Technical highlights

Invasive plant and animal research 2014–15

Queensland Government

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Cover image: Releasing Neochetina bruchi weevils onto water hyacinth, Santo, Vanuatu

Contents

Introduction

This document summarises the 2014–15 research program of the Invasive Plants and Animals Research group in Biosecurity Queensland. Our applied research program aims to better manage Queensland's worst weeds and pest animals, reducing their impacts on agriculture, the environment and the community.

Our work is undertaken at five centres across the state:

- Ecosciences Precinct, Dutton Park
- Health and Food Sciences Precinct, Coopers Plains
- Robert Wicks Pest Animal Research Centre, Toowoomba
- Tropical Weeds Research Centre, Charters Towers
- Tropical Weeds Research Centre, South Johnstone.

We also collaborate with numerous Queensland, interstate and overseas organisations. Higher degree students are supported to work on several research projects in weed and pest animal management.

The research projects summarised in this document cover the development of effective control strategies and methods (e.g. biological control and herbicides), as well as improved knowledge of pest species' biology and assessment of pest impact.

Notable achievements of the research program for 2014–15 are outlined below.

Invasive plant research

- Biological control projects are currently under way to find and host test new agents for control of prickly acacia, bellyache bush, Siam weed, mikania, lantana and several cacti (*Cylindropuntia* species). Mass rearing and release of biocontrol agents approved for release in Australia is also being undertaken for several weeds, including parkinsonia and lantana. Redistribution of parthenium biocontrol agents from central Queensland is also under way to combat more recent outbreaks in southern Queensland.
- Ecological and control research is being undertaken to support eradication programs on numerous weeds targeted for eradication through either state or national programs, including red witchweed, miconia, mikania and limnocharis. The main aims are to ensure effective control options are available and to collect important ecological data that will aid decision making, such as determining the frequency and duration of control activities.
- Several trials are currently under way to identify effective herbicides, application rates and techniques for control of several priority weeds in Queensland, including prickly acacia, calotrope, bellyache bush, Siam weed, lantana, Navua sedge, stevia, koster's curse, rubber vine, alligator weed, cabomba and invasive grasses such as Gamba grass.
- Ecological research to assist management (e.g. seed longevity, environmental requirements) is being undertaken on numerous weeds.

Pest animal management

- Feral deer projects are under way in South East Queensland and north Queensland. In South East Queensland, the locations and movement of red deer are being studied as well as an assessment of the damage they are causing in peri-urban areas. In north Queensland, ecological studies of chital deer include assessment of movement, diet, body condition and reproductive status over a three-year period in grazing lands.
- A site near Wallangarra has been established to monitor rabbit populations before an anticipated release of a rabbit haemorrhagic disease 'boost' (RHD Boost) strain in the future. Few areas in Queensland have the required density to fit in with the sampling protocol being followed by other states. Basic biological measurements on rabbit populations in far north Queensland (Charters Towers to Atherton) are being taken to understand how these populations survive in an environment that should be too hot during the breeding season for the populations to persist.
- Various aspects of peri-urban wild dog management are being examined in an extensive field trial in South East Queensland. The movements of collared dogs are being recorded, while the diet and disease status of dogs destroyed in council trapping programs is also being determined. The possible use of ejectors is being examined by using non-lethal devices in peri-urban environments.
- The genetic composition of feral cats in far-western Queensland that have been caught in various control programs and associated activities is being analysed in an attempt to understand their movements, especially during irruptions. Tissue samples (› 2500) have been collected from feral cats shot as part of routine control programs conducted by Department of National Parks, Sport and Racing staff at Astrebla Downs National Park and surrounding areas. This research will help us understand source populations of feral cats and ensure these cat populations are managed as a whole, not just in part. Such information should assist in planning any control programs, especially those aimed at protecting areas of high biodiversity value.
- A trial is under way to determine the rate of environmental degradation of wild dog baits containing the toxin PAPP. Comparisons are being made between surface-laid baits and buried baits. This information is invaluable for developing appropriate and safe management strategies for bait use (e.g. determining safe withholding periods for domestic dogs from baited areas).
- We are continuing to monitor kangaroo and wild dog abundance and pasture condition inside and outside a large cluster fence in south-western Queensland.

Research services

- At Coopers Plains, our chemistry group produces 1080 solution for use in pig, dog and fox baits. The group also tests various poisons as possible causes of death for animal mortalities reported by the public. In addition, testing for residues in baits is carried out to quantify how long chemicals last in the environment.
- Obtaining minor-use permits from the Australian Pesticides and Veterinary Medicines Authority, as required for certain weed species, herbicides, application methods and situations or environments.

Funding, collaboration and research priorities

In the 2014–15 financial year, Biosecurity Queensland's Invasive Plant and Animal Research program received funding from a number of sources. Queensland Government base funds provided $2.4 million; contributions from the Land Protection Fund amounted to $1.6 million; and funding under contracts with external partners totalled $0.6 million (see 'External funding', page 23). Notable funding bodies for the latter were the Australian Government, Meat and Livestock Australia and the Invasive Animal CRC.

Our research program for 2014–15 was endorsed by the Research Review Committee—a group of senior scientific, operations and policy staff from Biosecurity Queensland plus representatives from our external stakeholders, including local government, AgForce, Queensland Farmers Federation and the Regional NRM Groups Collective. The committee critically reviews proposed project outcomes and allocated investments, and makes recommendations on strategic priorities, existing research gaps and projects due for scientific review.

Further information

For further information visit the 'Invasive plant and animal research' page on www.biosecurity.qld.gov.au. Journal articles and scientific reports can be obtained by emailing project leaders (see 'Research staff', pages 24–25). In addition, you can browse our recent scientific publications in the eResearch archive at www.biosecurity.qld.gov.au (search **eResearch archive**).

Part 1: Invasive plant research

1. Weed seed dynamics

Project dates

August 2007 – June 2020

Project team

Shane Campbell, Christopher Crowley, Emma Carlos and Dannielle Brazier

Project summary

There are many declared weeds for which we know little about their seed ecology and longevity. In this project, seed longevity of priority weeds is being investigated in two different soil types (black clay and river loam), under two grass-cover conditions (grassed and non-grassed) and at four burial depths (0, 2.5, 10 and 20 cm). These weeds include yellow oleander, mesquite, prickly acacia, chinee apple, parthenium, orange-flowering and pink-flowering lantana, Gamba grass, calotrope, leucaena, yellow bells, Captain Cook tree, neem and stevia.

During the past 12 months, the findings on the seed longevity of calotrope were published in *The Rangeland Journal*. A paper on the seed longevity of Chinee apple will also soon be submitted for publication. Like calotrope, chinee apple was found to have a relatively short-lived seed (< 2 years), with persistence greater if seeds are located on the soil surface and not buried. However, calotrope has highly germinable seed and the short persistence is associated with seeds germinating when they receive favourable moisture conditions, particularly if buried, as sufficiently high moisture levels are more prevalent in soil. Chinee apple, on the other hand, will not readily germinate if still contained in a hard surrounding shell (endocarp) which imposes a level of physical dormancy. A lot of seeds tend to decay before they get the opportunity to germinate.

Collaborators

- Bob J. Mayer, senior biometrician, Department of Agriculture and Fisheries(Queensland)
- Faiz Bebawi

Key publications

Bebawi, FF, Campbell, SD & Mayer, RJ 2013, 'Persistence of bellyache bush (*Jatropha gossypiifolia* L.) soil seed banks', *The Rangeland Journal*, vol. 34, pp. 429–438.

2. Best practice management of wet tropics weeds

Project dates

July 2012 – June 2016

Project team

Melissa Setter, Stephen Setter and Wayne Vogler

Project summary

The Wet Tropics bioregion of north Queensland is of high economic, social and environmental value. Unless they are well managed, numerous weed species threaten to degrade these values.

This research directly supports on-ground weed management by investigating aspects such as seed longevity, time to reproductive maturity, dispersal mechanisms and control options for priority species.

Current research includes:

- *Navua sedge (Cyperus aromaticus)*

The findings from herbicide trials that concluded in 2013–14 have contributed to a minor-use permit for the control of Navua sedge being issued by the APVMA (http://permits.apvma.gov.au/PER80065.PDF). This permit allows use of the herbicide Sempra (Halosulfuron-methyl 750 g/kg) for control of Navua sedge in commercial and industrial areas and rights-of-way, including footpaths and roadside verges. The background data has also been supplied to Sempra's manufacturer, Nufarm, to support a case for label registration of Sempra, including its use in pastures. A scientific paper incorporating the most recent herbicide research on Navua sedge has also been accepted for publication in *Plant Protection Quarterly*.

- *Bogmoss (Myaca fluviatilis)*

A shadehouse trial on herbicide control of emergent bogmoss is in progress. Plants have been established and the herbicide treatments will be implemented once they accumulate sufficient biomass.

- *Seed persistence in water (several species)*

Laboratory trials on the viability of Navua sedge, leuceana, hymenachne and neem seed after varying periods of immersion in fresh, brackish and saline water have been completed. All species except neem retained some viability after 14 weeks immersion in each water type. Bellyache bush seed will be tested next.

Collaborators

- Biosecurity officers (Queensland)
- Far North Queensland Regional Organisation of Councils
- Cairns Regional Council
- Cassowary Coast Regional Council
- Tablelands Regional Council
- land managers

3. Controlling calotrope (*Calotropis procera*) in northern Australia

Project dates

June 2010 – May 2015

Project team

Shane Campbell and Christopher Crowley

Project summary

This project concluded in May 2015 and was part of a larger, collaborative, MLA-funded research program aimed at improving our understanding of the control, distribution, rate of spread, invasiveness and other aspects of the ecology

of calotrope. Biosecurity Queensland focused on improving control options, while Charles Darwin University and the Northern Territory Department of Land Resource Management researched the ecological aspects.

From the control research, several new herbicide options for calotrope control have been identified. Foliar spraying using two chemicals (2,4-D amine and imazapyr/glyphosate) gave satisfactory mortality, particularly on smaller plants (≤ 1.5 m in height). A range of options for treating low densities or small patches were also found, including methods that can be incorporated into routine activities (such as checking bores). They include: using a mixture of triclopyr/picloram (Access) and diesel applied using basal bark techniques; cut stumping using neat glyphosate or a picloram-based gel (Vigilant II) on small- to medium-sized plants; and ground applications of the residual herbicides hexazinone (Velpar L) and tebuthiuron (Graslan). For treatment of large, dense infestations, aerial applications of tebuthiuron (Graslan) were found to be highly effective. Approval will be sought in 2015–16 to incorporate these additional options into an existing minor-use permit for calotrope (PER12497).

Investigations into using machinery to control calotrope found high mortality is achievable provided plant stems are severed 10–20 cm below ground. Cutter bars and blade plough-style equipment would be able to achieve this level of damage, but large-scale seedling recruitment should be expected afterwards. A dieback phenomenon that started affecting plants during the course of the project was found to greatly reduce plant densities at a site where permanent transects were regularly monitored. If this dieback persists and spreads, it may provide some level of population control and complement more traditional techniques, such as herbicides.

Collaborators

- Meat and Livestock Australia
- Charles Darwin University
- Department of Land Resource Management (Northern Territory)
- University of Queensland
- Dow AgroSciences
- landholders Peter Woollett, Ann Woollett and John Nelson

Key publications

Vitelli, J, Madigan, B, Wilkinson, P & van Haaren, P 2008, 'Calotrope (*Calotropis procera*) control', *The Rangeland Journal*, vol. 30(3), pp. 339–48.

Grace, BS 2006, 'The biology of Australian weeds 45. *Calotropis procera* (Aiton) W.T. Aiton', *Plant Protection Quarterly*, vol. 21(4), pp. 152–160.

Campbell, SD, Roden, L & Crowley, C 2013, 'Calotrope (*Calotropis procera*): A weed on the move in northern Queensland', in *Proceedings of the 12th Queensland weed symposium*, M O'Brien, J Vitelli & D Thornby (eds), Weed Society of Queensland, Brisbane, Australia, pp. 11–14.

4. Biological control of bellyache bush (*Jatropha gossypiifolia*)

Project dates

January 2007 – June 2016

Project team

K Dhileepan, Di Taylor, Liz Snow and Jason Callander

Project summary

Native-range surveys for biological control agents were conducted in Bolivia and Peru. The Jatropha leaf-miner (*Stomphastis* sp.) from Peru was imported into quarantine in Brisbane and host-specificity tests are in progress. No-choice host-specificity tests have been completed for 10 test plants species. So far, larval development has occurred only on bellyache bush (*Jatropha gossypiifolia*) and *Jatropha curcas*, both approved biocontrol targets.

The Jatropha leaf-webber (*Morosaphycita morosalis*) was imported from India and a colony has been established in quarantine. Host-specificity tests are in progress.

Transplant field trials in Bolivia and quarantine tests in South Africa suggest bellyache bush is susceptible to attack by the Jatropha gall midge (*Prodiplosis longifila*). In Bolivia, a field-transplant experiment to study the field-host range of the gall midge is currently in progress. It involves five crop plants: tomato, potato, capsicum, a citrus and the castor oil plant.

Host-range tests for the Jatropha leaf rust (*Phakopsora arthuriana*) were completed by the UK's Centre for Agriculture and Bioscience International (CABI) for 41 test plant species. The rust sporulated on the non-target species, *Aleurites moluccana* (weakly susceptible) and *Beyeria viscosa* (moderately susceptible). To ascertain the susceptibility of these non-target species to the Jatropha rust under natural field conditions, four non-target plants (*Aleurites moluccana*, *Beyeria viscosa*, *A. rockinghamensis* and *J. curcas*) and bellyache bush (*J. gossypiifolia*) were exported to Trinidad. The field susceptibility trial will commence in November 2015.

Collaborators

- A Balu and S Murugesan, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Damian Rumiz, Museo de Historia Natural Noel Kempff Mercado (Santa Cruz, Bolivia)
- Diana Silva Davilla, Museo de Historia Natural (Lima, Peru)
- Jurate De Prins, Natural History Museum (UK)
- Marion Seier and Kate Pollard, CABI (UK)
- Naitram 'Bob' Ramnanan, CABI (Trinidad)
- Stefan Neser, Plant Protection Research Institute (Pretoria, South Africa)
- Tanya Scharaschkin, Queensland University of Technology
- Victor Hugo Sanchez, Instituto Nacional de Investigacion Agraria (Tarapoto, Peru)

Key publications

Heard, TA, Dhileepan, K, Bebawi, F, Bell, K & Segura, R 2012, *'Jatropha gossypiifolia L.*—bellyache bush', in M Julien, RE McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 324–333.

Heard, TA, Chan, RR, Senaratne, KADW, Palmer, WA, Lockett, CJ & Lukitsch, B 2009, '*Agonosoma trilineatum* (Heteroptera: Scutelleridae) a biological control agent of the weed bellyache bush, *Jatropha gossypiifolia* (Euphorbiaceae)', *Biological Control*, vol. 48(2), pp. 196–203.

Bebawi, FF, Lockett, CJ, Davis, KM & Lukitsch, BV 2007, 'Damage potential of an introduced biological control agent *Agonosoma trilineatum* (F.) on bellyache bush (*Jatropha gossypiifolia* L.)', *Biological Control*, vol. 41(3), pp. 415–22.

Bebawi, FF, Vitelli, JS, Campbell, SD, Vogler, WD, Lockett, CJ, Grace, BS, Lukitsch, B & Heard, TA 2007, 'The biology of Australian weeds 47. *Jatropha gossypiifolia* L.', *Plant Protection Quarterly*, vol. 22(2), pp. 42–58.

5. Biological control of prickly acacia (*Vachellia nilotica* ssp. *indica*)

Project dates

January 2007 – June 2016

Project team

K Dhileepan, Di Taylor, Jason Callander (from December 2014) and Kumaran Nagalingam (until December 2014)

Project summary

Prickly acacia, a Weed of National Significance is a target for biocontrol, but there has been limited success finding biocontrol agents to date. Based on the field-host range in its native India, a scale insect (*Anomalococcus indicus*), a green leaf-webber (*Phycita* sp. B), and a leaf weevil (*Dereodus denticollis*) were prioritised for host-specificity tests in quarantine. The host specificity of these insects is being assessed in quarantine in Brisbane.

No-choice host-specificity tests for the scale insect have been completed for 71 non-target plant species. The scale insect completed development on 15 species, four of which sustained development comparable to prickly acacia. This result may be an artefact of the laboratory environment. A trial to study the field susceptibility of some of the Australian native test plant species that supported development of the scale insect was therefore established in India. It is in progress.

No-choice host specificity tests for the green leaf-webber sourced from India, have so far been completed for 12 plant species. The leaf-webber completed development on five species, but only four non-target test plant species sustained larval development comparable to prickly acacia. Oviposition-choice tests have been initiated for the 10 non-target test plant species that supported larval development, among which egg-laying was recorded on only one test plant species. Erratic and inconsistent egg-laying in quarantine by the green leaf-webber resulted in the death of the colony. The green leaf-webber will be reimported from India to re-establish a colony in quarantine and continue host-specificity testing.

The leaf-weevil has been imported into quarantine on multiple occasions from India, but is yet to be successfully cultured in quarantine. However, a change in culturing practices has led to increased egg-laying and larval-hatching success in quarantine. Attempts to rear the larvae on prickly acacia roots and on a semi-synthetic diet have not been successful. A completely synthetic diet is currently being considered.

A gall thrip (*Acaciothrips ebneri*), two gall mites (*Aceria liopeltus* type 1 and type 2) and a galling cecidomyiid (*Lopesia niloticae*) have been identified as prospective biological control agents for prickly acacia in Ethiopia. Permits to import the gall thrips into quarantine have been obtained. Further surveys for prospective biocontrol agents for prickly acacia will focus on Ethiopia.

Collaborators

- A Balu and S Murugesan, Institute of Forest Genetics and Tree Breeding (Coimbatore, India)
- Stefan Neser, Plant Protection Research Institute (Pretoria, South Africa)
- Marion Seier and Kate Pollard, CABI (UK)
- A Raman, Charles Sturt University (NSW)

Key publications

Dhileepan, K, Balu, A, Senthilkumar, P, Murugesan, M & Shivas, R 2013, 'Survey and prioritisation of potential biological control agents for prickly acacia (*Acacia nilotica* subsp. *indica*) in southern India', *Biocontrol Science and Technology*, vol. 23, pp. 646–664.

Dhileepan, K 2009, '*Acacia nilotica* ssp. *Indica*', in R Muniappan, DVP Reddy & A Raman (eds), *Weed biological control with arthropods in the tropics: towards sustainability*, Cambridge University Press, UK, pp. 17–37.

6. Biological control of invasive vines (*Dolichandra unguis-cati* and *Anredera cordifolia*)

Project dates

July 2001 – June 2016

Project team

K Dhileepan and Liz Snow

Project summary

Cat's claw creeper and Madeira vine are Weeds of National Significance in Australia. Three biological control agents have been released for cat's claw creeper, a leaf-sucking tingid (*Carvalhotingis visenda*), a leaf-tying moth (*Hypocosmia pyrochroma*) and a leaf-mining beetle (*Hylaeogena jureceki*). A leaf-feeding beetle (*Plectonycha correntina*) was released over 2011–13 to control Madeira vine; its establishment is being monitored.

The tingid has become established widely and is causing visible damage in the field. Evidence of field establishment of the leaf-tying moth has been seen in two release sites (Boompa and Coominya) in south-eastern Queensland. The leaf-tying moth appears to have spread and established widely in areas

surrounding the two release sites. However, there has been no evidence of the moth's establishment on other release sites to date. Monitoring the establishment and spread of the moth will continue.

More than 73,000 of the leaf-mining beetles have been released across 130 release sites in Queensland. This includes about 31,000 adults released over 56 sites from July 2014 to June 2015. This figure includes starter colonies of the beetle supplied to various Landcare groups, community groups and local governments. The beetle has become established in a majority of the release sites, and has shown an excellent ability to spread from initial release areas. A small colony of the beetle will be kept to supply community groups and councils with insects to establish colonies and for some limited field releases.

Future research will focus on monitoring the establishment and spread of the beetle, the moth and the tingid. If additional funds are available, CABI in the UK will undertake preliminary host-specificity testing of two cat's claw creeper rust pathogens, a gall rust (*Uropyxis rickiana*) and a leaf-rust (*Prospodium macfadyenae*) sourced from Brazil and Paraguay.

Joshua Comrade Buru (PhD student, QUT) is continuing to study the morphological, ecophysiological and phenological variations between the two forms of cat's claw creeper. The study identified significant differences in the seed germination and polyembryony levels between the two forms, suggesting why one form of the cat's claw creeper is more invasive than the other.

The Madeira vine leaf-feeding beetle has been released at 86 sites in Queensland. However, there is no evidence of any widespread establishment and dispersal of the beetle in the field.

Collaborators

- Tanya Scharaschkin, Queensland University of Technology
- Anthony King and Stefan Neser, Plant Protection Research Institute (Pretoria, South Africa)
- Marion Seier and Kate Pollard, CABI (UK)
- Robert Barreto, Universidade Federal de Viçosa (Brazil)
- Gympie and District Landcare Group, South Burnett Regional Council
- Queensland Parks and Wildlife Service
- Burnett Mary Regional Group
- Moggill Creek Catchment Group
- Gold Coast City Council
- Brisbane City Council
- SEQ Catchments
- NSW Environmental and Aquatic Weed Biological Control Taskforce

Key publications

Dhileepan, K, Taylor, D, Treviño, M & Lockett, C 2013, 'Cat's claw creeper leaf-mining beetle *Hylaeogena jureceki* Obenberger (Coleoptera: Buprestidae), a host-specific biological control agent for *Dolichandra unguis-cati* (Bignoniaceae)', *Australian Journal of Entomology*, vol. 52, pp. 175–181.

Dhileepan, K 2012, '*Macfadyena unguis-cati* (L.) A.H. Gentry—cat's claw creeper', in M Julien, RE McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 351–359.

Dhileepan, K, Treviño, M, Bayliss, D, Saunders, M, McCarthy, J, Shortus, M, Snow, EL, & Walter, GH 2010, 'Introduction and establishment of *Carvalhotingis visenda* (Hemiptera: Tingidae) as a biological control agent for cat's claw creeper *Macfadyena unguis-cati* (Bignoniaceae) in Australia', *Biological Control*, vol. 55, pp. 58–62.

Dhileepan, K, Snow, EL, Rafter, MA, McCarthy, J, Treviño, M & Wilmot Senaratne, KAD 2007, 'Leaf-tying moth *Hypocosmia pyrochroma* (Lepidoptera: Pyralidae), a host-specific biological control agent for cat's claw creeper *Macfadyena unguis-cati* (Bignoniaceae) in Australia', *Journal of Applied Entomology*, vol. 131, pp. 564–568.

Dhileepan, K, Treviño, M & Snow, EL 2007, 'Specificity of *Carvalhotingis visenda* (Hemiptera: Tingidae) as a biocontrol agent for cat's claw creeper *Macfadyena unguis-cati* (Bignoniaceae) in Australia', *Biological Control*, vol. 41, pp. 282–290.

7. Biological control of parthenium (*Parthenium hysterophorus*)

Project dates

July 2004 – June 2018

Project team

K Dhileepan, Christine Perrett, Segun Osunkoya (until October 2014) and Jon Robson (from November 2014)

Project summary

Biological control of parthenium (*Parthenium hysterophorus*), a Weed of National Significance, began in Australia in the mid-1980s. Nine insects and two rust fungi have been released against parthenium. All but one of these agents have become established and most are widespread and effective in central Queensland. However, many of the agents are not present in southern and south-eastern Queensland where parthenium is emerging as a serious weed.

Information on the population dynamics of parthenium in south-eastern Queensland is needed. Also, there is a need to redistribute the successful parthenium biological control agents from central Queensland into parthenium-infested areas in southern and south-eastern Queensland.

In south-eastern Queensland, the demography of parthenium weed (seedling emergence, establishment, growth, survival and fecundity) and the incidence of various biological control agents have been recorded at two trial sites (Kilcoy and Helidon Spa) at monthly intervals. Estimation of the soil seed-bank was made at both sites at the beginning (September/October 2014) and at the end (May/June 2015) of parthenium growing season.

At Helidon Spa, the parthenium population remained low, but residual populations continued to persist throughout the year, including winter. The winter rust was widespread during the cooler months and there was some evidence of the stem-galling moth (*Epiblema strenuana*) but no evidence of the leaf-feeding beetle (*Zygogramma bicolorata*). There was some evidence of the establishment of the seed-feeding weevil (*Smicronyx*

lutulentus) which was introduced in April 2014 from central Queensland.

The Kilcoy site witnessed very high parthenium population levels due to above-average rainfall. There was little evidence of effective biological control. At the end of the parthenium season, there were only a few galls of the moth and very few adult beetles. There was no evidence of winter rust, summer rust or any other biological control agents.

There was no evidence of any widespread biocontrol activity in other parthenium sites surveyed in the south (Mitchell region) and south-east (e.g. Gatton and Wivenhoe Dam) region.

This project will focus on field collection and redistribution of the seed-feeding Smicronyx weevil, the root-boring Carmenta moth (*Carmenta* nr. *ithacae*), the stem-boring Listronotus weevil (*Listronotus setosipennis*), the winter rust (*Puccinia abrupta* var. *partheniicola*) and the summer rust (*Puccinia xanthii* var. *parthenii-hysterophorae*) from central Queensland to south and south-eastern Queensland. This will be enhanced by funding from the Australian Government Department of Agriculture and Water Resources under the Rural Research and Development for Profit Program and Meat and Livestock Australia.

Collaborators

- Steve Adkins and Bo Yong Shi, University of Queensland
- Rachel McFadyen (St George)
- S Raghu, CSIRO Ecosystem Dynamics
- Tom Garrett and Holly Hosie, Queensland Murray–Darling Committee
- Judith Symonds, Maranoa Landcare
- Ross Bigwood, Greg Nicholson and Pat Ryan, Junction View Pest Management Group
- Trevor Armstrong, Oxley Creek Catchment Association
- Femi Akinsami, University of Queensland
- Mariano Trevino (Brisbane)

Key publications

Dhileepan, K & McFadyen, RE 2012, '*Parthenium hysterophorus* L.—parthenium', in M Julien, RE McFadyen & J Cullen (eds), *Biological control of weeds in Australia: 1960 to 2010*, CSIRO Publishing, Melbourne, pp. 448–462.

Dhileepan, K 2009, 'Managing *Parthenium hysterophorus* across landscapes: limitations and prospects', in S Inderjit (ed.), *Management of invasive weeds*, *invading nature – Springer series in invasion ecology* (vol. 5), Springer Science, pp. 227–260.

Dhileepan, K & Strathie, L 2009, '20. *Parthenium hysterophorus*' in R Muniappan, DVP Reddy & A Raman (eds), *Weed biological control with arthropods in the tropics: towards sustainability*, Cambridge University Press, Cambridge, UK, pp. 272–316.

8. Biological control of *Mikania micrantha*

Project dates

July 2014 – June 2016

Project team

Michael Day, Natasha Riding and Wilmot Senaratne

Project summary

Mikania micrantha was first reported in Queensland in 1998 and is also present on Christmas Island and Cocos Island. Mikania is the target of a national cost-share eradication program. However, recent cyclones have hampered the eradication program and the latest review of the program suggested biocontrol options should be investigated. The rust *Puccinia spegazzinii* is deemed host-specific, having been tested in four countries against a total of 175 species, representing 48 families, including 70 species in the Asteraceae.

The rust was subsequently released in several countries, including India, China, Taiwan, Papua New Guinea (PNG), Fiji and Vanuatu. It has established in all countries except India and China. In PNG, field monitoring and laboratory trials show the rust suppresses the growth of mikania. In both PNG and Vanuatu, where it has been widely released, anecdotal information suggests mikania is beginning to be suppressed and flowering reduced.

The rust was imported into quarantine at the Ecosciences Precinct and will be tested against species in the Eupatorieae subfamily. If specificity is confirmed, an application seeking its release will be submitted to the Australian Department of Agriculture and Water Resources and the Australian Department of Environment.

Collaborators

- National Agricultural Research Institute (PNG)
- National Agriculture Quarantine and Inspection Authority (PNG)
- CABI (UK)
- Ministry of Natural Resources (Palau)

Key publications

Day, M 2012, '*Mikania micrantha* Kunth—mile-a-minute', in M Julien, R McFadyen, & J Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 368–372.

Day, MD, Kawi, AP, Ellison, CA 2013, 'Assessing the potential of the rust fungus *Puccinia spegazzinii* as a classical biological control agent for the invasive weed *Mikania micrantha* in Papua New Guinea', *Biological Control*, vol. 67, pp. 253–261.

Day, MD, Kawi, AP, Fidelis, J, Tunabuna, A, Orapa, W, Swamy, B, Ratutini, J, Saul-Maora, J & Dewhurst, CF 2013, 'Biology, field release and monitoring of the rust *Puccinia spegazzinii* de Toni (*Pucciniales: Pucciniaceae*), a biocontrol agent of *Mikania micrantha* Kunth (Asteraceae) in Papua New Guinea and Fiji', in Y Wu, T Johnson, S Sing, S Raghu, G Wheeler, P Pratt, K Warner, T Center, J Goolsby & R Reardon (eds), *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, USA, pp. 211–217.

9. Biocontrol of *Cylindropuntia* spp.

Project dates

March 2009 – June 2016

Project team

Michael Day, Peter Jones and Wilmot Senaratne

Project summary

The cacti *Cylindropuntia* spp. are native to the tropical Americas. The group includes *Cylindropuntia rosea* (Hudson pear) and *C. tunicata*, both of which are Class 1 weeds found in Queensland, and *C. fulgida* and *C. imbricata*, which are more widespread Class 2 weeds in Queensland.

C. rosea was approved as a target for biocontrol in 2008 and the remaining *Cylindropuntia* spp. were approved as targets in 2013. Seven biotypes of *Dactylopius tomentosus*, including one which had already been released in Australia in 1925 to control *C. imbricata* were tested to determine their specificity and their effectiveness against each of the eight naturalised species of *Cylindropuntia* in Australia.

All seven biotypes are host-specific to the genus *Cylindropuntia*. The *D. tomentosus* 'cholla' biotype released in South Africa was very effective against *C. fulgida* var. *mamillata* and an application seeking approval for its field release has been submitted to the Australian Department of Agriculture and Water Resources and the Australian Department of Environment.

Host specificity and efficacy trials against four biotypes of *D. tomentosus* collected from the USA are still in progress. Most *Cylindropuntia* sp. are attacked by at least one of the biotypes; however, an effective biotype has not been found to control *C. spinosior*.

Collaborators

- Department of Primary Industries (NSW)
- Dr Helmuth Zimmermann
- local governments in central and western Queensland

Key publications

Jones, PK, Holtkamp, RH, Palmer, WA & Day, MD 2015, 'The host range of three biotypes of *Dactylopius tomentosus* (Lamarck) (Hemiptera: Dactylopiidae) and their potential as biological control agents of *Cylindropuntia* spp. (Cactaceae) in Australia', *Biocontrol Science and Technology*, vol. 25, pp. 613–628.

Holtkamp, RH 2012, '*Cylindropuntia imbricata* (Haw.) F. M. Knuth—rope pear *Cylindropuntia rosea* (DC.) Backeb.—Hudson pear', in M Julien, R McFadyen & JM Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 198–202.

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10. Biocontrol of *Lantana camara*

Project dates

July 1996 – June 2015

Project team

Michael Day, Natasha Riding, Kelli Pukallus and Judy Clark

Project summary

Lantana is a serious weed of grazing, forestry and conservation areas. It is found throughout coastal and subcoastal areas of eastern Australia, from the Torres Strait islands in the north to the Victorian border in the south. Lantana can be controlled using chemicals, machinery and fire but some of these methods are not viable in forestry or conservation areas or are not economically feasible. Biological control is seen as the only viable option in many areas. Although biocontrol has been in progress since 1914, recent research has emphasised the need to target agents that damage specific parts of the plant or the different climatic areas in which lantana grows.

This project aims to improve biocontrol of lantana in Queensland through active collaboration with the Plant Protection Research Institute (South Africa), CABI (Europe-UK), the NSW Biocontrol Taskforce and local councils and Landcare groups. Initial host-specificity testing of the rust *Puccinia lantanae* by CABI has been completed; however, additional tests must be conducted on *Verbena officinalis* var. *gaudichaudii* and species in the family Acanthaceae to clarify specificity. Seeds and plants of the extra species have been sent to CABI and additional testing has commenced.

The budmite *Aceria lantanae* has been approved for field release. Releases have been conducted widely in south-eastern and north Queensland and galls have been seen at up to 15 sites. Note that gall presence and persistence in the field depends on weather conditions and whether plants are in flower.

Collaborators

- CABI (UK)
- Plant Protection Research Institute (South Africa)
- NSW Weed Biocontrol Taskforce
- Queensland Parks and Wildlife Services
- Department of Agriculture and Fisheries (Queensland)
- local governments in coastal and sub-coastal Queensland

Key publications

Day, M 2012, '*Lantana camara* L.—lantana', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, pp. 334–346.

Day, MD, Broughton, S & Hannan-Jones, MA 2003, 'Current distribution and status of *Lantana camara* and its biological control agents in Australia, with recommendations for further biocontrol introductions into other countries', *Biocontrol News and Information*, vol. 24(3), pp. 63N–76N.

Day, MD, Wiley, CJ, Playford, J & Zalucki, MP 2003, *Lantana: current management status and future prospects*, Australian Centre for International Agricultural Research, Canberra, 128 pp.

11. Biocontrol of *Chromolaena odorata*

Project dates

July 2011 – June 2016

Project team

Michael Day, Natasha Riding and Wilmot Senaratne

Project summary

Chromolaena odorata was first reported in Queensland in 1994 and is also present on Christmas Island and Cocos Island. It was the target of a national cost-share eradication program until 2013. It was approved as a target for biocontrol in 2011, following several reviews.

The gall fly *Cecidochares connexa* is deemed host-specific, having been tested in four countries against a total of 81 species, representing 18 families, including 23 species in the Asteraceae. The fly was subsequently released in several countries, including Papua New Guinea (PNG), Indonesia, Micronesia and Timor Leste, where it is controlling or aiding the control of chromolaena. It was imported into quarantine at the Ecosciences Precinct in Brisbane in February 2012 for the purposes of further host-specificity testing.

Twenty species in the Eupatorieae subfamily were tested in choice-minus-the-host-plant trials. Some larvae completed development to adult on *Praxelis clematidea*. Further tests showed development of the fly was poor on *P. clematidea* and populations could not be sustained. Furthermore, field observations in Palau found no gall formation on *P. clematidea*.

An application seeking the release of the fly has been submitted to the Australian Department of Agriculture and Water Resources and the Australian Department of Environment.

Collaborators

- National Agricultural Research Institute (PNG)
- National Agriculture Quarantine and Inspection Authority (PNG)
- Bureau of Agriculture (Palau)

Key publications

Day, MD, Bofeng, I & Nabo, I 2013, 'Successful biological control of *Chromolaena odorata* (Asteraceae) by the gall fly *Cecidochares connexa* (Diptera: Tephritidae) in Papua New Guinea', in Y Wu, T Johnson, S Sing, S Raghu, G Wheeler, P Pratt, K Warner, T Center, J Goolsby & R Reardon (eds), *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, USA, pp. 400–408.

Day, MD, Brito, AA, da Costa Guterres, A, da Costa Alves, AP, Paul, T & Wilson, CG 2013, 'Biocontrol of *Chromolaena odorata* in Timor Leste', in C Zachariades, LW Strathie, MD Day & R Muniappan (eds), *Proceedings of the eighth international workshop on biological control and management of* Chromolaena odorata *and other Eupatorieae*, Agricultural Research Centre – Plant Protection Research Institute, Pretoria, South Africa. pp. 134–140.

Day, M & McFadyen, RC 2012, '*Chromolaena odorata* (L.) King and Robinson – chromolaena', in M Julien, R McFadyen & J Cullen (eds), *Biological Control of Weeds in Australia*, CSIRO Publishing, Melbourne, pp. 162–169.

12. Biological control of parkinsonia (*Parkinsonia aculeata*)

Project dates

March 2013 – July 2017

Project team

Kelli Pukallus and Judy Clark

Project summary

This collaborative project with CSIRO, involves the mass rearing, release and monitoring of *Eueupithecia cisplatensis*, called 'UU', for the biological control of parkinsonia (*Parkinsonia aculeata*) within Queensland. UU, a leaf-feeding geometrid caterpillar from Argentina, defoliates the leaflets, weakening the plant. This should result in lower flower and pod production.

The Tropical Weeds Research Centre (TWRC) started releases from its UU colony in early 2013, encompassing the Burdekin, Whitsunday and Dalrymple Regional Council areas, and into central Queensland. A total of 42 release sites have been established, with over 2907 adults, 123 600 pupae and 375 240 larvae/eggs being released from TWRC to date. Release sites cover various terrains, climatic conditions and land uses: inland, open woodlands, gullies, coastal and riparian areas, private grazing properties, national parks, local government land reserves and mining leases.

Establishment has been noted at 13 release sites within northern Queensland and four in central Queensland. UU has also spread over 5 km from the nearest release site at several locations and these populations have been persisting throughout the seasons. Releases will continue for another year, expanding into new release sites.

Collaborators

- Andrew White, Gio Fichera and Raghu Sathyamurthy, CSIRO (Brisbane)
- Marina Wall, Fitzroy River and Coastal Catchments
- Russell Bailey, Isaac Regional Council
- Juliana McCosker, Queensland Department of Environment and Heritage Protection
- Biosecurity officers (Queensland)

13. Improving weed biocontrol in Papua New Guinea

Project dates

January 2013 – December 2015

Project team

Michael Day

Project summary

Mikania micrantha is a Class 1 weed in Queensland and is currently the target of a national cost-share eradication program. The plant is also a serious weed in numerous Pacific island countries, including Vanuatu. The rust *Puccinia spegazzinii* which was released and has established in Fiji and Papua New Guinea (PNG) was introduced into Vanuatu in 2012. It has established on several islands but still needs to be released on many other islands where mikania is a problem.

Agents to control parthenium and water hyacinth (both Class 2) have also been introduced, but field releases of both agents need to continue in climatically suitable areas where they are not already present. Effective biocontrol agents for cat's claw creeper and lantana (both Class 3) may also be introduced from other countries in which they are established.

Support for the eradication of some species from various locations will continue to be provided. Formal training in various aspects of weed biocontrol will be provided in Australia, Vanuatu and other countries.

Collaborators

- National Agriculture Quarantine Inspection Authority (PNG)
- National Agricultural Research Institute (PNG)
- PNG Oil Palm Research Association
- Department of Foreign Affairs and Trade (Australia)
- Department of Land Resource Management (Northern Territory)

Key publications

Day, MD, Bofeng, I & Nabo, I 2013, 'Successful biological control of *Chromolaena odorata* (Asteraceae) by the gall fly *Cecidochares connexa* (Diptera: Tephritidae) in Papua New Guinea', in Y Wu, T Johnson, S Sing, S Raghu, G Wheeler, P Pratt, K Warner, T Center, J Goolsby & R Reardon (eds), *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, USA, pp. 400–408.

Day, MD, Kawi, AP, Fidelis, J, Tunabuna, A, Orapa, W, Swamy, B, Ratutini, J, Saul-Maora, J, Dewhurst, CF 2013, 'Biology, field release and monitoring of the rust *Puccinia spegazzinii* de Toni (*Pucciniales: Pucciniaceae*), a biocontrol agent of *Mikania micrantha* Kunth (Asteraceae) in Papua New Guinea and Fiji', in Y Wu, T Johnson, S Sing, S Raghu, G Wheeler, P Pratt, K Warner, T Center, J Goolsby & R Reardon (eds), *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, USA, pp. 211–217.

Day, MD, Kawi, A, Kurika, K, Dewhurst, CF, Waisale, S, Saul-Maora, J, Fidelis, J, Bokosou, J, Moxon, J, Orapa, W & Senaratne, KADW 2012, '*Mikania micrantha* Kunth (Asteraceae) (mile-a-minute): its distribution and physical and socio economic impacts in Papua New Guinea', *Pacific Science*, vol. 66, pp. 213–223.

14. Improving weed management in Vanuatu

Project dates

November 2011 – December 2014

Project team

Michael Day

Project summary

Mikania micrantha is a Class 1 weed in Queensland and is currently the target of a National Cost-Share Eradication program. The plant is also a serious weed in numerous Pacific island countries, including Vanuatu.

The rust *Puccinia spegazzinii*, which was released and has established in Fiji and Papua New Guinea, was introduced into Vanuatu in 2012. It has established on several islands but still needs to be released on many other islands where mikania is a problem.

Agents to control parthenium and water hyacinth (both Class 2 weeds in Queensland) have also been introduced, but field releases of both agents need to continue in climatically-suitable areas where they are not already present. Effective biocontrol agents for cat's claw creeper and lantana (both Class 3 weeds in Queensland) may also be introduced from other countries in which they have established.

Support for the eradication of some species from various locations will continue to be provided. Formal training in various aspects of weed biocontrol will be provided in Australia, Vanuatu and other countries.

Collaborators

- Biosecurity Vanuatu
- National Agriculture Quarantine and Inspection Authority (PNG)
- Secretariat of the Pacific Community, Department of Foreign Affairs and Trade (Australia)

Key publications

Day, M 2012, '*Mikania micrantha* Kunth – mile-a-minute', in M Julien, R McFadyen & J Cullen (eds), *Biological control of weeds in Australia*, CSIRO Publishing, Melbourne, Australia, pp. 368–372.

Day, MD, Kawi, AP & Ellison, CA 2013, 'Assessing the potential of the rust fungus *Puccinia spegazzinii* as a classical biological control agent for the invasive weed *Mikania micrantha* in Papua New Guinea', *Biological Control*, vol. 67, pp. 253–261.

Day, MD, Kawi, AP, Fidelis, J, Tunabuna, A, Orapa, W, Swamy, B, Ratutini, J, Saul-Maora, J & Dewhurst, CF 2013, 'Biology, field release and monitoring of the rust *Puccinia spegazzinii* de Toni (*Pucciniales: Pucciniaceae*), a biocontrol agent of *Mikania*

micrantha Kunth (Asteraceae) in Papua New Guinea and Fiji', in Y Wu, T Johnson, S Sing, S Raghu, G Wheeler, P Pratt, K Warner, T Center, J Goolsby & R Reardon (eds), *Proceedings of the XIII international symposium on biological control of weeds*, Forest Health Technology Enterprise Team, Morgantown, USA, pp. 211–217.

15. Water weed management research

Project dates

October 2010 – July 2016

Project team

Tobias Bickel and Christine Perrett

Project summary

Currently, there is a lack of registered herbicides to control established and emerging aquatic weeds in Australia, in particular for submersed aquatic weeds such as cabomba. We investigated the efficacy of a new herbicide that is not registered for aquatic use in Australia, which is used in the USA to control a range of aquatic weeds. The data generated from this project will assist with future registration of this herbicide in Australia.

An outdoor trial was conducted at the Ecosciences Precinct in Brisbane to test the efficacy of the new herbicide to control five aquatic plants (three invasive target and two native non-target species) at four different concentrations: 0 parts-per-billion (ppb) = control, 100 ppb = low, 200 ppb = medium, 400 ppb = high.

A single water column treatment achieved good control of cabomba and sagittaria in terms of biomass reduction (84–89%) even at the lowest application rate and good mortality at all rates (14–86%), but had no long-term effects (0% mortality) on the other species (egeria, hydrilla and vallisneria).

Therefore, this herbicide is quite specific and a promising tool for the future control of cabomba and sagittaria. Future research will investigate the minimum contact time necessary to achieve a desired control level and also research the effect of pH and application modes on the efficacy of this herbicide.

Collaborators

- Brisbane City Council
- CSIRO
- Seqwater
- Noosa and District Landcare
- Department of Primary Industries (Victoria)
- Department of Primary Industries (NSW)
- University of Queensland
- Griffith University
- Sumitomo Chemical
- Maxspred

Key publications

Bickel, TO & Schooler, SS 2015, 'Effect of water quality and season on the population dynamics of *Cabomba caroliniana* in subtropical Queensland, Australia', *Aquatic Botany*, vol. 123, pp. 64–71.

Bickel, TO 2015, 'A boat hitchhiker's guide to survival: Cabomba caroliniana desiccation resistance and survival ability', *Hydrobiologia*, vol. 746, pp. 123–134.

16. Impacts of aquatic weeds: mosquito proliferation

Project dates

July 2012 – July 2016

Project team

Tobias Bickel and Christine Perrett

Project summary

There are frequent claims that dense stands of floating and submersed aquatic weeds create breeding grounds for mosquitoes and therefore pose a serious health issue. Previously, we established that not all aquatic weeds support mosquito breeding and identified water hyacinth as the main species of concern.

Over the past year, a water hyacinth infestation located in Corinda was monitored monthly to investigate the temporal dynamics and species composition of the breeding mosquito population in water hyacinth stands. A method was also developed to sample mosquito larvae that physically attach to water hyacinth roots and are not collected with traditional sampling tools.

We detected 10 species of mosquito larvae in the water hyacinth stands. Among these were *Culex annulirostris* larvae, a major pest species and carrier of Ross River virus and dog heartworm. We also collected *Anopheles bancroftii* throughout the year: a suspected malaria vector and ferocious biter of humans. Large numbers of the specialised *Mansonia* and *Coquillettidia* larvae, which directly attach to water hyacinth roots to satisfy their oxygen needs, were also collected. While these are of minor concern for disease spread in Australia (they are important vectors of filariasis overseas), they are a significant biting pest locally.

Future experiments will investigate the ecological drivers that determine mosquito larvae distribution in water weed infestations. This knowledge will help us develop water weed management scenarios that specifically address one of the impacts of water hyacinth.

Collaborators

- Brisbane City Council
- Gold Coast City Council
- Scenic Rim Regional Council

17. Control and ecology of *Stevia ovata*

Project dates

July 2012 – June 2018

Project team

Melissa Setter, Stephen Setter and Simon Brooks

Project summary

While *Stevia ovata* (candyleaf) is recorded only in the southern Atherton Tablelands region of north Queensland, it is deemed such a threat to the area that it has been declared under local law by the Tablelands Regional Council. It is ranked as the sixth highest priority weed in the council's Local Area Pest Management Plan 2013–17.

Candyleaf is also included in weed lists from the Far North Queensland Pest Advisory Forum and the Wet Tropics Management Authority and is Category 3 Restricted Biosecurity Matter in the Queensland *Biosecurity Act 2014*.

A *Stevia ovata* working group of stakeholders—including local government, state government, energy companies and landholders—requested research into herbicide control of *Stevia ovata* be undertaken, along with studies to determine seed-bank longevity and age to reproductive maturity. Research into the following aspects has been completed:

- germination requirements
- reproductive maturity
- seed longevity in soil (in the Wet Tropics and the Dry Tropics of north Queensland)
- seed longevity in water
- pilot herbicide screening
- herbicide screening.

A further field experiment to refine suitable rates of successful herbicides commenced in June 2015. Low-volume/high-concentration techniques (suited to less accessible *Stevia ovata* sites) will be tested mid-2016.

Collaborators

- Stevia ovata stakeholder group includes community members, energy companies, local councils and government
- Biosecurity officers (Queensland)
- Far North Queensland Regional Organisation of Councils
- Tablelands Regional Council
- Terrain NRM

18. Invasive grass ecology and management

Project dates

July 2006 – June 2016

Project team

Wayne Vogler and Emma Carlos

Project summary

This project aims to improve on the limited herbicide options for invasive grasses. Most options are non-selective and so risk significant non-target damage.

Initial herbicide research using both granular and liquid forms of flupropanate has been promising for the control of gamba grass, perennial mission grass and grader grass, but not thatch grass. Field testing of hormone herbicides (2,4-D and Dicamba) on grader grass to reduce seed set to near zero is planned following an earlier successful pilot study.

Collaborators

- Queensland Parks and Wildlife Service
- Biosecurity officers, (Queensland)
- Mareeba Shire Council
- landholders
- North Queensland Dry Tropics

Key publications

Vogler, WD & Green W, 2011, 'Spray topping: a potential tool for managing grader grass (*Themeda quadrivalvis*)', in J Hodgon *et al*. (eds), *Proceedings of the 11th Queensland weed symposium, Queensland Weed Society*, Brisbane, Australia.

Vogler, WD 2009, *Grader grass management guide*, Burdekin Dry Tropics Natural Resource Management, Northern Gulf Resource Management Group, Southern Gulf Catchments, Australia, 8 pp.

Abom, R, Vogler, W & Schwarzkopf, L 2015, 'Mechanisms of the impact of a weed (grader grass, *Themeda quadrivalvis*) on reptile assemblage structure in a tropical savannah', *Biological Conservation*, vol. 191, pp. 75–82.

19. Ecology and management of *Chromolaena odorata*

Project dates

July 2008 – June 2016

Project team

Simon Brooks, Kirsty Gough, Stephen Setter, Shane Campbell and Melissa Setter

Project summary

The project supports the transition from eradication to ongoing management for *Chromolaena odorata* (Siam weed) by providing biological and control information to a range of stakeholders.

A paper identifying efficient herbicide options for treating remote, dense patches of Siam weed with low-volume herbicide applications has been published. Two further papers on the effects of fire on soil-borne and plant-borne seed are being drafted.

Data from a buried packet trial of the seed longevity of Siam weed seed in the dry tropics showed no surface seed is viable and less than 2% of buried seed is viable after five years' burial. This is consistent with an earlier trial in the wet tropics.

To better understand the potential distribution of *Chromolaena odorata*, seed from the wet tropics coast and Townsville areas has been included in an experiment examining the effect of temperature variability on seed viability.

Pot trials at Charters Towers and South Johnstone have shown that initial flowering behaviour is seasonally driven, as observed in the field. Plants established in between August and January commence flowering in early May. Growth, biomass and maturity data are being collected in conjunction with field data.

Collaborators

- Biosecurity Queensland staff at Charters Towers, South Johnstone, Mareeba and Townsville
- Queensland Parks and Wildlife Service

Key publications

Brooks, SJ, Gough, KL & Campbell, SD 2014. 'Refining low-volume, high-concentration herbicide applications to control *Chromolaena odorata* (L.) King & Robinson (Siam weed) in remote areas', *Plant Protection Quarterly*, vol. 29, pp. 71–77.

20. Eradication progress and biology of tropical weed eradication targets

Project dates

July 2008 – June 2018

Project team

Simon Brooks, Kirsty Gough, Stephen Setter, Shane Campbell and Melissa Setter

Project summary

The project concentrates on the key biological parameters influencing the field operations that are targeting tropical weeds for eradication, such as seed-bank persistence, age to maturity, and dispersal potential. The project also assesses control measures for these weeds.

During 2014–15, a buried packet field trial investigating *Miconia racemosa* seed persistence was established at the same site as current long-term seed-persistence trials for *Clidemia hirta*, *Miconia calvescens*, *Miconia nervosa* and *Mikania micrantha*. A glasshouse trial of *Limnocharis flava* seed persistence with varying periods of immersion is continuing. Field seed-bank densities and seedling population dynamics of *Clidemia hirta* and *Limnocharis flava* are also being monitored within individual infestations.

Field crew data and observations on the growth to maturity and reproductive seasonality of invasive melastomes are being collated to refine guidelines for identifying and preventing seed producing plants. New analysis of visit-frequency data and the location of large plants will facilitate investigations of survey accuracy. The second stage of an age-to-maturity pot trial on *M. micrantha* found some plants grew from cuttings to flowering in 137 to 203 days in a quarantine glasshouse.

The project also develops and refines measures of eradication progress and considerable advances were made in refining eradication reporting data to meet program milestones and to improve spatial and temporal consistency for all the target species.

Collaborators

- National Four Tropical Weeds Eradication Program
- North Region Biosecurity officers (Queensland)
- CSIRO Ecosystems Science (Atherton)

Key publications

Breaden, RC, Brooks, SJ & Murphy, HT 2012, 'The biology of Australian weeds 59. *Clidemia hirta* (L.) D. Don.', *Plant Protection Quarterly*, vol. 27(1), pp. 3–18.

Weber, JM and Brooks, SJ 2013, 'The biology of Australian weeds 62. *Limnocharis flava* (L.) Buchenau.', *Plant Protection Quarterly*, vol. 28(4), pp. 101–13.

21. Herbicide management of prickly acacia

Project dates

November 2013 – June 2017

Project team

Wayne Vogler, Emma Carlos and Nathan March

Project summary

The use of spray misting as a potential control option for prickly acacia regrowth continues to be investigated in the Mitchell grasslands region of western Queensland. Trial work at Julia Creek and Winton has further supported the concept and refined application rates of fluroxypyr (Starane Advanced). Based on the findings, a minor-use permit for spray misting of prickly acacia will be sought from the Australian Pesticides and Veterinary Medicines Authority.

Seed pod thickness, seed coat texture and seed hardness have been found to be good predictors of seed viability. These predictors will be further refined during the next year so that a visual method for determining seed viability will be available to land managers.

Novel herbicide application technique trials have been established to test helicopter (i.e. heli-drop), quad bike spreader and 'Epple Skatter gun' applications of tebuthiuron, as well as foliar spraying of seedlings using boom sprays.

All techniques have proven effective at herbicide application; however, final efficacy will not be determined until later in 2015–16.

Collaborators

- Southern Gulf Catchments
- Desert Channels Queensland
- Central West Local Government
- Central West Queensland and Southern Gulf landholders
- Biosecurity officers (Queensland)

22. Herbicide application research

Project dates

July 2009 – June 2016

Project team

Shane Campbell and Christopher Crowley

Project summary

The objective of this project is to improve herbicide control options for priority weeds in central, western and northern parts of the state.

Recently, we have been investigating the use of low-volume/high-concentration applications (splatter method) of herbicides on priority weeds. Bellyache bush, along with other weeds such as Siam weed and lantana, can now be effectively treated with metsulfuron-methyl using this technique.

Field testing of several herbicides is currently under way on rubber vine and prickly acacia.

Results of single-rate application of several agents on rubber vine:

Herbicide applied	Percentage of plants treated showing no signs of live growth six months post-application
triclopyr/picloram/aminopyralid (Grazon Extra)	100
triclopyr/picloram/aminopyralid (Tordon Regrowth Master)	96
aminopyralid/metsulfuron-methyl (Stinger)	85
metsulfuron-methyl (Brush-Off)	77
metsulfuron-methyl + glyphosate	38

A further assessment will be undertaken 18 months after the treatment of September 2015. This assessment will be followed by a rate-response trial using triclopyr/picloram/aminopyralid (Grazon Extra), the best-performing herbicide.

Data from the prickly acacia trial is still being analysed. It appears aminopyralid/fluroxypyr (Hotshot) is the best-performing herbicide, although efficacy has not been as good in the field as recorded during an earlier pot trial on young plants. At this stage, it looks like a suitable recommendation could be forthcoming for treating small plants (< 1 m in height) but not larger plants.

Collaborators

- Northern Gulf Resource Management Group

Key publications

McKenzie, J, Brazier, D, Campbell, S, Vitelli, J, Anderson, A & Mayer, R 2014, 'Foliar herbicide control of sticky florestina (*Florestina tripteris* DC.)', *The Rangeland Journal*, vol. 36, pp. 259–265.

23. Using molecular approaches to detect the presence of invasive species

Project dates

July 2012 – June 2016

Project team

Joseph Vitelli, Jane Oakey and Peter Jones

Project summary

This project aims to develop a methodology for the detection of environmental DNA (eDNA) of invasive species in aquatic environments. The initial test species will be *Mimosa pigra* and *Annona glabra*, two wetland pest plants. Both are Weeds of National Significance and are currently either the target of eradication (*M. pigra*) or extensive control (*A. glabra*) within Queensland.

Using eDNA to detect invasive species in aquatic systems could improve surveillance accuracy and efficiency, and potentially lead to better delimitation and early detection of invasive species in these systems.

Overseas, eDNA has been detected successfully for Asian carp and American bullfrogs and other cryptic or rare aquatic species. Biosecurity Queensland has had recent success with invasive mussels and red-eared slider turtles and is helping develop the technique for tilapia. The project has a state-wide focus and will combine field, glasshouse and laboratory studies. The project consists of three parts:

1. probe development to amplify, confirm and validate DNA detection
2. assess eDNA release by the target species to determine water sampling strategies (including decay rates)
3. field validation in catchments infested with either *M. pigra* or *A. glabra*.

Plant material from target and non-target species was collected for analysis during 2013–15. Laboratory assessments and field validations will be undertaken during 2015–16.

Collaborators

- Mackay Reef Catchments
- local governments
- Biosecurity officers, including Stacey Harris, Helen Haapakoski, Michelle Smith and Shane Haack (Queensland)

Key publications

Vitelli, JS, Oakey, J, Madigan, BA, Driver, L, Chamberlain, AA, & Heard, TA 2011, 'Molecular tools help determine the origins of *Mimosa pigra* infestations in Queensland, Western Australia and the Northern Territory', in J Hodgon (ed.), *Proceedings of the 11th Queensland weed symposium. Weed management; back to basics*, The Weed Society of Queensland, Mackay, Australia, pp. 65–68.

Applying granular flupropanate using a quad bike spreader for Gamba grass control

Christopher Crowley conducting mortality assessments of rubber vine

Demonstrating the use of splatter guns to a ranger group in north Queensland

Judy Clark monitoring biocontrol agent *Eueupithecia cisplatensis* at a parkinsonia release site

Tying on larva sprigs of biocontrol agent *Eueupithecia cisplatensis* at a parkinsonia release site

Wayne Vogler explains spray misting at a WoWW prickly acacia field day at Julia Creek

Amazon frog bit before herbicide treatment

Amazon frog bit 56 days after herbicide treatment

Anna Williams and Natasha Riding burying red witchweed seed packets

Red witch weed growing on sugar cane

Coquillettidia and *Mansonia* mosquito larvae attach to the roots of water hyacinth

Aquatic weed herbicide trial

Cylindropuntia fulgida at Moama, Queensland

Leaf-webber (*Morosaphycita morosalis*) damage on bellyache bush

Dactylopius tomentosus biotype effective against *Cylindropuntia fulgida*

Phakopsora arthuriana rust infection on bellyache bush

Damage from leaf-miner *Stomphastis* sp. on bellyache bush

Puccinia spegazzini pustules on *Mikania micrantha* in quarantine at ESP

Cluster fences are predicted to facilitate more effective management of pasure resources

Cluster fencing at Tambo is being monitored and evaluated by DAF researchers

Feral cat feeding on a macropod carcass

Mature chital stag with tracking collar in the Charters Towers region of north Queensland

Setting a foot-hold trap for wild dogs

Wild dog with a tracking collar

24. Red witchweed research program

Project dates

August 2013 – June 2023

Project team

Joseph Vitelli, Natasha Riding, Anna Williams and Annerose Chamberlain

Project summary

In July 2013, *Striga asiatica* (red witchweed) was discovered in sugar cane at Habana, near Mackay, and has since been gazetted as a notifiable pest in Queensland. Red witchweed is one of the world's worst weeds, as it is an obligate parasite of host plants such as corn (maize), sorghum, rice, sugar cane, cowpeas and other grain crops, such as millet and barley.

In addition, red witchweed can also parasitise more than 60 other species of grasses. Striga species have been described as 'one of the most serious biological constraints to food production' over large parts of sub-Saharan Africa, where they affect more than 40 per cent of cereal crops and have led to US$7 billion in agricultural production lost annually.

The Red Witchweed Response Plan identified research as an important component of the eradication program. Research priorities include determining aspects of red witchweed biology, detection methods and evaluating control techniques. A trial site has been established with buried sachets of red witchweed seed and treated with fumigation, false and true host crops, and pre- and post-emergent herbicides.

Collaborators

- Infested property owners Anthony Abela, Steve and Neiola Vella, Gale and Joe Gretch
- Dave McCallum, Mackay Area Productivity Services
- Farleigh Mill Mackay
- Biosecurity SA
- NRM biosecurity manager John Virtue, Primary Industries and Regions South Australia
- Technical solutions engineer John Roynon
- BOC Australia account manager gas applications Cassandra Robb and business manager Chris Dolman
- Brian Robotham, Scanconsulting

Key publications

Permit (PER14357) Various products/Various crops/ Witchweeds. Expires 31 Aug 2018

Permit (PER14361) Ethylene/Infected premises/Witchweeds. Expires 31 Mar 2019

25. Class 1 weed control packages

Project dates

July 2008 – June 2016

Project team

Joseph Vitelli, Annerose Chamberlain and Anna Williams

Project summary

This project aims to develop reliable and effective control options that can be integrated into eradication programs for Queensland Class 1 weeds (currently, 53 Class 1 species are naturalised).

The project also collects basic ecological data (e.g. time to reproductive maturity and soil seed-bank persistence) to determine optimal application (e.g. timing, frequency) of control. The project has a state-wide focus, bridging both aquatic and terrestrial environments, and combines field, glasshouse and laboratory studies.

Alligator weed has been the main species targeted since 2013. Eradication efforts for alligator weed have been hampered by a lack of effective control options (in particular, herbicides targeting its underground storage organs) and is a key knowledge gap identified in the *Weeds of National Significance alligator weed* (Alternanthera philoxeroides Griseb.) *strategic plan 2012–17*.

The work at the Ecosciences Precinct in Brisbane is building on past research and evaluating new herbicides, frequency and timing of applications and herbicide-application rates (i.e. concentrations). Studies involve control of both above- and below-ground material.

Collaborators

- Brisbane City Council
- Capricorn Pest Management Group
- Logan City Council
- Seqwater
- Brett Cawthray, Gladstone Regional Council
- Duaringa rural lands officer Scott Day, Central Highlands Regional Council
- Juliet Musgrave, Fraser Coast Regional Council
- local governments
- Tony Dugdale, Department of Environment and Primary Industries (Victoria)
- Biosecurity officers, including Michael Graham, Lyn Willsher, John Reeve, Stacey Harris, Dan McCudden, Helen Haapakoski, Shane Haack and Duncan Swan (Queensland)

Key publications

Silcock, RG, Mann, MB, Chow, S & Vitelli, JS 2012, 'Herbicides to control poisonous *Pimelea* species (Thymelaeaceae)', *Crop Protection*, vol. 31(1), pp. 99–106.

Vitelli, JS & Madigan, BA 2011, 'Evaluating the efficacy of the EZ-Ject herbicide system in Queensland, Australia', *Rangeland Journal*, vol. 33(3), pp. 299–305.

Bebawi, FF, Vitelli, JS, Campbell, SD & Mayer, RJ 2011, 'Impact of control strategies on bellyache bush (*Jatropha gossypiifolia* L.) mortality, seedling recruitment, population dynamics, pasture yield and cost analysis', *Rangeland Journal*, vol. 33(3), pp. 277–286.

26. Improved knowledge of pig population dynamics

Project dates

July 2013 – January 2015

Project team

Matt Gentle, Tony Pople and Joe Scanlan

Project summary

This project investigates the determinants of feral pig population fluctuations (i.e. numerical response). This is important for predicting population fluctuations and modelling the effects of control practices or strategies.

Rates of population increase of feral pigs appear to be strongly dependent on survival rates of juveniles. Sows cease to lactate when their crude protein intake drops below critical levels, resulting in high mortality of piglets. Rainfall is an important determinant of plant growth, and therefore protein levels.

In reality, the potential rate of increase is likely to be a function of food supply driven by rainfall (Choquenot 1998), although the actual rate of increase will be obviously influenced by other factors influencing mortality (e.g. disease, predation, control).

We are using rainfall/food supply as the key driver, but other factors (e.g. dog predation, baiting, harvesting, disease, availability of animal prey) are being investigated where possible. Field requirements are minimal as we are using previously collected field data (Gentle et al. 2013 and other) with additional data collated from unpublished sources.

Annual rates of increase for feral pig populations have been calculated for 21 sites, and corrected for the commercial harvest rate, 1080 baiting and other control (e.g. aerial shooting). Correlations between rate of increase and potential predictor variables (rainfall, pasture biomass and pasture growth) from AussieGRASS modelling, lagged for different time periods (0, 3, 6 and 12 months) have been completed on 10 sites with long time-series data.

Preliminary correlations indicate that pasture growth, pasture biomass and standardised rainfall are suitable predictors of population dynamics, particularly for southern Queensland sites in the Brigalow Belt bioregion. Candidate models comparing predictor variables and time periods are currently being completed using regression analysis.

Collaborators

- John Carter, Department of Science Information Technology Innovation (Queensland)
- Department of the Environment and Heritage Protection (Queensland)
- Australian Quarantine and Inspection Service
- Queensland Murray–Darling Committee

Key publications

Gentle, M & Pople, A 2013, 'Effectiveness of commercial harvesting in controlling feral pig populations', *Wildlife Research*, vol. 40(6), pp. 459–469.

Choquenot, D 1998, 'Testing the Relative Influence of Intrinsic and Extrinsic Variation in Food Availability on Feral Pig Populations in Australia's Rangelands', *Journal of Animal Ecology*, vol. 67, pp. 887–907.

Pople, AR, Grigg, GC, Phinn, SR, Menke, N, McAlpine, C & Possingham, HP 2010, 'Reassessing spatial and temporal dynamics of kangaroo populations' in *Macropods: the biology of kangaroos, wallabies and rat-kangaroos*, CSIRO Publishing, Melbourne, Australia, pp. 197–210.

27. Impacts of rabbits on vegetation dynamics in southern Queensland

Project dates

July 2013 – December 2015

Project team

Joe Scanlan, Michael Brennan and Peter Elsworth

Project summary

All grazing has the potential to influence pasture condition. Rabbits can exert considerable pressure on pasture from grazing, comparable to that of domestic livestock (Scanlan & Berman 1999).

The pasture growth model GRASP now has the capability to simulate changes in pasture condition (Scanlan et al. 2014) as a result of changes in pasture utilisation (i.e. the amount of forage consumed as a proportion of amount produced). Thus, utilisation depends on seasonal growing conditions (giving a particular amount of growth) and also on the number of grazing animals, domestic, native and feral (giving the amount of forage consumed).

Grazed and exclosure treatments were applied to areas with and without rabbits in the Stanthorpe area. Simulations based on the field data indicate rabbit populations would have to be much higher and/or growing conditions much poorer than experienced during this trial work for rabbits to negatively affect pasture or livestock production.

Pasture condition improved in all treatments, whether grazed or excluded from all grazing. Data has been collected to use within the economic analysis of the impact of various rabbit populations on beef cattle properties in southern Queensland. These economic analyses are being completed.

Key publications

Scanlan, JC & Berman, D 1999, 'Determining the impact of the rabbit as a grazing animal in Queensland', *Proceedings of the VI International Rangeland Congress*, Townsville, Australia, pp. 520–521.

Scanlan, JC, Berman, DM & Grant, WE 2006, 'Population dynamics of the European rabbit (*Oryctolagus cuniculus*) in north eastern Australia: simulated responses to control', *Ecological Modelling*, vol. 196(1), pp. 221–236.

Scanlan, JC, McIvor, JG, Bray, SG, Cowley, RA, Hunt, LP, Pahl, LI, MacLeod, ND & Whish, GL 2014, 'Resting pastures to improve land condition in northern Australia: guidelines based on the literature and simulation modelling', *The Rangeland Journal*, vol. 36, pp. 429–443.

28. Rabbits in north Queensland

Project dates

July 2013 – June 2016

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

Rabbits have traditionally been in low numbers in north Queensland, most likely due to the problems of breeding in this warmer part of the state; however, there are reports of increasing rabbit numbers.

While rabbits are not seen as a major issue by most landholders, they recognise that rabbits are breeding up and could become a problem. Biosecurity officers and local governments recognise the problem and need better information for the implementation of management programs.

In southern and western Queensland, the biology of rabbits is well known, as are control techniques to manage them. This is not the case in north Queensland, where temperatures are generally higher than what is considered suitable for successful breeding (Cooke, 1977). Rabbits are, however, persisting in this region and so must be breeding.

Initial surveys have shown rabbits are using hollow logs and bushes as harbour rather than constructing warrens. Some breeding with reduced litter sizes has been observed year-round. Further surveys will help find the most successful breeding periods and the environmental conditions that support successful breeding.

Collaborators

- Tablelands Regional Council
- Mareeba Shire Council
- Charters Towers Regional Council
- Dalrymple Landcare

Key publications

Cooke, B 1977, 'Factors limiting the distribution of the wild rabbit in Australia', *Proceedings of the Ecological Society of Australia*, vol. 10, pp. 113–120.

29. RHD Boost monitoring

Project dates

April 2014 – June 2017

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

Rabbit haemorrhagic disease virus (RHDV) has greatly reduced rabbit numbers throughout Australia. Recent evidence of resistance (Elsworth et al. 2012) and the presence of a non-pathogenic rabbit calicivirus (RCV-A1) that provides partial protection against RHDV (Strive et al. 2009; Strive et al. 2013) have led to the exploration of an additional strain of RHDV to be imported into Australia for release.

This national project—called RHD Boost—has completed its laboratory testing phase and has identified the best strain for release. To assess its success in the wild and better understand the epidemiology of the disease for future releases, field sites are being established throughout Australia.

In Queensland, two sites are being monitored to assess the rabbit populations prior to and following the release of RHD Boost. If successful, this new strain will help maintain low rabbit numbers, but will need to be integrated with conventional control methods to be fully effective.

Collaborators

- Invasive Animals Cooperative Research Centre
- CSIRO
- Department of Primary Industries (NSW)
- Primary Industries and Regions Biosecurity (South Australia)
- Shane Lampard, Somerset Regional Council
- Craig Magnussen and Peter Rouen, Southern Downs Regional Council
- Harley West, Landcare
- Darling Downs – Moreton Rabbit Board

Key publications

Elsworth, PG, Kovaliski, J & Cooke, BD 2012, 'Rabbit haemorrhagic disease: are Australian rabbits (*Oryctolagus cuniculus*) evolving resistance to infection with Czech CAPM 351 RHDV?' *Epidemiology and Infection*, vol. 140, pp. 1972–1981.

Strive, T, Wright, JD & Robinson, AJ 2009, 'Identification and partial characterisation of a new lagovirus in Australian wild rabbits', *Virology*, vol. 384, pp. 97–105.

Strive, T, Elsworth, PG, Liu, J, Wright, JD, Kovaliski, J & Capucci, L 2013, 'The non-pathogenic Australian rabbit calicivirus RCV-A1 provides temporal and partial cross protection to lethal Rabbit Haemorrhagic Disease Virus infection which is not dependent on antibody titres', *Veterinary Research*, vol. 44, pp. 51.

30. Assessing impact of rabbits on horticulture

Project dates

July 2013 – December 2015

Project team

Peter Elsworth, Michael Brennan and Joe Scanlan

Project summary

The economic cost of rabbits to agricultural industries in Australia is currently estimated at approximately $200 million per year (Gong et al. 2009) and would have been much more significant in the absence of viral biocontrol tools (Cooke 2013). These figures, however, are produced from estimated losses to the beef and wool industries as a result of competition for feed with livestock.

Little is known about the effect rabbits have on horticultural crops, although it has long been known that they eat them

(Rowley, 1963). This industry is not considered in the estimates of economic costs that rabbits cause to Australia.

Queensland produces one-third of the nation's fruit and vegetable produce—an industry worth more than $2 billion per year (figures from Growcom). Many of the growing areas are in regions of high rabbit numbers or regions of potential rabbit expansion. Using controlled experiments, the damage of rabbits to certain horticultural crops will be determined. This will enable land users to make better management decisions in regards to control of rabbits.

Collaborators

- University of Queensland (Gatton)
- Growcom
- Somerset Regional Council
- Southern Downs Regional Council
- Landcare
- Darling Downs – Moreton Rabbit Board
- Invasive Animals CRC

Key publications

Cooke, B, Chudleigh, P, Simpson, S & Saunders, G 2013, 'The Economic Benefits of the Biological Control of Rabbits in Australia, 1950–2011', *Australian Economic History Review*, vol. 53, pp. 91–107.

Rowley, I 1963, 'Bait materials for poisoning rabbits, I. Studies on the acceptance of bait materials by caged rabbits', *Wildlife Research*, vol. 8, pp. 56–61.

31. Rabbit population viability in southern Queensland and the influence of above-ground harbour

Project dates

July 2013 – December 2015

Project team

Joe Scanlan, Michael Brennan and Peter Elsworth

Project summary

Data from the Stanthorpe region indicates the mortality rate of rabbits that live in above-ground harbour is much higher than for rabbits that live in warrens. This raises the question as to whether these rabbits can sustain a population if their only harbour is above ground.

An individual-based model of rabbits in the region has been developed using the NetLogo software. The model allows comparison of the effects of different habitat suitability (specifically the amount of harbour) on the population dynamics.

With reproductive and mortality rates observed during the trial at Cottonvale (Stanthorpe) and other similar work, rabbits could survive in good, fair and poor habitat suitability in the absence of predation and with harbour. However, a modest amount of predation limited survival overall and prevented survival in the poor habitat. Similarly, removal of harbour also reduced the likelihood of long-term survival.

A feature not yet included in the model is predation being linked to habitat suitability. Such a model could contribute to the regional scale modelling work of Murray et al. (2014).

Key publications

Murray, JV, Berman, DM & van Klinken, RD 2014, 'Predictive modelling to aid the regional-scale management of a vertebrate pest', *Biological Invasions*, vol. 16, pp. 2403–2425.

32. Adaptive management of peri-urban deer in South East Queensland

Project dates

March 2015 – June 2017

Project team

Michael Brennan, Matt Amos, Tony Pople, Hellen Haapakoski and Stacy Harris

Project summary

Wild deer populations (rusa, red, fallow and chital) in South East Queensland have grown to a size where they are now considered serious pests. Their impacts range from agricultural production losses (crop and forestry damage, competition with livestock), browsing and grazing damage in conservation areas, and collisions with vehicles.

Deer populations appear to be growing, requiring management plans for current populations to have an eye to the future by not just controlling current impacts, but, ideally, containing populations and developing capability for future control. There has been limited control effort in South East Queensland, but control is frustrated by availability of effective control tools, community opposition and concern over public safety and non-target injury when applying lethal control.

The project is focused on deer (primarily red and rusa) hotspots in the Sunshine Coast area, in particular within the Gympie, Noosa and Sunshine Coast Regional Council areas. An initial workshop was held in February 2015 with staff from these councils. These councils have only recently begun monitoring deer species and an aspect of the project will be to support and help refine monitoring activities. Seasonal movements of deer will also be examined using radio telemetry.

The project will assess the cost-effectiveness of removing deer through trapping and shooting, and the effectiveness of using radio-collared 'Judas' animals. A toxin-delivery device has been built and deployed in a non-toxic trial, following success in New South Wales. Community views on deer and their management will be canvassed to identify acceptable management action.

Collaborators

- Ben Curly and Phil Herrington, Gympie Regional Council
- Richard Mylan, Noosa Shire Council
- Mark Kimber, Sunshine Coast Regional Council
- Rob Hunt, National Parks and Wildlife Service (NSW)
- Biosecurity officers Duncan Swan, Matt Ryan and Lyn Willsher (Queensland)
- Biosecurity Queensland policy staff Petra Skoien and Carmel Kerwick
- Mark Ridge, Darling Downs – Moreton Rabbit Board

Key publications

Amos, M, Baxter, G, Finch, N, Lisle, A, & Murray, P 2014, 'I just want to count them! Considerations when choosing a deer population monitoring method', *Wildlife Biology*, vol. 20(6), pp. 362–370.

Doerr, ML, McAninch, JB, & Wiggers, EP 2001, 'Comparison of 4 Methods to Reduce White-Tailed Deer Abundance in an Urban Community', *Wildlife Society Bulletin*, vol. 29(4), pp. 1105–1113.

Hunt, RJ, Claridge, AW, Fleming, PJS, Cunningham, RB, Russell, BG, & Mills, DJ 2014, 'Use of an ungulate-specific feed structure as a potential tool for controlling feral goats in Australian forest ecosystems', *Ecological Management & Restoration*, vol. 15, pp. 231–238.

33. Ecology and management of chital deer in north Queensland

Project dates

July 2014 – December 2017

Project team

Tony Pople, Mike Brennan, Matt Amos and Joe Scanlan

Project summary

Little is known about the basic ecology of chital deer (*Axis axis*) in Australia despite it being established in north Queensland since the late 1800s. Populations have been spreading and increasing in size over the past 20 years. Chital deer are increasingly being viewed as a serious pest animal, mainly through competition with cattle.

Information on their impacts, control methods and capacity for increase and spread is needed to develop long-term management strategies. Limiting factors are likely to be a combination of dingo predation and food supply, particularly availability of water and high-quality food.

Helicopter surveys using mark-recapture line-transect methods determined the broad-scale distribution and abundance of chital deer in their historical range near Charters Towers, estimating a population around 30,000. Walked surveys were undertaken simultaneously along some of the aerial survey lines, enabling further calibration of the aerial counts. The population is patchily distributed across the landscape, with animals concentrated around homesteads and permanent water. This offers strategic opportunities for control. The association between deer-abundance, habitat and wild-dog abundance will be examined in 2016.

Shot samples of deer have been taken in dry and wet seasons on two properties to monitor the seasonal decline in body condition and change in diet of deer and year-to-year variation in reproductive output. These parameters will be related to population density and pasture conditions. Dietary overlap with cattle is also being examined in a Masters study.

A cull of over 500 deer on one property represented approximately a 22% removal. The effectiveness of this and follow-up removals is being monitored.

Collaborators

- Neal Finch, Department of Environment and Heritage Protection (Queensland)
- Keith Staines and Glen Harry, Sporting Shooters Association of Australia
- University of Queensland students Kurt Watter (Masters), Cameron Wilson (Masters), Dan Baillie (Honours), Peter Murray and Greg Baxter
- Lauren O'Bryan and Rodney Stevenson, Biosecurity Queensland

Key publications

Fewster, RM & Pople, AR 2008, 'A comparison of mark-recapture distance-sampling methods applied to aerial surveys of eastern grey kangaroos', *Wildlife Research*, vol. 35, pp. 320–330.

Forsyth, DM & Davis, NE 2011, 'Diets of non-native deer in Australia estimated by macroscopic versus microhistological rumen analysis', *The Journal of Wildlife Management*, vol. 75, pp. 1488–1497.

Simard, MA, Dussault, C, Huot, J & Côté, SD 2013, 'Is hunting an effective tool to control overabundant deer? A test using an experimental approach', *The Journal of Wildlife Management*, vol. 77, pp. 254–269.

34. Peri-urban wild dog ecology and management

Project dates

July 2012 – June 2016

Project team

Matt Gentle, Ben Allen, James Speed and Lee Allen

Project summary

Management tools used to control wild dogs across rural Australia have restricted use in peri-urban areas. Peri-urban wild dog management is often contentious and difficult to implement given the presence of a variety of stakeholders with wide-ranging and often conflicting ideologies. This is confounded by the lack of information about the ecology of peri-urban wild dogs, or how best to control their increasing impacts, including spreading zoonotic diseases, maiming and killing domestic pets and livestock, and harassing and attacking people.

This project aims to improve our understanding about wild dog ecology, impacts and management in these difficult-to-manage peri-urban areas. Almost two-thirds of the funding is through the Invasive Animals Cooperative Research Centre.

The movement ecology of wild dogs is being studied using 36 satellite collars deployed in the Sunshine Coast – Moreton Bay, City of Gold Coast and Townsville local government areas. Wild dogs travel an average of 6.4 km/day (n = 28). Temporal patterns in daily activity are highly variable, although most dogs are crepuscular or nocturnal. Some collared dogs have occupied largely circular home range areas, inclusive of bushland, as expected. Others have occupied road edges almost exclusively.

Breeding and pup-rearing is occurring within a few hundred metres of houses and built-up areas. Several dogs regularly travel into suburban areas and walk around houses at night.

Diet analysis (n = 546 scats) indicated a high occurrence of mammals, with apparent regional differences. Smaller mammals are more common in dog diets from south-eastern Queensland, whereas larger mammals (e.g. agile wallabies) are more common in dog diets in north Queensland. Human-sourced food is rarely detected.

A trial to determine the rate of degradation of PAPP (a new toxin for wild dogs) in commercially-manufactured baits is being completed. This will help to inform pest managers about the longevity of PAPP baits. This is a necessary piece of information to develop management strategies for PAPP use, for example in determining withholding periods for domestic dogs from baited areas.

Collaborators

- Invasive Animals Cooperative Research Centre
- Department of Primary Industries (NSW)
- Meat and Livestock Australia
- Brisbane City Council
- Council of the City of Gold Coast
- Logan City Council
- Moreton Bay Regional Council
- Somerset Regional Council
- Sunshine Coast Regional Council
- Tweed Shire Council
- University of New South Wales
- University of Queensland

Key publications

Allen, BL, Goullet, M, Allen, LR, Lisle, A & Leung, LK-P 2013, 'Dingoes at the doorstep: Preliminary data on the ecology of dingoes in urban areas', *Landscape and Urban Planning*, vol. 119, pp. 131–135.

Gentle, M, Allen, B, Speed, J & Allen, L 2014, 'The impacts and management of peri-urban wild dogs', in Gentle, M (ed.), *Program and abstracts 16th Australasian vertebrate pest conference*, Invasive Animals CRC, Brisbane, Australia, 26–29 May 2014, p. 110.

Harriott, L, Gentle, M, Traub, R, Soares Magalhães, R & Cobbold, R 2014, 'Disease prevalence and public health risks of peri-urban wild dogs', in Gentle, M (ed.), *Program and abstracts 16th Australasian vertebrate pest conference*, Invasive Animals CRC, Brisbane, Australia, 26–29 May 2014, p. 108.

35. Wild dogs and calf loss: analysis of Cash Cow

Project dates

September 2013 – June 2015

Project team

Lee Allen

Project summary

Cash Cow was a $3.5 million, MLA-funded (DAF/University of Queensland) project conducted between 2008 and 2011 on 72 beef cattle properties across northern Australia to identify the causes of poor reproductive performance.

The follow-up Cash Cow study identified a significantly higher mean calf loss on properties whose owners perceived that wild dogs affected their enterprise and baited (11.8%) or intermittently controlled wild dogs by trapping and shooting (10.8%) compared to those properties whose owners perceived wild dogs were not a problem and took no action to control wild dogs (6.3%). Independent manipulative studies comparing calf loss with and without baiting generally fail to detect baiting effects on calf predation in most years.

The large Cash Cow dataset provided a unique opportunity to further explore the relationship between calf loss, seasonal conditions and wild dog management. The supplementary analysis of the Cash Cow data incorporated wild dog management histories, annual rainfall (relative to long-term mean annual) and monthly rainfall for individual Cash Cow properties into a statistical model.

Baiting frequency had no effect on calf loss in mature cows. Compared to annual baiting calf loss was higher in first-lactation cows when baiting was not conducted, yet no different to when baiting was conducted twice or more annually. This suggests other factors are involved.

Calf loss was higher in dry and very wet years. This analysis suggests predation events could be predicted and subsequently managed before losses are sustained.

Collaborators

- Prof Mike McGowan, Cash Cow Principal Investigator
- University of Queensland School of Veterinary Science
- Geoff Fordyce and Tamsin Barnes, Queensland Alliance for Agricultural and Food Innovation, University of Queensland
- Kieren McCosker, Department of Primary Industry and Fisheries (Northern Territory)

Key publications

Allen, LR 2014, 'Wild dog control impacts on calf wastage in extensive beef cattle enterprises', *Animal Production Science*, vol. 54, pp. 214–220.

McGowan, M, Fordyce, G, O'Rourke, P, Barnes, T, Morton, J, Menzies, D, Jephcott, S, McCosker, K, Smith, D, Perkins, N, Marquart, L, Newsome, T & Burns, B 2014, *Final report, Northern Australian beef fertility project: Cash Cow*, Meat & Livestock Australia Limited, North Sydney, Australia, p. 301.

36. Cluster fencing evaluation

Project dates

October 2013 – December 2018

Project team

Lee Allen, Joe Scanlan, Peter Elsworth and Tony Pople

Project summary

In 2013, South West NRM contracted groups of graziers to cooperatively erect predator-proof 'cluster fences' around multiple, contiguous grazing properties in order to better manage livestock predation and total grazing pressure.

Current control of wild dogs involves a combination of baiting, trapping and shooting. To be effective, these methods need to be applied on a broad-scale across multiple properties, requiring participation by a high proportion of landholders. Participation in control programs remains a constant challenge despite facilitation by government and industry. Kangaroo control similarly needs to be broad-scale to be effective, but is currently sporadic and uncoordinated. Cluster fences offer a potential solution and a means for landholders to be self-sufficient, but the approach requires assessment before they can be widely promoted.

This project is monitoring the numbers of kangaroos, wild dogs and other species inside and outside one cluster fence to provide the empirical data to evaluate the cost-effectiveness of cluster fencing. Changes in pasture biomass and composition are also being monitored as improved pasture production from reduced kangaroo numbers is expected to translate into increased livestock production.

Collaborators

- Catherine Crowden, South West NRM
- Bill Johnson, Department of Agriculture and Fisheries (Queensland)
- Philip Maher, Department of Natural Resources and Mines (Queensland)

Key publications

Allen, L, Engeman, R & Krupa, H 1996, 'Evaluation of three relative abundance indices for assessing dingo populations', *Wildlife Research*, vol. 23, pp. 197–206.

Engeman, R & Allen, L 2000, 'Overview of a passive tracking index for monitoring wild canids and associated species', *Integrated Pest Management Reviews*, vol. 5, pp. 197–203.

Engeman, R, Pipas, M, Gruver, K, Bourassa, J & Allen, L 2002, 'Plot placement when using a passive tracking index to simultaneously monitor multiple species of animals', *Wildlife Research*, vol. 29, pp. 85–90.

37. Feral pig movements: individual- and population-scale

Project dates

June 2014 – June 2016

Project team

Matt Gentle and Joe Scanlan

Project summary

This project uses GPS tracking to assess the movements of feral pigs in an agricultural landscape of southern Queensland. This will improve our knowledge of feral pig movements and ranging behaviour, particularly: habitat use, foraging and rest areas, periods when crop (or other commodity) areas are utilised, and range size.

Tissue samples for DNA analysis will also be opportunistically collected from routine feral pig control programs conducted within and adjacent to research sites. Samples would be assessed for relatedness to help determine the size and boundaries of population management units. Funding will be sought to complete the DNA analysis in future years.

This work is part of a professional doctorate study by a Queensland Murray–Darling Committee (QMDC) officer working with both the University of New England (Australia) and Pennsylvania State University (USA). This study aims to foster community engagement through scientific research.

QMDC is responsible for completing the field work and the community engagement component; Biosecurity Queensland staff are assisting in the design of the ecological study, data analysis and preparation of scientific articles from this data.

The primary field component of this project—collaring of feral pigs—was delayed until 2016 to fit in with other project milestones, specifically implementing pre-treatment surveys for the initial community engagement component. Field sites, consisting of properties managed or leased by Origin Energy, Queensland Gas Corporation and Santos, have been identified and approved for use.

Collaborators

- Queensland Murray–Darling Committee
- Biosecurity Queensland
- Origin Energy
- Queensland Gas Corporation
- Santos
- Various landholders, primarily farmers and graziers

Key publications

Marshall, D, Gentle, M & Alter, T 2014, 'Using ecological research to reduce barriers to achieve effective feral pig management', in Gentle, M (ed.), *Program and abstracts 16th Australasian vertebrate pest conference*, Invasive Animals CRC, Brisbane, Australia, 26–29 May 2014, p. 75.

38. Feral cat ecology: population-scale movements

Project dates

July 2014 – June 2016

Project team

Matt Gentle, James Speed and Jane Oakey

Project summary

At Astrebla Downs National Park (ADNP) in western Queensland, predation by feral cats is a significant threat to the greater bilby—a threatened small mammal species.

Feral cat densities at ADNP increase dramatically following 'flush' periods of food surplus (e.g. native long-haired rat plague). Following a decline in this temporary prey source, the remaining (high-density) population of feral cats poses an increased predation pressure to bilbies.

The high abundance of feral cats triggered the Queensland Parks and Wildlife Service (QPWS) to launch an intensive management program. While this program focuses on reducing cat abundance on ADNP, it is uncertain whether these animals are residents, offspring of residents, or immigrants from outlying or adjacent areas. Understanding the 'source' or population boundary of cats at ADNP is important to help improve management—to ensure that the 'whole', not just part, of the cat population can be managed.

More than 3000 tissue samples have been collected through the QPWS management program in far western Queensland. This project will determine 'proof of concept' for the application of DNA to determine population boundaries of the feral cat population at ADNP. If this project is successful, funding will be sought to increase the sample size and scope of this study.

Collaborators

- Barry Nolan, Department of National Parks, Sport and Racing (Queensland) and Maree Rich, Department of National Parks, Sport and Racing (Queensland)

Key publications

Rich, M, Nolan, B, Speed, J & Gentle, M 2014, 'Lessons in feral cat control – can adaptive management provide the solution?' in Gentle, M (ed.), *Program and abstracts 16th Australasian vertebrate pest conference*, Invasive Animals CRC, Brisbane, Australia, 26–29 May 2014, p. 43.

39. Chemical registration: providing tools for invasive pest control

Project dates

July 2012 – June 2018

Project team

Joseph Vitelli and David Holdom

Project summary

Biosecurity Queensland holds permits for use of pesticides to control invasive plants and animals. The need for permits has increased as pesticide registrants focus primarily on more profitable crop protection rather than environmental protection, resulting in reduced availability of pesticides for controlling invasive species.

Applications to obtain registrations or permits for pesticide use follow a set of guidelines laid down by Australian Pesticides and Veterinary Medicines Authority (APVMA). More information is required for new (unregistered) pesticides than for registered products. The volume of information required also varies depending on the sensitivity of the situation (e.g. aquatic environments) and the extent to which the proposed new use varies from existing registered or permitted uses.

Through collaboration with local governments, agribusiness and scientists, the project facilitates the development of chemical-registration submissions and the review and evaluation of permits and products for herbicides used by Biosecurity Queensland and local government authorities for the control of invasive plants.

Timely permit submissions will ensure:

1. key deliverables within the Invasive Plants and Animals Program are met
2. extended delays in acquiring new emergency and minor-use permits to control declared pest plants are minimised
3. an effective network is maintained with the APVMA to ensure a seamless renewal and permit-extension process.

Collaborators

- Local governments
- Seqwater
- Agribusinesses, including Sumitomo Chemical, Nufarm Australia, Macspred and Dow AgroSciences
- Department of National Parks, Recreation, Sport and Racing (Queensland)
- Department of Transport and Main Roads (Queensland);
- Biosecurity officers, including Sonia Jordan, Steve Csurhes, Corey Bell, Craig Hunter, Michael Graham, Lyn Willsher, John Reeves, Stacey Harris and Duncan Swan

Key publications

APVMA issued nine new permits to Biosecurity Queensland during FY2014–15:

- Permit (PER11463) Various products and chemicals / Non-Agricultural areas / Environmental Weeds. Expires 30 Jun 2018.
- Permit (PER80472) Glyphosate, Metsulfuron methyl & Amitrole / Aquatic situations / Water mimosa & Dead and awake. Expires 31 Jan 2019.
- Permit (PER11920) 2,4-D Amine, Metsulfuron methyl, 2,4-D Amine + Picloram / Pasture Stock Routes, Roadsides & Non Crop Situations / Florestina. Expires 31 Mar 2020.
- Permit (PER11540) Haloxyfop / Ponds, Drainage areas, Waterways, Pastures, roads & Utility reserves / Hymenachne. Expires 30 Jun 2016.
- Permit (PER14849) Various herbicides / Non-agricultural, native vegetation and pasture / Kudzu. Expires 31 Aug 2019.
- Permit (PER80929) Metsulfuron-methyl / Pastures, Roadsides, Non-crop areas, Rights of way, Forests, Reserves and Bushland / Bahia Grass and Fireweed. Expires 30 May 2020.
- Permit (PER13684) Triclopyr, picloram (Access Herbicide and Tordon DSH); Fluroxypyr (Starane Advanced Herbicide); Glyphosate (Roundup Biactive) & Imazapyr (Unimaz 250 SL Herbicide) / Various situations / Pond Apple. Expires 30 Jun 2020.
- Permit (PER80065) Sempra Herbicide (halosulfuron-methyl) / Roadsides, rights-of-way, footpaths, commercial and industrial areas / Navua Sedge. Expires 31 Mar 2017.
- Permit (PER14122) Metsulfuron-methyl / Non-potable waterways / Kidneyleaf mudplantain. Expires 30 Jun 2020.

Where other states hold permits for identical situations, APVMA encourages the inclusion of other states on those permits. This process is much faster than applications for a new permit, typically requiring days rather than months.

40. Pest management chemistry

Project dates

Ongoing

Project team

Stephen Were, Patrick Seydel and Alyson Herbert

Project summary

This project provides chemistry services to science, policy and operational activities within Biosecurity Queensland's Invasive Plants and Animals Program.

These services comprise pesticide advice and 1080 production for pest management in Queensland and toxicological and eco-toxicological investigations into the use of vertebrate pesticides. The project is undertaken in Biosecurity Queensland's Chemical Residue Laboratory at the Queensland Government's Health and Food Sciences Precinct at Coopers Plains, Brisbane.

Forensic toxicology

Over the year, our laboratory performed more than 80 investigations into possible animal poisonings: 57 for sodium fluoroacetate; 21 for strychnine; and five for anticoagulants. While most investigations related to domestic dogs and cats, a number involved feral cats.

Formulation chemistry

During the year, our formulation facility produced 2175 litres of 1080 36g/L pig bait solution in accordance with upcoming registration of the formulation with the APVMA.

Testing of post-preparation sodium fluoroacetate solutions and meat baits continued throughout the year.

External funding

Research and development contracts

Project/research area	Funding body	Funds ($)
Weed biocontrol in Solomon Islands and Vanuatu	AusAID	27 000
Weed biocontrol in Papua New Guinea	AusAID	88 000
Controlling calotrope in northern Australia	Meat and Livestock Australia	125 000
Biological control of prickly acacia	Meat and Livestock Australia	146 000
Biological control of weeds in Melanesia	Australian Centre for International Research	28 000
Biological control of *Lantana camara*	NSW Weed Biocontrol Taskforce	4 000
DNA sampling of pond apple	Reef Catchments	6 000
Peri-urban wild dog control	Invasive Animals Cooperative Research Centre	203 000
Total		**627 000**

Land Protection Fund

Project/research area	Funds ($)
Weed seed dynamics	4 000
Herbicide application research	159 000
Biological control of bellyache bush	114 000
Biological control of prickly acacia	87 000
Biological control of cat's claw creeper	161 000
Biological control of cactus	77 000
Biological control of lantana	63 000
Biological control of mother of millions	1 000
Rearing and release of weed biological control agents	139 000
Biocontrol evaluation	135 000
Restoration evaluation	1 000
Water weed ecology and management research	141 000
Feral deer best-practice research	87 000
Wild dog best-practice research	115 000
Rabbit best-practice research	280 000
Pesticide authorities	74 000
Pest management chemistry and chemical registration	99 000
Total	**1 638 000**

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Publications and presentations

Journal articles

Abom, R, Vogler, W & Schwarzkopf, L 2015, 'Mechanisms of the impact of a weed (grader grass, *Themeda quadrivalvis*) on reptile assemblage structure in a tropical savannah', *Biological Conservation*, vol. 191, pp. 75–82.

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Forums and workshops

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Carlos, E 2014, *Prickly acacia seed germination in saline conditions*, War on Western Weeds Advisory Group meeting, Hughenden, Australia, 21–22 October.

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Dhileepan, K 2014, *Biological control of prickly acacia*, Indonesian delegation (weed biological control), Ecosciences Precinct, Brisbane, 18 December.

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Riding, N, 2015, *Beaut Bugs, Bees & Beetles Cross-Pollination Event*, Gympie Landcare, Australia, 5 March.

Riding, N 2015, *Biological control of weeds*, North Burnett Regional Council, Gayndah, Australia, 26 March.

Rusli, M, Leung, L & Elsworth, P 2015, *Lockyer Valley Rabbit Group Meeting*, attended by landholders and the Lockyer Valley Regional Council, Gatton, Australia, 24 April.

Setter, M 2015, *Stevia ovata research*, Tablelands Regional Council Pest Advisory Committee and Stevia working group meeting, Ravenshoe, Australia, 4 March.

Setter, MJ 2015, *Research update*, Tropical Class 1 operational meeting, Cairns, Australia, 12 March.

Snow, EL 2015, *Beaut Bugs, Bees & Beetles Cross-Pollination Event*, Gympie Landcare, Australia, 5 March.

Snow, EL 2015, *Cat's claw creeper biocontrol*, Gayndah Council Weed Workshop, Gayndah, Australia, 26 March.

Taylor, DBJ 2015, *Biological control of cat's claw creeper*, NSW North Coast 2015 Weeds Forum, Tweed Heads South, Australia, 25 March.

Vogler, W 2014, *Prickly acacia herbicide application techniques update*, War on Western Weeds Advisory Group meeting, Hughenden, Australia, 21–22 October.

Vogler, W 2014, *Prickly acacia heli-drop and other herbicide application techniques*, Gulf Catchments Pest Taskforce, Julia Creek, Australia, 24–25 November.

Vogler, W 2014, *Prickly acacia spray misting*, Shire Rural Lands Officer Group meeting, Boulia, Australia, 17 September.

Vogler, W 2014, *Grader grass ecology and management*, North Queensland Dry Tropics Lolworth Creek Landcare meeting, Glencoe Station, Charters Towers, Australia, 2 September.

Vogler, W 2014, *Grader grass ecology and management*, Beef Producer meeting, Junction Creek Station, Charters Towers, Australia, 5 September.

Vogler, W 2014, *Grader grass ecology and management*, Beef Producer Meeting, Greenvale, Australia, 20 August.

Vogler, W 2015, *Prickly acacia heli-drop and other herbicide application techniques*, Shire Rural Lands Officer Group meeting, Winton, Australia, 18 March.

Vogler, W 2015, *Grader grass ecology and management*, North Queensland Dry Tropics Woodstock Landcare meeting, Woodstock, Australia, 15 May.

Vogler, W 2015, *Weed management tools update*, Western Districts Capacity Building Workshop, Idalia National Park, Blackall, Australia, 16 April.

Vogler, W 2015, *Prickly acacia heli-drop and other herbicide application techniques update*, War on Western Weeds Advisory Group meeting, Richmond, Australia, 28–29 April.

Vogler, W 2015, *Prickly acacia seed passage through cattle*, Prickly Acacia spread prevention forum, Longreach, Australia, 26 May.

Vitelli, JS 2015, *Chemical control of cacti*, Weed Management – Biosecurity officers, Ecosciences Precinct, Brisbane, Australia, 6 March.

Vitelli, JS 2015, *Mimosa pigra eDNA research update*, Mimosa pigra stakeholders meeting, Proserpine, Australia, 17 February.

Wang, R, Leung, L & Elsworth, P 2015, *Lockyer Valley Rabbit Group Meeting*, landholders and Lockyer Valley Regional Council, Gatton, Australia, 24 April.

Lectures and seminars

Allen, L 2015, *Progress report of Morven's cluster fence*, Cluster Area Management Project Monitoring meeting, Brisbane, Australia, 24 June.

Brooks, SJ 2014, *Research on eradication target species*, University of Queensland students, Charters Towers, Australia, 16 July.

Campbell, SD 2014, *Herbicide control techniques*, University of Queensland students, Charters Towers, Australia, 16 July.

Campbell, SD 2014, *Weed identification*, School of Distance Education students, Charters Towers, Australia, 28 October.

Day, MD 2014, *Biological control and Class 1 weeds*, Ecosciences Precinct, Brisbane, Australia, 23 July.

Pukallus, K 2014, *Biological control overview and TWRC projects*, University of Queensland students, Tropical Weeds Research Centre, Charters Towers, Australia, 16 July.

Pukallus, K 2014, *Biological control project update*, Tropical Weeds Research Centre & Prior Street Department of Agriculture, Fisheries and Forestry staff 'Get together', Tropical Weeds Research Centre, Charters Towers, Australia, 26 August.

Snow, EL 2015, *Update on biological control of cat's claw creeper and Madeira vine*, Habitat Brisbane Seminar Series, Downfall Creek, McDowall, Australia, 6 August.

Vitelli, J 2015, *Aquatic herbicide research involving flumioxazin*, attended by Chris van der Hoven (Sumitomo marketing manager), Doug Paton (Sumitomo R&D development manager), Patrick Press (Sumitomo Queensland regional manager) and Ray Gurney (Macspred Australia northern regional manager), Ecosciences Precinct, Brisbane, Australia, 9 April.

Vitelli, J 2015, *Aquatic herbicide research*, Seqwater Mid-Brisbane and Tributaries Aquatic weeds workshop, Lake Wivenhoe Information Centre, Fernvale, Australia, 12 May.

Field days

Brennan, M 2014, *Chital deer project update*, Pest Forum, Mt Oweenee Station, Charters Towers, Australia, October 31.

Brennan, M 2014, *Chital deer project update*, Dalrymple Landcare day, Charters Towers, Australia, December.

Brooks, SJ 2015, *Emerging weeds in the lower Burdekin and splatter gun demonstration*, NQ Dry Tropics Pest and Weed day, Ayr, Australia, 1 May.

Gentle, M 2014, *Wild dog management and research*, Wild dog and Vertebrate Pest Workshops, Kandanga, Tansey and Wolvi, Australia, 26–28 August.

Gentle, M 2014, *1080 and non-target impacts of baiting*, Wild dog and Vertebrate Pest Workshops, Kandanga, Tansey and Wolvi, Australia, 26–28 August.

Jones, PK 2015, *Management of coral cactus*, Longreach Landcare and Desert Channels NRM, Longreach, Australia, 31 March.

Jones, PK & Day, MD 2015, *Management of coral cactus*, Southwest NRM, Moama, Australia, 25 May.

Jones, PK & Day, MD 2015, *Management of coral cactus*, landholders, Hebel, Australia, 28 May.

Leung, L & Elsworth, P 2015, *Rabbit control in the Lockyer Valley*, landholders, Gatton, Australia, 18 February.

Scientists in School

Pukallus K 2014, *Year 1 classroom, Science*, Millchester State Primary School, Charters Towers, Australia.

Pukallus, K 2015, *Plant Science Competition*, Millchester State Primary School, Charters Towers, Australia.

Radio and TV

Day, MD 2015, Biocontrol of coral cactus, ABC Radio, broadcast 31 March, Australia.

Snow, EL, Department of Science, Information Technology and Innovation, Brisbane, *New beetle to control the spread of cat's claw creeper, SEQ Catchments*, ‹https://www.youtube.com/watch?v=F-aPTOCGLXU›, uploaded July 2014.

Notes

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