It is possible to achieve long term control from classical biological control
- The effect of the agents is not restricted to one area and they have the ability to spread
- Biological control is environmentally friendly and non toxic
- Control is usually specific to the targeted weed
- Good against weeds where other control methods are not viable or prohibitively expensive

Potential disadvantages are:

- Initial research when introducing a new agent may take several years to complete resulting in a high short term cost
- Long term commitment to a program usually requires Government or other funding agency support
- The release of natural enemies may raise unreasonable expectations resulting in the abandoning of existing control measures
- The possibility of wrong decisions being made, resulting in the release of agents which may become problems
- In Australia, substantial or useful reduction of the target weed only occurs in two thirds of long term programs
- Cannot be commercialised
- In some cases native species have become dependent on the target weed - for example frugivores and weedy species with berries as fruit

TARGET WEEDS

Bitou bush and boneseed (*Chrysanthemoides monilifera*)

Two subspecies of *Chrysanthemoides monilifera*, subsp. *rotundata*, bitou bush, and subsp. *monilifera*, boneseed, have been introduced to Australia from South Africa and are now among Australia's worst environmental weeds. A biological control program was established in 1987 to combat these two weeds and the first agents were released in 1990. To date, six insect species have been released for bitou bush control, four of which have established. Bitou tip moth, *Comostolopsis germana*, and bitou seed fly, *Mesoclanis polana*, are now widely established in NSW. Another agent, bitou tortoise beetle, *Cassida* sp., is currently surviving in low numbers in NSW but only in the vicinity of the initial release sites. Approval for the release of bitou leaf roller moth, *Tortrix* sp., was granted in 2001 and a number of releases have been made in NSW since then. Establishment was slow in the early stages of the project but it now appears that *Tortrix* sp. is established at a number of sites. Releases will continue and the Federal Governments Caring For Our Country initiative has provided funding for a community rearing and redistribution project on *Tortrix* sp. as well as resources to promote the schools based Weed Warriors program.

Six species of agents have been released for boneseed control, but despite repeated and often large releases, none of these agents have established in the field. Predation by indigenous invertebrates such as ants and spiders is suspected as being a key factor in preventing establishment of foliage feeding agents in Tasmania, South Australia and Victoria.

Leaf buckle mite, *Aceria* sp., is one of several additional agents being investigated for boneseed control. Despite failure of several agents to establish in the field, especially on boneseed, the biological control program has delivered some successes.

Blackberry (*Rubus fruticosus* aggregate)

Blackberries of the *R. fruticosus* aggregate originate in Europe and are now a major weed of pastures and forests on the tablelands and cooler parts of adjoining regions of NSW as well as other areas of wet temperate southern Australia. In NSW the *R. fruticosus* aggregate consists of at least seven taxa. *Rubus anglocandicans* (previously known as *Rubus procerus* or *Rubus discolor*) is the most common blackberry in NSW. A survey carried out in 1984 estimated blackberry was causing an annual loss in NSW, Victoria and Tasmania of \$42 million due to reduced production and control costs.

Biological control of blackberry began in the early 1980s with the study of blackberry rust, *Phragmidium violaceum*. This rust was studied in Europe, where it originated, to assess its safety as a control agent of blackberries in Australia. Research showed the rust is specific to blackberry and will not damage other commercial *Rubus* species such as raspberries or loganberries. It did, however, damage thornless varieties of blackberry where members of the *R. fruticosus* complex are part of the genetic makeup of these blackberries.

An illegally introduced strain of the rust was first detected in 1984. It still appears to be common but ineffective. A damaging strain of the rust, first released in 1991, has not been found in the field in recent times. Unfortunately, in some areas it appears that susceptible forms of blackberry have been replaced by other taxa of blackberry more resistant to the original strain of rust.

Blue heliotrope (*Heliotropium amplexicaule*)

Blue heliotrope is native to South America and was probably introduced as an ornamental during the 1800s. It is widespread in pastures and fallows in south-east Queensland and northern NSW but scattered populations can be found in most regions of the state.

Potential biological control agents for blue heliotrope were studied in Argentina and the most promising, blue heliotrope leaf beetle, *Deuterocampta quadrijuga*, was approved for release in 2001. Since that time a number of releases have been made in NSW. Some of these have established and releases are continuing. *D. quadrijuga* has also been included in the Weed Warriors program.

Bridal creeper (*Asparagus asparagoides*)

Bridal creeper, a native of South Africa, was introduced as an ornamental and is commonly found in home gardens. It causes significant problems due to its extensive root and water bearing tuber system and scrambling nature which chokes out vegetation on which it grows. The underground perennial root system makes control using conventional methods almost impossible.

Bridal creeper has spread through NSW, Victoria, South Australia and Western Australia. It is a problem in citrus orchards in the Murrumbidgee Irrigation area and around Windsor, west of Sydney, and is responsible for the degradation of many thousands of hectares of native bushland in NSW and other states in southern Australia.

The search for biological control agents for bridal creeper began in the early 1990s in South Africa where CSIRO scientists conducted surveys and identified four potential agents. Since then three of these agents have been imported and released. Bridal creeper leafhopper, *Zygina* sp., was approved for release in 1999. Since then extremely large numbers of releases of the insect have been made in every state in southern Australia. The majority of these have established and at many sites *Zygina* sp. is causing severe defoliation. *Zygina* sp. is also

being reared and redistributed as part of the Weed Warriors program. Bridal creeper rust, *Puccinia myrsiphylli*, was approved for release in 2000. *P. myrsiphylli* causes considerable damage to bridal creeper in South Africa and appears to be having a significant impact in Australia. A leaf feeding beetle, *Crioceris* sp., was released by CSIRO and some state agencies but it has failed to establish at any of the release sites.

Cats claw creeper (*Macfadyena unguis-cati*)

Cats claw creeper, a native of Central and South America, was introduced into Australia as an ornamental and used in many older-style gardens in Queensland and NSW.

Unfortunately, it is an extremely aggressive climber. Cat's claw creeper has the ability to completely smother native vegetation including large trees. Many bushland areas in northern NSW and Queensland already have serious infestations of this weed. It has a vigorous root and tuber system which significantly complicates control options. The plant functions as an ecosystem transformer. It alters rainforests and other habitat, especially in riparian areas, by collapsing the margins thus creating new niches for invasion.

Cat's claw creeper does not have a persistent seed bank, but produces large quantities of underground root tubers. It spreads by seed dispersal but its mechanism of persistence is through the tuber bank. The inaccessibility of root tubers and their ability to regenerate are major barriers to control. Management of cat's claw creeper focuses on reducing the rate of shoot growth to limit its ability to climb and smother native vegetation, and reducing tuber biomass to minimise the tuber bank.

Two agents, cat's claw creeper tingid, *Carvalhotingis visenda*, and cat's claw creeper leaf-tying moth *Hypocosmia pyrochroma*, have been released in NSW and Queensland. *C. visenda* has established widely and is having an impact on cats claw creeper populations in some areas. *H. pyrochroma* has established in Queensland but has only been released at a limited number of sites in NSW. Further releases of both agents are planned.

Another agent, a leaf mining buprestid beetle, *Hylaeogena jurecki*, is currently undergoing quarantine testing although its release is still some time off.

Gorse (*Ulex europaeus*)

Gorse is native to Europe and is considered by New Zealand to be their worst pasture weed. It is highly invasive in grazing, forestry and conservation areas where it forms dense, often impenetrable, thickets protected by the plants' spines. It occurs in the tablelands and slopes areas of NSW, although the species is not common in this state.

Gorse spider mite, *Tetranychus lintearius*, was first approved for release in Australia in 1997. Since that time a large number of releases have been made in Victoria and Tasmania. This mite appears to readily establish and is capable of causing significant damage to gorse. However, in New Zealand, the USA and Tasmania predatory mites have limited its effectiveness. A few releases were made in NSW in 2002. The mite has established but there has not been much spread from these somewhat isolated nursery sites. *T. lintearius* is the first in a suite of agents that could be released for gorse control in NSW.

Groundsel bush (*Baccharis halimifolia*)

Groundsel bush is a native of Florida and coastal areas adjacent to the eastern side of the Gulf of Mexico. It was introduced into the Brisbane region as an ornamental in the early 1900s and has spread through coastal areas of south-east Queensland and northern NSW. It is also starting to extend its range inland. It is a rapid coloniser of cleared, unused land in both agricultural and environmental areas where it is particularly suited to moist gullies, salt marsh areas and wetlands. It also does well on high, cleared slopes.

A biological control program against groundsel bush began in 1967. Since then over 35 different species of insects have been tested but only six have established in the field. Overall, biological control has not been achieved and research on insects has now been curtailed in preference for research on plant diseases. The first releases of a rust fungus, *Puccinia evadens*, from Florida commenced in 1998 and this pathogen is now established at several sites. It acts as both a leaf and stem parasite, causing defoliation during summer and winter and stem dieback over summer.

Horehound (*Marrubium vulgare*)

Horehound is native to Europe, Asia and northern Africa. It is found in most areas of NSW and is a common weed of disturbed areas and pastures, especially in inland NSW.

Horehound plume moth, *Wheeleria spilodactylus*, was first released in NSW in 1994. Since that time a large number of releases have been made and this insect appears to readily establish at most sites. It is capable of causing significant defoliation at many of these sites. Horehound clearwing moth, *Chamaesphecia mysiniiformis* was first released in NSW in 2004, following earlier releases in Victoria and South Australia.

Lantana (*Lantana camara*)

Lantana is a significant weed of coastal and sub-coastal eastern Australia from Cape York, Queensland to Mt Dromedary, NSW. It is also present in the Northern Territory and Western Australia. It invades national parks reducing biodiversity, as well as forestry and grazing areas, where it decreases pasture production and poisons cattle and sheep.

Biological control of *L. camara* has been conducted in Australia since 1914 and 31 agents have been introduced with 17 species establishing, although only four appear to cause regular significant damage. These are the leaf-mining beetles *Octotoma scabripennis* and *Uroplata girardi*, the sap-sucking bug *Teleonemia scrupulosa* and the seed fly *Ophiomyia lantanae*. The current focus is on lantana rust, *Prospodium tuberculatum*, which was approved for release in 2001. Since then a number of releases have been made but unfortunately early releases were severely impacted upon by a prolonged drought in NSW. Despite initial setbacks *P. tuberculatum* has now established at over 100 sites and continues to spread. Recent rains on the NSW coastal strip have increased the impact of this extremely damaging pathogen.

The next agent likely to be released is lantana bud mite, *Aceria lantanae*. The host testing of *A. lantanae* has been completed by the Plant Protection Research Institute (PPRI) in South Africa. The bud mite did not attack any of the plant species tested. PPRI has submitted a report on their testing to Alan Fletcher Research Station (AFRS) who will seek approval for the mites release in Australia.

Nodding thistle (*Carduus nutans*)

Nodding thistle is native to Europe, northern Africa and Asia. It occurs primarily in annual pasture systems on tablelands areas of NSW. Three agents have been released for nodding thistle control. These were a weevil, *Rhinocyllus conicus* which feeds in the thistle flower receptacle and destroys developing seeds, nodding thistle seed fly, *Urophora solstitialis* which also feeds in the receptacle and nodding thistle rosette weevil, *Trichosirocalus mortadelo* (previously included in *T. horridus*). All three of these insects have established throughout the range of nodding thistle with *T. mortadelo* being the most damaging causing up to 40% mortality of rosettes and reducing seed production by more than 70%. Effectiveness of *U. solstitialis* has been limited by interspecific competition with *R. conicus*.

Paterson's curse (*Echium planatagineum*)

Paterson's curse is native to the Mediterranean region and western Europe. It is found in all regions of NSW but is particularly abundant in the central and south-western slopes and eastern Riverina regions where it often becomes the dominant plant in winter pastures. Six agents have been released over a number of years, all of which have established in the field. These are the leaf-mining moth, *Dialectica scalariella*, the crown weevil, *Mogulones larvatus*, the root weevil, *Mogulones geographicus*, the flea beetle, *Longitarsus echii*, the stem beetle, *Phytoecia coerulescens* and the flower-feeding beetle, *Meligethes planiusculus*.

Most agents breed slowly so it will take many years for them to breed up and disperse naturally throughout NSW. The weevils and flea beetle are the most damaging agents with more than 50% of Paterson's curse and viper's bugloss, *Echium vulgare*, rosettes being killed at ungrazed research sites seven years after release.

Salvinia (*Salvinia molesta*)

Salvinia is native to Brazil and was first recorded in Australia near Sydney in 1952, and a year later near Brisbane. It is thought to have been introduced originally as an aquarium plant. The main infestations of salvinia are found in coastal streams from Cairns in North Queensland to the South Coast of NSW. Infestations have also been recorded near Perth, Darwin, Melbourne and Adelaide. To date, only isolated infestations have been recorded on inland waterways. In NSW, salvinia is common in the Tweed, Richmond, Clarence, and Macleay catchments, the Central Coast and metropolitan areas. Significant infestations have and still are posing problems in the Hawkesbury-Nepean system and in Wollombi Brook near Cessnock. Salvinia is still found in aquarium and rockery ponds as an illegally propagated aquatic plant. There is a belief that many infestations have been deliberately spread in order to harvest plants for sale in the aquarium industry. Based on its temperature tolerance, the potential distribution of salvinia includes water bodies in every Australian state and territory. Although the climate would not be suitable for rapid growth, salvinia could probably survive in Tasmania and Victoria, which are currently free from major infestations.

Salvinia weevil, *Cyrtobagous salviniae*, was introduced into Australia from south-eastern Brazil by CSIRO in 1980. Salvinia weevils were first released in Australia into Lake Moondarra near Mount Isa and, in less than 12 months, destroyed an estimated 30,000 tonnes of weed, clearing the 800 hectare lake. In warmer tropical regions of Queensland and Papua New Guinea, *C. salviniae* has been an extremely effective biological control agent. On the NSW North Coast, success has been variable. In areas south of Grafton the shorter growing season and cooler climate has produced less positive results. Control has been achieved as far south as Sydney, but not at all release sites. The success of the weevil in NSW depends on the local climate and nutrient status of salvinia.

Scotch broom (*Cytisus scoparius*)

Scotch broom originated in Europe and has now spread to many temperate areas of the world. Its history in Australia is somewhat clouded although it is likely that original introductions of this species were as ornamentals. It is a serious problem in some parts of the tablelands regions of NSW, particularly the Barrington Tops, where it seriously affects native bushland, forestry and grazing land. Scotch broom is also a significant problem in Victoria, and Tasmania and to a lesser extent in the Adelaide Hills, South Australia.

A biological control campaign against Scotch broom commenced in 1990. The first release of a biological control agent was the twig mining moth, *Leucoptera spartifoliella* in 1993. The larvae of *L. spartifoliella* mine shoots of Scotch broom and heavy attack will stunt

plant growth. It has been released at a number of sites in NSW, Tasmania, Victoria and South Australia and has established at some of these but has only built up into damaging numbers in southern NSW. Many releases have now been made from insects reared in the field in southern NSW. The program continued with the release of the psyllid, *Arytainilla spartiophila*, in 1994. This insect feeds on buds and stunts the growth of young shoots. At present *A. spartifoliella* is only known to be established in the Southern Tablelands region of NSW. The third insect to be released was a seed feeding bruchid, *Bruchidius villosus*, in 1995. Larvae of this beetle feed on developing seeds of Scotch broom. It is also only known to have established in the southern tablelands of NSW. A gall forming mite, *Aceria genistae*, was first released in NSW in 2010 but it is too early to comment on its impact.

Scotch, Illyrian and stemless thistles (*Onopordum* spp.)

Despite their name, Scotch thistles are not Scottish. They, as well as Illyrian and stemless thistles are native to southern Europe, the Mediterranean region, western and central Asia and Asia Minor. This apparent discrepancy in common names highlights the importance of correct taxonomic identification of plant hosts.

These thistles are found in most areas of NSW. Scotch thistle, *O. acanthium* is a weed of pastures and lucerne crops in the tablelands and slopes areas. Illyrian thistle, *O. illyricum* occurs in the central and southern tablelands areas and appears to have hybridised with *O. acanthium* in many areas. Stemless thistle, *O. acaulon* is found in the northern tablelands, slopes and plains but is most serious in pastures in south-western NSW.

A number of insect species have been released for biological control of *Onopordum* thistles. The first of these was the seed-head weevil, *Larinus latus*, which is now widely established. Its ability to destroy most of the seed in a flowerhead makes it a good biological control agent. At some NSW sites this insect has reduced seed production by more than 80%. The second agent is the stem-boring weevil, *Lixus cardui*, which is now widely established. *L. cardui* is not capable of killing *Onopordum* thistles, its activity mostly weakens the plant, makes it less competitive and reduces seed production. This action allows insects such as *L. latus* to have a greater impact on the plant population. Another insect which has established on *Onopordum* thistles is the crown moth, *Eublemma amoena*. Larvae can bore into the crown and plant root leading to death of smaller plants. Larvae of subsequent generations feed in leaves of bolting stems, causing similar leaf shrivelling and death. The rosette weevil, *Trichosirocalus briesei*, was first released in 1997 but at present there is little evidence of establishment.

Spear thistle (*Cirsium vulgare*)

Spear thistle is native to Europe, western Asia and northern Africa. It is also sometimes referred to as Scotch thistle and is the floral emblem of Scotland. It is found throughout NSW and occurs in most types of environment although it is rare in arid inland NSW. It is particularly common in overgrazed pastures. Three agents have been released, all of which have established. These are spear thistle receptacle weevil, *Rhinocyllus conicus*, spear thistle seed fly, *Urophora stylata* and spear thistle rosette weevil, *Trichosirocalus horridus*. *U. stylata* is fairly widespread and is capable of causing significant damage at times.

Spiny emex (*Emex australis*)

Spiny emex is native to southern Africa but has now been spread to most areas of the world. It is believed to have been introduced to Western Australia as a vegetable (cape spinach) in the 1800s. It is common in crops and pastures throughout southern, temperate Australia. Several releases of red apion weevil, *Apion miniatum*, have been made in both southern and northern NSW since 1999. No evidence of establishment has been found and the program has been discontinued.

St John's wort (*Hypericum perforatum*)

St John's wort is native to Europe, western Asia and northern Africa. It was introduced into Australia for ornamental and/or medicinal purposes during the mid 1800s and is now a serious pasture and bushland weed in the tablelands and slopes regions of NSW. It may also cause photosensitisation and dermatitis in light skinned stock, especially sheep. Three insects, a beetle, *Chrysolina quadrigemina*, an aphid, *Aphis chloris*, a root boring beetle, *Agrilus hyperici* and a mite, *Aculus hyperici*, have been introduced for its control. These agents are now widely established and have variable impacts on *H. perforatum*.

Water hyacinth (*Eichhornia crassipes*)

Water hyacinth, a perennial aquatic plant native to the Amazon Basin in South America, is widely recognised as the world's worst aquatic weed. It was exported from Brazil during the late 19th and early 20th centuries as an ornamental and has since spread throughout tropical, subtropical and warm temperate regions of the world where it causes major environmental and cultural problems by degrading aquatic ecosystems. It was brought to Australia in the 1890s as an ornamental. The first record of water hyacinth in NSW was in 1895. In 1897, the government botanist J. H. Maiden noted that it had spread rapidly in ponds in the Royal Botanic Gardens in Sydney. At that time, he warned that the plant should be kept away from the northern rivers where it 'may very rapidly become a serious pest'. Water hyacinth is extremely fast growing and forms dense impenetrable mats across water surfaces that severely impact biodiversity and limit access by humans, machinery, animals and birds. It degrades water quality and has a massive evapotranspiration rate, causing water loss into the atmosphere at up to 6 times loss from open water.

Four insects from South America have been released by CSIRO since 1975 and all are well established across NSW. There are two weevil species, *Neochetina eichhorniae* and *Neochetina bruchi*, and two moth species, *Niphograpta albiguttalis* and *Xubida infusellus*. *Neochetina eichhorniae* has been successful in destroying large water hyacinth infestations in tropical northern areas of Australia. Eggs are laid in the bulbous leaf stalks and the larvae tunnel through the plant tissue, which is then attacked by bacteria and fungi. This causes the plant to become waterlogged and death can occur under heavy attack. This weevil is inactive during winter. *Neochetina bruchi* is more active through the winter and is now well established from northern Queensland to Sydney, although both weevils are much less effective in subtropical and cooler areas of NSW. *Niphograpta albiguttalis* is well established in northern NSW and Queensland. Its larvae tunnel into leaf stalks and buds, as do the larvae of *Xubida infusellus*. Both species are very damaging to young plants and luxuriant weed growth but their impact is often temporary and patchy.

Unfortunately biological control cannot be solely relied upon for effective control of water hyacinth in NSW. It will provide some reduction in flowering and growth rates of the plant and occasionally mat sinkage has occurred as a result of insect damage.

CONFLICTS OF INTEREST

Fireweed (*Senecio madagascariensis*)

Fireweed is an annual or biennial herb that has become a troublesome pasture weed in eastern Australia. In 1991 it was approved as a target weed for biological control in Australia. The centre of origin of Australian forms of fireweed has now been identified as South Africa, in particular the Natal province, rather than Madagascar as its name implies.

Early surveys to find biological control agents focussed on Madagascar and failed to find any insect sufficiently host specific to consider for importation. This is not surprising, since the surveys were carried out on the wrong plant. However, the number of insect species found in Australia on both *S. madagascariensis* and Australian native *Senecio*

species, especially *Senecio pinnatifolius*, would indicate that the likelihood of finding an agent that does not damage native *Senecio* spp. is very low. Investigations were carried out in Natal, and under quarantine conditions in Australia, on a strain of the rust fungus, *Puccinia lagenophorae*. Experiments demonstrated that Australian *S. madagascariensis* plants were susceptible to isolates of the South African rust fungus. However, the virulence of the South African rust fungus isolates of this Australian rust were not superior to Australian *P. lagenophorae* isolates. Therefore, no attempt was made to introduce any of the South African isolates.

Fireweed continues to be the subject of political interest with the Australian Government committing significant funding towards another search for potential biological control agents. The newly elected NSW Government has also made fireweed a priority species in its Controlling Noxious Weeds 2011-15 policy statement.

Lippia (*Phyla canescens*)

Lippia is native to South America where it occurs in southern Ecuador, Peru, Chile, Argentina, Uruguay, Paraguay and Bolivia. In Australia it is found in South Australia, Victoria, NSW, Western Australia and Queensland. Lippia was estimated to infest 5.3 million hectares of the Murray-Darling Basin in 2004. It was originally introduced as a lawn species and used to stabilise soil and prevent erosion on banks of irrigation canals and around weirs but has now become an important weed of inland areas subject to flooding, usually downstream of irrigation areas. Lippia spreads mainly by movement of plant pieces but also by seed. It overruns native vegetation, has limited forage value and appears to be capable of suppressing growth of neighbouring plants. It is closely related to *Phyla nodiflora* which is essentially non-weedy and is regarded by some taxonomists as native although this status is disputed by others. Lippia's close affinity with *P. nodiflora* could create problems for future biological control programs. Lippia was formally nominated as a target species for biological control in 2006.

Mother-of-millions (*Bryophyllum delagoense* and *Bryophyllum xhoughtonii*)

Bryophyllum delagoense is an escaped ornamental originating from Madagascar. *Bryophyllum xhoughtonii* is a hybrid bred in cultivation. Five *Bryophyllum* species are naturalised but only *B. delagoense* and *B. xhoughtonii* are increasing over substantial areas of south-eastern Queensland and north-eastern NSW. Mother-of-millions is well adapted to dry areas but also grows well in coastal areas. *Bryophyllum delagoense* produces seed while the hybrid does not. However both species produce masses of embryoids (plantlets) that are formed on the leaf edges. This makes these plants difficult to eradicate.

These plants, and especially their flowers, are highly toxic to stock and occasionally cause significant cattle deaths. When cattle are under stress or in unusual conditions they are more likely to eat strange plants. Shifting cattle to new paddocks, moving stock through infested rubbish dumps and reduction of availability of feed due to flood or drought, can all contribute to poisoning. Since the plant flowers from May to October, during the dryer months of the year, the scarcity of feed may cause cattle to consume lethal amounts of mother-of-millions.

The South African citrus thrips, *Scirtothrips aurantii*, is present in Queensland and northern NSW. This thrips damages the outer tissue of the mother-of-millions plant and also lays its eggs under this outer tissue. Overseas, *S. aurantii* is reported to be a pest of citrus, in Australia the form of *S. aurantii* present has only been found on *Bryophyllum* spp. Where high populations of thrips exist they reduce the number of viable plantlets and flowers on mother-of-millions. Thrips populations vary from year to year according to mother-of-millions populations and climate. *S. aurantii* should not be seen as a long term

control strategy, only a control option to complement other techniques such as chemical treatment and burning.

Four insect species found in Madagascar or southern Africa between 2000 and 2003 were considered potential biocontrol agents for mother-of-millions. Two of these agents, the stem boring weevils *Osphilia tenuipes* and *Alcidodes sedi*, were studied in quarantine at AFRS and, although having potential to attack closely related ornamental species such as *Kalanchoe blossfeldiana* and *Echeveria* spp., are still being considered for release if they can be approved under the *Biological Control Act 1987*. No native Australian flora are attacked by these weevils.

Silver-leaf nightshade (*Solanum elaeagnifolium*)

The native range of silverleaf nightshade is from central and south-western North America to temperate South America. It is a competitive, deep-rooted perennial weed whose root system can reach 5 m in depth with roots interconnecting between above ground *S. elaeagnifolium* shoots. It depletes soil moisture and nutrient reserves, competes strongly with crops and pastures and reduces the value of land. It can also be poisonous to stock although is not readily eaten. In infested areas winter cereal and annual pasture production can be significantly reduced. Broadleaf summer crops are virtually impossible to grow due to its competitive ability and because there are no herbicides that can be used against it in those crops. Silverleaf nightshade also quickly produces a large seedbank, with one plant producing up to 60 berries, each containing up to 70 seeds. Seeds can remain viable for up to 10 years. The plant thrives on summer rains and its seed is easily spread by birds, sheep, machinery, water and contaminated produce. It can also be spread rapidly by cultivation, with plants regenerating from pieces of root 1cm long and from depths of 1m.

There has been a considerable amount of work done in South Africa on this weed, culminating with the release of the chrysomelid beetle, *Leptinotarsa texana*. Host testing in South Africa indicated that this beetle would attack eggplant in no-choice tests, a risk the South African authorities were ultimately prepared to take. Field studies following the release of *L. texana* have shown no attack of eggplant to occur. As eggplant is an important crop in some areas of Australia, this situation would have to be clarified prior to any work being carried out in Australia. There are also many native *Solanum* spp. that are similar in appearance and growth to *S. elaeagnifolium*.

NEW PROGRAMS

Grass weeds

The Queensland Department of Natural Resources, Mines & Water (now DEEDI) conducted a project in Africa in 2007 looking for potential biological control agents for Parramatta grass, *Sporobolus africanus*, giant rat's tail grasses, *S. natalensis* and *S. pyramidalis* and giant Parramatta grass, *S. fertilis*. A smut fungus, *Ustilago sporoboli-indici* and stem wasp *Tetrasema* sp. were identified as showing some promise. Unfortunately, these agents proved to have relatively low efficacy against the target species and were not host specific so the project was terminated.

Sporobolus fertilis is a serious coastal pasture weed of eastern Australia especially in northern NSW. In recent years, some graziers in infested regions around Grafton, NSW, have stopped spraying with herbicide because *S. fertilis* density appeared to be declining in pasture with plants in those areas exhibiting bright orange leaders in the tillers. A study was carried out to ascertain the extent of the decline and to find if it was due to a pathogen. Twelve types of microorganism were isolated: ten fungi, bacteria and non-pathogenic nematodes. Of these, the only microorganism that caused similar symptoms in seedling trials was *Nigrospora oryzae*, which was isolated only from the roots and base of the

tillers. *N. oryzae* is therefore the likely cause of the symptoms observed and appears to be causing a significant decline in *S. fertilis* in the field, holding promise for biological control. This is particularly useful as *S. fertilis* has developed herbicide resistance in this area. In trials to date *N. oryzae* has proven to be host specific, not even attacking the closely related *S. pyramidalis*.

Hudson pear (*Cylindropuntia rosea*)

Hudson pear, a native of Mexico, is believed to have escaped from a cactus nursery in the Lightning Ridge district. It was possibly introduced to Australian opal fields by miners and may have been used to protect their diggings from nocturnal prowlers and thieves. *C. rosea* has particularly vicious spines that are capable of penetrating footwear and even tyres on vehicles. The current Australian distribution of *C. rosea* is north-western NSW (primarily around the opal mining areas of Lightning Ridge, Grawin and Glengarry and at Cumborah, although infestations have also been reported from Brewarrina, near Coonamble and Goodooga), South Australia (from the Flinders Ranges south to Morgan), in Western Australia, in the Northern Territory and in Queensland. Estimates of the area of NSW infested range from 60 000 to in excess of 100 000 hectares.

C. rosea reproduces vegetatively and not by seed. Prospects for satisfactory levels of control using traditional methods, such as herbicides, are poor given the types of terrain and vegetation in which infestations are located. Any missed plants, or missed plant parts that contact the ground and form roots, have the capacity to form new infestations.

The prospects for successful biological control of *C. rosea* are fairly good as previous biological control programs targeting cacti have proven highly successful. *Dactylopius tomentosus*, a species of cochineal insect introduced to control rope pear, *C. imbricata*, attacks *C. rosea* but is not particularly damaging. Recent South African research has shown that there are several strains of *D. tomentosus* present in Mexico, at least one of which is likely to be more damaging to *C. rosea*. There should be few host specificity issues as there are no native Australian species in the Cactaceae. A strain of *D. tomentosus* was imported into Queensland DEEDI quarantine facilities in late 2010 and host specificity testing is currently under way. Additional exploration in Mexico and DNA studies to determine the provenance of the Australian *C. rosea* population are also currently under way.

Madeira vine (*Anredera cordifolia*)

Madeira vine is a vigorous perennial climber or scrambling shrub which is native to north and central South America. It is a significant environmental weed which forms dense mats that cover trees and shrubs. Reproduction is predominantly vegetative by aerial and subterranean tubers, the density of which can be up to 1500 per m². Tubers are dispersed by water, animals, soil and garden waste movement.

Madeira vine was originally introduced to Australia as an ornamental. It is a major environmental weed of coastal and sub-coastal areas from southern Queensland to NSW, where it threatens lowland subtropical rainforest, riparian lands, bushland remnants and conservation areas. Infestations have been recorded from Cairns to Hobart along the eastern seaboard as well as near Adelaide and Perth. It is also a problem along watercourses in the slopes region of NSW around Tamworth.

Chemical control methods are available. However application of herbicide to vines high up in host trees is not easy and there is a high risk of damage to non-target plants growing beneath the vines. Severed lianas left in the host tree die, but the aerial tubers remain viable, fall off and start to grow. Irrespective of whether control methods are mechanical, physical or chemical, there is a need to treat infested areas repeatedly over a number of

years because of the aerial tubers. This severely limits the size of areas that can be treated and makes management extremely difficult.

A collaborative biological control program between South Africa and Australia commenced in 2006. The leaf beetle *Plectonocha correntina* was approved for release from quarantine in early 2011 following extensive host specificity testing. Releases should commence in NSW and Queensland shortly.

TAKE HOME MESSAGE

Weed biological control, if successful, reduces the target weed to a minor component of the invaded system. However, it must be remembered that biological control is not a 'silver bullet' and will not eradicate any weed species. Integrated control utilising a combination of biological control, strategic herbicide application and other suitable management techniques is often necessary. Any integrated program will have to ensure that sufficient biological control agents remain following other forms of treatment to ensure re-establishment of biological control agent populations. An ongoing commitment to control is vitally important as many of the target weed species have long lived seed banks. It is also essential to prevent the niche previously occupied by a weed being reinvaded by the same species or by another (possibly worse) weed species.

ACKNOWLEDGEMENTS

I thank John Hosking for his comments on an earlier draft of this paper.

REFERENCES AND FURTHER INFORMATION

Groves, R.H., Shepherd, R.C.H. and Richardson, R.G. (Eds.) 1995. *The Biology of Australian Weeds*. Vol. 1. R.G. and F.J. Richardson, Melbourne.

Harley, K. L. S. and Forno, I. W. 1992. *Biological control of weeds: a handbook for practitioners and students*. Inkata Press: Melbourne.

Julien, M.H. and Griffiths, M.W. (Eds.) 1998. *Biological Control of Weeds: A World Catalogue of Agents and their Target Weeds*. 4th Edition. CABI Publishing UK.

Julien, M.H., McFadyen, R.E.C., Cullen, J.M., (Eds.) 2011. *Biological Control of Weeds in Australia*. CSIRO Publishing, Melbourne, Australia.

Panetta, F.D. (Ed.) 2009. *The Biology of Australian Weeds*. Vol. 3. R.G. and F.J. Richardson, Melbourne.

Panetta, F.D., Groves, R.H. and Shepherd, R.C.H. (Eds.) 1998. *The Biology of Australian Weeds*. Vol. 2. R.G. and F.J. Richardson, Melbourne.

Parsons, W.T. and Cuthbertson, E.G. 1992. *Noxious Weeds of Australia*. (Inkata Press, Melbourne).

A COMMUNITY IN CRISIS – BEGA VALLEY SHIRE NSW

The social and economic implications of noxious weeds management

**Ann Herbert
Weeds Manager
Bega Valley Shire Council**

A little history

Ten years ago, Council ran a series of facilitated community workshops throughout the Shire to develop a Shire Weeds Strategy in conjunction with other land managers and the community. These workshops were driven by a demand for change in how weeds were managed in the Shire.

The outcome was a community-owned Strategy outlining goals, actions and timelines. All those involved - community members, Council and other land managers - made commitments to include weed management as a key component of vegetation and broader land management projects and programs, work more closely together and be part of on-going planning and implementation of the goals spelt out in the Strategy.

The Strategy, now incorporated into Southern Rivers Regional Weed Management Strategy, outlined specific activities and timelines, identifying responsible parties and requiring Council weeds officers and other agency representatives to report back to the community on progress.

These workshops were driven by the community – there was a perception that not enough was being done by Council to combat the weed threat and a belief that agencies were not working together in weed management programs. They were, to all intents and purposes, a ‘new start’ in a cooperative weed management program.

But what did the next ten years bring and where will 2021 see us?

The realities – social, economic and environmental

The pressures on landholders to ‘keep their properties clean’ are challenged by the difficulty in managing all weeds including those declared noxious weeds. Many landholders have succeeded over the years and kept their farms weed-free and they are proud of their skills. Others do not include weed management as part of their program; still others have given up and accept weeds as part of the vegetation landscape and, unless prompted, do little or nothing.

Many weeds have adverse effects on productivity and other values including conservation and recreational values. These include African lovegrass, widespread over much of the Bega River valley, but manageable in other areas of the Shire, serrated tussock largely being

successfully managed, and the emerging weed, Chilean needle grass, which is confined to a small area.

These are just three of the listed noxious weeds. As well, there are weedy species that many landholders effectively manage – they do not want to see them on their land – fleabane, cobbler’s peg and fennel are good examples this year, a result of plentiful regular rain. Many thistles are not declared in the Shire – landholders still control them. It is a management decision to exclude undesirable species whatever their weedy status.

To declare or not

While there are over 90 declared noxious weeds in Bega Valley Shire (the Local Control Authority - LCA), about twenty are of concern and are the species we target as part of the inspection management programs. Does the fact that these twenty are declared noxious affect how landholders and land managers look at them?

That is a difficult question. Committed managers will manage land to exclude those plants that are not of benefit to their enterprises, but only to a level where they are not a significant threat. Thus, weedy species may be present in pasture at low levels. Whether or not the weed is declared noxious is immaterial.

Where there are rare and isolated infestations of weedy species (cane needle grass on a single property within five km of Bega township) or a species has yet to be found in an area (Coolatai grass springs to mind) , it is beneficial that local control authorities can require their control and take appropriate action to ensure landholders control the target species effectively. At this stage, it is economically feasible to ensure effective control in most cases.

With the changes in how the Department of Primary Industries funds local control authorities, the responsibilities for widespread weed controls falls upon the LCA. Many do not have the resources to effectively manage such weeds and positive outcomes in the longer term may be questionable.

Declaration of a weedy species as noxious does have a place. It enables the LCA to require effective control and reduces likelihood of spread and establishment in the area. It is a vital tool when a weed is found only in isolated areas or as individual plants. It does, however, place a burden on landholders, some of whom may resent the requirements and undermine effective control works, which they may see as benefitting the wider community rather than themselves.

I will use fireweed to illustrate the effects of a weed on a community.

The fireweed story

Fireweed has become the 'flagship' species in the battle against weeds. Why? Because it is so easily identifiable, because of its competitiveness, its toxicity, the perceived difficulty of controlling it but mostly because of the bright yellow flower.

It was first recorded in Australia at Raymond Terrace in 1918 – an accidental traveller – and in the Shire in 1967. Council considered applying for its declaration as a noxious weed in 1988 and it was finally declared noxious in 1992 – a slow process during which time fireweed continued to spread.

Despite the rising costs of managing fireweed, the community continued to support it remaining a declared noxious weed in 1995, supporting the increasingly costly program - to both Council and landholders.

In 1995, research done by University of Sydney demonstrated that control programs were not halting the spread of fireweed and it had yet to reach its limits. The community began to express concern that neither they nor Council had the resources to management fireweed effectively in 1995

Fireweed remains a declared Class 4 noxious weed in Bega Valley. It has become the 'one that got away' for those landholders who are successful managers. It has been present in the valley for decades and has been contentious for many of those years.

Misinformation has turned it into an ogre - 'the insidious and toxic noxious weed' – unmanageable, killing stock, entering the food chain, beating herbicide controls and outcompeting pastures. While some of this may be accurate, it paints a picture of hopelessness in terms of developing effective management strategies.

That is not a good start for making decisions. While information is available on using a number of management 'tools' to manage fireweed and landholders are urged to target fireweed with herbicide at specific times, often the rush to spray it begins when the paddock turns yellow..

Investigating and adopting other management options is often a last resort. The easy option - using herbicides -may not involve consideration of changes in management and other market opportunities. It is hard look at your enterprise dispassionately and make decisions about changing it to accommodate changing circumstances.

Landholders who have run cattle all their lives may need to think about whether sheep or goats have a role in weed management. Many are managing properties their forebears settled, properties that support the family – often the sole or very significant income source. They regard themselves as beef producers and identify strongly with their cattle. They need to re-assess their past stocking and other management practices in light of changing attitudes to efficient grazing practices, paddock sizes, the value of native pastures compared with introduced species and consider pasture rehabilitation or sowing of selected species.

While on paper this may look simple –solve a problem by changing practices, the reality is very different. People, particularly those who have been on a property for many years or who have a bond with their enterprise, identify strongly with them and the way they manage. To change requires a shift in how a person sees him or herself. Often, it is a slow process particularly to those looking on but otherwise uninvolved.

The biological control option

Bega Valley Fireweed Association, formed by a group of local landholders in 2005 has worked tirelessly, promoting the need to undertake research into the possibility of a biological control for fireweed.

The group formed as a direct result of what they saw as lack of action and concern at all levels of government at the threat posed to agriculture by fireweed. Initially self-funded, the group has attracted significant grants from both State (for research into the human costs of fireweed)and Federal governments (initial enquiry into the feasibility of further research into biological controls for fireweed, which is currently under way).

While previous work done by Professor Brian Sindel failed to find a biological control, CSIRO researchers are currently assessing whether or not to undertake further research in South Africa where it is now believed *Senecio madagascariensis* originated.

Research will take many years and may result in a negative outcome but it is the biocontrol that many have pinned their hopes on, believing it is the ‘silver bullet’. There is poor understanding of what a biocontrol can and cannot achieve.

Biocontrols do not eradicate a target plant. Rather, they reduce it to a level that sustains them – they are not going to destroy their food source. The target species will remain – possibly at a level that may satisfy those it affects but it will not be destroyed. Thus, a biocontrol becomes another tool in the arsenal. Unfortunately, with fireweed, many want to believe it will be the end of it and do not want to hear any other message.

Changes to fireweed management

Recent years have seen the fight to manage fireweed effectively being lost despite intensive inspection, education and awareness and roadside programs. Inability to do so and expect landholders to do the same led to Council seeking community input into several options. Following a month-long exhibition the majority of respondents (98%) elected to have it remain a Class 4 noxious weed with a specific statement that Council would take no legal action where fireweed is not controlled

- Retain fireweed as a class 4 Noxious Weed with management actions of ongoing community education and awareness, and note in the Management Plan that council will not be instigating legal action against any landowner regarding the control of Fireweed.

Thus this Class 4 weed, widespread throughout the Shire, will be ‘managed’ through a continuing community education and awareness program to build a community will to take ownership of the problem and act to minimise the effects.

Fireweed Field Days

A series of Field Days were held throughout the Shire during April, timed to coincide with the autumn germinations. These were well-attended and generated good discussions.

Experts in fireweed management spoke about herbicide controls and other management options, developing an integrated weed management program using available 'tools', the opportunities of developing partnerships in land management projects given that weed management is regarded as a key component by participants in any such project. These projects are driven by Southern Rivers CMA and project partners such as the Council. They include funding a Project Officers working with communities and liaising with Council weeds officers to obtain better vegetation management outcomes as part of developing a Property Management Plan on individual rural properties.

Local landholders spoke at each of the Days, outlining their programs, successes and failures. This generated discussion among the participants, with the result being much more positive than similar days in previous years.

While the mood appears to be changing and landholders are starting to take some responsibility for their weed management programs, only a small percentage of rural landholders took advantage of these Days. Similar Field Days, while attracting significant numbers, still fail to attract the majority of people they are targeted at.

Change

Change is happening in the valley. Long time beef cattle producers are moving to incorporate sheep or goats into grazing programs. They are changing the way they graze their paddocks, subdividing them, rotationally grazing and spelling them to promote better pasture use and growth.

Paddocks are being prepared, sown to cereal crops for one or two years and then to new pastures. Agronomists are actively sought for their advice, as are other expert land managers such as soil scientists and livestock agents.

Weed management programs are targeted to specific paddocks where high pasture productivity is required, seed is to be harvested or hay and silage is made. Many are seeing the value of using sheep or goats to manage some weeds and they are seeing financial benefits from the changes. They have to overcome their fear of change to incorporate shifts such as these.

This is not solely the result of widespread community change in attitudes to accept responsibility for weeds and take positive steps to better management. With the breaking of the drought, good stock prices, and good pastures going into winter, weed management will become a greater part of land management as landholders see the benefits of a good weed management program.

Weed management should be approached so that positive outcomes can be achieved resulting in a socially, environmentally and economically healthy wider community with a better understanding of weed management and a commitment to implementing long-term effective programs with a real chance of success

And what of 2021?

We will still have weeds and will still be battling them. But we will have better tools and we will better integrate our land use and management skills.

There are other weed management options. At recent Fireweed Field Days in the Shire people suggested we need to explore the possibility of developing herbicides or identifying diseases that attack the roots or the soil seed store.

By 2021, we will have a better understanding of how to manage Australian soils to advantage native and desired introduced species to such an extent that weedy species are progressively outcompeted. Weed management will be a key component of all land management plans and projects.

ACKNOWLEDGMENTS

Jamie Dixon-Keay for the accompanying film footage

Alan Smith for his historical archive of weeds issues in the Bega Valley

Stuart Cameron for his advice and editing skills

Those landholders prepared to step out of their comfort zone and try new management techniques



CONFLICT BETWEEN THE *NOXIOUS WEEDS ACT 1993* AND OTHER NSW LEGISLATION

Dr Stephen B. Johnson¹ and Mr Sydney Lisle²
NSW Department of Primary Industries,
Weed Ecologist, ORANGE¹
State Weed Control Coordinator, WAGGA WAGGA²

SUMMARY

New South Wales Department of Primary Industries (NSW DPI) is the lead agency for noxious weed management in the state. However, there are a number of agencies, including NSW DPI, who have responsibility for managing vegetation, the environment and cultural values and who have legislation to support their efforts.

This can, and does, lead to conflict and confusion in efforts to manage noxious weeds because of the interactions between the *Noxious Weeds Act 1993* (NWA) and at least nine other NSW Acts and Regulations and one Australian Government Act.

All specific sources of this conflict and disparity are not discussed in this paper. Despite this, a full exploration of the conflicting issues is needed. This exploration should include discussion on the best ways to manage invasive plant issues in NSW in the future, examining alternate methods posed in other legislation, and any other legislation deemed relevant.

There are a number of reasons why conflicts between legislation occur. Firstly, in the enactment of some Acts since 1993, these pieces of legislation (including attendant policies and procedures) have not thoroughly considered the impact of their requirements on the NWA. This includes parts of the NSW *Threatened Species Conservation Act 1995*, *Native Vegetation Act 2003* (and *Native Vegetation Regulation 2005*), *Plantations and Reafforestation Act 1999* (and *Plantations and Reafforestation (Code) Regulation 2001*), *Nature Conservation Trust Act 2001* and the Australian Government *Environmental Protection and Biodiversity Conservation Act 1999*. We consider how the precedence of the NWA in NSW should apply in these cases.

In other cases, where precedence applies to Acts enacted before 1993, that is the NSW *Heritage Act 1977* and the *Environmental Planning and Assessment Act 1979*, parts of these Acts are in conflict with the NWA. This conflict can be resolved by careful examination of the issues by responsible government agencies.

In a more unusual case, there is still confusion over delegation of appointment/authorisation of inspectors under the NSW *Local Government Act 1993* despite advice that the appointment of inspectors should be made under the NWA. A further source of confusion has been with the NSW *Trees (Disputes between Neighbours) Act 2006*. In this case, it is important to recognise that the 2007 Regulation now allows for the management of neighbourhood conflicts about trees, vines and bamboo that are not 'weedy' issues.

In examining some of the causes of conflict and confusion, this paper suggests solutions to the problems that are encountered. These solutions are being reviewed as part of the five-year statutory review of the *Noxious Weeds Act 1993*.

INTRODUCTION

The New South Wales Invasive Species Plan (NSW ISP) provides the overarching framework for the management of all invasive species, including weeds, in NSW (NSW Government, 2008). There are many broad strategies and management tools available to achieve the aims of the ISP.

New South Wales Department of Primary Industries (NSW DPI) is the nominated lead agency for weed management in the state under the ISP. Legislation is a key management tool used by NSW DPI, in partnership with local government, to affect better weed management. The key piece of legislation used is the *Noxious Weeds Act (NWA) 1993*.

As part of the five year statutory review of the NWA, a number of conflicting interactions with other legislation have been identified. This includes at least nine other NSW Acts and Regulations and one Australian Government Act.

In many cases, legislation enacted since 1993 (with attendant policies and procedures) has not thoroughly considered the impact of their requirements on the enactment of the NWA. This includes parts of the NSW *Threatened Species Conservation Act (TSCA) 1995*, *Native Vegetation Act (NVA) 2003* (and *Native Vegetation Regulation (NVR) 2005*), *Plantations and Reafforestation Act 1999* (and *Plantations and Reafforestation (Code) Regulation 2001*), *Nature Conservation Trust Act 2001* and the Australian Government *Environmental Protection and Biodiversity Conservation Act (EPBC) 1999*. A selection of the conflicting issues between the NWA and the TSCA and NVA/NVR are examined to provide examples of how these conflicting issues can be addressed.

In other cases, the enactment of the NWA did not thoroughly consider earlier legislation enacted such as the *Heritage Act 1977* and the *Environmental Planning and Assessment Act 1979*. Similarly, confusion about the precedence of the *Local Government Act (LGA) 1993* with the NWA also remains. A short discussion relating to the confusion over the appointment/authorisation of inspectors under relevant legislation is contained in this paper, as is an amendment to the NWA that will remove this ambiguity.

In the final case examined, an increase in neighbourhood conflicts about trees, vines and bamboo not covered by the NWA has necessitated the enactment of additional legislation, that is the *Trees (Disputes between Neighbours) Act (TDbNA) 2006*. An explanation of the TDbNA and the 2007 regulation is outlined to help inform how the most appropriate circumstances for the TDbNA to be used. This discussion aims to reduce confusion about both pieces of legislation.

DISCUSSION OF CONFLICTS

An important overarching principle in the following discussion is that compliance with one piece of legislation should not preclude compliance with all other relevant legislation. Said another way, adherence with one piece of legislation should not result in an offence occurring under another. Conflict arises when this can not reasonably occur.

Threatened Species Conservation Act 1995 and Noxious Weeds Act 1993

Under the NWA, local control authorities may require owners and occupiers of land to control noxious weeds (sections 18 and 35 of the NWA). To comply with this, land owners and occupiers need to comply with many other pieces of legislation, for example the NSW *Pesticides Act 1999*, but particularly the *Threatened Species Conservation Act (TSCA) 1995*. The TSCA seeks to conserve and protect threatened biodiversity and necessary habitat across NSW and is managed by the Minister for the Environment (and that Department).

Weed managers who are compelled to control weeds in areas of threatened biodiversity must first obtain a license under section 91 of TSCA. The Minister for the Environment requires (under policy), that weed management occur within a property vegetation plan. As part of this requirement, those undertaking weed control, either contracted or retained staff, land owners and/or occupiers need to be either qualified bush regenerators or to have undertaken extensive TAFE training. This requirement is cost-prohibitive for many.

Perverse outcomes often then result in that:

- weeds are often not controlled in a timely fashion (if at all); and
- groups/owners/occupiers without such qualifications are subject to criminal action if;
 - they have controlled weeds, but have also negatively impacted threatened biodiversity in the process (under the TSCA); or
 - they did not control weeds (under the NWA), which then results in a further threat to the biodiversity the TSCA has been designed to protect.

There are a range of solutions that are available, all of which preserve the primary objective of the TSCA **and** allow the management of weeds in a less cost-prohibitive manner. These include:

- that property vegetation plans be prepared on a site basis with review by a joint committee of Environment staff and either NSW DPI staff, or local government staff (since local government are responsible for the enactment of the NWA). A similar precedent of inter-departmental cooperation with respect to research minor use herbicide permits in fresh-water aquatic habitats exists;
- that recognition of existing skills and training of retained staff at specific locations e.g. ground staff (and for these specified locations only) be granted, at least until further training is achieved;
- that skills auditing of retained staff working at specific locations occurs so that tailored training of these staff can occur while allowing necessary weed management to achieve broader threatened biodiversity outcomes;
- that supervision of untrained staff or residents by Environment staff occurs at specific locations; and/or
- that individual auditing and/or accreditation of land owners and occupiers occurs so that they can help achieve broader threatened biodiversity outcomes.

Alternatives that are unlikely to garner support include a general exemption from licensing being inserted in the TSCA for the control of noxious weeds (for example section 11 (1b) of the *Native Vegetation Act 2003*) or amendment of the NWA to exempt areas that have threatened biodiversity from the requirements of the TSCA. However done, it is essential that the TSCA and its subordinate documents recognise the negative effects of failure to manage invasive plants.

Native Vegetation Act 2003/Native Vegetation Regulation 2005 and Noxious Weeds Act 1993

Legislation to protect native vegetation, for example the *Native Vegetation Act (NVA) 2003* and the *Native Vegetation Regulation (NVR) 2005* is managed by the Minister for the Environment (and that Department). This legislation can make the legitimate management of weedy native species more difficult. In partial recognition of this, exemptions are granted for the management of native species declared noxious under the NWA (section 11 of the NVA).

At least three issues arise from this. The first is how to best manage weedy native species that are not declared noxious. This brings with it lobbying pressure for declarations that are not consistent with NWA objectives. Following on from this, the second issue is the use of such declarations to subvert the intentions of the NVA/NVR. Finally, the removal of a native species from declaration can result in misunderstandings about continued best management of the species.

The management of native species not declared noxious may occur under the following mechanisms in the NVA/NVR, including:

- in a range of permitted activities such as sustainable grazing, continuation of existing farming activities, clearing of certain groundcover where less than 50% is indigenous species and routine agricultural management activities (for example sections 11, and 20-24 of the NVA; sections 13-23 of the NVR). All such activities can be performed without a Property Vegetation Plan (PVP); and/or
- under Property Vegetation Plans for clearing of areas with greater than 50% indigenous groundcover. A PVP is likely to require that alternate areas be managed to offset the impact of clearing; and/or
- when the species is listed as an Invasive Native Scrub (INS) by a Catchment Management Authority (CMA). An INS is a “plant species that invades vegetation communities where it has not been known to occur previously that regenerates densely following natural or artificial disturbance, and results in change of structure and/or composition of the vegetation community, and is **within** its natural geographic range or distribution.” (Anon., 2010). Management can then occur according to a PVP, and/or
- when the species is listed as a feral native species (section 17 of the NVR). A feral native species is defined as a species **outside** its natural range on the land where it is listed (on a CMA basis). Management of such species is generally specified by the Minister for the Environment.

There has been pressure to list or maintain declarations of native species where the above exemptions/mechanisms do not apply, or they have been perceived to be too onerous. Among a range of possible solutions, the most likely to maintain the objectives of the NVA/NVR and NWA is a small amendment to the NVR. The definition of a feral native species as detailed in section 17 of the NVR could be expanded to include 'serious agricultural and environmental weeds' **within** their native range. As a feral native species, the weed would then be subject to management as specified by the Minister of the Environment.

Local Government Act 1993 and Noxious Weeds Act 1993

Local Government have been responsible for the management of noxious weeds in NSW since 1906. These functions were part of the *Local Government Act 1919* before 1993. Upon revision of that Act, noxious weeds functions were placed in the NWA in 1993. Because both the *Local Government Act (LGA) 1993* and the NWA were enacted at the same time, no precedence exists.

While it is preferable that local government delegate functions for noxious weeds under the NWA (for example sections 35 and 60 of the NWA), there is some discussion as to whether delegation for noxious weed functions should occur under the LGA (for example sections 377-381 of the LGA).

To clarify this matter, an amendment is proposed for the NWA that will specify that the delegation of functions under the NWA must be executed under the NWA.

Trees (Disputes between Neighbours) Act 2006/Trees (Disputes between Neighbours) Regulation 2007 and Noxious Weeds Act 1993

Until recently, there was no legislative framework to resolve neighbourhood disputes concerning vegetation. These conflicts occurred in urban, residential or rural-residential settings and for a wide variety of reasons including when plants were used as a visual screen, when plants may have caused injury to others, or when plants and/or their roots damage property, for example fences, amenity services such as water and sewage, or building foundations and structures.

The impacts outlined above do not fit within the framework of the NWA, that is they do not generally cause serious threat (or threat) to primary production, the environment or human health. As such, the NSW government enacted the *Trees (Disputes between Neighbours) Act (TDbNA) 2006* and expanded the definition of tree to include bamboo and/or vines under the *Trees (Disputes between Neighbours) Regulation 2007*.

As suggested by the title of the TDbNA, that Act is to provide for proceedings in the Land and Environment Court for the resolution of disputes between neighbours concerning trees (and now bamboo and vines). This includes trees that cause, or are likely to cause damage and injury, as well as high hedges that obstruct sunlight or views. These plants may or may not be recognised as weeds by the community, or be declared noxious by the NWA. As explained above, management of declared noxious weeds deemed to threaten primary production, the environment or human health will continue under the NWA.

FOR FURTHER INFORMATION ON LEGISLATION

<http://www.legislation.nsw.gov.au/>

ACKNOWLEDGEMENTS

Staff from NSW DPI and the former Department of Environment, Climate Change and Water have contributed to ideas to this paper.

REFERENCES

Anon. (2010). Managing invasive native scrub to rehabilitate native pastures and open woodlands. A best management practice guide for the Central west and Western catchments. Central west and Western Catchment Management Authorities. Available online at

<http://cw.cma.nsw.gov.au/OurNaturalAssets/managinginvasivenativescrub.html>

NSW Government (2008). New South Wales Invasive Species Plan. 2008-2015. NSW Department of Primary Industries, Orange. 28 pp. Available online at

<http://www.dpi.nsw.gov.au/agriculture/pests-weeds/nsw-invasive-species-plan>

NURSERY & GARDEN INDUSTRY NSW & ACT – AN ASSOCIATION WEEDING OUT PERCEPTION AND GROWING FORWARD WITH EDUCATION AND RISK MANAGEMENT

Michael Danelon
Industry Development Officer
Nursery & Garden Industry NSW & ACT, PO Box 3013 Rouse Hill NSW 2155

The Nursery and Garden Industry (NGI) both within NSW and ACT and nationally is actively working to minimise the impact of invasive plants and to ensure less plants will be sold with the potential to “Jump the Garden Fence”. If you support the claims within the report “Jumping the Garden Fence” then the NGI is responsible for the introduction of many of the invasive plants in Australia with some 65 % of them alleged to be from garden escapes.

The history of weeds in Australia is varied. In part the NGI has contributed to the issue – but we are actually committed to stop the impact of Invasive Plants on our natural and our modified environments.

Our role in the nursery and garden industry is to encourage both members and non members to discontinue growing and selling weeds and offering for sale superior alternative selections and seek to work with governments and groups committed to reducing the spread of weeds.

The NGI have been actively engaged in educating the nursery industry and gardeners about the risk of plants becoming invasive when inappropriate plants are grown and mismanaged in certain environments. This is not a rapid or is it an easy task to achieve!

To this day, there are still individuals and organisations that utilise garden escapes to raise awareness of invasive plants rather than engaging with the NGI to utilise the successful Grow Me Instead (GMI) program.

For years, the NGI both nationally and across the states and territories has been working with governments and other stakeholders to achieve this with the most prominent being the development and implementation of GMI program which:

- Encourages gardeners to remove and replace targeted know invasive plants
- Encourages nurseries to stop growing and selling plants with weedy potential and promotes the list of suitable alternatives
- Educate garden centre staff to have local weed expertise and knowledge to advise gardeners of suitable alternatives and
- Encourages the industry to identify local weedy or invasive plants and voluntarily remove them from sale.

It achieves these objectives with an agreed selection criteria.

1. Identifying a list of target species considered as garden escapees;
 - a. A plant behaving ‘aggressively’
 - b. A plant actively modifying the ecosystem
 - c. Plants currently available for sale in garden centres.

2. Identifies non-invasive alternatives used in place of the target plants
 - a. Which will fill the same or similar role in the garden
 - b. Is suitable for a range of local conditions
 - c. Is commercially available

The Nursery & Garden Industry of NSW & ACT (NGINA) pioneered the GMI program with support from the Discovering Alternatives to Garden Escapes (DAGE) committee and financial support from Environmental Trust (NSW Government) and the Australian Government under Department of Agriculture, Fisheries and Forestry Landcare Program.

The NGINA engaged various land and water conservation groups, local councils within Sydney and NSW Department of Agriculture to develop and release the first GMI booklet for the greater Sydney district within NSW.

In September 2007 a second GMI booklet was produced through financial support provided by Southern Rivers Catchment Management Authority, Bega Valley, Eurobodalla, Shoalhaven and Wollongong City Councils and Illawarra Noxious Weeds District Weeds Authority. This second booklet covers the NSW South Coast from Wollongong to the Victorian border.

The GMI program then gained a national focus with financial support received from the Federal Government under the “Defeating the Weed Menace” program in 2007. This has resulted in booklets produced for each state and territory of Australia to produce their own specific GMI resource and resource kit to assist industry in defeating the weed menace.

Part of addressing the issue of avoiding future garden plants from becoming possible invasive plants is to produce better alternatives. These alternatives will need to have demonstrated their superiority and lack of weedy potential with low seed set. Vegetative propagated, self incompatible or sterile cultivars from within the same Genus or family are being developed and examples of this are evident in *Agapanthus* and *Gazania*.

The challenge for the future of plant producers is to grow plants that are structurally appealing with exciting foliage colour or texture, large colourful flowers; they must however also have low water requirements and be pest and disease free and cope with a wide range of soil conditions.

The NGI is not just relying on the GMI program to address the issue of invasive plants. There are multiple elements to how the industry is achieving this:

- Invasive Plants Policy developed for members

It considers the key issues, concerns and responsibilities via widespread consultation with positive promotion of the initiatives and commitments addressing environmental issues such as invasive plants. This important policy document is available on the NGIA website – www.ngia.com.au

- Appointment of NGIA Environmental Policy Manager and National Environment Committee

The role of the Environmental Policy Manager (EPM) and National Environment Committee is to coordinate industry’s response to key environmental issues, including Invasive Plants.

- Noxious Weed Advisory Committee – NGI representatives

- National Plant Labelling Guidelines with reference to invasive and poisonous plants
- Industry Programs with regular Industry publications include: Nursery Papers' and various other communications e.g. E-compost and Clippings, Invasive Plants Position
- Best Management Programs under NGIA Farm Management System including: Accreditation (NIASA and AGCAS), Environmental Management System – EcoHort and BioSecure HACCP.

A significant amount of progress has been made by industry by utilisation of the GMI program and voluntary adoption of the plant labelling guidelines. Several industry plant labelling workshop focus groups were facilitated by Industry and Investment NSW and the NGINA since November 2008 to address Goal 1 of the NSW Invasive Species Plan. The aim is to prevent the establishment of new invasive species and the objective is for industry to develop and implement labelling standards for invasive species.

The NGI already have plant labelling guidelines, however the assessment of which plants grown may be invasive weeds is a knowledge gap and this is where development of a weed risk assessment process (WRAP) has been fostered.

There are numerous declared and volunteer weed lists in circulation and the NGINA expect many are in development without consultation with the NGI as to how a plant is included on a weed list. As an industry we need to ask the following questions:

- Who defines a plant as a weed?
- What assessment process or evidence is being used to create these lists and
- Which ones are based on fact or science?

Undoubtedly the greatest challenge facing the nursery and garden industry is determining which plants are weedy or have future weedy potential.

There are numerous declared and volunteer weed lists, examples of organizations or groups are

- Weeds of National Significance (WONS) through the National Weeds organisations and now declared in each state.
- Weed Alert list (like WONS 2)
- Biosecurity Australia
- AQIS weed assessment
- State/Territory Government – Declared noxious lists, these can be declared across the state or regionally and some local governments have legal controls and obligations in some states
- Local Government lists
- Local Landcare and Green groups lists
- World Wildlife Fund/CSIRO list
- Bushcare groups

Climate Change happens every day and the debate seems to be about the rate that global warming is accelerating and this may well have an impact on how plants behave under different climatic conditions.

As an industry we must plan ahead, however the difficulty for our industry is to predict both the current and future fashion in plants and how they will adapt to a perceived changing climate.

With adequate research and rigorous trialling of new plants and the use of accepted weed risk assessment, hopefully, we may be able to predict whether currently fashionable plants, for instance some of the grasses, succulents and native species, will become weeds of the future.

To assist in assessing plants the NGIA has partnered with stakeholders to develop a suitable Weed Risk Assessment based upon the Botanic Gardens Weed Risk Assessment Procedure (WRAP). The intent is to screen 1000 common ornamental taxa cultivated in Australian nurseries for sale to the public to ascertain the degree of weed risk associated with each species.

Using the existing Botanic Gardens WRAP as a template the NGIA are seeking to review the WRAP by a project steering committee to modify it to suit commercial plants rather than plants which exist either in collections or grown at the various Botanic Garden sites across Australia where the tool has been applied.

Once a suitable WRAP has been developed, it is envisaged that this project will lead to the development of an Australian white list of low risk ornamental taxa, which is a list of safe plants to cultivate for production, distribution and sale to the general public by production nurseries across Australia.

Whilst the fine tuning of the WRAP is occurring and assessments will be conducted the nursery can still help to reduce the impact of weeds by undertaking the following:

- Be aware of which plants are weedy and keep up to date with this information.
- Check the species name and any varieties being sold against weed lists in your region - consider alternate plants to recommend
- Promote and sell non-weedy alternatives
- Encourage gardeners to 'retrofit' gardens
- Promote best practice gardening as a way of reducing the risk of garden plants jumping the garden fence, for example
 - Responsible disposal of green waste/garden clippings
 - Deadheading/removing seeds
 - Care with mulching and composting.

Acknowledgements

Dr Anthony Kachenko, National Environment and Technical Policy Manager, NGIA
NGINA GMI committee

References and further information

NGIA website – www.ngia.com.au
NGIA – Farm Management System
NGIA - GMI program
NGIA – National Plant Labelling Guidelines
NGIA – Nursery and Garden Industry Invasive Plants Position
NGIA – Nursery Papers

GARDEN ESCAPEES AND OTHER WEEDS OF BUSHLAND AND RESERVES

Booklet development

Terry Inkson
Noxious & Environmental Weeds Coordinator
Great Lakes Council, Forster NSW

INTRODUCTION

In 2007 Great Lakes Council (GLC) developed and produced an informative, booklet on Garden Escapees & Other Weeds found on Bushland Reserves. This clear and concise booklet provides residents with reference material that is easily read and understood. The booklet typifies weeds and general garden plants growth habit for residents / general community to easily identify plants that threaten the integrity of the remnant bushland and foreshore reserves.

Approximately 65% of noxious and environmental weeds have escaped from home gardens*.

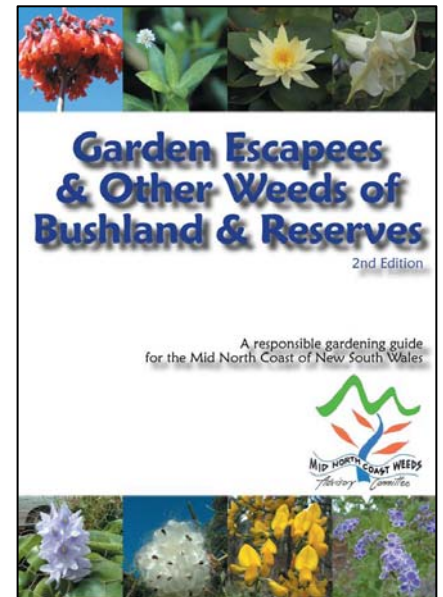
Great Lakes Council produced this booklet in partnership with the following agencies:

- M.N.C. Weeds Coordinating Committee
- Gloucester Shire Council
- Greater Taree City Council
- Kempsey Shire Council
- Port Macquarie - Hasting Council
- Hunter Central Rivers CMA
- NPWS
- Landcare NSW
- Dept of Lands
- Mid North Coast Coast Care

The Mid North Coast Weeds Coordinating Committee (MNCWCC) requested GLC expand the contents of the booklet for a wider release across the region to include neighbouring Councils including Greater Taree City Council, Kempsey Shire Council, Port Macquarie - Hastings Council and Gloucester Shire Council.

The booklet was created on behalf of and under the auspice of the MNCWCC in an effort to help expand the knowledge of the community and other Government Agencies in the management of weeds. The response to the publication was over whelming with this resource being sent to most states of Australia and now being used by NSW Primary Industries, CMA, NPWS and the RTA.

Sydney Weeds Committee also requested to use the intellectual property so the booklet could be modified for distribution throughout the Sydney region.



To date 43,000 copies of this resource have been printed and distributed across the Mid North Coast of NSW and throughout the wider Sydney Basin.

Coincidentally, the booklet has been run parallel with the CRC for Weed Management Education Power Point Package "What Does Your Grow, and the NSW No Space 4 Weeds campaign.

In addition the booklet is aligned to and used as a resource within the:

- Mid North Coast W.A.P.
- Mid North Coast Regional Weeds Strategy
- National Weeds Strategy
- Mid North Coast Regional Control Plans for Specific Weeds
- NSW Invasive Spp Plan 2008-2015
- Great Lakes Council Noxious Weeds Policy
- Great Lakes Council Occupational Health and Safety Policy
- Great Lakes Council Greening Strategy
- Noxious Weeds Act
- Great Lakes Council Plans of Management (various reserves)

RELATES TO BROADER LOCAL GOVERNMENT DIRECTIONS

The booklet presents a comprehensive view of the threats to Bushland and resources posed by "garden escapees and other weeds".

Apart from being used by other Government Departments it is highly regarded by local on-ground groups using the material for their every day activities. This in turn allows Council to fulfil its role under the *Noxious Weeds Act 1993* and other relevant legislation in promoting best practice and providing educational material. Council, through this publication is advocating its responsibility towards sustainable management.

As significant land owners' responsibility for sustainable management lies squarely on Council's shoulders, the publication helps Council adhere to its corporate goals and more importantly meet the requirements of integrated planning legislation by providing a vessel to assist in the sustainable management of its natural resources.

DEMONSTRATES INNOVATIVE SOLUTIONS TO ENVIRONMENTAL PROBLEMS

The Mid North Coast region has produced an informative, concise and attractive reference material for residents regarding weeds and general garden plants that stand to threaten the integrity of valuable, remnant bushland and foreshore reserves.

The booklet has brought together a range of information that was located on a number of brochures and reference material. Whilst this information can be found in various reference materials, the compilation of local weeds into a booklet specific to our area makes the information readily available to every one regardless of their knowledge base.

The booklet is provided at no charge to residents furthering the availability of the information to everyone. In addition to hard copies of the booklet, it is also available in

electronic format (pdf) with hyperlinks to internal pages, external websites and email addresses. The electronic version forms a part of a comprehensive weed management package issued on Compact Disk and distributed to land managers both locally and interstate that are working within the region.

The booklet was officially launched in October 2009 during Weed Busters Week. MNCWCC has received extremely good feedback from the wider community as a whole.

The following Book Review was conducted by Mr Gordon Rowland of “Indigenous Landscape Design Australia”

"This comprehensive booklet describes the nature of invasion and provides detailed instructions on controlling the spread of invasive plants. Around 280 invasives are described, with 150 colour photographs to aid identification. Lists of 120 suggested native alternatives are included. Researched and produced for Great Lakes Council on the New South Wales mid-north coast, almost all species identified as invasive, have invaded bushland throughout coastal New South Wales, and many of these have also become invasive in other States and Territories of Australia.

An outstanding, thoroughly researched guide that offers practical solutions to a major ecological problem."

DEMONSTRATES LONG TERM SUSTAINABLE SOLUTIONS

Weed Management staff of the Mid North Coast Region are committed to the on going education process regarding noxious and environmental weeds.

The depth of weed invasion in Australian bush can be overwhelming. It is recognised that the ongoing control measures Councils implement regarding weed management is minimal compared to the problem. Whilst we are successfully targeting our noxious weeds, and some severe infestations of environmental weeds, the increase in residential development has seen an increase in garden escapees.

We believe the most successful method for managing this growing problem is developing an intense education and public awareness program. The booklet will be invaluable as the forerunner in this program that will be complimented with continuing letter drops, public weeds display, workshops, selection of target weeds, offers of plant replacement etc. MNCWCC also believes the vast number of volunteers within its region will ensure it maintains this booklet as a working document.

The objectives of this booklet were:

1. To provide information to the general public, dune care / bush care volunteers and council staff on the potential impact many garden specimens can have on the natural environment.
2. To provide information on the control of weed species, responsible gardening techniques and information regarding the different types of weeds and their significance within the Noxious Weeds Act 1993.

3. To provide information that promotes and enforces Council's ongoing commitment to raising the awareness with the general public on the potential threat environmental weeds and garden plants can have on the natural environment.
4. To effectively reduce the spread of weeds, particularly garden escapees on foreshore and natural reserves that have adjacent residential development by promoting the identification of problem plants and effective control measures.
5. To support the works council volunteers undertake on council managed lands through the education of the wider community on weeds and their impact on the natural environment.
6. To provide this information in a colourful and illustrated way with local weed species that display the plants in their local habit, keeping them true to form.
7. To provide the material in a manner that was attractive, easily read and inviting to the layman.
8. To provide a resource material that was cost effective and easily modified to target a broader audience if required.

Funding was obtained through the CMA, NPWS, Mid North Coast Weeds Coordinating Committee, the Department of Lands and the constituent Councils of the Mid North Coast of NSW.

Weed Management staff have researched the dominant weed species growing on fore shores and in village areas. The issues facing Councils regarding invasive garden plants and poor garden management by neighboring properties is typical with many other reserves maintained by Council Volunteers and staff.

The information within the booklet is significant to a local level regarding the specific weed specimens. The information regarding correct or responsible garden management is common on a national level.

REFERENCES AND FURTHER INFORMATION

* Groves, R.H., Boden, R. & Lonsdale, W.M. 2005.

Jumping the Garden Fence: Invasive Garden Plants in Australia and their environmental and agricultural impacts.

CSIRO report prepared for WWF-Australia.

WWF-Australia, Sydney.

Water Hyacinth Case Study

Potentially catastrophic economic and environmental disaster averted.

Mel Wilkerson
Noxious Weeds Inspector
Tumut Shire Council

Abstract

Water Hyacinth (*Eichhornia crassipes*), was found in a paddock dam waterflow and in several garden ponds in Tumut Shire, on the 18th of March 2011. This marked the third infestation in the Riverina of that weed. The plants were removed and destroyed, however, the potential threat presented, had they been left undetected or controlled, is one of significant or even catastrophic environmental and economic loss. A short case tracking study will show that identification and source tracking is not a difficult task with the right approach. In this case, the original distribution point was over 400 km and 20 years from the detected infestation. A brief summary of some of the potential “specific impacts” of water hyacinth will also be addressed as well as its exponential growth potential.

Introduction

Water Hyacinth was found in a property dam waterflow near Tumut, and in several garden ponds in the Batlow area of Tumut Shire. The plants found in the Tumut area originated from a Garden nursery in Sydney where it was sold as a pond plant about 20 years earlier. Eventually it made its way to the Tumut area through the most common means of pathway distribution – Human distribution and lack of awareness.

Following the discovery in the Tumut area, the plants were removed and destroyed and an awareness and identification campaign was launched. This consisted of a Field day presentation on the weed and recognition, delivery of information sheets to garden nurseries and retailers, a locally distributed newsletter, media releases in the local and regional newspapers and a series of radio interviews to discuss the plant. This was well received by the local community and sparked several calls of concern about garden pond plants however, none of the reported possible culprits were water hyacinth. The greatest focus however that seemed to come out of it was recognition that the potential threat that water hyacinth presented, had it been left undetected or controlled, was one of significant or even catastrophic environmental and economic loss.

A report on the “what if” scenario was presented to council which outlined the potential for destruction that could be caused by this weed if left unchecked. Also noted was that the “what if” scenario was averted by quick action.

The “what if” scenario essentially illustrated a worst case which was based on the potential growth rate of the plant scenario. Under optimum (perfect) conditions it can double its mass every 5 days, forming new plants. It is important to note however that optimum conditions very rarely are achieved and the actual figures are more likely about one quarter of the “worst case scenario” potentials. Nevertheless, it still represents a significant threat to both the environment and the economy.

Discussion

Water hyacinth is one of the world's worst aquatic weeds. It infests rivers, dams, lakes and irrigation. It devastates aquatic environments and costs billions of dollars every year in control costs and economic losses. It grows in still or slow-flowing fresh water in tropical and temperate climates. This plant will tolerate a wide range of temperatures, growth conditions and climatic extremes including frost. Where water levels have receded, plants can survive on damp soil for several months.

Impact - Specific impacts include:

- blocking irrigation channels and rivers and restricting livestock access to water
- destroying natural wetlands/eliminating native aquatic plants
- reducing infiltration of sunlight
- changing the temperature, pH and oxygen levels of water
- reducing gas exchange at the water surface
- increasing water loss through transpiration (greater than open water evaporation)
- altering the habitats of aquatic organisms
- restricting recreational use and reducing aesthetic values of waterways
- reducing water quality from decomposing plants
- destroying fences, roads and infrastructure when large floating rafts become mobile during flood events, and
- destroying pastures and crops when large floating rafts settle over paddocks after floods.

Reproductive potential. Under optimum (perfect) conditions water hyacinth can double its mass every 5 days, forming new plants on the ends of stolons. It also grows from seed which can remain viable for 20 years or longer. This enormous reproductive capacity causes annual reinfestation from seed and rapid coverage of previously treated areas, making ongoing control necessary.

The “what if” scenario. In essence this scenario shows that if one plant gets loose into a favourable water system, with the right conditions, it will continue to double and you will potentially have 4,722,366,482,869,645,213,696¹ plants in 1 year. In the local environment what this meant was recognizing that if nothing was done, in a period of a few years, the Tumut River system would be devastated, Blowering Dam recreational fishing eliminated, the Murrumbidgee catchment could be inundated, and economic and environmental loss could mean millions in annual lost tourism revenue and likely millions in management expenses.

A realistic picture. Optimum perfect conditions however are rarely achieved outside of a controlled environment. The reproductive scenario represented above would be unlikely to occur naturally. It is conceivable that one quarter of the potential growth could be achieved in a climate of stable temperature and water flows and a healthy nutrient supply. Locally, allowing for seasonal dormancies and other climactic factors, the number of potential reproduced plants in a “favourable” local environment would likely be in the millions or even billions, which nevertheless still represents a significant threat to the environment and the economy and potential devastation to a local aquatic tourism industry.

¹The figure 4 sextillion, 722 quintillion, 366 quadrillion, 482 trillion, 869 billion, 645 million, 213 thousand 696 was based on the (Calculation formula) Total = plant 1(1+2(rate)) for 72 (cycles 5 days). This figure is based on mother-daughter-daughter plant duplication and does not calculate additional plants from seed growth

Case Study: March 2011 – Water Hyacinth Tumut Shire Council

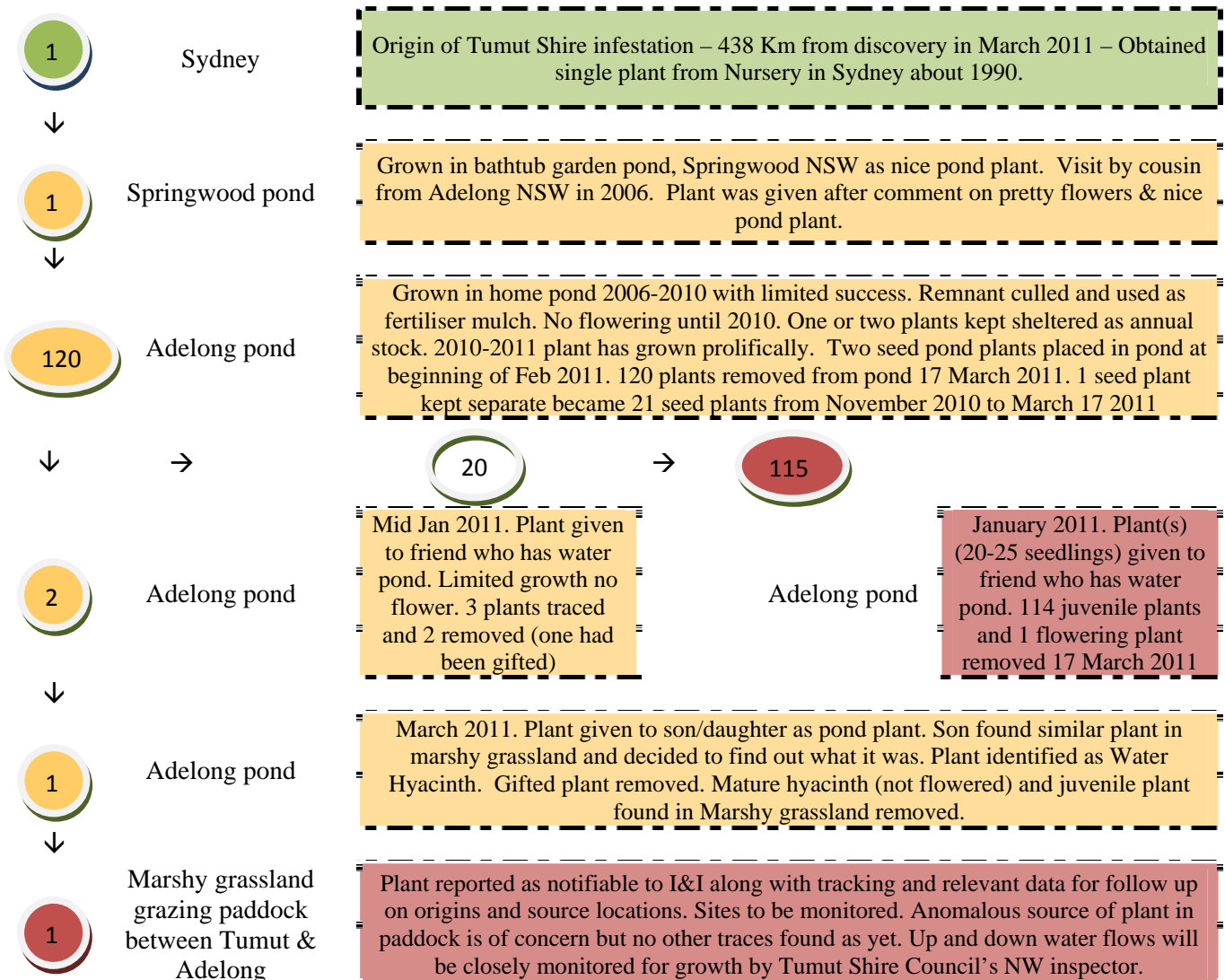
Summary - On Friday 11 March 2011, a dispute over the value of a gifted garden pond plant prompted an identification request from Industry and Investment NSW. The recipient had found a similar plant in the marshy area of a recently flooded paddock. The recipient thought it might be a weed. Tumut Shire Council’s Noxious Weed Inspector was contacted, and on Tuesday 15 March met the person with the plant and identified it as Water Hyacinth.



An inspection of the marshy grassland revealed one adult plant and one juvenile seedling. Both were removed. The source of the plants in the paddock is still not determined but will be closely monitored.



The original source of the plants was tracked to a single purchase from a Sydney garden nursery in about 1990. In total 240 Water Hyacinth plants were removed and the sites contained. One Anomalous site will continue to be closely monitored. The origins, locations and distribution sources have been reported and neutralised.



Outcome: A potentially major environmental threat and economic disaster has been averted.

Conclusion

This event represents only one of three infestations of Water Hyacinth in the Riverina area and the first, and hopefully the last, in Tumut Shire. What is most important to take away is the fact that small problems such as finding plants in a pond do not get highlighted until they become major issues which are then almost too late to deal with.

The “what if scenario” outlined in this paper may be considered fear mongering by many Councils or even those that hold the purse strings to deal with weeds, however the reality is these small problems are where our big problems come from. It is necessary to show the “what if” potential to cost and resources dealing with noxious weeds. Too often the mindset does not focus on the “potential” until it is too late. Education to landholders is crucial however, what is often overlooked is education of Council’s and bureaucrats who rarely get to see the issue until it is in the tens or hundreds of thousands of dollars to combat the problem. In an ideal world, rapid reaction and management, such as in this case study and for example the other Riverina infestations and management excellently done in the Wagga and Albury areas rarely get brought to light. What happens then is the usual current mindset an old adage, “no problem = no funding”. What this should really say is problem not reported or highlighted means “major problem = too much to deal with and too costly to control”.

References

NSW Department of Primary Industries, 2010, Water Hyacinth Primefact.

Improved adoption of management strategies for silverleaf nightshade (*Solanum elaeagnifolium*)

Hanwen Wu¹, Rex Stanton²

¹EH Graham Centre for Agricultural Innovation (Industry & Investment NSW and Charles Sturt University), Wagga Wagga Agricultural Institute, PMB, Wagga Wagga NSW 2650, Australia.

²E H Graham Centre for Agricultural Innovation (Industry & Investment NSW and Charles Sturt University), Charles Sturt University, Locked Bag 588, Wagga Wagga NSW 2678, Australia

Corresponding author: hanwen.wu@industry.nsw.gov.au

ABSTRACT

Silverleaf nightshade is a typical example of an intractable, deep-rooted, summer perennial weed which significantly impacts on crop and pasture production. It is currently classified as a noxious weed state-wide in South Australia and Victoria, and in one third of the local control authority regions of New South Wales. Control practices have traditionally been ineffective for achieving consistent and reliable results. A series of 14 workshops were run across southern Australia in 2010 and 2011 to deliver the latest research information and best management practices (BMP) for silverleaf nightshade and to identify underlying drivers influencing BMP adoption.

INTRODUCTION

Silverleaf nightshade infests 140,000 hectares respectively in SE Australia, with the potential to infest 398 million hectares in Australia (Kwong *et al.* 2006). The economic impact of the weed comprises direct control costs, production losses (crop and fodder conservation yields), reduced land value and marketability, environmental degradation and social costs. McLaren *et al.* (2004) estimated that the average financial impact for farms infested with silverleaf nightshade was \$1,730 per year in direct control costs and \$7,786 in lost production. Silverleaf nightshade is costing \$10m annually to agricultural industries in South Australia alone.

The presence of both a seedbank and a rootbank contributes to the spread, persistence and intractable nature of the weed. Many of the current practices have been successful in minimising seed set, however, these practices have had limited effect on the rootbank, thereby resulting in the persistent reshooting of silverleaf nightshade year after year.

A previous research project commissioned by Meat & Livestock Australia has resulted in the production of a “Best Management Practice Guide on Silverleaf Nightshade”(http://www.csu.edu.au/research/grahamcentre/research/publications/docs/SLN_BMPguide.pdf). The research identified a dual action approach, with a combination of chemical and non-chemical control strategies, to target the seedbank and rootbank.

The latest research and management information was delivered to more than 400 farmers, advisors and weed control officers through a series of 14 workshops in NSW, Victoria and

South Australia in 2010 and 2011.

Two surveys were conducted at each workshop. One was a baseline survey at the start of the workshop to collect farmer knowledge and awareness on the weed, control tactics, control cost and area infested, and the second was conducted at the end of the workshop to gather information on the likelihood and scale of adoption of the management strategies presented in the BMP.

Through the workshop, some underlying drivers for improved adoption were identified, such as perceived peer pressure for good weed control, the need of maintaining self-image and social standing within the local farming community and the extreme dislike of the presence of this weed. These factors will spur the adoption process. However a number of underlying barriers influencing adoption of the BMP were also identified.

1. LACK OF AWARENESS OF THE PROBLEM

The workshops identified that awareness of the potential impact of silverleaf nightshade varied greatly among farmers and between regions. A concern among farmers who attended the workshops was that land managers who are not familiar with silverleaf nightshade underestimate its damaging potential. Many farmers with new and small infestations knew little about the seriousness of this weed and were often unaware of the importance of controlling this weed at the very early stage of infestation. If the weed is left uncontrolled, it will gradually expand to a scale that is hard to management. Farmers with new or small infestations are in the best position to effectively manage or eradicate the weed. Unfortunately, awareness of the potential threat and cost of this persistent weed was not consistently evident among farmers. The lack of awareness in some farmers tends to be a deterrent to adoption. Those who are aware of the invasive nature of silverleaf nightshade were more likely to adopt the BMP.

2. FUNDAMENTAL ATTRIBUTION ERROR

Weeds tend to move around without boundaries via machinery, stocks, birds and wild animals and water movement, which decreases motivation to adopt the BMP as reinfestation events are often beyond the control of the farmer. Workshop participants commented that if no concerted management efforts are taken at regional or catchment level, farmers who actively adopt the BMP will waste their investment as sources of re-infestation remain unchecked.

It is not uncommon that farmers perceive that the weed management depends on external factors rather than their own actions, which will discourage BMP adoption (Frisvold *et al.* 2009). Farmers tend to attribute weed problems to the behaviour of others (poorly managed or vacant neighbouring lands) and natural elements (weather, wildlife, and plant characteristics) outside their control, while overlooking their own inactions (Wilson *et al.* 2008; Doohan *et al.* 2010). This behaviour has typically been described as the fundamental attribution error (Jones and Nisbett 1971).

3. LACK OF ECONOMIC VIABILITY

Economic viability has been a major factor driving adoption of weed control tactics, in

particular when the benefit of these tactics has a long-term focus. Farmers will be more likely to adopt BMPs that have immediate short-term benefits. The BMP for silverleaf nightshade control integrates the use of non-chemical and chemical options. The use of these residual, picloram based herbicides could be cost-prohibitive, especially for farmers with large infestations. Pannell (2002) argued that high adjustment cost is one of the key obstacles to the adoption of some new technologies as it requires investment of time and effort from the farmers. The initial high cost of implementing the BMP may deter some farmers unless the farmer is convinced that the perceived long term benefits outweigh the short term costs.

4. THE PERCEIVED BELIEF OF A MAGIC BULLET

Workshop participants frequently asked for a quick herbicide-based solution for control or eradication of this weed. There is a strong perceived belief among farmers that a magic silver bullet will soon be available on the market. Unfortunately, there is no single measure that can provide rapid and complete control of this perennial weed. A systems approach integrating multiple control components is the best way to effectively manage silverleaf nightshade. Farmers without this perception will be reluctant to adopt the BMP.

5. INCREASED SYSTEMS COMPLEXITY AND UNCERTAINTY

The BMP provides a diversity of control methods, resulting in the potential perception of increased management complexity, which subsequently hampers the adoption by farmers (Bastiaans *et al.* 2008). Implementing BMPs is much more complex relative to relying solely on herbicides. The greater the complexity, the greater the information that landholders require to be certain about the consequences of adoption (Pannell *et al.* 2006). Complexity may also increase the managerial costs and logistical difficulties (Waller *et al.* 1998).

6. GEOGRAPHIC ISOLATION

Geographically isolated landholders are often restricted in access to available information. Presenting workshops in locations favourable to these landholders was an important step to increasing the awareness of these landholders to the problem and the potential control measures that could be adopted. Pannell *et al.* (2006) reported that the physical distance of the property from sources of information influenced the rate of adoption. More distant landholders are less likely to adopt, because they are less exposed to the information.

7. SYSTEM COMPATIBILITY

Decisions to adopt a BMP will rely on the compatibility of the BMPs with the existing production system. Farming systems differ dramatically between and within regions. The use of picloram-based products is an integral part of the BMP, aiming to target the rootbank and to reduce the reshoot of the following year. However, the plant-back issue associated with the use of these products might pose potential conflicts with current farming practices and crop rotations. If the plant-back issue is not properly addressed, farmers will be less likely to adopt the BMP.

8. ATTITUDE ISSUES

Silverleaf nightshade has become a serious weed since 1960s. With limited research support and scarce management information, many farmers have been struggling in achieve satisfactory control. In many cases, despite committed and dedicated control efforts, farmers have made little progress towards long term control or eradication. Frustration is overwhelmingly evidenced among workshop participants. Many farmers have gradually learnt to live with silverleaf nightshade despite their strong dislike of the weed. Continuous research support and extension programs are crucial for improved confidence among these farmers to manage this weed.

CONCLUSION

Throughout the year, farmers need to make many decisions on how to profitably manage their production systems. Weed management is only a small part of the decision-making process. The series of workshops reported here identified some underlying socio-economic barriers that act against farmers making the decision to adopt new weed control tactics. Any sound extension program will have to address these socio-economic issues.

Multiple extension channels, repetition, multiple deliverers of the message, and harnessing of peer pressure are among the standard tools of effective extension agents (Pannell *et al.* 2006). Multiple approaches will meet the need of different landholders who might have different learning styles and different preferences of receiving information through different channels (Bardsley 1982).

Simply posting BMP information on the Internet is not enough, since there is no guarantee that the information will be accessed (Malone *et al.* 2004). Traditional fact-sheets and booklets from government departments, field days and workshops are still regarded as very useful (Meulen *et al.* 2006).

We have found that running workshops across regions is a good platform to influence farmers' decision-making to adopt the BMP. The face-to-face discussions and the sharing of experiences among farmers was highly rewarding. Many workshop participants indicated an intention to trial the BMP tactics on their properties. However, motivating farmers to trial the BMP is not the end of information delivery process. Follow-up and one-on-one communications with the farmers are essential to ensure the successful implementation of the BMP on farm. The current short funding cycle for research is a deterrent for this follow-up process to occur within research projects and must therefore be continued by appropriately trained extension personnel.

It is necessary to mobilise various stakeholders, such as state departments, local councils, CMAs, landcare groups, agricultural consultants and spraying contractors to boost adoption of the BMP.

ACKNOWLEDGEMENT:

The authors are grateful for the financial support from Meat and Livestock Australia.

REFERENCES

Bardsley B 1982. Farmers' assessment of information and its sources. (School of Agriculture and Forestry, University of Melbourne: Melbourne).

- Bastiaans L., Paolinir R. and Baumann DT 2008. Focus on ecological weed management: what is hindering adoption? *Weed Research* 48, 481-491.
- Doohan D., Wilson R., Canales E. and Parker J 2010. Investigating the human dimension of weed management: new tools of the trade. *Weed Science* 58, 503-510.
- Frisvold GB., Hurley TM. and Mitchell PD 2009. Adoption of best management practices to control weed resistance by corn, cotton, and soybean growers. *AgBio Forum* 12(3&4), 370-381.
- Malone S., Herbert DA Jr. and Pheasant S 2004. Determining adoption of integrated pest management practices by grains farmers in Virginia. *Journal of Extension* 42, 4.
- Meulen AW van der., Reeve IJ. and Sindel BM 2006. Insights into motivations and barriers for weed control in grazing districts of southern Australia. *In Proceedings of the 15th Australian Weeds Conference*, pp. 99-102.
- Jones EE. and Nisbett RE 1971. The actor and the observer: divergent perceptions of the causes of behavior. pp 79-94. In E. E. Jones, D. E. Kanouse, H. H. Kelley, R. E. Nisbett, S. Valins and B. Weiner, eds. *Attribution: Perceiving the Causes of Behavior*. Morristown, NJ: General Learning Press.
- Kwong RM., Sagliocco JL., Weiss J., Hunt T. and Morfe T 2008. Feasibility of biological control of silverleaf nightshade in Australia. *In Proceedings of the 16th Australian Weeds Conference*, pp 256-258.
- McLaren DA., Morfe TA., Honan I. and Holtkamp R 2004. Distribution, economic impact and attitudes towards silverleaf nightshade (*Solanum elaeagnifolium* Cav.) in Australia. *In Proceedings of the 14th Australian Weeds Conference*, p. 701.
- Pannell DJ 2002. Human dimensions of integrated weed management. *In Proceedings of the 13th Australian Weeds Conference*, pp 8-15.
- Pannell DJ., Marshall GR., Barr N., Curtis A., Vanclay F. and Wilkinson R 2006. Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal Experimental Agriculture* 46, 1407-24.
- Waller BH., Hoy CW., Henderson JL., Stinner B. and Welty C 1998. Matching innovations with potential users, a case study of potato IPM practices. *Agricultural Ecosystem and Environment* 70, 203-215.
- Wilson RS., Tucker MA., Hooker NH., LeJeune JT. and Doohan D 2008. Perceptions and beliefs about weed management: Perspectives of Ohio grain and produce farmers. *Weed Technology* 22, 339-350.