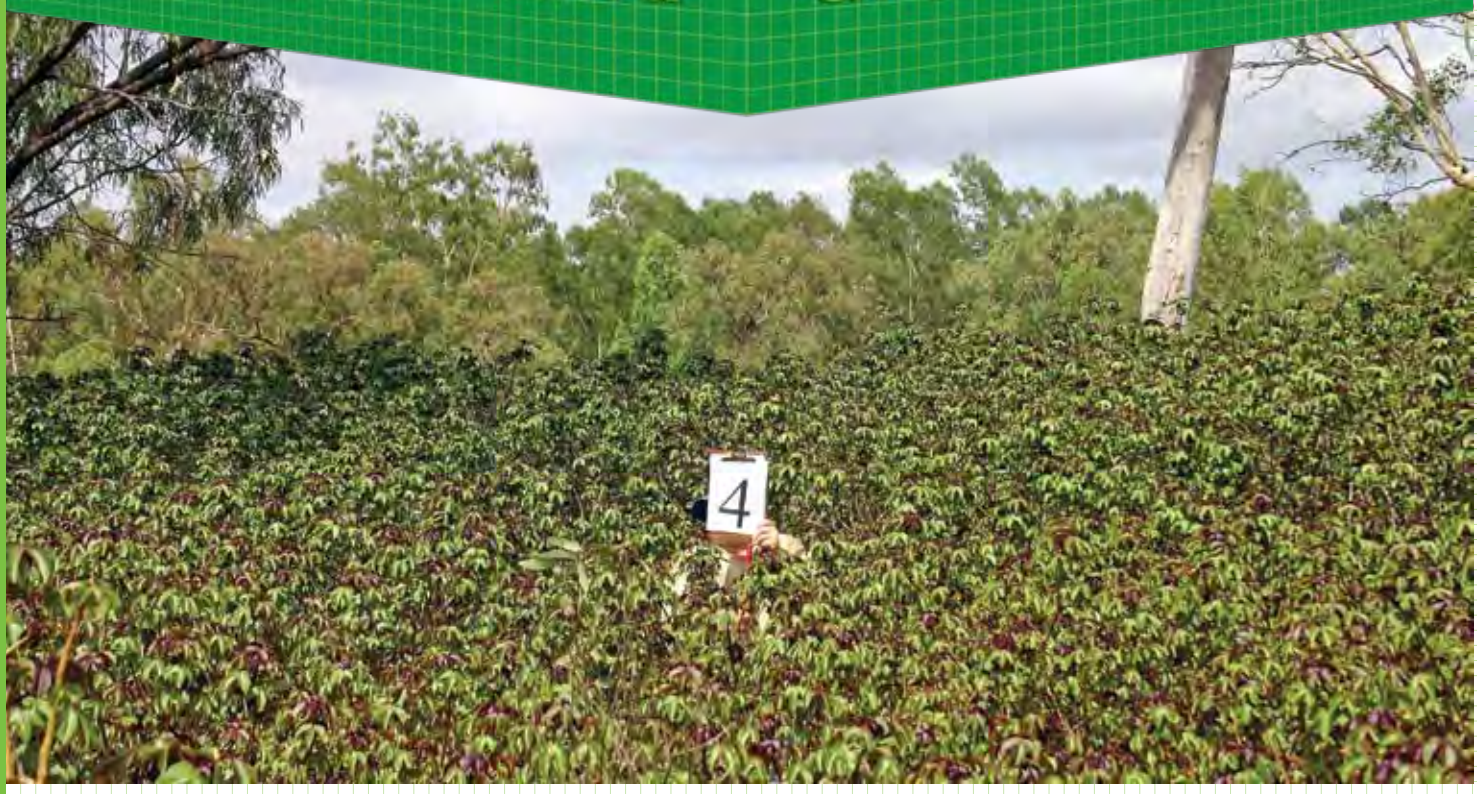
Queensland **the Smart State**

» 2007-08

TECHNICAL HIGHLIGHTS

Invasive plant and animal research



Biosecurity Queensland

Queensland Government
Department of **Primary Industries and Fisheries**

Queensland **the Smart State**

TECHNICAL HIGHLIGHTS

Invasive plant and animal research 2007–08

Queensland Government
Department of **Primary Industries and Fisheries**

PR08–3948

Research conducted by
Invasive Plant and Animal Science
Biosecurity Queensland
Department of Primary Industries and Fisheries

Research conducted at:

- Alan Fletcher Research Station, Sherwood, Queensland
- Robert Wicks Pest Animal Research Centre, Toowoomba and Inglewood, Queensland
- Tropical Weeds Research Centre, Charters Towers and South Johnstone, Queensland

The Department of Primary Industries and Fisheries (DPI&F) seeks to maximise the economic potential of Queensland's primary industries on a sustainable basis.

Important note

This report contains incomplete information and does not constitute an official medium for the publication of results. Information herein should not be quoted without permission of the authors concerned.

Herbicide trial results reported here are provided for information only and do not constitute a formal recommendation. Before using or advising on the use of herbicides, please read the product label for rates and methods of application or contact the Animal and Plant Health Service, DPI&F, Queensland for current approved usage (www.dpi.qld.gov.au or call 13 25 23 for more details).

Cover photographs

(Clockwise from top):

Bellyache bush infestation at Mt Ravenswood.

Seed traps below the bird-dispersed weeds *Passiflora subpeltata* and *Solanum mauritianum*.

Eggs of the leaf beetle *Plectonycha correntina* on a Madeira vine leaf.

Feral pig in Lakefield National Park.

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Message from the Director-General

Technical highlights reports on the latest achievements of current research undertaken by the state government on priority weeds and pest animals in Queensland. Since the Invasive Plant and Animal Science team moved to Biosecurity Queensland in March 2007, this annual publication has become an important part of the Department of Primary Industries and Fisheries' (DPI&F's) service portfolio.

Biosecurity Queensland is responsible for coordinating the Queensland Government's efforts to prevent, respond to and recover from pests and diseases that threaten the economy and environment. As such, it is essential that we understand how best to prevent the introduction of new pests into the state, how to eradicate recently introduced pests and how to manage pests that have established over large areas—questions that the Invasive Plant and Animal Science team helps answer through its research.

In 2007–08, the research team has continued to make notable advances in their field. Three new biocontrol agents for two of our most serious environmental weeds, cat's claw creeper and lantana, have ben released into the field and several more promising insects affecting other priority weeds have been acquired and tested in DPI&F quarantine facilities. New ecological experiments have increased our understanding of invasive weeds, providing information that can be directly used in eradication and control efforts. Research into the management of our most destructive pest animals is giving us important insights into effective baiting strategies for feral pigs and wild dogs and providing us with information that will allow us to manage the development of disease resistance in rabbits. Our research program has attracted over $2.5 million in external funds, which shows that many others also regard weed and pest animal research as an excellent investment.

Invasive plant and animal research benefits from intensive collaboration with other research providers and the resources provided by external funding bodies, particularly Queensland's regional councils. Government agencies on the federal, state and local levels contribute to many of the research projects documented in this report. I would particularly like to extend the department's thanks to the many landholders, local government staff and community and regional body representatives who provide vital assistance to our projects. Without their help much of this research would not be possible. I also commend staff of the Invasive Plant and Animal Science team for the professional way that they continue to improve the management of invasive pests in Queensland.

Finally, I am pleased to bring your attention to the *Technical highlights* feedback survey attached to this publication. With this effort to gain a better understanding of our clients' information preferences, the Invasive Plant and Animal Science team is acting on DPI&F's 'fresh approach' to research partnerships and service delivery, announced by the Minister for Primary Industries and Fisheries, the Hon. Tim Mulherin, on 24 June 2008. I invite you to complete this survey to advise us of your information needs and satisfaction with current services. Your partnership is critical to our success.

Robert Setter
Director-General
Department of Primary Industries and Fisheries

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Executive Summary

Achievements

In the past year, our team of scientists has continued to make significant progress in delivering innovative, quality research for improved management of Queensland's weeds and pest animals. The key achievements from our four program areas include:

Integrated weed management

New, improved, integrated and adaptive management practices for the control of priority weeds continue to be developed.

Progress in the biocontrol program has focussed on two major rangeland weeds—bellyache bush and prickly acacia. Molecular studies investigating the geographical origin of Australian bellyache bush populations suggest there have been multiple introductions to Australia. These findings have informed current surveys for new biological control agents in Central and South America, and so far, we have imported two shipments of a stem-boring weevil for host-testing. A simulated herbivory study on prickly acacia has identified the type of damage most likely to have a detrimental impact on this woody weed. This information has guided our new exploration program for biological control agents, which recently commenced in India. We have also investigated the use of Landsat imagery for monitoring biocontrol agent impacts on prickly acacia infestations. Results indicate that remote technologies can successfully detect defoliation events, but further validation through comparative on-ground monitoring is required.

Herbicide trials on several problem weeds, such as Captain Cook tree and florestina, have progressed well. We are also testing a new tool for applying herbicides on woody weeds by stem injection—the EZ-Ject herbicide lance. If effective, this tool would help the operator avoid direct contact with the herbicide and the technique could be applied on individual plants also in sensitive environments, without affecting surrounding native vegetation or contaminating waterways.

Landscape protection and restoration

Three major environmental weeds of Queensland continue to be targeted by our biocontrol program. In partnership with community groups, we have successfully commenced a release program for two approved biocontrol agents of cat's claw creeper. Since May 2007, over 32 000 tingid bugs have been released at 40 sites and over 10 000 moths have been released at 18 sites across Queensland and northern New South Wales. The lantana herringbone leaf-mining fly was approved for field release in September 2007 and we have since released over 45 000 insects at 43 sites. We have also made significant advances in the acquisition and host-testing of several further biocontrol agents targeting lantana and Madeira vine.

A number of ecological experiments on invasive vines and bird-dispersed weeds have increased our understanding of the processes of weed invasion and provided intriguing first answers to the question of why weeds can dominate native species. A glasshouse experiment comparing the resource use efficiency of invasive vines and their native counterparts indicated that the higher competitiveness of invasive vines may be linked to their ability to step-up photosynthetic rate as resource availability increases, and their greater investment in leaves and stems at the expense of roots. These findings have direct implications for selecting native species for restoration.

Analyses of weed eradication programs have shown encouraging results regarding eradication progress of several Class 1 weeds. For Siam weed, enhanced ground and aerial searches have proved efficient in detecting new infestations, resulting in an increasing percentage of infestations in the control and monitoring phases. In the *Mimosa pigra* eradication program, we have recorded an 86% decline in the soil seed bank in the core infested area from 2002–07.

Pest animal management

Research into new and improved management practices for priority pest animals has concentrated on feral pigs, wild dogs, rabbits, foxes and rodents.

Radio telemetry of wild dogs in southern and central Queensland is providing useful insights into their movement patterns. We have collared 49 dogs to date and dispersal has occurred over large distances (in one instance over 400 km) and into recently baited areas. These results will inform buffer zone requirements around non-baited areas and the timing of baiting.

Pig baiting trials showed that, to be effective, 1080 baits need to be consumed in higher doses than those usually achieved in aerial baiting campaigns. Our efforts to develop a cyanide bait faced numerous obstacles, including frequent rejection of the bait and an apparent tolerance to cyanide in pigs, so that further testing has now ceased. Field trials on cyanide baiting for foxes also showed limitations, mainly relating to frequent rejection of the toxin. Improvements in palatability, presentation and delivery of cyanide baits are needed.

A new project on the role of harvesting in feral pig management has started. We aim to estimate the relationship between pig impact (on crop production and the environment) and pig density in selected sites, and to measure the effectiveness of commercial and recreational harvesting in controlling pig populations. So far, we have completed a survey of landholders to determine the distribution of pig damage, its perceived cost and the control methods employed; 80% of respondents reported crop damage by pigs, with many believing losses were greater than 5% of crop value.

Studies of resistance to rabbit haemorrhagic disease virus (RHDV) in rabbits have determined resistance to varying degrees across Australian populations. These results raise concerns about the reliance on rabbit haemorrhagic disease (RHD) as a control tool and re-emphasize our previous findings that warren ripping,

particularly aimed at 'source' populations, is one of the most effective control techniques for managing rabbits.

Research services

In the research services program, we have obtained or renewed permits for the use of seven pesticides and maintained manufacturing of required amounts of 1080 solutions for use in Queensland's pest animal control programs. In crop residue studies of potential rodenticides for in-crop use, we found no residues of the two candidate formulation actives—zinc phosphide and bromethalin—in wheat, chickpea, sorghum and sunflower, although bait was applied at 100 times the rate envisaged for actual crop use. Additional studies showed that bromethalin degraded rapidly in sunlight.

Business report

The transition of the research group into Biosecurity Queensland is now complete, with all web content migrated to the DPI&F website and an interim strategic plan for Invasive Plant and Animal Science prepared.

As in previous years, our research program for 2007–08 was endorsed by the Research Review Committee—a group of senior scientific, operations and policy staff from Biosecurity Queensland. As part of this process a current and proposed project portfolio is prepared and used by the committee to critically review proposed project outcomes and allocated investments. The committee makes recommendations on research priorities, existing research gaps and projects due for scientific review.

Accordingly, bellyache bush, Madeira vine and feral pig research workshops were held at Alan Fletcher Research Station (AFRS) in July 2007, November 2007 and March 2008 respectively. Internal and external researchers and stakeholders reviewed existing knowledge, identified research gaps and set the direction for future research for these weed and pest species.

In the financial year 2007–08, Invasive Plant and Animal Science received total funding of $6.77 million. Government base funds amounted to $4.27 million, the Land Protection Fund provided $1.56 million and funding from research and development contracts with external partners totalled $0.94 million (see table below).

The senior management and research team did not change in 2007–08. Significant changes include the transfer of Senior Scientist Joe Vitelli from the Tropical Weeds Research Centre (TWRC) to AFRS, where he will deliver research on priority Class 1 weeds, and the creation of a new Senior Scientist position at TWRC to manage Wet Tropics weeds research. Dr Lindsay Norgrove has been appointed in this role, but is yet to commence duties. In July 2007, Dr Olusegun Osunkoya has joined our team at AFRS as a Senior Scientist managing the delivery of weed ecology research. Two long serving members of staff departed this

External funding 2007–08

Project	Funds ($)	Funding body
Understanding grader grass ecology for improved management	104 000	Burdekin Dry Tropics Natural Resource Management, Northern Gulf Resource Management Group and Southern Gulf Catchments
Integrated management of bellyache bush in northern Queensland	11 000	CRC for Australian Weed Management
Integrated management of parkinsonia	5000	CRC for Australian Weed Management
Integrated management of parkinsonia	20 000	CSIRO
Florestina herbicide trial	19 000	Desert Channels Queensland
Biological control of prickly acacia	94 000	Meat and Livestock Australia
Biological control of mikania vine in PNG and Fiji	154 000	ACIAR
Biological control of two weeds in East Timor	6500	ACIAR
Ecology of bird dispersed weeds	80 000	CRC for Australian Weed Management
Weed eradication feasibility and program evaluation	67 000	CRC for Australian Weed Management
Best practice baiting—dispersal and seasonal movement of wild dogs	80 000	Bureau of Rural Sciences
Best practice baiting—dispersal and seasonal movement of wild dogs	19 000	Desert Channels Queensland
Feral pig impacts on freshwater ecosystems	28 000	Department of the Environment, Water, Heritage and the Arts
Development of a cyanide bait for monitoring feral pigs	41 000	Bureau of Rural Sciences
Resistance to RHDV in Australian rabbits	164 000	IACRC
Effective and safe rodent management	51 000	Grains Research and Development Corporation

year, namely Tom Anderson who retired after many years of service as Senior Technical Officer at AFRS and Vicki Ryan who departed TWRC after 12 years of dedicated service as the Centre Administration Officer. In 2007–08, a total of 87 staff were engaged at our five research locations.

Collaboration and extension

The past year has seen many successful collaborations with our partners. We continue to be a core participant in the Invasive Animals Cooperative Research Centre (IACRC), working closely with pest animal experts from across Australia on a range of joint projects (e.g. on rabbit resistance to RHDV or the development of a new bait for wild dogs, foxes and cats).

The Cooperative Research Centre (CRC) for Australian Weed Management, which has received extensive contributions from our group as a core participant, came to a close on 30 June 2008. Our scientists have led several key projects, often gaining national and international recognition. For example, Dr Dane Panetta was invited by the California Department of Food and Agriculture to visit their facilities, share his expertise in a weed eradication workshop and deliver a lecture for which he was awarded the prestigious Dan Hess Lectureship. Dr Gabrielle Vivian-Smith, Dr Carl Gosper, Dr Chris Stansbury and Dr Eve White received the Weeds CRC award for 'Best Scientific Project (Program 3: Landscape Management)' for their project 'Ecology and management of bird-dispersed weeds'.

We continue to build fruitful partnerships with a wide range of national and international research institutions; government agencies at the federal, state and local levels; regional natural resource management bodies; local community groups; industry associations and private businesses. Key research collaborators include CSIRO, The University of Queensland (UQ), Queensland University of Technology (QUT), James Cook University, Australian Centre for International Agricultural Research (ACIAR) and the Agricultural Research Council—Plant Protection Research Institute, South Africa (ARC-PPRI). New international partnerships were established with two Indian research groups, the Arid Forest Research Institute (AFRI) and the Institute of Forest Genetics and Tree Breeding (IFGTB) as well as CAB International (CABI) Europe-UK. Many of our research activities require field trials or sampling on the properties of private landholders. We greatly value their continued support.

Communication of results is an essential part of our research. Research results are communicated to scientific and land management professionals through publications and conferences. This year, our scientific staff authored or co-authored 23 peer-reviewed articles in international (18) and national (5) journals, submitted 35 contributions to conference proceedings and published one monograph. Extension activities were delivered to community or industry groups, landholders and land managers in the form of workshops, forums, lectures, seminars and public field days. All publications and extension activities from the past year are listed in Appendixes 4 and 5.

Two major conferences brought together weed and pest animal scientists and professionals from across Australia and beyond this year: the 16th Australian Weeds Conference, held in Cairns in May 2008, and the 14th Australasian Vertebrate Pest Conference, held in Darwin in June 2008. Our scientists made significant contributions to both, including the preparation and presentation of talks and posters, organisation of field trips, co-editing of conference proceedings and involvement in organizing committees. Staff also presented their research to national and international stakeholders at the Ninth International Conference on the Ecology and Management of Alien Plant Invasions in Perth, the Australia and New Zealand IOBC Biocontrol Conference in Sydney and the 21st Asian Pacific Weed Science Society Conference in Colombo, Sri Lanka.

I am pleased to present this report to our clients, as well as to our collaborators and colleagues. If you have any comments or require further information, please contact me (gabrielle.viviansmith@dpi.qld.gov.au) or one of our research group's professional leaders.

Dr Gabrielle Vivian-Smith
Principal Scientist
Invasive Plant and Animal Science

Part 1 Integrated weed management

1 Understanding grader grass (*Themeda quadrivalvis*) ecology for improved management

Objectives

- Understand responses of grader grass to fire frequency and timing, effect of fire on seed production and viability, and changes in pasture composition due to fire.
- Quantify pasture quality.
- Quantify seed longevity of grader grass.
- Determine grader grass seed germination requirements and level and duration of seed dormancy.

Staff

Wayne Vogler (Leader), Will Green, Ashley Owen and Rebecca Stacey (TWRC)

Collaborators

EPA/QPWS, Undara National Park

DNR&W Fire Unit

Southern Gulf Catchments

Northern Gulf Resource Management Group

Burdekin Dry Tropics Natural Resource Management

Landholders

Rationale

Management of invasive grasses has received little attention in comparison to research undertaken on other exotic weeds. There is a general lack of understanding of appropriate control options, particularly ones that are economical for application over large areas of low value land and in areas of high conservation value.

Grader grass has the potential to change biodiversity, reduce conservation values and reduce grazing animal production over large areas of the tropical savannas. It has been identified by the Environmental Protection Agency (EPA)/Queensland Parks and Wildlife Service (QPWS) (North Region) as a critical conservation issue threatening biodiversity in national parks. It has also been identified in the pest management plans of several local governments as a significant threat both economically and environmentally, and by the Mitchell River Watershed Management Group as a significant weed species.

This project aims to understand some basic ecological aspects of grader grass in response to management and natural conditions, so that management recommendations are based on science rather than anecdotal evidence.

Methods

Seed longevity

Soil seed banks are sampled at least annually in areas where seed input has been stopped. We also estimate seedling emergence in these areas to determine what proportion of the seed bank emerged and what proportion decayed. We establish artificial seed banks by burying seed in mesh bags, then recover these bags at various intervals and test seed viability by germination and use of standard tetrazolium testing procedures.

Effect of fire, physical biomass removal and seed head removal

In this trial we examine the effect of fire, physical biomass removal and grader grass seed head removal on grader grass soil seed banks, seedling recruitment and pasture composition. This is a replicated plot trial where each of the treatments (fire during dry season, fire at start of wet season, seed head removal, biomass removal during late dry season) is imposed on an annual basis. We impose combinations of treatments as the results of initial treatments are obtained. This includes monitoring changes in pasture species and biomass composition (using the Botanal methodology), soil seed banks of grader grass, seasonal growth cycle of grader grass, grader grass plant survival and seed production and changes in soil fertility.

Pasture quality studies

From the field sites, we sample a number of grass species at various growth stages and conduct analyses to determine their digestibility and protein contents. We use this information to determine possible grazing options that could be incorporated into management programs for grader grass.

Seed dormancy and germination studies

We subject grader grass seed to various temperature and light regimes to determine the optimum conditions for germination. We also investigate the effect of smoke on germination and assess the viability and dormancy of seeds at various durations after maturity.

Progress

Seed longevity

The percentage of hard seed declined by approximately 50% for buried seed and by approximately 70% for seed located on the soil surface during the first three months of the artificial seed bank trial (Figure 1). This decline in hard seed occurred during the first three months of the wet season, suggesting that seed germination was the principal cause of the decline. There was little change in hard seed during the dry season, with the next significant decline occurring during the following wet season (Figure 1). Again, this suggests that the principal

driver of seed bank decline is germination following significant rainfall events. Following two wet seasons, surface hard seed (regardless of cover) and buried hard seed (without cover at 2 cm and 5 cm depth) had declined to less than 10% (Figure 1), while hard seed in other treatments remained at about 25%. This suggests that vegetative cover and burial depths below 2 cm may assist in maintaining seed viability for longer periods.

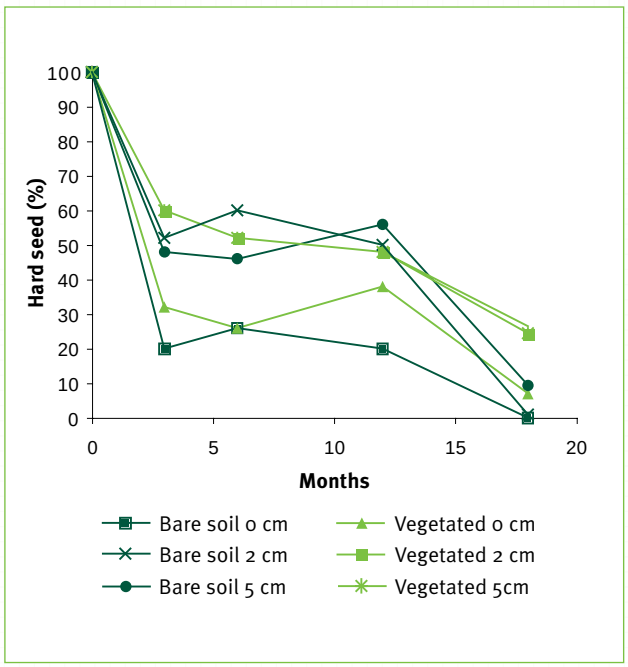

Figure 1. Grader grass hard seed decline in artificial seed banks buried in bare and vegetated plots at 0 cm, 2 cm and 5 cm depths.

90% of the grader grass natural seed bank germinated on the first significant rain of the wet season. This indicates that seed depletion may be relatively quick given suitable conditions. Soil seed bank assessments following the 2006–07 wet season confirmed depletion of the natural soil seed bank, with about 10% of the original soil seed bank remaining.

Effect of fire, physical biomass removal and seed head removal

Grader grass biomass was generally maintained in fire and slashing and removal treatments applied at any time of year. In contrast, where disturbance was minimal, such as in the control plots, herbicide and landholder-managed treatments, grader grass biomass declined following two years of treatment application (Figures 2 and 3). This was also the case where slashing prior to seed set reduced seed production to almost zero. This suggests that grader grass invasion and dominance is inherently related to the level of disturbance within a pasture system, whether by overgrazing, fire, slashing or intensive soil disturbance such as along roads or fire breaks.

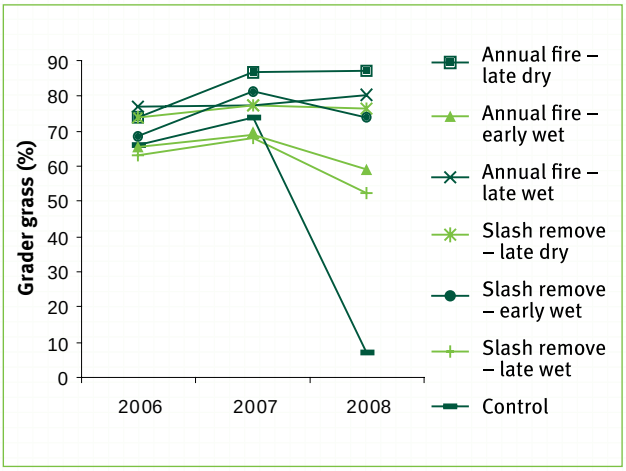

Figure 2. Grader grass biomass in fire, slashing and removal and control treatments at Lynwater Station.

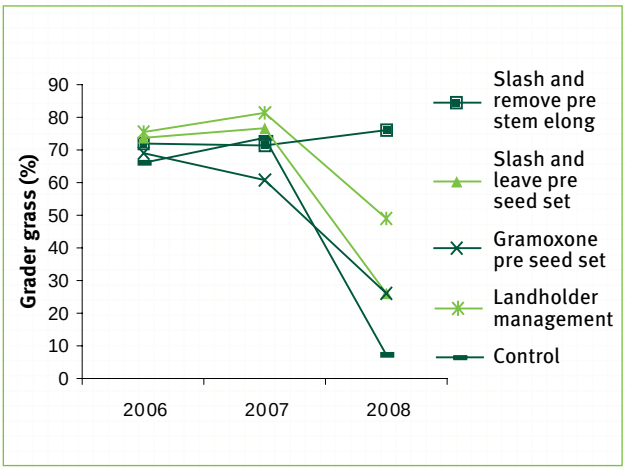

Figure 3. Grader grass biomass in herbicide, slashing pre-seed set, landholder managed and control treatments at Lynwater Station.

Pasture quality studies

These studies concluded after comparing the quality of grader grass with 10 other pasture grasses at four times during the year. While young grader grass has higher protein and is more digestible than many of the other pasture grasses, protein and digestibility decline to levels similar to those of other grasses once it becomes reproductive.

Seed dormancy and germination studies

Fresh grader grass seeds (two months after maturity) have a relatively low level of dormancy, which reduces to negligible levels after eight months (Figures 4 and 5). Light and alternating temperatures stimulate germination, particularly with fresh seed, although there are some seeds in the population that will germinate in darkness with constant temperatures (Figure 4). As seed ages (eight months after maturity) the effect of light and alternating temperatures on seed germination declines, with seed germinating over a wide range of temperatures in both light and dark conditions (Figure 5).

Seed of grader grass matures during the late wet season (April–June) and is normally subject to a 6–8 month

dry season. The negligible dormancy remaining after eight months coincides with the onset of the next wet season, placing grader grass in a position of having large quantities of viable seed ready to take advantage of ideal growing conditions in wet-dry tropical savanna systems.

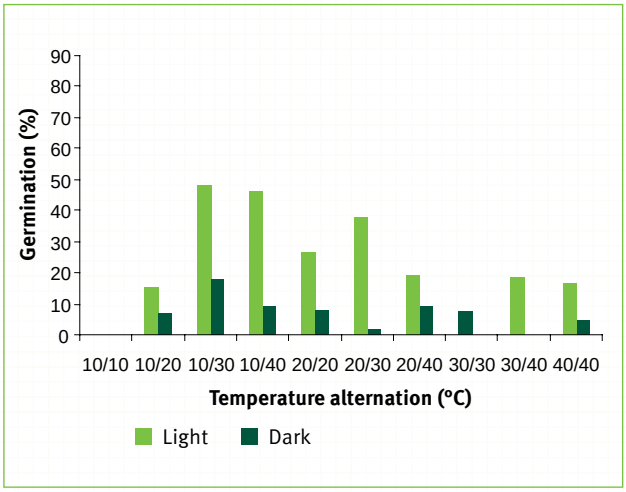

Figure 4. Grader grass germination two months after seed maturity under 12 hour alternating and constant temperatures in total darkness and with 12 hours of light per day.

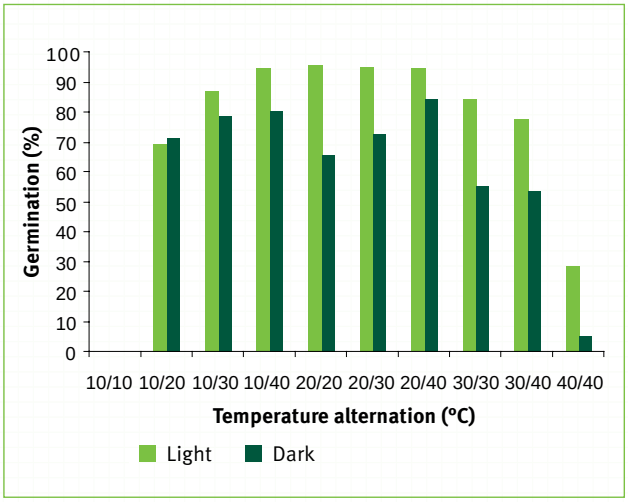

Figure 5. Grader grass germination eight months after seed maturity under 12 hour alternating and constant temperatures in total darkness and with 12 hours of light per day.

Funding

Queensland Government
Southern Gulf Catchments
Burdekin Dry Tropics Natural Resource Management
Northern Gulf Resource Management Group

Expected completion

Ongoing

2 Integrated management of bellyache bush (*Jatropha gossypiifolia*) in northern Queensland

Objectives

- Develop an integrated management strategy for bellyache bush.
- Evaluate the efficacy of combinations of fire, slashing, and foliar herbicides (Brush-Off®) on mortality, seedling recruitment and survival of bellyache bush.
- Better understand the ecology of bellyache bush and its implications for timing and effectiveness of control strategies.
- Promote changes in management practices that will lead to sustainable levels of production.

Staff

Faiz Bebawi (Leader), Joe Vitelli, Shane Campbell and Kirsty Gough (TWRC)

Rationale

Bellyache bush, a native of tropical America, is a major weed of the Burdekin and Mitchell River catchments in Queensland. It is also starting to spread into the Fitzroy catchment and other areas of central and northern Queensland. Dense infestations generally form along river flats, creek banks, and disturbed roadsides. This project aims to develop best practice management strategies for bellyache bush in order to reduce its spread and current areas of infestation.

Methods

There are two areas of research associated with this project—integrated weed control and weed ecology of bellyache bush.

Integrated weed control

We examine the impact of single treatments (fire and slashing) on bellyache bush at two north Queensland sites near Charters Towers (Sandy Creek and Larkspur). We also undertake a five-year integrated management trial in riparian habitats adjacent to Sandy Creek and Southern Cross Creek at Branmore Station (previously Almora Station) near Charters Towers, to determine the most effective combination of fire, slashing, stick-raking and chemical treatments for controlling bellyache bush.

Weed ecology

A range of experiments are conducted to help fill knowledge gaps about bellyache bush seed ecology, competitive ability under different simulated grazing pressures, population dynamics and impact of integrated control treatments on pasture composition and yield.

Seed bank: We have established a trial (in December 2000) at two sites—Riverview (rocky habitat) and Millview (heavy clay habitat)—to determine seed bank

longevity of bellyache bush after the complete removal of infestations. We monitor seedling emergence by removing all emergent seedlings monthly for 72 months.

Seed longevity: We have initiated a trial on seed longevity in March 2001 at Larkspur (Photo 1), burying two types of bellyache bush seeds (intact and ant-discarded) at six depths (0 cm on mulched ground; 0 cm on bare ground; 5 cm, 10 cm, 20 cm and 40 cm) under natural and rain-shelter conditions.

Photo 1. Seed longevity trial site at Larkspur showing seed burial plots under natural conditions (uncovered grids) and rain excluded plots (covered grids).

Pasture management research: We have established a competition trial (in September 2002) at Branmore Station to determine the impact of five simulated grazing intensity regimes [no grazing (uncut pasture), low grazing (cut at 40 cm height), medium grazing (cut at 20 cm height) and high grazing (cut at 10 cm height) and no pasture (pasture removed)] on four bellyache bush densities [control (no bellyache bush), low density (2 plants m^{-2}), medium density (6 plants m^{-2}) and high density (12 plants m^{-2})].

Progress

Integrated weed control

The integrated weed control field trials at Branmore Station and Millview Station were completed in June 2006. We are currently analysing results and preparing them for publication.

Weed ecology

Seed bank: This experiment is completed. For final results see *Technical highlights 2006–07*.

Seed longevity: Intact seeds exhumed after 36 months have expired under natural conditions, compared with 72 months for ant-discarded seeds (Figure 1). Both intact and ant-discarded seeds expired in the rainfall-excluded site 84 months after burial (Figure 1). The trial is complete.

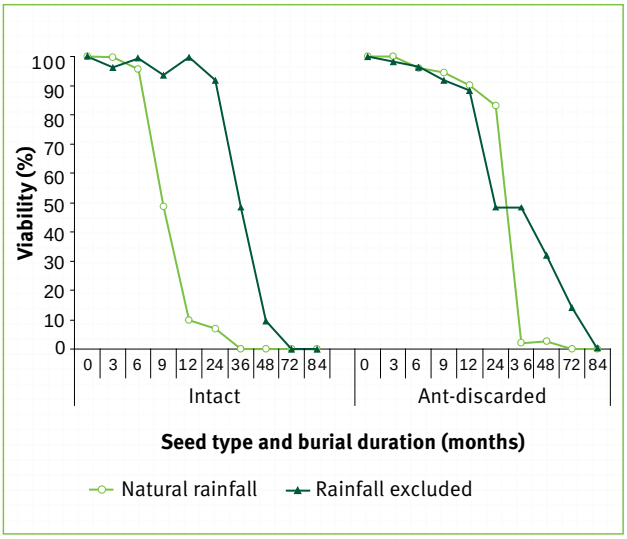

Figure 1. Viability of intact and ant-discarded seeds over 84 months in natural and rainfall-excluded sites over all burial depths. (Vertical bars indicate the standard error (SE) of the means.)

Pasture management research: Under the simulated grazing conditions of this trial, pasture yield has been 25% and 13% greater in high and medium grazing plots compared with those that have received low grazing (Figure 2), irrespective of the density of bellyache bush present.

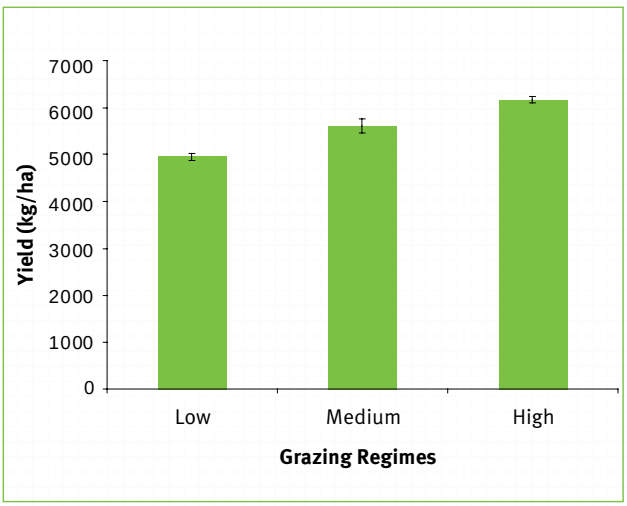

Figure 2. Pasture yield as affected by different simulated grazing regimes. (Vertical bars indicate the SE of the means.)

After six years, minimal mortality (1%) has occurred in areas devoid of pasture (i.e. pasture removed). In contrast, mortality has ranged from 37% in the no grazing plots to 51% under high grazing. The trial is ongoing.

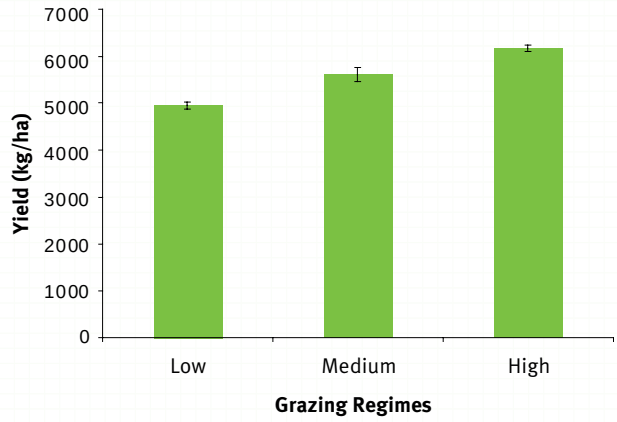

Figure 3. Mortality of bellyache bush plants in areas devoid of pasture (NP) and as affected by no grazing (NG), low grazing (LG), medium grazing (MG) and high grazing (HG) regimes six years after treatment. (Vertical bars indicate the SE of the means.)

Funding

Land Protection Fund

Queensland Government

CRC for Australian Weed Management

Expected completion

June 2009

3 Ecology and management of Captain Cook tree (*Cascabella thevetia*) in northern Queensland

Objectives

- Better understand the ecology of Captain Cook tree and the implications for timing and effectiveness of control strategies.
- Evaluate the effectiveness of chemical control techniques including basal bark, cut stump, foliar application, and stem injection on Captain Cook tree.

Staff

Faiz Bebawi (Leader), John McKenzie (Leader), Joseph Vitelli, Kirsty Gough, Dannielle Brazier, Ashley Owen and Shane Campbell (TWRC)

Collaborators

John Ramsey, Landholder (Meadow Vale Cattle Station, Mingela)

Rationale

Captain Cook tree is a Class 3 weed (a garden escapee) that has established some relatively large infestations in northern Queensland, particularly along riverbanks of the Douglas River and major creeks of the lower and upper Burdekin catchment near Mingela and Ravenswood. Captain Cook tree is toxic to humans and animals and dense infestations (Photo 1) out-compete native pastures and reduce plant and animal biodiversity as well as pasture productivity. It will continue to spread throughout its current range unless controlled. Understanding the ecology of Captain Cook tree and developing effective control options is essential to reducing its economic, environmental and social impacts.

Photo 1. Dense infestation of Captain Cook tree at Will Creek, Mingela.

Methods

There are two areas of research associated with this project—weed ecology and control of Captain Cook tree.

Weed ecology

Four major experiments are underway.

Experiment 1 determines the age to reproductive maturity, growth and seedling survival rate of the peach variety grown under natural conditions of either full sunlight or shade at Will Creek, Mingela. We have established a completely randomised design with six replications in a dense monoculture of Captain Cook tree. The full sunlight treatment is achieved by cut-stumping and spraying all Captain Cook tree plants growing within plots. In contrast, the control treatment (shade treatment) is left uncut. We tag 25 seedlings (with cotyledons still attached to the hypocotyl) in each plot and monitor their growth rate (basal diameter and plant height), survival rate and age to reproductive maturity. We also monitor seed production and seed predation.

Experiment 2 is conducted in a shade house at the Tropical Weeds Research Centre (TWRC) to compare the time taken for the yellow and peach varieties to reach reproductive maturity under different light and plant density conditions. The experiment is a 2 x 4 x 2 factorial replicated four times using a split plot design. Factor A is two shading intensities (natural light and 70% shade) assigned to the main plots, factor B is four planting densities (1 plant, 2 plants, 4 plants and 8 plants per pot) assigned to the sub-plots and factor C is the two varieties (peach and yellow) assigned to the sub-sub-plots. We grow plants from seed in plastic pots (50 cm diameter x 40 cm depth) filled with river loam soil and monitor growth rate (basal diameter and plant height), flowering density (number of flowering stalks), and seed production.

Experiment 3 determines the effects of monthly ambient temperatures on germination of the peach and yellow varieties. A 2 x 12 factorial replicated four times using a split plot design is conducted at TWRC. Factor A is the two varieties (peach and yellow) assigned to the main plots and factor B is the 12 sowing periods (January through to December) assigned to the sub-plots. We sow 50 freshly harvested seeds per replicate at the beginning of each month in 40 cm diameter plastic pots filled with river loam soil; the moisture level is maintained at field capacity. We then remove germinated seeds from the pots as they emerge, with any un-germinated seeds extracted after eight weeks and tested for viability.

Experiment 4 determines the germination temperature range of the yellow and peach varieties using a thermogradient incubator. A 10 x 2 factorial replicated

Technique	Chemical	Active Ingredient	Rate*
Basal bark	Access®	triclopyr (240 g L^{-1}) + picloram (120 g L^{-1})	1:30D
Basal bark	Access®	triclopyr (240 g L^{-1}) + picloram (120 g L^{-1})	1:60D
Basal bark	Starane* Advanced	fluroxypyr (333 g L^{-1})	1:66.6D
Basal bark	Starane* Advanced	fluroxypyr (333 g L^{-1})	1:33.3D
Basal bark	Diesel		D
Basal bark	Control		0
Cut stump	Access®	triclopyr (240 g L^{-1}) + picloram (120 g L^{-1})	1:30D
Cut stump	Access®	triclopyr (240 g L^{-1}) + picloram (120 g L^{-1})	1:60D
Cut stump	Starane* Advanced	fluroxypyr (333 g L^{-1})	1:66.6D
Cut stump	Starane* Advanced	fluroxypyr (333 g L^{-1})	1:33.3D
Cut stump	Vigilant®	picloram (43 g kg^{-1})	straight
Cut stump	Brush-Off®	metsulfuron methyl (600 g kg^{-1})	1 g:10W
Cut stump	Brush-Off®	metsulfuron methyl (600 g kg^{-1})	1 g:1W
Cut stump	Tordon* DSH	triclopyr (200 g kg^{-1}) + picloram (100 g L^{-1})	1:20W
Cut stump	Tordon* DSH	triclopyr (200 g kg^{-1}) + picloram (100 g L^{-1})	1:40W
Cut stump	Amicide® 625	2,4-D (625 g L^{-1})	1:5W
Cut stump	Amicide® 625	2,4-D (625 g L^{-1})	1:10W
Cut stump	Pestmaster® Aqua-Tech® Glyphosate 360	glyphosate (360 g L^{-1})	1:2W
Cut stump	Pestmaster® Aqua-Tech® Glyphosate 360	glyphosate (360 g L^{-1})	1:4W
Cut stump	Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	1:14.75W
Cut stump	Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	1:29.75W
Cut stump	Diesel		D
Cut stump	Control		W

Table 1. Chemicals and rates used in basal bark and cut stump trials. (* D = Diesel; W = Water)

four times using a split plot design is conducted. Factor A comprises 10 temperature gradients assigned to the main plots and factor B is the two varieties (peach and yellow) assigned to the sub-plots. We place lots of 50 freshly harvested seeds in 500 mL plastic containers (15 cm x 10 cm x 3.4 cm) filled to 1 cm depth with soil and moistened with distilled water. Four trays of each variety are placed in each of the 10 temperature compartments of the incubator which delivers a temperature range of 10–55 °C during the day and a temperature range of 5–32 °C during the night. We count and remove germinated seeds from each tray on a daily basis. After each daily investigation the position of the trays is re-randomised within each chamber to minimise heat exposure bias. Germination is considered to have ceased when no seeds germinate for two weeks after the last recorded germination. We then test un-germinated seeds for viability.

Weed control

We conduct four experiments at Will Creek (Mingela) to determine which herbicides and rates are most effective in controlling Captain Cook tree using basal bark, foliar, cut stump or stem injection techniques.

For each technique, we have established a completely randomised experiment incorporating three replications. We test the efficacy of herbicides on three size classes [Class 1 (‹ 20 mm), Class 2 (21–50 mm), and Class 3 (› 51 mm)]. Each size class comprises 10 plants that are tagged and painted for future reference and we also record their reproductive status prior to treatment. A summary of herbicides and rates is given in Tables 1 and 2. We use an arbitrary rating system to assess treatment damage.

Progress

Weed ecology

Experiments 1 and 2 commenced on 31 January 2008 and 25 December 2007 respectively. Preliminary results from Experiment 1 indicate that young plants growing in the field under natural light are significantly taller (39%) and have significantly larger basal diameters (65%) compared with plants under shade (Figures 1 and 2). In contrast, the shade house study (Experiment 2) is showing that plants growing under natural light are significantly shorter (29%) compared with plants

Technique	Chemical	Active Ingredient	Rate*
Foliar	Grazon* DS	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1})	1:150W
Foliar	Grazon* DS	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1})	1:300W
Foliar	Grazon* Extra	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1}) + aminopyralid (8 g L^{-1})	1:150W
Foliar	Grazon* Extra	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1}) + aminopyralid (8 g L^{-1})	1:300W
Foliar	Brush-Off®	metsulfuron methyl (600 g kg^{-1})	10:100W
Foliar	Brush-Off®	metsulfuron methyl (600 g kg^{-1})	20:100W
Foliar	Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	1:112.25W
Foliar	Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	1:224.75W
Foliar	Starane* Advanced	fluroxypyr (333 g L^{-1})	1:200W
Foliar	Starane* Advanced	fluroxypyr (333 g L^{-1})	1:100W
Foliar	Control		W + wetter
Stem injection	Tordon* DSH	triclopyr (200 g kg^{-1}) + picloram (100 g L^{-1})	1:4W
Stem injection	Tordon* DSH	triclopyr (200 g kg^{-1}) + picloram (100 g L^{-1})	1:8W
Stem injection	Velpar® L	hexazinone (250 g L^{-1})	1:2W
Stem injection	Velpar® L	hexazinone (250 g L^{-1})	1:4W
Stem injection	Pestmaster® Aqua-Tech® Glyphosate 360	glyphosate (360 g L^{-1})	1:0W
Stem injection	Pestmaster® Aqua-Tech® Glyphosate 360	glyphosate (360 g L^{-1})	1:1W
Stem injection	Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	1:2.75W
Stem injection	Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	1:5.75W
Stem injection	Arsenal® 250	imazapyr (250 g L^{-1})	1:4W
Stem injection	Control		W + wetter
Stem injection	Brush-Off®	metsulfuron methyl (600 g kg^{-1})	1 g L^{-1}
Stem injection	Brush-Off®	metsulfuron methyl (600 g kg^{-1})	0.5 g L^{-1}

Table 2. Chemicals and rates used in foliar and stem injection applications. (* W = Water)

under shade. However, similar to the field experiment, plants growing under natural light have significantly larger basal diameters (7%) compared with plants under shade. For all treatments in the shade house experiment, the yellow variety is significantly taller (11%) whereas the peach variety has significantly larger basal diameter (3.3%) compared with the yellow variety. Both experiments are ongoing.

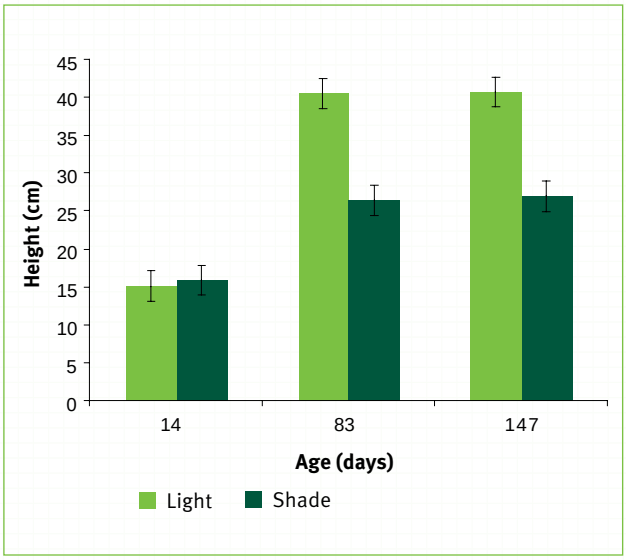

Figure 1. Plant height of the peach variety of Captain Cook plants as affected by age and light conditions at Mingela. (Vertical bars indicate the least significant difference (LSD) at p < 0.05.)

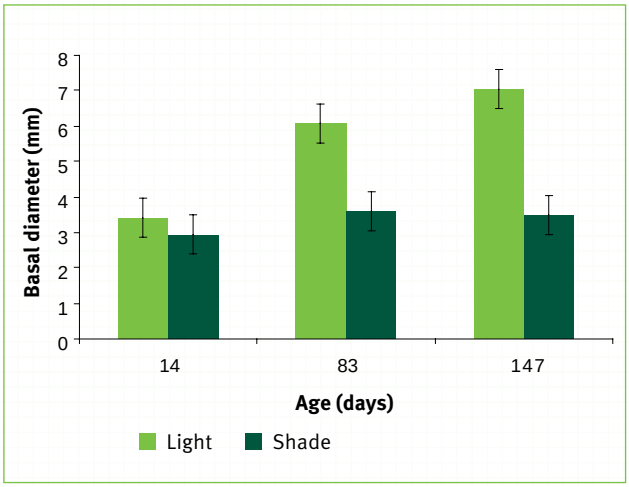

Figure 2. Basal diameter of the peach variety of Captain Cook plants as affected by age and light conditions at Mingela. (Vertical bars indicate the LSD at p < 0.05.)

The two germination experiments (Experiments 3 and 4) have commenced but results are not yet available.

Weed control

All experiments have been initiated, but results are not yet available.

Funding

Land Protection Fund
Queensland Government

Expected completion

January 2013

4 Florestina (*Florestina tripteris*) herbicide trial

Objectives

Find herbicides to effectively control florestina plants and identify which of these could reduce seedling recruitment from the soil seed bank following primary treatment.

Staff

John McKenzie (Leader), Danielle Brazier, Ashley Owen, Shane Campbell and Joe Vitelli (TWRC)

Collaborators

Brett Carlson (Desert Channels Queensland)

Rationale

Florestina is believed to have been accidentally introduced into Australia in contaminated pasture seed during the 1960s (as was parthenium). Unlike parthenium, however, florestina was introduced into a drier environment around Tambo in central western Queensland, with a further infestation found at Barcaldine in 1989. Florestina can start flowering (Photo 1) relatively quickly after rain, allowing it to survive in environments with limited and variable rainfall and in disturbed areas (such as road verges, fence lines or well utilised pastures).

Within this project we aim to:

- Complete a broad chemical screening trial to identify potential herbicides for control of florestina.
- Establish a rate response trial using the herbicides from the screening trial that provided high mortality and some residual control of seedling regrowth.
- Seek registration of the most effective herbicides through the Australian Pesticides and Veterinary Medicines Authority (APVMA) to aid in the management of florestina.

Photo1. Young florestina plants can reach reproductive maturity quickly.

Methods

Chemical screening trial

To determine the efficacy and the residual effect of a range of herbicides, we undertake a randomised complete block experiment with each treatment replicated four times (see Table 1 for a list of the herbicides and rates used). The field site is located on Kyneton, a mixed grazing enterprise 30 km south-east of Barcaldine. We count both adult and seedling (non-flowering) florestina plants present in plots (4 m2) before application of herbicides. We then apply chemical mixes using an Ag-Murf® pressurised applicator at a volume of 1500 L ha^{-1}. Post-treatment measurements of plant mortality and seedling regrowth are also undertaken.

Rate response trial

We have also established a rate response trial at Barcaldine using a similar design and methodology to that used for the screening trial. However, only those herbicides that exhibited high mortality and residual activity during the screening trial are included (Table 2).

Demonstration site

A demonstration site will be established incorporating the herbicides and rates that provide highest mortality and residual control while having limited effect on the pasture species present.

Trade name	Active ingredient	Concentration (L or g ha^{-1})	Recruitment (seedlings m^{-2})	Change in plant density (%)
Brush-Off®	metsulfuron methyl (600 g kg^{-1})	7	1.25^{efgh}	88.38^{abc}
Brush-Off®	metsulfuron methyl (600 g kg^{-1})	14	0.75^{fgh}	98.75^{bc}
Brush-Off®	metsulfuron methyl (600 g kg^{-1})	28	0^{h}	96.38^{abc}
Roundup®	glyphosate (360 g L^{-1})	1.5	60.13^{a}	84.80^{abc}
Roundup®	glyphosate (360 g L^{-1})	3	24.13^{ab}	73.23^{abcd}
Grazon* DS	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1})	1.5	0^{h}	93.73^{abc}
Grazon* DS	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1})	3	0^{h}	91.35^{abc}
Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	1.5	0^{h}	96.86^{bc}
Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	3	0^{h}	90.73^{abc}
Amicide® 625	2,4-D (625 g L^{-1})	4	1.13^{efgh}	89.90^{abc}
Amicide® 625	2,4-D (625 g L^{-1})	2	2.63^{efg}	83.54^{abc}
Lontrel*	clopyralid (300 g L^{-1})	0.3125	4.13^{efg}	97.09^{bc}
Lontrel*	clopyralid (300 g L^{-1})	0.625	0.63^{gh}	80.08^{abc}
Starane* 200	fluroxypyr (200 g L^{-1})	0.75	39.38^{ab}	71.26^{bcd}
Starane* 200	fluroxypyr (200 g L^{-1})	1.5	17.13^{ab}	70.14^{cd}
Lantana 600	dichlorprop (600 g L^{-1})	3	17.13^{bc}	80.76^{abc}
Lantana 600	dichlorprop (600 g L^{-1})	6	$7c^{def}$	52.10^{de}
Flame®	imazapic-ammonium (240 g L^{-1})	0.375	19.25^{bcd}	73.87^{abcd}
Basta®	glufosinate-ammonium (200 g L^{-1})	2.5	27.88^{b}	44.10^{ef}
Basta®	glufosinate-ammonium (200 g L^{-1})	5	25.63^{ab}	76.89^{abc}
DSMA Clear	DSMA (220 g L^{-1})	3.4	4.25^{def}	44.38^{ef}
Arsenal® 250	imazapyr (250 g L^{-1})	3	1.13^{efgh}	96.45^{abc}
Glean®	chlorsulfuron (750 g L^{-1})	20	7.63^{cde}	79.64^{abc}
Sencor® 480 SC	metribuzin (480 g L^{-1})	1.5	2.5^{efgh}	86.56^{abc}
Daconate®	MSMA (800 g L^{-1})	10	44.5^{ab}	91.84^{abc}
Organic Interceptor™	pine oil (680 g L^{-1})	300	30.38^{ab}	70.70^{bcd}
200 mL Amicide® 625 + 20 g Brush-Off® 100 L^{-1}	2,4-D (625 g L^{-1}) + metsulfuron methyl (600 g kg^{-1})	3	0^{h}	99.62^{a}
Hotshot*	aminopyralid (10 g L^{-1}) + fluroxypyr (140 g L^{-1})	300	0^{h}	94.76^{abc}
Control		4	19.88^{ab}	26.83^{f}

Table 1. Chemicals and rates used in the chemical screening trial on florestina and their effect on mortality and seedling recruitment. (Values followed by the same letter in columns are not significantly different, $p < 0.05$.)

Progress

Chemical screening trial

This trial was initiated in September 2007 and preliminary results indicate there are a number of herbicides that provide high mortality and some residual control (Table 1), particularly metsulfuron-methyl, triclopyr/picloram, 2,4-D/picloram, 2,4-D, clopyralid, aminopyralid/fluroxypyr and picloram products. We will continue to monitor plots containing residual chemicals while they remain active.

Rate response trial

This trial was initiated in January 2008. While final results are not yet available, a number of herbicides are demonstrating very good knock down and residual effects, even though the field site has received limited and sporadic rainfall to date (Photo 2).

Photo 2. The effectiveness of Tordon* 75-D sprayed at 3 L ha^{-1} along the access road to the field site.

Funding

Desert Channels Queensland
Land Protection Fund

Expected completion

December 2009

Trade name	Active ingredient	Manufacturer	L or g ha^{-1}
Brush-Off®	metsulfuron methyl (600 g kg^{-1})	DuPont	60.00
Brush-Off®	metsulfuron methyl (600 g kg^{-1})	DuPont	7.00
Brush-Off®	metsulfuron methyl (600 g kg^{-1})	DuPont	14.00
Grazon* DS	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1})	Dow AgroSciences	0.75
Grazon* DS	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1})	Dow AgroSciences	1.50
Grazon* DS	triclopyr (300 g L^{-1}) + picloram (100 g L^{-1})	Dow AgroSciences	3.00
Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	Dow AgroSciences	0.75
Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	Dow AgroSciences	1.50
Tordon* 75-D	2,4-D (300 g L^{-1}) + picloram (75 g L^{-1})	Dow AgroSciences	3.00
Amicide® 625	2,4-D (625 g L^{-1})	Nufarm	1.44
Amicide® 625	2,4-D (625 g L^{-1})	Nufarm	0.72
Amicide® 625	2,4-D (625 g L^{-1})	Nufarm	0.36
Lontrel*	clopyralid (300 g L^{-1})	Dow AgroSciences	0.60
Lontrel*	clopyralid (300 g L^{-1})	Dow AgroSciences	0.90
Lontrel*	clopyralid (300 g L^{-1})	Dow AgroSciences	1.20
Hotshot*	aminopyralid (10 g L^{-1}) + fluroxypyr (140 g L^{-1})	Dow AgroSciences	4.00
Hotshot*	aminopyralid (10 g L^{-1}) + fluroxypyr (140 g L^{-1})	Dow AgroSciences	2.00
Hotshot*	aminopyralid (10 g L^{-1}) + fluroxypyr (140 g L^{-1})	Dow AgroSciences	1.00
Tordon* Granules	picloram (20 g kg^{-1})	Dow AgroSciences	3750
Tordon* Granules	picloram (20 g kg^{-1})	Dow AgroSciences	7500
Tordon* Granules	picloram (20 g kg^{-1})	Dow AgroSciences	15000
Control			0.00

Table 2. Chemicals and rates used for the rate screening trial.

5 Evaluating the effectiveness of the EZ-Ject herbicide lance

Objectives

Evaluate the effectiveness of the EZ-Ject herbicide lance as a control method for woody weeds in Queensland using both glyphosate-filled shells and imazypyr-filled shells.

Staff

Joseph Vitelli and Barbara Madigan (TWRC)

Rationale

The EZ-Ject herbicide lance is a relatively new technique for the control of woody plants by stem injection. The stainless steel lance has gripping teeth at the end and a spring-loaded assembly that injects .22 brass shells filled with water soluble herbicide into the cambium layer of woody plants. No mixing of or contact with the herbicide is required by the operator. The longer version of the lance (1.5 m) holds up to 100 shells in each of four separate shell chambers. The shells are implanted at a downward angle evenly around the circumference of the base of the plant. Two herbicides (glyphosate and imazypyr) are registered for use with the lance in the United States and Canada. Both labels recommend a rate of one shell approximately every 10 cm. Plants may be injected at any time of the year and may be standing in water or wetlands, though the injection site should be above the water level.

To trial this control method, three woody weeds were chosen, each from a different family and each infesting a different area of Queensland. Yellow oleander (*Cascabela thevetia*), family Apocynaceae, is a Class 3 declared plant that is highly toxic and invades native vegetation. Velvety tree pear (*Opuntia tomentosa*), family Cactaceae, is a Class 2 declared plant found predominantly in the brigalow belt of Queensland. It replaces useful species and can form dense stands of large plants. Pond apple (*Annona glabra*), family Annonaceae, is a Weed of National Significance (WONS) and a Class 2 declared plant that can grow in flooded areas of fresh, brackish or salt water. In swampy areas it forms dense thickets capable of replacing existing ecosystems.

If the herbicide lance is effective in controlling these plants, and is subsequently registered for use in Queensland, another tool would be available for woody weed control, particularly in sensitive areas. Use of the herbicide lance would allow individual plants to be treated without affecting surrounding native vegetation. Operators would be able to stand at a distance from plants, helping to avoid contact with any thorns or spines. Plants in wet areas could be treated without fear of water contamination. This treatment method could also be used year round.

Methods

Yellow oleander near Mingela, velvety tree pear near Inglewood and pond apple near Babinda are treated with the EZ-Ject herbicide lance in split plot design experiments with the herbicide as the main plot (glyphosate and imazypyr) and the number of cartridges as the sub-plot (0, 1, 2, 3 and 4 shells). We replicate each treatment four times and the experimental unit consists of 15 plants. All treated plants have a basal diameter of 10–15 cm. We assess plants one month, six months and 12 months after treatment using a damage rating scale and determine plant mortality at the final assessment.

Progress

We have applied treatments on yellow oleander and velvety tree pear; pond apple plants have been selected and will be treated in July 2008.

Funding

Queensland Government

Expected completion

October 2009

Photo 1. Pond apple plant following stem injection by the EZ-Ject herbicide lance system.

6 Biological control of bellyache bush (*Jatropha gossypiifolia*)

Objectives

- Identify suitable biological control agents for host-specificity testing through review of earlier survey work and exploration (in collaboration with CSIRO).
- Import potential biological control agents, conduct host-specificity tests and seek approval of host-specific agents for field release.
- Conduct pathogenicity and host-range testing of the bellyache bush rust fungus (*Phakopsora jatrophicola*) as a potential biocontrol agent for bellyache bush.
- Evaluate the ability of bellyache bush to respond to simulated herbivory and identify the type and frequency of herbivory that will be required to reduce its growth and vigour.
- Mass-rear, release and monitor the current biological control agent *Agonosoma trilineatum*.

Staff

K. Dhileepan (Leader), Bill Palmer, Di Taylor (from December), Matthew Shortus (from January) (AFRS), Catherine Lockett, Kelli Pukallus (until February), Will Green, Ben Madigan, Tricia Voigt (from March) (TWRC) and Karina Pyle (QUT Honours Student)

Collaborators

Marion Seier (CABI Europe-UK, United Kingdom)

Ricardo Segura (CSIRO Entomology, Mexican Field Station)

Tim Heard (CSIRO Entomology, Brisbane)

Andrew Lowe and Peter Prentis (University of Adelaide)

Tanya Scharaschkin and S. Raghu (QUT)

Fiona Barron, Co-ordinator (Mitchell River Watershed Management Group)

Sid Clayton, Rural Lands Officer (Tablelands Regional Council)

Merv Pyott, Land Protection Officer (Burdekin Shire Council)

Russell Graham, Pest Management Officer (Cook Shire Council)

Trevor Meldrum, Assistant Pest Management Officer (Cook Shire Council)

Rationale

Bellyache bush is a serious and expanding weed of northern Queensland. It invades rangeland, particularly in riparian zones, and forms dense thickets that reduce productivity and biodiversity. All parts of the plant, especially the seeds, are toxic and there have been several instances where the death of grazing animals has been attributed to this weed.

Bellyache bush is a declared target for biological control. The bellyache bush jewel bug (*Agonosoma trilineatum*), the only biological control agent released to date, is not known to be established in the field. The final release of this agent in north Queensland was made in December 2007. Having an effective biocontrol agent is considered necessary to halt bellyache bush spread and reduce its impact. Hence, the bellyache bush biocontrol program was recommenced to screen other potential agents identified during earlier surveys in Central America. The project also involves surveys in South America in countries with similar climatic conditions to areas with bellyache bush infestation in Australia. Potential agents will be prioritised based on their potential impact.

Methods

Rearing and release of Agonosoma trilineatum

Insects are reared on cut foliage with seed capsules in the laboratory and glasshouses at TWRC and release mated adults in north Queensland. For distant and remote sites, we send insects in styrofoam containers with a rosette of fresh foliage with seeds and a cool block for release by local stakeholders. We then conduct visual inspections for adults, nymphs and evidence of feeding on seed capsules within 1–4 weeks of release at most of the sites. Stakeholders undertake periodic inspections of remote far northern sites.

Plant molecular studies

DNA is extracted from 252 leaf samples obtained from the herbarium collections at the Missouri Botanical Gardens, CSIRO Entomology Mexican Field Station, Queensland Herbarium, Noumea Herbarium (all dried leaves), and from the field throughout Australia (fresh leaves) using a Nucleospin 96 Kit. We determine the geographical origin of non-native bellyache bush populations using chloroplast microsatellites (cpSSRs). In addition, we use polymorphic cpSSR markers to assess patterns of haplotypic diversity among *J. gossypiifolia* leaf samples collected in the native and introduced ranges.

CLIMEX models

The native range distribution is compiled of bellyache bush based on herbarium records and plant databases. We then use a climate-modelling tool (CLIMEX) to compare the climates of the native and introduced ranges of bellyache bush to identify climatically suitable locations for agent exploration. We use the composite match index (CMI), which determines the level of climatic similarity between locations, to compare four bellyache bush infestations in Australia (Charters Towers, Palmerville, Burketown and Katherine) with bellyache bush's native range. Here, we use all climatic variables (maximum and minimum temperatures, relative humidity and rainfall) in the comparison and prioritise locations with CMI values above 0.6. We also develop a CLIMEX model to aid in the selection of release sites for *A. trilineatum*.

Simulated herbivory

We have imposed simulated herbivory on the Queensland bronze variety of bellyache bush plants in the field at Charters Towers. Field plants (seedlings,

mature and old plants) are assigned to one of the three simulated herbivory treatments (defoliation, shoot tip damage and defoliation + shoot tip damage) at varying frequencies (no herbivory, single, two and three events of herbivory). Defoliation involves manual removal of all leaves and shoot tip damage is inflicted by cutting 5 cm off shoot tips of all branches. We record the plant height, number of branches, number of leaves, number of flowers, number of seed capsules and basal stem diameter every 6–8 weeks. Approximately eight weeks after the final herbivory treatments (May–June 2008), we harvest all surviving plants and record various plant parameters (plant height, basal stem diameter, number of branches, number of leaves, number of seed capsules and plant biomass).

An honours project has been initiated in April 2008 to evaluate how different Australian bellyache bush populations (Queensland bronze, Western Australian green, Katherine green and Darwin purple) respond to simulated herbivory. Here, we assign potted plants from field-collected seedlings of various bellyache bush populations to two herbivory treatments (defoliation and shoot tip damage) at varying frequencies (no damage, single, two and three events of damage). We then record the impact of damage on plant growth (shoot length, basal stem diameter, number of leaves, and number of branches) and ecophysiology (photosynthesis and stomatal conductance) every five weeks. We will harvest all plants at the end of the trial (September 2008) and record various plant parameters (shoot length, basal stem diameter, number of branches, number of leaves and plant biomass). Results from this study will help to identify whether all of the bellyache bush populations in Australia are equally susceptible to damage, and if not, which populations, and what morphological parts of the plant, are worth targeting for biological control.

Native range explorations

CSIRO Entomology staff based at the Mexican Field Station conduct surveys to catalogue insects associated with bellyache bush in North America (Mexico), Central America (Nicaragua, Costa Rica, Honduras and Guatemala), South America (Columbia, Venezuela, Ecuador, Brazil, Argentina, Paraguay and Bolivia) and the Caribbean Islands (Puerto Rico, St Kitts and Dominica). Potential agents are exported to the Alan Fletcher Research Station (AFRS) for further host-specificity tests.

CAB International (CABI) in Mexico, in collaboration with staff from the CSIRO Mexican Field Station, conducts a survey for the presence of spores of the rust fungus (*Phakopsora jatrophicola*) on bellyache bush and other potential alternate hosts. Freshly collected teliospores of *P. jatrophicola* are exported to CABI facilities in the United Kingdom (UK) for subsequent germination and inoculation experiments. Pathogenicity tests are conducted to evaluate the potential impact of the rust on morphologically distinct bellyache bush varieties in Australia. Host-range testing of the bellyache bush rust against six closely related and economically important plant species is also conducted at CABI Europe-UK.

Host-specificity tests

The bellyache bush stem-boring weevil (*Cylindrocopturus jatrophae*) is imported from Mexico into the AFRS quarantine facility for rearing and host-specificity testing. Preliminary host-specificity of the rust fungus (*P. jatrophicola*) is carried out at CABI Europe-UK using test plants supplied by AFRS. If the results are encouraging, we carry out a detailed host-specificity test involving all approved test plants.

Photo 1. Bellyache bush stem-boring weevil (*C. jatrophae*) adult.

Progress

Mass-rearing and release of Agonosoma trilineatum

We made the final release of *A. trilineatum* in early December 2007 at a coastal site on Rita Island near Ayr. Eight releases totalling over 3000 adults and 1000 nymphs were made at five sites between late July and early December 2007. The most promising signs of insect establishment were seen in May and early June 2008 when small numbers of insects were seen at the site of the final release. Multiple insect releases had been made at this site between May and December. Monitoring of establishment status is ongoing.

Bellyache bush research workshop

A bellyache bush research workshop was held on 17 July 2007 to review existing knowledge and to identify research gaps. Representatives from DPI&F (AFRS, TWRC, Robert Wicks Pest Animal Research Centre (RWPARC) and Invasive Plants and Animals), Northern Territory Government, CSIRO Entomology, the Cooperative Research Centre (CRC) for Australian Weed Management, The University of Queensland (UQ), Queensland University of Technology (QUT) and The University of Adelaide attended the workshop.

Plant molecular studies

In total, we identified 33 haplotypes, of which 25 and 15 haplotypes were recorded in the native range and introduced range, respectively. Nine haplotypes were shared between the native and introduced range of bellyache bush. A neighbouring joining tree indicated

that native haplotypes formed three distinct clades, and that geographically restricted haplotypes from each of these clades were present in the introduced range. We observed no difference in haplotypic diversity between the native and introduced range. These results suggest that multiple introductions of diverse bellyache bush haplotypes from throughout the native range have occurred in the introduced range.

CLIMEX models

The climate match detected climatically similar locations in Paraguay, Bolivia, Brazil and small regions in Venezuela for all four Australian infestation sites, both in summer and winter. Additionally, Mexico, Ecuador and Peru showed CMI values between 0.6–0.8 in the climate match for all locations during winter. Regions in north Paraguay, Bolivia and western Brazil with high ecoclimatic index values would be the most climatically appropriate for sourcing biological control agents, as these areas are characterised by seasonally dry winters and wet summers, similar to areas in Australia with bellyache bush infestations.

We developed a CLIMEX model of the potential geographic range of *A. trilineatum* based on its native range distribution. The model suggests that the tropical eastern coast of Queensland and the northern areas of the Northern Territory are climatically more suitable for the agent than inland and southern areas.

Simulated herbivory

The simulated herbivory trial in Charters Towers was completed in May–June 2008 and data analysis is in progress. Due to difficulties in removing entire plants with intact root systems, we removed only the above ground parts of old (large) experimental plants for biomass estimation. The honours research project comparing plant response to simulated herbivory is in progress and will be completed in September 2008.

Native range exploration

CABI has signed a contract to conduct a survey in Mexico to make a fresh collection of the rust fungus, and to ascertain its specificity in the field. CSIRO Entomology signed a further contract to conduct surveys in Central and South America and to supply prioritised biological control insects from Central America. CSIRO Entomology staff surveyed bellyache bush in the semi-arid zones in north-eastern Brazil and Peru during July–August 2007 and concluded that these areas are not suitable for further exploration because they have no natural populations of this species. Exploration for potential agents in Paraguay and Peru is in progress.

Host-specificity tests

Permits to import the stem-boring weevil (*C. jatrophae*) and the leaf-feeding moth (*Xylesthia* sp.) were obtained. We received two shipments of field-collected *C. jatrophae* adults (Figure 1), larvae and pupae from Mexico into the AFRS quarantine facility in April and in May 2008. Adult mortality in the high security area was high, and we therefore obtained approval to move the newly emerged adults to the medium security area from the Australian Quarantine and Inspection Service (AQIS). Transfer of adults to medium security and the provision of a honey solution as supplementary adult food have improved adult survival. However, there is no sign of oviposition or larval development, despite trialling a range of conditions. Attempts to induce oviposition are continuing. We will initiate host-specificity tests as soon as the rearing method for this insect is standardised. We did not progress the importation of the leaf-feeding moth as subsequent identification confirmed this species as *X. pruniramiella*, a known pest of plums in North America. We also developed a list of test plants for host-specificity tests based on phylogeny and circulated it to relevant agencies for approval. All Australian bellyache bush varieties and other *Jatropha* species have been sent to CABI to conduct pathogenicity and preliminary host-specificity testing of the bellyache bush rust.

Funding

Land Protection Fund

Queensland Government (Blueprint for the Bush)

Burdekin Dry Tropics Natural Resource Management

Logistical support

Christian Mille (Institut Agronomique néo-Calédonien, New Caledonia)

Noumea Herbarium, New Caledonia

Jim Solomon (Missouri Botanical Garden, United States)

Tim Heard and Ricardo Segura (CSIRO Entomology)

Bron Routley (Department of Natural Resources, Environment and the Arts, NT)

Noel Wilson (Department of Agriculture and Food, WA)

Gordon Guymer (Queensland Herbarium, Brisbane)

Nathan March and Coby Seaborn (DPI&F, Cloncurry)

Angelika Hesse (Darwin City Council)

Mitchell River Watershed Management Group, Cairns

Expected completion

2009

7 Biological control of parthenium (*Parthenium hysterophorus*)

Objectives

Monitor the field persistence and abundance of parthenium biocontrol agents—the summer rust (*Puccinia melampodii*), the clear-wing moth (*Carmenta ithacae*) and the stem-galling weevil (*Conotrachelus albocinereus*).

Staff

K. Dhileepan (Leader), Mariano Treviño (AFRS) and Catherine Lockett (TWRC)

Collaborators

Steve Adkins (UQ)

Rationale

Parthenium is a WONS and biological control is potentially one of the most effective and economically viable management options. Among the various biological control agents introduced against parthenium in Queensland, the summer rust is an agent suited to areas with hot and dry weather conditions. It was introduced from Mexico in 1999 and released at more than 50 infested sites in Queensland. The clear-wing moth, also native to Mexico, was released from 1998–2002. The stem-galling weevil from Argentina was released in Queensland from 1995–2000. Although all three agents have established in the field, their incidence and abundance in parthenium infestations in north and central Queensland is not fully known.

Methods

Parthenium sites are surveyed in central Queensland (Hutton Creek in Timor Station, Moolayember Creek, Albinia National Park, Springsure, Gordon Road between Emerald and Capella, Clermont, Wycarbah and Delargum) and north Queensland (Cardigan Station and Plain Creek) at the end of the parthenium growing season and record the incidence and abundance of various biological control agents, along with information on the abundance of parthenium at each site.

Sites in central Queensland were sampled in April 2008. At each site, we randomly sample five 0.25 m² quadrats and record the following parameters: number of parthenium plants, number of plants with rust, number of leaves with rust in each plant, and number of clear-wing moth and stem-galling weevil larvae and pupae per plant.

Sites in north Queensland were sampled in March 2008. At each property we sample a minimum of 20 sites, and in each site we sample five 1 m² quadrats, recording the following parameters: total number of parthenium plants, number of plants with rust infection, and proportion of leaf area (%) with rust infection.

Progress

Summer rust

Presence of the summer rust was evident at two sites (Plain Creek and Cardigan Station) in north Queensland, while eight out of 10 sites in central Queensland showed rust incidence (Figure 1). The number of leaves with rust infection varied widely between these sites, with higher numbers of rust infected leaves per plant in central Queensland than in north Queensland (Figure 1).

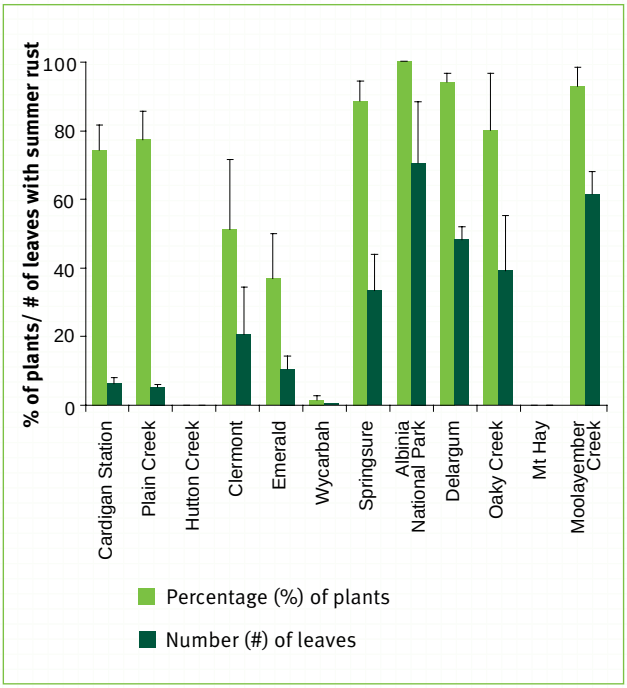

Figure 1. Incidence and abundance of parthenium summer rust (mean ± SE) in Queensland.

Clear-wing moth

As in previous years, we recorded a presence of parthenium clear-wing moth larvae only at the Wycarbah and Mt Hay sites in central Queensland. At both sites, the clear-wing moth was more abundant in 2008 than in the two previous years (Figure 2), with an average of 0.6 ± 0.11 larvae per plant. We did not recover the moth from any of the other release sites.

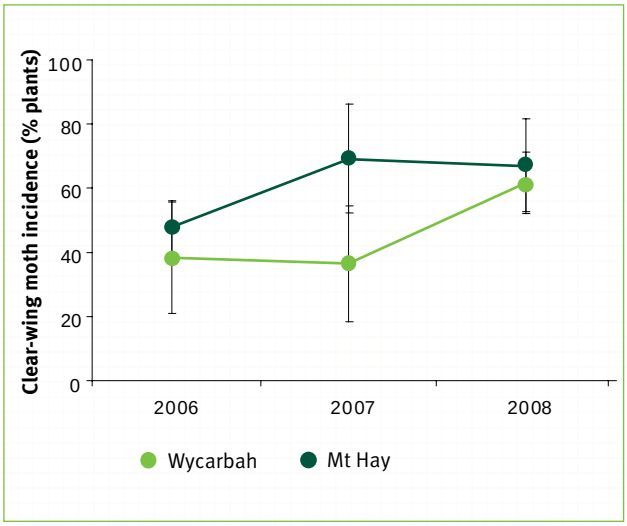

Figure 2. Parthenium clear-wing moth incidence (mean ± SE) in central Queensland.

Stem-galling weevil

This insect was not recorded at any of the survey sites.

Funding

Queensland Government

Expected completion

Ongoing

8 Biological control of prickly acacia (*Acacia nilotica* ssp. *indica*)

Objectives

- Conduct explorations in India, the native range source of the prickly acacia populations in Australia, for potential biological control agents.
- Understand the response of prickly acacia seedlings to simulated herbivory to facilitate the prioritisation of guilds of specialist herbivores as biological control agents based on their potential impacts.
- Quantify the impact of native insect herbivores on the survival and growth of prickly acacia seedlings under diverse field conditions in India and use this information for agent prioritisation.
- Monitor the prevalence and abundance of the established biological control agent *Chiasmia assimilis* from South Africa.
- Examine whether remote sensing can be used to detect changes to the foliage cover of prickly acacia due to defoliation by *C. assimilis*.

Staff

K. Dhileepan (Leader) and Bill Palmer (AFRS), Catherine Lockett, Kelli Pukallus (until February) and Tricia Voigt (from March) (TWRC)

Collaborators

Syed Ahmed (AFRI, Jodhpur, India)

A. Balu (IFGTB, Coimbatore, India)

Tim Danaher, SLATS project (DNR&W)

Moya Calvert, Project Officer—Modelling (DPI&F)

Rationale

Prickly acacia is a WONS and is currently widespread throughout the natural grasslands of western Queensland. Classical biological control, a low-cost and permanent alternative, is considered a viable option for the long-term sustainable control of this weed.

The need for effective biological control agents continues to be a priority in the Mitchell grass downs. Genetic studies have revealed that the invasive prickly acacia population in Australia is the subspecies *A. nilotica indica*, which is native to India and Pakistan. We have conducted surveys in Pakistan and now propose to conduct surveys in India. The occurrence of several native *A. nilotica* subspecies, along with other native and non-native *Acacia* species (including species native to Australia), highlights the advantage of conducting surveys in India where the field host-specificity of potential agents could be determined.

Understanding plant response to herbivory facilitates the prioritisation of guilds of specialist herbivores as biological control agents based on their potential impacts. Empirical studies on the response of prickly acacia seedlings to simulated herbivory will guide

agent selection in India (i.e. type and intensity of herbivory required).

Methods

Simulated herbivory

Information on the susceptibility of prickly acacia to herbivory is limited and there is no information available on the plant organ (i.e. leaf, shoot and root in isolation or in combination) most susceptible to herbivory.

We evaluate the ability of similar sized prickly acacia seedlings (n = 360; 16–18 weeks old) to respond to different types of simulated herbivory (100% defoliation, 30% shoot damage, 30% root damage, and combinations thereof), at varying frequencies (no herbivory, single, two and three events of herbivory) to identify the type and frequency of herbivory that will be required to reduce growth and vigour.

Explorations in India

Contractors conduct surveys in natural groves and plantations in arid regions of Rajasthan, Gujarat, Tamil Nadu and Karnataka states at regular intervals (4–6 times a year, covering all seasons) to catalogue insect herbivores and plant pathogens associated with various subspecies of *A. nilotica* in India. Insect herbivores exhibiting host-specificity in field surveys are tested in glasshouse trials to confirm host-specificity. The impact of native insect herbivores on seedling survival and growth under field conditions is evaluated in an insecticide exclusion trial, conducted over three years at three sites each in Rajasthan and Gujarat.

Agent monitoring

We monitor incidence and abundance of the prickly acacia leaf-feeding geometrid (*Chiasmia assimilis*) at a coastal site in north Queensland (Ashfield). We collect two hundred 30 cm tip cuttings (20 per tree) at this site every 6–8 weeks, and record the number of larvae, along with estimates of the percentage of defoliation and percentage of normal leaf cover present (this varies seasonally). We also monitor a further three sites—one coastal (Inkerman) and two western (Mona Vale and the Hughenden)—to study the incidence and abundance of *C. assimilis* as well as the prickly acacia noctuid (*Cometaster pyrula*).

Remote sensing

We estimate foliage projective cover (FPC) of prickly acacia infestations at four properties in the Bowen area (Newstead, Ashfield, Gumlu and Inkerman Station) using Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) imagery developed by the Statewide Landcover and Trees Study (SLATS) project. We then analyse the modelled FPC to determine whether prickly acacia defoliation events can be detected remotely. If changes are detected, they are correlated against field measurements of prickly acacia defoliation events by the introduced biological control agent (*C. assimilis*) at these sites.

Progress

Simulated herbivory

Defoliation and shoot damage, individually, had a significant negative impact on prickly acacia seedlings, but for the defoliation to be effective, more than two defoliations were required, whereas single shoot damage was enough to cause a significant reduction in plant vigour (Figure 1). Hence, a leaf herbivore which has the potential to complete multiple generations (multivoltine) would be desired. On the other hand, just one attack by a shoot tip borer/feeder might be adequate. Root damage had a negligible impact on prickly acacia. A combination of defoliation and shoot damage had the greatest negative impact on prickly acacia seedling vigour, even with a single bout of herbivory. The results suggest the need for prioritising a shoot tip herbivore in combination with a multivoltine leaf herbivore as biological control agents for further host-specificity tests.

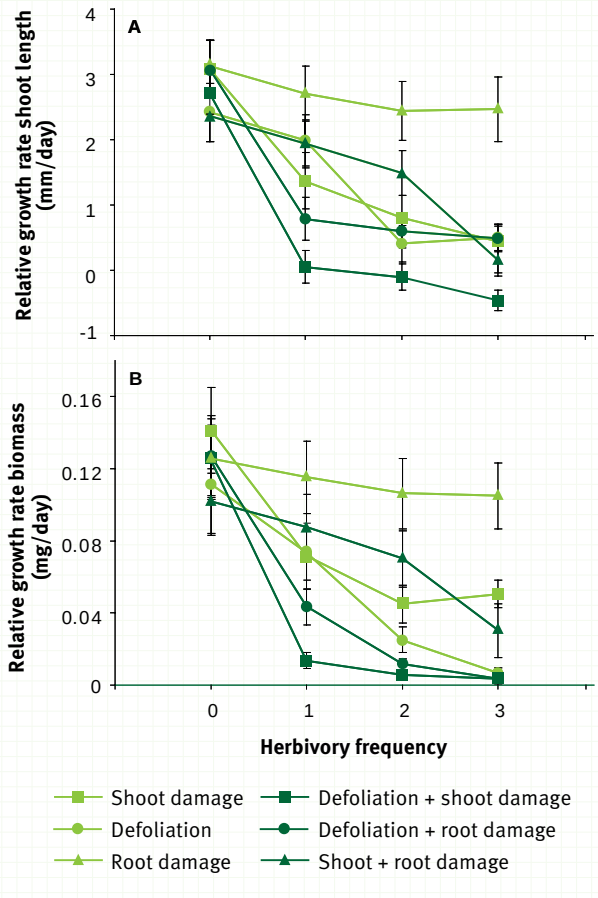

Figure 1. Impact of type and frequency of simulated herbivory on the growth rates (mean ± SE) of (A) shoot length and (B) total biomass in prickly acacia seedlings.

Explorations in India

The initiation of the project in India was delayed by more than eight months. This was due to delays in obtaining approval from the Indian Government, finalising contracts with collaborating Indian research agencies and staff selection.

After obtaining approval from the Indian Government (December 2007), contracts with the Arid Forest Research Institute (AFRI) (February 2008) and the Institute of Forest Genetics and Tree Breeding (IFGTB) (March 2008) were signed and the project was initiated in March 2008.

Staff selection has been finalised at AFRI and two entomologists and a plant pathologist will commence explorations from mid-July 2008. Various positions are currently advertised at IFGTB. It is expected that project staff will be in place and the survey initiated in July–August 2008.

Suitable prickly acacia sites in Rajasthan, Gujarat, Tamil Nadu and Karnataka states have been identified for survey and field exclusion studies. Prickly acacia seedlings have been procured for the field exclusion trials.

Agent monitoring

Chiasmia assimilis continues to be seasonally abundant in coastal Queensland, causing severe defoliation at Inkerman and Ashfield properties. At Inkerman, large numbers of adults and larvae were seen in October 2007, resulting in complete defoliation. At Ashfield, adults and larvae were less abundant in October 2007, causing only moderate defoliation (22%), but numbers increased to high levels in April 2008, resulting in complete defoliation. At Mona Vale in western Queensland, a survey in November 2008 revealed a low *C. assimilis* population, causing only 10% defoliation. To date, there has been no confirmation of establishment of *C. pyrula* at any of the sites where it had been released until June 2007.

Remote sensing

Remote sensing with Landsat imagery (Figure 2) detected defoliation events due to biological control, but only in areas with high-density prickly acacia (e.g. Inkerman and Ashfield) and not in areas with medium to low prickly acacia densities (e.g. Gumlu and Newstead). Further research is required to establish base low and high prickly acacia FPC values to quantify the levels of defoliation. This would involve carrying out field work in conjunction with satellite data capture dates, at times of full foliation and complete defoliation.

Photo 1. Satellite image of Inkerman Station in north Queensland. (Prickly acacia infestation framed in red.)

Funding

Land Protection Fund

Queensland Government (Blueprint for the Bush)

Meat and Livestock Australia

Logistical support

Governments of Gujarat, Rajasthan, Tamil Nadu and Karnataka States

Indian Council of Forestry Research and Education

Newstead, Ashfield, Gumlu, Inkerman and Mona Vale properties

Expected completion

2011

9 Biological control of weedy sporobolus grasses (*Sporobolus pyramidalis, S. natalensis, S. fertilis, S. africanus and S. jacquemontii*)

Objectives

- Achieve biological control of the five weedy sporobolus grasses (*Sporobolus pyramidalis, S. natalensis, S. fertilis, S. africanus and S. jacquemontii*) infesting areas of Australia.
- Determine the biology and host-specificity of two organisms, the sporobolus leaf smut (*Ustilago sporoboli-indici*) and the sporobolus stem wasp (*Tetramesa sp.*), which are potential biological control agents.
- Propose the release of the leaf smut and the stem wasp in Australia if proved host-specific.

Staff

Bill Palmer (Leader) and Wilmot Senaratne (AFRS)

Collaborators

Mark Laing, Professor and Chair of Plant Pathology (University of KwaZulu-Natal, South Africa)

Kwasi Yobo, Post Doctoral Fellow (University of KwaZulu-Natal, South Africa)

Mike Morris, Principal—Plant Health Products (Stellenbosch, South Africa)

Arne Witt, Division Manager (ARC-PPRI, South Africa)

Ayanda Nongogo, Student (University of Witwatersrand & ARC-PPRI, South Africa)

Roger Shivas, Principal Plant Pathologist (DPI&F)

Bryan Simon, Principal Botanist (EPA)

Rationale

Five exotic grasses, collectively known as the weedy sporobolus grasses, are serious weeds along Australia's eastern seaboard. They are generally unpalatable, cause loss of production and ultimately lower property values. The grasses are easily dispersed and conventional methods of control are either costly or ineffective.

Interest in the biological control of the weedy sporobolus grasses began in 2000 and coincided with the establishment of the former Department of Natural Resources and Water (DNR&W) South African Field Station, which conducted surveys for potential agents throughout southern Africa. Two possible agents were selected for further study.

Methods

For this project, we negotiated contracts with two external South African researchers. Professor Mark Laing of the University of KwaZulu-Natal undertakes biology and host-specificity studies of the leaf smut, which was previously found to have infected the three African species of the weedy sporobolus grasses in South Africa. Mr Arne Witt of the Agricultural Research Council—Plant Protection Research Institute (ARC-PPRI) studies the stem wasp.

The study of the smut is divided into two phases, both conducted in South Africa. In the first phase the smut is cultured and methods for infecting plants investigated. The smut is then tested against Australian populations of all the weedy sporobolus grasses to determine whether they are susceptible, and against a small number of Australian native *Sporobolus* spp. The results of these studies determine whether full host-testing leading to release in Australia should proceed.

The study of the stem wasp is also divided into two phases. The first phase, undertaken in South Africa, determines whether the insect can be reared in the laboratory. If it is successfully reared and shipped, we import it into quarantine facilities at AFRS for full host-testing.

Progress

With the support of the Australian Weeds Committee, we applied to the Natural Resource Management Standing Committee (NRMSC) in 2004 to have the weedy sporobolus grasses approved as targets for biological control. However, NRMSC has not made their decision yet.

Studies of the leaf smut commenced in January 2005 at the University of KwaZulu-Natal. The smut was successfully cultured and infections were observed on Australian populations of *S. pyramidalis, S. natalensis, S. africanus* and *S. fertilis*, but not on *S. jacquemontii*. This result was of particular interest because *S. jacquemontii* is the only species of American origin, indicating that the smut may discriminate between *Sporobolus* spp. and therefore be sufficiently host-specific for biocontrol purposes. However, further host-range trials with the smut fungus against 10 native Australian *Sporobolus* grass species indicated that four of these developed symptoms of infection typical of the smut fungus. The results of these studies were assessed by about 20 scientists or stakeholders, resulting in a consensus view that approval for the release of the smut fungus in Australia is unlikely.

Work on the stem wasp was discontinued because all efforts to rear it in the laboratory were unsuccessful; this is an essential criterion for host-testing within a quarantine facility. In September 2007, the project leader visited South Africa to see the experimental work and to discuss whether there were any alternative approaches that might be taken with the smut. Discussions were also undertaken in London with CABI Europe-UK plant pathologists. As a result of these discussions and others with the project's funding body, Meat and Livestock Australia (MLA), we decided to discontinue this line of investigation.

In May 2008, we held new discussions with Victorian scientists and MLA as to whether the endemic pathogen *Nigrospora oryzae*, which has been observed to affect giant Parramatta grass in Australia, could be developed as a mycoherbicide.

Funding

Land Protection Fund
MLA

Expected completion

October 2008

10 Biological control of mother-of-millions (*Bryophyllum* spp.)

Objectives

- Achieve biological control of the poisonous weed, mother-of-millions, by introducing and releasing exotic insect species or pathogens.
- Produce risk, economic, stakeholder and partner analyses for the mother-of-millions weed problem.
- Support any application under the *Biological Control Act 1987* through the various processes of the Act and determine whether the Act can be used to assist biological control projects.

Staff

Bill Palmer (Leader) and Wilmot Senaratne (AFRS)

Collaborators

Jim Thompson, Director—Biosecurity Science (DPI&F)

Bruce Wilson, General Manager—Invasive Plants and Animals (DPI&F)

Rationale

Mother-of-millions is an invasive, exotic weed from Madagascar causing environmental, social and economic impacts. It is toxic to cattle and can have a substantial economic impact to the beef and dairy cattle industries in eastern Australia. Environmental costs of the weed include competition with native plants, loss of food plants for native herbivores, loss of amenity value and general chemical contamination of the environment.

Surveys for potential biocontrol agents for mother-of-millions began in 2000 and resulted in the selection of four potential agents for study. We studied two of these, the weevils *Osphilia tenuipes* and *Alcidodes sedi*, in detail in the quarantine facility at AFRS, while preliminary studies of the other agents were undertaken in South Africa. All potential biocontrol agents for mother-of-millions had narrow host ranges but were capable of attacking very closely related, exotic, ornamental plants such as *Kalanchoe blossfeldiana* and *Echeveria* spp. All agents would therefore require approval through the *Biological Control Act 1987*, as well as the standard approvals from AQIS and the Department of the Environment, Water, Heritage and the Arts (DEWHA).

When conflicts of interest exist with the biological control of a weed, Australian proponents for the control can have both targets and agent organisms declared under the Act so that they are not legally liable for identified adverse effects and legal injunctions cannot be brought to prevent releases of the agent. The process involves applying to the Natural Resource Management Ministerial Council (NRMMC). If NRMMC unanimously supports the application, a Biological Control Authority then seeks the views of all stakeholders and determines the benefits and costs of the proposed biological control. If, on balance, the benefits outweigh costs, the NRMMC may by unanimous opinion approve the declaration of target and agent organisms under the Act.

Methods

We assessed the extent of the mother-of-millions weed problem to Queensland stakeholders and its amenability to biological control. Fauna surveys of *Bryophyllum delagoense* and closely related species were undertaken in areas of Madagascar and southern Africa where the plant occurs naturally. The biology and host ranges of potential biocontrol agents were studied at both the former DNR&W South African Field Station and in the quarantine facility of AFRS. If approval for release can be obtained, we mass-rear agents and release them throughout the range of the weed in Queensland. We then monitor the releases to determine establishment progress and any effects of the agent.

Progress

We maintained cultures of *O. tenuipes* and *A. sedi* in quarantine throughout the year. These insects remain promising biocontrol agents if they can be approved for release.

The Natural Resources Policies and Programs Committee instigated a review of procedures relating to the approval of biological control agents in Australia after Queensland indicated that it may apply under the Act in relation to mother-of-millions. A workshop was held for stakeholders in Adelaide in December 2007.

In October 2007, we attended a meeting and field day in Miles to discuss the issues. The very clear indication from that meeting was that stakeholders did want the agents to be progressed through the Act despite the time and effort this would take.

We prepared briefings for DPI&F executive management. However, the machinery-of-government transition to Biosecurity Queensland has delayed resolution of this issue.

Funding

Land Protection Fund

Expected completion

Ongoing

Part 2 Landscape protection and restoration

1 Biological control of cat's claw creeper (*Macfadyena unguis-cati*)

Objectives

Achieve biocontrol of cat's claw creeper using introduced insect species.

Staff

K. Dhileepan (Leader), Di Taylor (from December), Mariano Treviño, Deanna Bayliss (until December), Jayd McCarthy (from December), Mathew Shortus (from January) (AFRS), Karina Pyle (QUT Honours Student) and Manu Saunders (UQ Honours Student)

Collaborators

Stefan Neser (ARC-PPRI, South Africa)

Gimme Walter (UQ)

Tanya Scharaschkin, Peter Mather and David Hurwood (QUT)

Rationale

Cat's claw creeper is a major weed in coastal Queensland and New South Wales, where it poses a significant threat to biodiversity in riparian and rainforest communities.

Cat's claw creeper is a structural parasite and produces stolons and subterranean root tubers. Classical biological control appears the most suitable management option for this weed. Management objectives are focused on reducing the rate of shoot growth to limit the weed's ability to climb and smother native vegetation, as well as reducing tuber biomass to minimise the tuber bank.

We used plant genotype and climatic similarities as filters to identify areas for future agent exploration in cat's claw creeper's native range, and plant response to herbivory and pre-release evaluations as 'predictive' filters for agent prioritisation. Agents from the same plant genotype and from areas with similar climatic conditions are more likely to provide effective biological control. Adopting such a systematic approach makes agent selection decisions explicit, allows for more rigorous evaluation of agent performance and yields a better understanding of the success and failure of agents in weed biological control.

Methods

Mass-rearing and field release

We mass-rear and release two biological control agents, the leaf-sucking tingid (*Carvalhotingis visenda*) and the leaf-tying moth (*Hypocosmia pyrochroma*), in partnership with community groups. We use a simple and cost-effective method to mass-rear the leaf-tying moth by replacing potted plants with field-collected cut foliage to allow greater numbers of insects to be released in the field.

Temperature tolerance studies

Cat's claw creeper is an invasive liana with a wide climatic tolerance. For the leaf-sucking tingid and the leaf-tying moth to be effective, both agents must survive and develop in a range of temperatures.

For the tingid, we evaluate the effect of constant temperatures (0 °C to 45 °C) on adult survival and longevity, oviposition and incubation periods, and nymphal survival and development in temperature-controlled cabinets. The degree-day requirements for tingid eggs and nymphs are estimated by the reciprocal of the slope of the fitted linear regression. The potential number of tingid generations per year is predicted by dividing the cumulative degree-days in a location by the degree-day requirement to complete development (egg to egg).

For the leaf-tying moth, we evaluate the effects of constant temperature (15 °C to 40 °C) on adult survival, oviposition, larval development and pupal diapause also in temperature-controlled cabinets.

Genetic diversity in tingid populations

The tingid approved for field release was originally collected from South America in 2002. Since then, it has been maintained under glasshouse conditions for over 90 generations, initially in South Africa and then in Australia.

Such long-term maintenance in glasshouse conditions often leads to a genetic bottleneck, resulting in reduced insect vigour and adaptability. Hence, we use a fresh collection of the tingid from its native range to mix with the existing laboratory colonies. We study genetic diversity among freshly collected (< six generations) and long-term lab maintained (> 90 generations) tingid populations, and identify any potential markers to differentiate the two populations in the field.

Bioevaluation

The impact of the tingid on two morphologically distinct (long pod and small pod) cat's claw creeper populations is studied in south-east Queensland.

In each site, similar sized cat's claw creeper seedlings (20 long pod + 20 small pod plants) are planted in the soil. A trellis is installed for each liana to grow on to. We inoculate half of the seedlings in each site (10 long pod + 10 small pod plants) with 20 tingid adults (treatment plants) per plant, while the remaining 20 plants remain insect-free (control plants). We then monitor all treatment and control plants at monthly intervals.

In treatment plants, we record the proportion of leaves with tingid damage as well as the number of adults, nymphs and oviposition marks for all or sub-samples of leaves. All control plants are monitored to ascertain that they remain insect-free. We record various plant growth

parameters (shoot length, number of shoots, basal stem diameter, number of leaves, etc.) at the beginning of the trial and at quarterly intervals.

The trial will be completed by August 2009. At the end of the trial, we will remove all plants from the soil, along with the subterranean tuber and roots, and record various plant parameters including the leaf, stem, tuber and root biomass.

Progress

Mass-rearing and field release

Approval to release the leaf-tying moth was obtained from AQIS and DEWHA in September 2007.

Mass-rearing and field release of the tingid and the moth has commenced in partnership with various Landcare groups, shire councils, catchment groups, private landholders and state schools participating in the Weed Warriors program.

Since May 2007, over 32 000 tingids (adults and nymphs) have been released at 40 sites and over 10 000 moths have been released at 18 sites. Sites range from northern New South Wales in the south to Mackay in the north, from Nerang and other coastal sites in the east to Taroom in the west. Sites cover a range of climatic conditions and include both riparian and non-riparian environments.

The tingid has established well in all of the release sites, but has been slow to disperse, moving only metres in the first six months after release. It is too early to ascertain field establishment status of the leaf-tying moth—it was released for only six months between November 2007 and April 2008, before field releases were stopped due to the winter pupal diapause. Releases of the moth will commence next spring once adults have emerged.

We have refined the mass-rearing method for the leaf-tying moth by replacing potted plants with field-collected foliage.

Temperature tolerance of leaf-sucking tingid

Adults showed tolerance for wider temperature ranges (0 °C–45 °C), but oviposition, egg hatching and nymphal development were all affected by both high (› 30 °C) and low (‹ 20 °C) temperatures.

Temperatures between 20–30 °C are the most favourable for adult survival, oviposition, egg hatching and nymphal development. The ability of adults and nymphs to survive for a few days at high (40 °C and 45 °C) and low (0 °C and 5 °C) temperatures suggests that extreme temperature events, which usually occur for short durations (hours), are unlikely to affect the tingid population.

In Australia, the potential number of generations (egg to egg) the tingid can complete in a year ranged from 10 in New South Wales to 15 in Queensland. A climatic model based on temperature tolerance studies suggests that inland areas are less favourable than coastal areas due to dry stress, while New South Wales is less suitable than Queensland due to cold stress.

Temperature tolerance of the leaf-tying moth

Adults were tested at three constant temperatures (20 °C, 25 °C and 30 °C) before diapause halted studies. Adults survived the longest at 20 °C, but had higher fecundity at 25 °C. Egg viability was also higher at 25 °C. Adults lived for only a few days at 30 °C. Females laid a similar number of eggs to the adults kept at 20 °C, though viability was lower. A similar proportion of larvae kept at 25 °C and 30 °C developed to the pupal stage, although results so far indicate that larval development occurs more rapidly at 30 °C than at 25 °C.

Genetic diversity in the the tingid populations

We received a population of field-collected *C. visenda* (29 adults + 53 nymphs) from Paraguay in March 2008. Adults were moved from a high security to medium security facility for mass-rearing. We have initiated host-specificity testing of the tingid on selected test plants, and if the insect is found to be host-specific, we will seek approval for its field release. In collaboration with researchers at QUT, genetic studies are underway to compare the tingid population that has been in quarantine since 2002 with the freshly field-collected tingid population.

Bioevaluation

We have selected sites with cat's claw creeper infestations in riparian (Nerang, Brookfield and Carseldine) and non-riparian (Oxley, Carindale and Bardon) areas, where the tingid has been released and there are early signs of its establishment. We have further planted similar-sized field-collected tubers of long pod and small pod varieties of cat's claw creeper in pots to be used in the field studies. It is expected that the field studies will be initiated in September–October 2008.

Funding

Land Protection Fund
Queensland Government (Blueprint for the Bush)
Burnett Mary Regional Group

Logistical support

Environmental Training and Employment Inc. (NSW)
EPA/QPWS
Seqwater (Wivenhoe Dam)
Brisbane City Council
Fraser Coast Regional Council
Ipswich City Council
Sunshine Coast Regional Council
Atkinson/Buaraba Catchment Landcare Group
Burnett Catchment Care Association
Gympie and District Landcare
Moggill Creek Catchment Group
Pine Rivers Catchment Association
Whitsunday Catchment Landcare
Weed Warriors (Boonah, Rathdowney, Homebush and Moggill State Schools)

Expected completion

Ongoing

2 Biological control of Madeira vine (*Anredera cordifolia*)

Objectives

Achieve biological control of the environmental weed, Madeira vine, by introducing and releasing exotic insect species or pathogens.

Staff

Bill Palmer (Leader), Di Taylor, Wilmot Senaratne and Liz Snow (AFRS)

Collaborators

Stefan Neser, Liame van der Westhuizen (ARC-PPRI, South Africa)

Rationale

Madeira vine is a South American plant that is an increasingly important environmental weed in eastern Australia. It is the only naturalised plant in the family Basellaceae in Australia, so there is a good chance that biocontrol agents found on Madeira vine would be sufficiently host-specific for a safe release. However, one exotic species from this family, Ceylon spinach (*Basella alba*), is grown in gardens in south-east Queensland. The project has good prospects of success and was rated highly at the Biocontrol Priorities Workshop held at AFRS in 2001. In South Africa, where Madeira vine is also a serious weed, there has been great interest in its biological control. South African scientists led by Dr Stefan Neser have identified some promising agents, which could be made available to this project. Host testing of two agents, the leaf beetles *Plectonycha correntina* and *Phenrica* sp., has been undertaken in South Africa and Argentina respectively.

Methods

Dr Neser has initiated a survey for suitable biological control agents in Argentina and Brazil. We anticipate further exploration during the course of this project. We import those insects considered suitable, mainly as a result of host-testing undertaken in South Africa, into the quarantine facilities at AFRS for final host-specificity testing and biology studies. We also develop climate matching models for prospective agents.

We submit applications to have Madeira vine approved as a target for biological control by the NRMSC and to have any suitable agents approved for release by AQIS and DEWHA. Approved agents are then mass-reared for distribution to climatically favourable areas. Following release, we monitor establishment progress and evaluate any effects of the agents.

Progress

A proposal was developed and submitted to target Madeira vine by biological control. The NRMSC approved Madeira vine as a target for biological control in February 2007.

In November 2007, we held a workshop at AFRS to discuss all aspects of the ecology and control of Madeira vine and to identify research gaps. Participants from universities, CSIRO and Greening Australia, as well as our own staff, attended the workshop. Prospects for biological control, including the *Basella alba* issue, were discussed. Some evidence was presented that foliage feeders may be more effective than agents that attack other plant parts. We also made efforts to engage Asian vegetable grower groups to ascertain the importance of *B. alba* to the Asian vegetable market. It appears that this plant has little commercial significance, although it is quite popularly grown by individual householders in the Asian community.

Two agents, *Plectonycha correntina* and *Phenrica* sp., were approved for import into quarantine facilities in Australia. In September 2007, the project leader visited South Africa to discuss agent-rearing and collaborative arrangements with ARC-PPRI. Subsequently, both insects were brought to the AFRS quarantine from laboratory populations kept in South Africa. We were able to rear *P. correntina* without problem within the quarantine but the *Phenrica* sp. culture did not persist. We received a second shipment of Phenrica sp. from South Africa in March 2008. This time we kept the culture in an evaporatively cooled, rather than a refrigerated air-conditioned, environment and the insect was cultured successfully.

We developed a host-test list of approximately 30 related plant species for the host-testing of the leaf-feeding insects. This list will be submitted for approval when we ascertain that we can obtain specimens of all species. Presently, we are sourcing plants on this list. It has been necessary to apply for a Queensland Environment Protection Agency permit to collect some species. When found, we grow specimens at AFRS and prepare them for experimentation.

Host-testing of *P. correntina* has commenced in 2008. Preliminary results support the overseas host-testing and indicate that this insect should be sufficiently host-specific to be considered for release. Results so far suggest that *Basella alba* will not be able to support populations of the leaf beetle. We have also undertaken biology studies on *P. correntina* to better understand its life history and to provide data for any future modelling efforts.

Presently, additional funding is being sought through the Commonwealth Government program, *Caring for our Country*.

Photo 1. Early instar (young) *Plectonycha correntina* larvae feeding on a Madeira vine leaf.

Funding

Land Protection Fund

Expected completion

Ongoing

3 Biological control of lantana (*Lantana camara*)

Objectives

Import, evaluate host-specificity, mass-rear, field-release and monitor biological control agents for lantana (*Lantana camara*).

Staff

Michael Day (Leader, December 2007–June 2008), Di Taylor (Leader, July–November 2007), Natasha Riding, Annerose Chamberlain, Ian Johnson (from February 2008) (AFRS), Catherine Lockett (Leader), Kelli Pukallus (until February) and Tricia Voigt (from March) (TWRC)

Collaborators

ARC-PPRI, South Africa
CABI Europe-UK, United Kingdom
Centre for Origin Research, United States
CSIRO Plant Industry
CSIRO Entomology
Department of Primary Industries, NSW
Department of Environment and Climate Change, NSW
EPA
UQ
Local governments in NSW
Local governments in Queensland

Rationale

Lantana is native to tropical America and was first introduced into Australia in the mid-1800s. It has since become a major weed of agricultural and natural ecosystems. In grazing lands, lantana dominates preferred pasture species, thereby decreasing productivity, and also interferes with mustering. Some varieties are toxic to livestock. It is estimated to cost the grazing industry over $100 million a year in lost production and control costs. In natural ecosystems, lantana can become the dominant understorey species, blocking succession and decreasing biodiversity. Lantana is a Class 3 weed in Queensland and has been the target of biocontrol programs since 1914.

Methods

Contracted entomologists in Mexico, South Africa and Europe locate and study the biology, biotype preference and host-specificity of potential biocontrol agents prior to their introduction into quarantine in Australia.

We then import suitable agents and determine their host-specificity. Any agents approved for field release are mass-reared and released in appropriate areas with the help of DPI&F Land Protection Officers and local government weed officers.

Progress

The lantana mirid (*Falconia intermedia*) has established at only three sites in north Queensland, despite an extensive release program throughout the state. Populations are increasing at all sites and damage is very noticeable. The agent has now spread up to 8 km from some sites.

The lantana rust (*Prospodium tuberculatum*) was released throughout all favourable areas in Queensland and New South Wales. The agent appears to have established at 34 sites in Queensland and following good rains throughout the summer of 2007–08, it has now dispersed up to 20 km from the point of release at many sites. In New South Wales, where conditions have been a little more favourable, the rust has established at 46 sites. It is widespread in northern New South Wales, spreading up to 20 km from some release sites, and up to 10 km on the central coast of New South Wales. Leaf drop due to the rust has been observed in both Queensland and New South Wales. Teliospores, the dormant stage of the rust life cycle, were found at 19 sites.

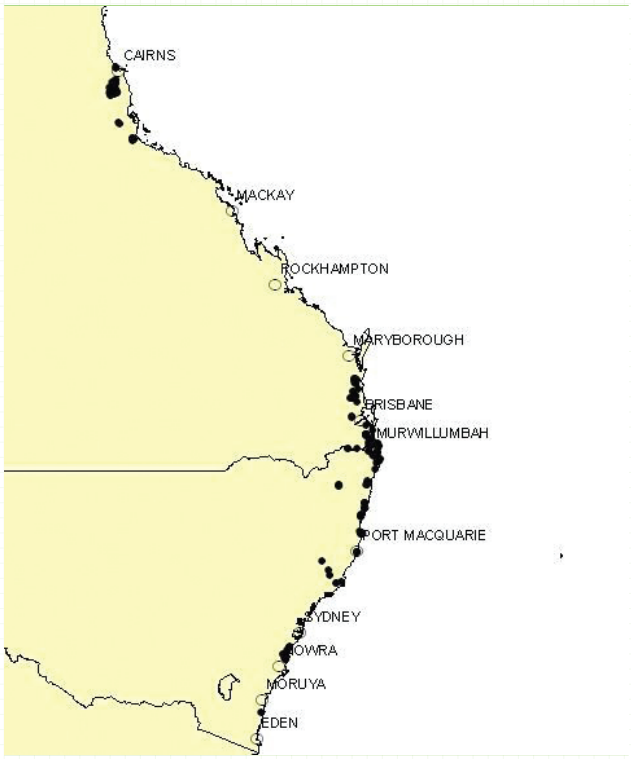

Figure 1. Map showing the current distribution of *Prospodium tuberculatum* in Australia.

The lantana stem-sucking bug (*Aconophora compressa*) continues to spread in Queensland and New South Wales. There has been noticeable die-back of lantana branches at numerous sites, including Brookfield, Toowoomba, Mt Fox, Atherton Tablelands and northern New South Wales.

Figure 2. Map showing the current distribution of *Aconophora compressa* in Australia.

Following the import of the lantana herringbone leaf-mining fly (*Ophiomyia camarae*) into quarantine from ARC-PPRI in October 2004, we successfully established a colony and completed host-testing on 11 plant species. No mines were seen on any species other than lantana and Lippia alba, and the agent was approved for release by AQIS. The application seeking its release was tabled in parliament and final approval was given in September 2007. Upon approval, mass-rearing and field-release has commenced at AFRS and TWRC. We produced a CLIMEX model to determine the most likely areas for establishment. To date, we have released over 45 000 insects at 43 sites. Mines have been observed at 11 sites in north Queensland and four sites in south-east Queensland.

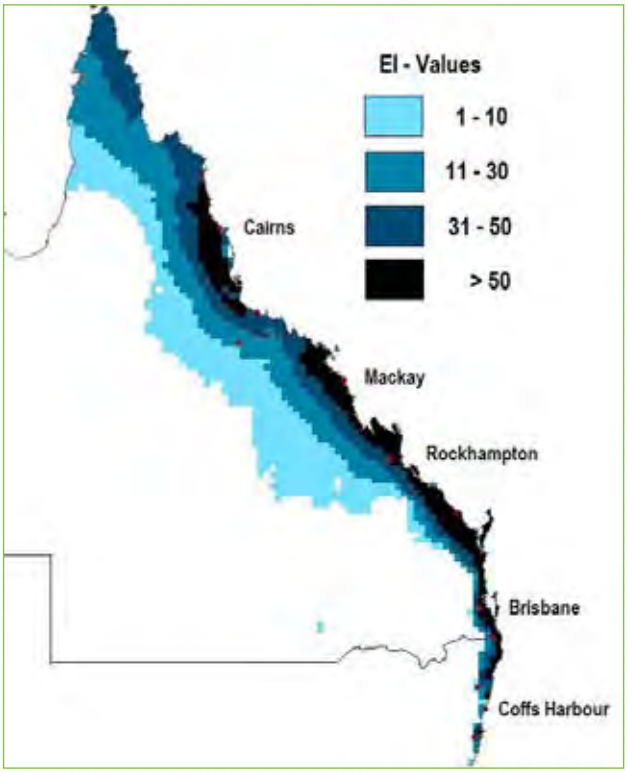

Figure 3. A CLIMEX model for *Ophiomyia camarae* showing areas of suitability.

As part of a requirement by AQIS we contracted ARC-PPRI to host-test a further four plant species against the lantana budmite (*Aceria lantanae*). The contract has been signed and we have shipped the first batch of plants. This work is due for completion by December 2008 and it is expected that the agent will be imported in early 2009, subject to test results and approval by AQIS.

We contracted CABI Europe-UK to study the biology, biotype preference and host-specificity of the pathogen *Puccinia lantanae*. The contract has been signed and we have shipped the first batch of plants. This work is due for completion by December 2008 and if appropriate, an application seeking its release in Australia will be prepared and submitted to Biosecurity Australia and DEWHA.

Lantana herbarium specimens from many different sites in eastern Australia, previously identified by lantana taxonomist Dr Roger Sanders as either *L. urticifolia* or *L. urticifolia* X *L. camara* hybrids, have now been re-identified following Dr Sanders' visit to Kew Gardens to examine type specimens. Most of the Australian herbarium specimens were deemed to be hybrids, with five species, *L. nivea, L. camara, L. horrida, L. strigocamara* and *L. hirsuta*, implicated. Dr Sanders will identify an additional 170 specimens from Australia, as well as about 110 overseas specimens.

Earlier DNA studies have suggested that Australian lantana has a close affinity to *L. urticifolia*, which has now been re-identified as *L. nivea*. A collaborative project with CSIRO Plant Industry investigating the genetic characteristics of lantana from different regions has commenced. Preliminary studies have found that there is little to separate lantana taxa within the same subsection. Considering that some biocontrol agents show preferences for different lantana varieties, and that different varieties have different levels of toxicity, further work is required to tease the group apart.

Funding

Land Protection Fund
Natural Heritage Trust
Manaaki Whenua – Landcare Research, New Zealand
CRC for Australian Weed Management

Expected completion

Ongoing

4 Biological control of mikania vine (*Mikania micrantha*) in Papua New Guinea and Fiji

Objectives

Introduce and establish biocontrol agents for mikania vine in Fiji and Papua New Guinea to:

- Reduce the impact of mikania vine to small block holders and plantation owners in areas where the weed is a problem.
- Reduce the seed load and thus the possibility of further spread into northern Australia.
- Establish successful biocontrol methods for use in northern Australia if required.
- Promote biocontrol as a safe and successful weed control method.
- Train scientists in Fiji and Papua New Guinea in biocontrol methods.

Staff

Michael Day (AFRS)

Collaborators

ACIAR

Secretariat of the Pacific Community

Ministry of Primary Industries, Fiji

National Agricultural Research Institute, Papua New Guinea

Cocoa and Coconut Institute, Papua New Guinea

Papua New Guinea Oil Palm Research Association

CABI Europe-UK, United Kingdom

Roch de Chenon, Consultant, Indonesia

Rationale

Mikania vine is native to the Caribbean and is now a major weed in most countries in the South Pacific and South-East Asia. The vine is currently confined to the Wet Tropics in north Queensland, where it has the potential to impact significantly on the sugar, horticultural, beef and tourist industries and to spread throughout northern Australia. Mikania vine is a Class 1 weed in Queensland and is subject to a national cost share eradication program. Increased control of the vine in countries such as Papua New Guinea and Fiji will reduce the risk of further spread into Queensland. A greater understanding of mikania vine and its biocontrol agents will boost Queensland's capacity to respond to an incursion if the eradication program is unsuccessful.

Methods

Suitable agents are selected, based on results of host-specificity testing and field observations in other countries, and import them into Fiji and Papua New Guinea. We send information on the agents' life histories and host ranges to our collaborators, and request import permits. For some agents, such as the butterflies *Actinote anteas* and *A. thalia pyrrha*, additional host-testing is conducted in Fiji prior to field release. For the mikania rust (*Puccinia spegazzinii*), additional host-testing is conducted by CABI Europe-UK. We submit reports on the host-testing of the agents to quarantine authorities in Fiji and Papua New Guinea. On approval, the agents are reared for release in both countries.

Following successful mass-rearing, we field release suitable agents throughout areas of Fiji and Papua New Guinea where mikania vine is a problem. Provincial staff assists in the release of agents as part of their training in biocontrol activities. Plant density and spread, insect populations and their impact on the plant is monitored.

Progress

The project commenced in Fiji in June 2006 and in Papua New Guinea in January 2007. The quarantine facility at Koronivia Research Station in Fiji was upgraded and we imported the butterflies in July 2006. Unfortunately, the culture died out in January 2007. We identified improvements to the rearing program and a new shipment was imported in late 2007. Host-specificity testing commenced in early 2008. However, the culture died out again before testing was complete. A decision to re-import the insect will be made pending the application to field release the rust.

Host-specificity testing of the *P. spegazzinii* was conducted by CABI Europe-UK and the rust was subsequently approved for import into Fiji in June 2007. A shipment of the rust was imported into Fiji in July 2007 and held at the laboratories at the Secretariat of the Pacific Community. We prepared an application seeking approval to field release the rust in Fiji and conducted three workshops to discuss the application. Yet, permission has still not been granted. We also submitted an application seeking approval to release the rust in Papua New Guinea in February 2008. Permission will be granted pending the successful upgrade of the quarantine facilities at Kerevat. The upgrade has been completed and we are now seeking final approval for the upgrade and the import application.

Studies on the growth rates of mikania vine in Fiji and Papua New Guinea showed that the plant can grow over 1 m per month. A database listing the sites where mikania vine is found in both countries is updated regularly. Mikania is found on all larger islands in Fiji and throughout all lowland provinces in Papua New Guinea. We also produced brochures on the mikania vine and distributed them throughout both countries.

Funding

ACIAR

Expected completion

June 2009

5 Understanding resource use efficiency and physiology of invasive woody vines of riparian zones in south-east Queensland for improved management

Staff

Olusegun Osunkoya (Leader), Christine Perrett and Deanna Bayliss (AFRS)

Collaborators

Tim Blumfield and Zhihong Xu (Griffith University)

Objectives

- Provide a better understanding of the physiological mechanisms contributing to the success of a suite of invasive woody vines of south-east Queensland.
- Provide information on growth stages and environmental conditions that are appropriate for management interventions of invasive woody vines.

Rationale

Vines allocate less carbon to support (i.e. stem) tissue, and thus continuously produce photosynthetic surface area. Some exotic members of this guild are invasive and have become structurally visible, forming major components along our rural waterways and disturbed landscapes, especially in forest communities.

These invasive woody climbers often displace and outcompete native species. What are the eco-physiological

Vine species	Light condition	LSP	LCP	AQE	RESP	Amax	Net photo	WUE	Tran-spira-tion	Cond.	SLA	LAR	RWR
Invasive (I)													
Balloon	High	511.86	10.66	0.09	-0.93	8.50	9.44	10.05	0.72	0.04	203.29	0.66	0.48
Balloon	Low	615.11	6.85	0.08	-0.25	7.56	7.81	5.58	1.27	0.09	642.35	10.85	0.35
Cat's claw	High	968.43	10.66	0.08	-0.78	11.35	12.12	7.31	1.42	0.15	161.09	0.49	0.50
Cat's claw	Low	428.30	5.50	0.08	-0.39	6.63	7.02	5.70	1.08	0.07	439.12	5.78	0.42
Madeira	High	424.82	8.75	0.06	-0.45	8.23	8.68	10.63	0.64	0.04	310.55	0.97	0.05
Madeira	Low	215.26	8.00	0.06	-0.40	3.83	4.23	3.39	0.89	0.05	867.88	10.41	0.08
White moth	High	445.37	10.83	0.05	-0.40	5.70	6.10	8.99	0.45	0.05	207.50	0.61	0.39
White moth	Low	365.32	4.00	0.05	-0.16	5.26	5.42	5.67	0.90	0.05	676.73	17.20	0.31
Native (N)													
Hibbertia	High	726.20	0.00	0.03	0.00	5.37	5.36	10.40	0.51	0.03	152.26	0.49	0.35
Hibbertia	Low	600.50	0.00	0.04	0.08	7.65	7.57	3.72	2.20	0.19	349.60	2.39	0.39
Pandorea	High	908.99	1.33	0.03	-0.08	10.34	10.41	8.34	1.25	0.11	137.54	0.99	0.58
Pandorea	Low	350.45	0.00	0.05	0.00	5.60	5.60	6.00	0.90	0.07	340.79	7.05	0.40
Parsonsia	High	477.69	8.72	0.07	-0.28	6.88	7.15	9.69	0.66	0.05	167.28	0.26	0.67
Parsonsia	Low	243.48	6.18	0.06	-0.29	3.92	4.20	7.65	0.52	0.03	634.95	1.57	0.73
Summary of tests													
Species effect		*	**	*	**	***	***	*	**	***	***	***	***
Moisture effect		NS	NS	NS	*	*	NS	NS	***	***	NS	NS	NS
Light effect		***	NS	NS	***	***	**	**	***	***	***	***	**
Guild effect		NS	*	*	**	NS	*	NS	NS	NS	***	***	*
Direction of guild difference			I > N	I > N	I > N		I > N				I > N	I > N	I < N

LSP = Light saturation point, µmol. m^{-2}. sec^{-1}
LCP = Light compensation point, µmol. m^{-2}. sec^{-1}
AQE = Quantum efficiency, µmol CO_2. $µmol^{-1}$ photon
RESP = Dark respiration rate, µmol. m^{-2}. sec^{-1}
Amax = Maximum photosynthetic rate, µmol. m^{-2}. sec^{-1}
Net photo = Net photosynthetic rate, µmol. m^{-2}. sec^{-1}
WUE = Water use efficiency, µmol CO_2. $mmol^{-1}$ H_2o
SLA = Specific leaf area, cm^2. g^{-1}
LAR = Leaf-area ratio, cm^2. g^{-1}
RWR = Root-weight ratio
Transpiration, $mmol.m^{-2}$. sec^{-1}
Cond. = Conductance, mol H_2o. m^{-2}. sec^{-1}

Table 1. Eco-physiological traits of invasive and native woody vines grown under two light and three moisture regimes. (NS = Not significant; * = p < 0.05; ** = p < 0.02; *** = p < 0.01)

traits that could enhance the superior growth, assumed better resource acquisition and use, and ultimately higher competitive ability of these invasive vines? Managing for desired functional traits (e.g. using native species with efficient water use and low light compensation points in restoration work) as opposed to functional groups (e.g. basing replacement choice on morphological or taxonomic similarity in restoration work) may provide a mechanistic link between plant community composition and ecosystem process, thus giving us the ability to design weed-resistant plant communities. There is a need to quantify traits relating to resource use efficiency, both under controlled conditions and in the field.

Methods

To quantify traits relating to resource use efficiency, we conducted experiments in the glasshouse during the summer–autumn of 2007–08 using plants raised from seedlings and/or cuttings.

Four invasive woody vines were compared with their native congeneric/ecological equivalents: cat's claw creeper (*Macfadyena unguis-cati*) vs. bower of beauty vine (*Pandorea jasminoides*), balloon vine (*Cardiospermum grandiflorum*) vs. *Cardiospermum halicacabum*, Madeira vine (*Anredera cordifolia*) vs. golden guinea flower snake vine (*Hibbertia scandens*) and white moth vine (*Araujia sericifera*) vs. monkey rope vine (*Parsonsia straminea*).

We investigated the influence of soil moisture (three levels) and light (two levels) on the growth (biomass and partitioning patterns) and physiological performance of the above species. At the end of the experiments plants were harvested. We are currently analysing the leaves for nutrient contents (nitrogen, ash, calorific value, carbon and nitrogen isotopic ratios) for derivation of leaf construction cost and resource (especially water and nitrogen) use efficiency.

Photo 1. Studying the eco-physiology of invasive (pictured is Madeira vine) vs. native vines in the glasshouse.

In addition to using univariate analysis to test and search for consistent differences between the invasive and the native vine species, we also use the multivariate technique of principal component ordination to explore (1) if the two guilds separate out in a multi-dimensional space and (2), if so, what are the main variables driving such a separation?

Progress

All tested species survived well in the two light conditions, with the exception of white moth vine. Light had a greater effect than moisture on growth and physiological performance of tested invasive and native species (Table 1).

Though maximum photosynthetic rate (Amax) was not different between the two guilds of vines, higher light (quantum) harvesting efficiencies (AQE) appear to overcompensate for the higher respiration loads (RESP) and high light compensation points (LCP) experienced by the invasive vines, ultimately resulting in their higher net photosynthetic rates (Net photo). In other words, net carbon gain (biomass production) was generally higher in the invasives primarily due to their higher light harvesting efficiency (AQE), especially in the high light condition. Furthermore, the invasive species have higher specific leaf area (SLA) than the natives. We failed to detect any significant difference in water use efficiency (WUE) between the two guilds, though the trend is towards a more conservative water use by the native species, especially in the low water regime.

Principal component ordination using 14 eco-physiological traits indicated a fair level separation of the invasive vines from the native counterparts (Figure 1), though the physiological behaviour of the native *Parsonsia* appeared to mirror those of the invasive species.

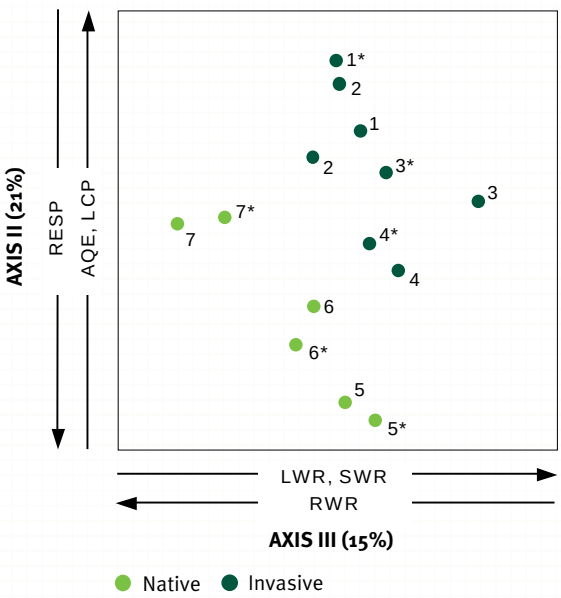

Figure 1. Principal component ordination on axes II and III of seven woody vine species grown at two light regimes based on 14 leaf eco-physiological traits. Variables that load significantly and hence separate the invasive from the native guilds are indicated as well as the proportion of variation captured by each axis. (* = high light regime. 1 = Balloon vine; 2 = Cat's claw creeper; 3 = Madeira vine; 4 = White moth vine; 5 = Hibbertia; 6 = Pandorea and 7 = Parsonsia. Trait abbreviations as in Table 1, except: LWR = Leaf-weight ratio; SWR = Stem-weight ratio)

Important traits driving this native-invasive dichotomy (mainly on axis II, with 21% explanatory power) were respiration rate (RESP), light compensation point (LCP),

light (quantum) harvesting efficiency (AQE) and, to a limited extent (on axis III with 15% explanatory power), biomass partitioning patterns, especially root-weight ratio (RWR). This suggests that higher competitiveness of the invasive vines is linked to (1) their ability to step-up photosynthetic rate and hence achieve higher growth rate under increasing resource (especially light) conditions and (2) greater investment in shoots (leaves and stems) at the expense of roots.

Based on findings reported here, the choice of native vine species to use in control/replacement of invasive ones should, amongst other traits, be based on possession of higher carbon fixation potential, high light use efficiency and greater biomass ratio plasticity, especially greater investment in leaves and shoots relative to roots.

Funding

Queensland Government

Expected completion

July 2009

6 Building population viability analysis models to gain a better understanding of control of invasive alien species: the case of *Lantana camara*

Objectives

- Use a size-structure population matrix and mathematical modelling to examine vital rates of growth, reproduction and survival of *Lantana camara* under various landscape scenarios in order to project its population growth into the future.
- Identify, from a suite of demographic parameters and with the aid of computer simulations and model predictions, the main driver/s of population growth that could be manipulated for management purposes.

Staff

Olusegun Osunkoya (Leader), Christine Perrett and Chandima Fernando (Casual) (AFRS)

Collaborators

Raghu Sathyamurthy (QUT)

Rationale

Lantana is a WONS. Many bio-agents have been released nationally and worldwide to control the impact and spread of the species, but success has been somewhat limited. There is a dearth of quantitative data encompassing the entire life cycle of the weedy plant (Figure 1). To date, no attempt has been made to carry out any population viability analysis (PVA) studies on the species, despite the widely held view that PVA, when done in concert with sensitivity analysis and numerical simulations, could help greatly in fine-tuning management strategies for control of invasive organisms. Results from PVA studies can highlight the weakest stage/s in the life cycle of an invasive plant that can then be the focus of control efforts. The project aims to fill this apparent gap in our understanding of the invasion biology of lantana. The study draws on vast but disjointed data in the literature on some aspects of the biology of the species (mainly seed-seedling phases and, to a limited extent, juvenile phase and adult reproductive capacity), and will be augmented with field collected data on specific life stages that are currently lacking (juvenile to adult transition and adult plant reproductive capacity).

Methods

The Yarraman area west of Brisbane (Nanango Shire, south-east Queensland) has been identified as suitable for collecting demographic data on lantana (see Table 1 and Figure 1). We use six sites containing low-moderate infestation of the weed but of differing soil properties, rainfall intensity, land-use type and weed-control practice to parameterise the species' vital rates for projection of its population growth.

Progress

A typical life cycle of lantana is shown in Figure 1 with elements of its vital rates. Scoping of the literature indicated that existing but limited data on lantana growth stages have large variation (Table 2). This limits the utility of such data for modelling, prediction and management of the species. In order to build a projection model with a good degree of accuracy, we have commenced work (mapping and tagging individuals of lantana plants) in each of the six Yarraman sites. Over the next 12–24 months we will follow their fates in terms of growth, fecundity and survival. We will also put out seeds to determine seed bank and seed–seedling transition values.

No	Site description	Current management	Site location / name
1	Abandoned pasture/ grazing land with low-moderate density of lantana	Mechanical harvesting or herbicide control	Yarraman; Farmer's property
2	Abandoned pasture/ grazing land with low-moderate density of lantana	Herbicide control	Yarraman; Farmer's property
3	Natural Eucalyptus forest with moderate proportion of lantana in the undergrowth	Burning to reduce fuel load and minimize fire incidence into adjacent pine plantation	Yarraman; Rocky creek
4	Natural Eucalyptus forest with moderate proportion of lantana in the undergrowth	Grazing (occasionally) by cows	Blackbutt; Gilla logging area - classified as Box-flat Eucalyptus forest
5	Matured hoop pine plantation (30 yrs) on a LOW rainfall site and with low density of lantana in the undergrowth	Mechanical harvesting via periodic thinning of the hoop trees from 1700 to 350 trees ha^{-1}	Yarraman; Compartment 201A
6	Matured hoop pine plantation (30 yrs) on a HIGH rainfall site with low density of lantana in the undergrowth	Mechanical harvesting via periodic thinning of the hoop trees from 1700 to 350 trees ha^{-1}	Blackbutt; Compartment 1 "Muddy"

Table 1. Sites for monitoring growth stages of lantana and their current management scenarios.

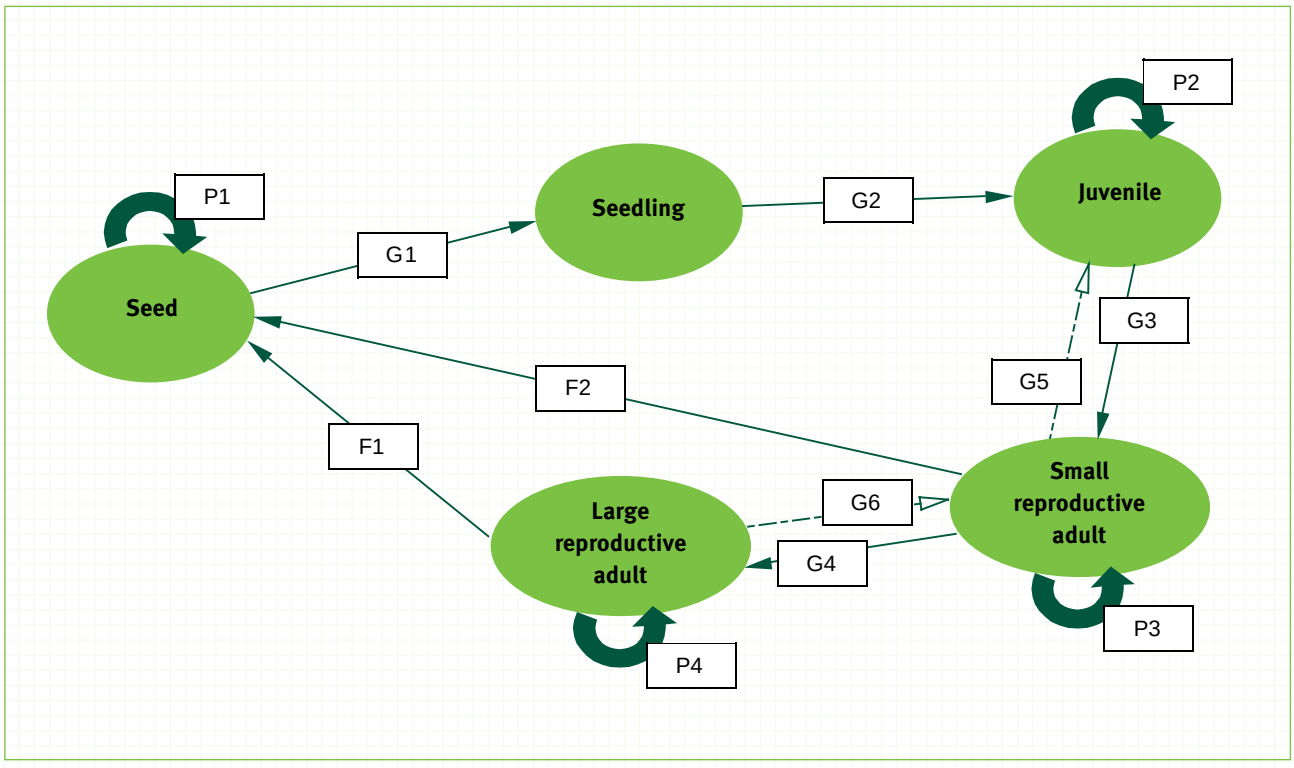

Figure 1. A simplified and hypothetical life cycle of lantana. G_n = Transition value for growth, P_n = Survival value and F_n = Fecundity/ reproduction value. Back transition (i.e. reduction in clump size or stem diameter) is possible for the reproductive adults (faint lines), especially under management regimes such as use of a biocontrol agent, herbicide or mechanical harvesting. Data exist in the literature to parameterise (in decreasing level of precision) P1, G1, G2 and F1/F2. Values for P2, P3, P4 and G3–G6 are currently being collected in the field.

		Stage in year *t*				
		Seed IPA (?)	**Seedling IPA (?)**	**Juvenile IPA (?)**	**Small adult IPA (?)**	**Large adult IPA (?)**
Stage *i* in year *t+1*	**Seed**	P1 0.0906 - 0.0998 (15.06 -1.63)	-	-	F2 12264 (?)	F1 24528 (?)
	Seedling	G1 0.260 - 0.543 (0.137 - 1.883)	-	-	-	-
	Juvenile	-	G2 (0.500 - 0.525) (0.368 - 0.569)	P2 (?)	P2 (?)	-
	Small adult	-	-	G3 (?)	P3 (?)	G6 (?)
	Large adult	-	-	-	G4 (?)	P4 (?)

Table 2. Mean (and variance) of transition values for lantana over a one-year period based on available data in the literature. (IPA = Initial population abundance, ? = Unavailable data and hence the main focus of the current project)

Funding

Queensland Government

Land Protection Fund

Natural Heritage Trust—WONS (lantana)

Logistical support

Forestry Plantations Queensland

Expected completion

Ongoing

7 Ecology of bird-dispersed weeds

Objectives

Better understand weed seed dispersal by birds in order to design more effective integrated weed management strategies.

Staff

Gabrielle Vivian-Smith (Leader), Eve White, Susan Harvey, Jayd McCarthy and Dane Panetta (AFRS)

Collaborators

Dr Carl Gosper (CRC for Australian Weed Management)

Anna Barnes (Griffith University)

Rationale

Bird-dispersed weeds constitute a complex weed problem for land managers. There is little quantitative information regarding the dispersal process and rates and patterns of weed spread. Furthermore, management strategies specific to this unique mode of dispersal are only in the early stages of development.

This project investigates spatial and temporal patterns of dispersal and establishment of bird-dispersed weeds and native species. This knowledge will assist with the design of integrated weed management strategies, whilst promoting the establishment of native species.

Methods

Major focus areas for the study include:

- investigating spatial and temporal patterns of seed rain of bird-dispersed exotic and native species in different early successional vegetation types
- determining whether spatial concordance exists between seed rain, seed bank composition and seedling recruitment in a range of bird-dispersed weed (and native) species, and how this varies between vegetation types
- investigating contagious dispersal (i.e. whether particular bird-dispersed weeds are associated with one another)
- determining existing knowledge and development of novel management approaches, including the application of fruit-functional traits to identify replacement plants suitable for use in habitat restoration.

The project is located in south-east Queensland and northern New South Wales, where a wide variety of bird-dispersed environmental weeds occur.

Progress

Patterns of dispersal and establishment of bird-dispersed weeds

We are currently completing a 12-month study investigating dispersal and establishment patterns of bird-dispersed weed and native species in three common early successional vegetation types: 'tree regrowth' areas dominated by camphor laurel (*Cinnamomum camphora*), shrubby 'edge' habitat ('shrub regrowth') dominated by wild tobacco (*Solanum mauritianum*), and 'native plantings'—restored sites comprised of native species. Our data indicate that dispersal and establishment patterns of bird-dispersed weeds and native species differ both at landscape and microsite scales.

Although we recorded the highest density of exotic bird-dispersed seeds in the seed rain and soil seed bank in shrub regrowth sites, similar densities of recruits (seedlings and saplings) were recorded among all vegetation types (Figure 1). Similarly, although we recorded the highest density of native seeds in the seed bank at native planting sites, recruitment of native bird-dispersed species was similar among vegetation types.

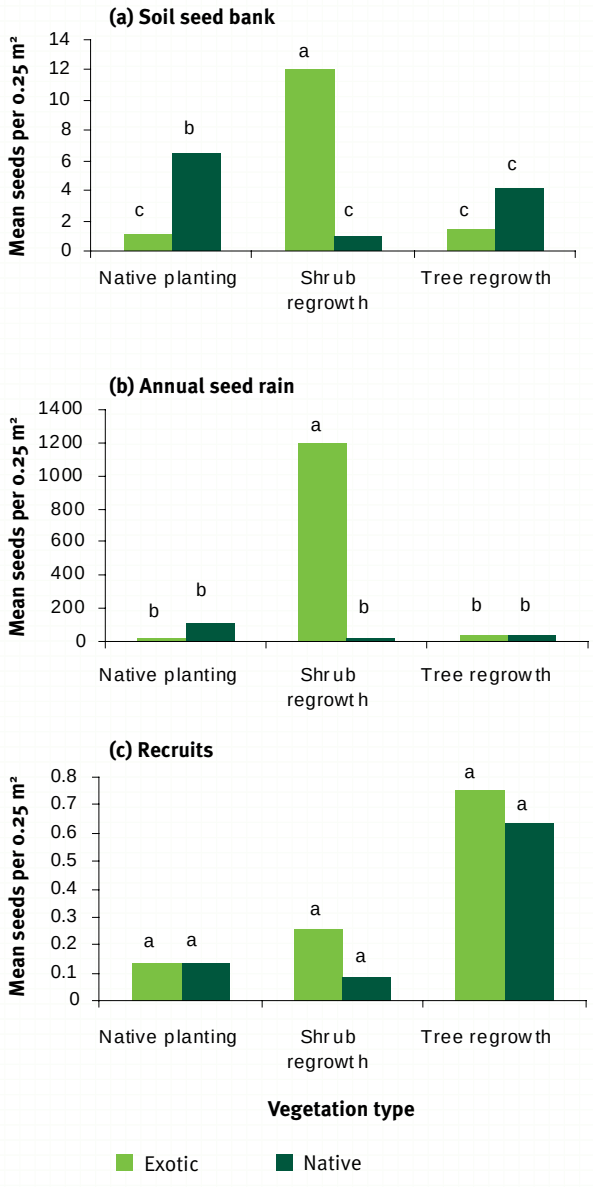

Figure 1. (a) Mean soil seed bank density, (b) annual seed rain density and (c) recruit density for exotic and native bird-dispersed species in three early successional vegetation types. Bars surmounted by the same letter are not significantly different at the 0.05 level.

Seed rain density and composition varies throughout the year. For instance, within tree regrowth sites, seed rain density and mean species richness for exotic bird-dispersed species peaked during the winter months (Figure 2).

At a microsite scale, within-patch variation in seed dispersal patterns exists, with seed rain density and species richness varying depending on species of canopy tree (the tree under which seed rain sampling is conducted), and whether or not the canopy tree is fruiting. For any given month, both density and species richness of exotic bird-dispersed seeds were higher beneath fruiting individuals of *C. camphora* than beneath both non-fruiting *C. camphora* trees or individuals of native *Guioa semiglauca* (regardless of whether the *G. semiglauca* individual was fruiting or not) (Figures 2a and 2b). This pattern was particularly pronounced in July, probably because this was the peak fruiting month for the bird-dispersed weed, large-leaf privet (*Ligustrum lucidum*).

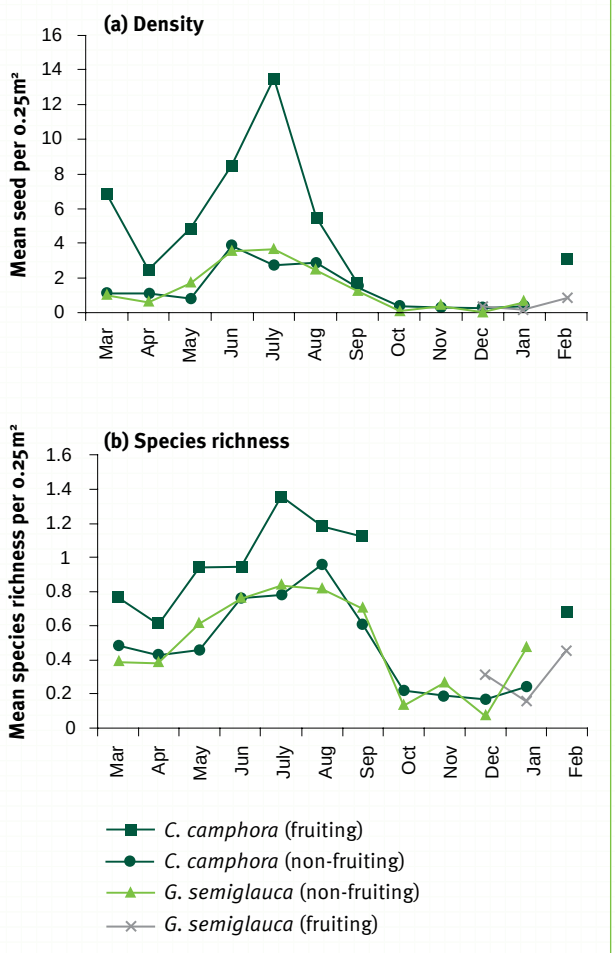

Figure 2. Mean monthly seed rain density (a) and species richness (b) of exotic bird-dispersed species beneath fruiting and non-fruiting individuals of exotic *Cinnamomum camphora* and native *Guioa semiglauca* in tree regrowth patches.

These data highlight the complexities of predicting dispersal and establishment patterns of bird-dispersed weeds. At a landscape scale, different early successional vegetation types are likely to have varying potential to promote—or, conversely, suppress—the dispersal and establishment of bird-dispersed weed species. However, patterns of seed dispersal also vary within patches at a microsite level. In order to further uncouple the dispersal and establishment phases for bird-dispersed weeds, we have collected, and are currently analysing, data which will allow us to determine which variables (e.g. sub-canopy light levels, herbaceous layer) influence establishment of bird-dispersed weed species once a seed has arrived at a site.

Funding

CRC for Australian Weed Management
Queensland Government
Natural Heritage Trust 2—WONS (lantana)

Expected completion

September 2008

Photo 1. Susan Harvey collecting seeds from seed traps in a shrub regrowth site.

8 Weed eradication feasibility and program evaluation

Objectives

- Provide a scientifically based rationale for decisions about the eradication of weed incursions.
- Refine eradication methods by using ecological information.
- Monitor selected eradication programs and document associated costs.
- Develop criteria to assess the progress of eradication.

Staff

Dane Panetta (Leader) (AFRS), Simon Brooks, Shane Campbell (TWRC), Stephen Setter and Katie Patane (CWTA)

Biosecurity Queensland—Land Protection staff based at South Johnstone and local government pest management officers provided data for eradication case studies.

Ecological studies of Class 1 weed eradication targets are conducted under the Ecology of Wet Tropics weeds project at South Johnstone and by CSIRO Sustainable Ecosystems staff in Atherton.

Rationale

Early intervention is the most cost-effective means for preventing weed incursions from rapidly expanding. Strategies to achieve this aim range from eradication—where the objective is to drive the incursion to extinction—to containment, which may vary from absolute to degrees of slowing its spread. Ongoing eradication and containment feasibility work should contribute to management decisions. To make informed decisions it is essential to gather case-study data to determine to what degree management objectives are achieved and assess progress towards eradication.

Methods

We have developed measures for the evaluation of eradication progress with regard to the delimitation (determining the extent of the incursion) and extirpation (local extinction) criteria.

We continue to collate data on eradication resources and progress for each infestation of clidemia (*Clidemia hirta*), limnocharis (*Limnocharis flava*), miconia (*Miconia calvescens, M. nervosa and M. racemosa*), mikania vine (*Mikania micrantha*) (under the National Four Tropical Weeds Eradication Program), mimosa (*Mimosa pigra*) and Siam weed (*Chromolaena odorata*) in Queensland. Data include method of detection, discovery over time, trends in infested areas, population decline and time since last detection.

Further investigations are being undertaken into the age to maturity, recruitment and soil seed bank rundown for *M. calvescens* and limnocharis under field conditions to support the local eradication efforts. Additional ecological data on clidemia, Siam weed and *M. calvescens* are presented in an additional report, 'Ecology of Wet Tropics weeds' (page 39).

Progress

Siam weed database

The Siam weed database provides information on many variables, including weed density, plant counts, seeding plants, net treated areas and work effort. These are used to create indicators of eradication progress. Analysis of this data demonstrates that 81% of infestations were in the control phase in May 2008. Since 2004, enhanced ground and aerial searches have detected many more infestations within river basins where the weed had been found previously. They have also helped to verify the absence of infestations in adjacent river basins. Although the number of infestations has doubled since 2003, the percentage of infestations in the monitoring phase (i.e. without detection of plants for at least 12 months) has increased slowly.

Detection processes

By December 2007, 78 locations—predominantly in coastal areas of north Queensland—had been found with contained garden specimens or naturalised infestations under the National Four Tropical Weeds Eradication Program. 50% of the locations were found by weed professionals who recognised a targeted species in the course of normal duties. Another 25% were found by members of the public who had seen extension material or made general enquiries about a weed. A further 18% of locations were found by tracing information through desktop enquiries or following links between locations. The remaining 7% of locations (all mikania vine near Ingham) were detected via targeted ground searches.

The prominence of detection by officers employed in weed-related field jobs suggests it is essential that this group can recognise target species. Tracing forward and back from known infestations, historical references and consideration of the effects of vectors of spread should be parts of the investigation of all new incursions. Cultivation of species has created a broad spread of isolated infestations, mostly originating from house blocks and spreading into natural areas. Furthermore, the small, disparate infestations of limnocharis or shade tolerant Melastomataceae species are not suited to aerial detection. Specific aerial and ground searches have proven to be less important for delimiting incursions of these weeds than other Australian eradication targets. Programs need to use different combinations of detection methods depending on the distribution, habitat and biology of the target species.

Limnocharis and mikania vine eradication

The discovery date, location, original infested area and time of last detection were compiled for all limnocharis (19 sites) and mikania vine (14 sites) infestations. Since 2005, one new mikania vine infestation was detected, and there have been only small increases in infested areas recorded since 2001. Ten limnocharis infestations are contained in aquatic features, with little or no emergence recorded since control measures commenced. Progress towards the local extinction of these two species is illustrated by an upward trend in the average time since plants were last detected at each

site (*E*) and a plateau in the discovery of new infested areas (Figures 1a and b). A paper on this work has been accepted by *Invasive Plant Science and Management*.

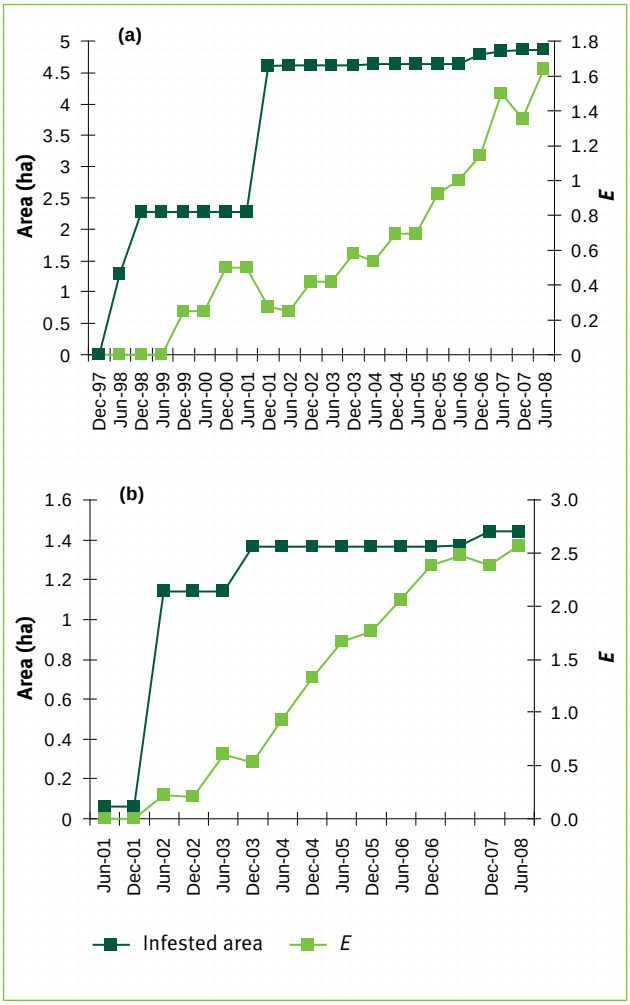

Figure 1. Time course of cumulative total infested area and mean time since last detection (*E*) for the (a) mikania vine and (b) limnocharis eradication programs in northern Queensland.

Single location melastome shrubs

We collated search effort, work effort and population data for the clidemia and miconia (*M. racemosa* and *M. nervosa*) eradication programs—these three bird-dispersed species are known to occur only at single locations in Australia. Although the miconia shrubs are not known outside of South America, their mass germination on steep disturbed banks, establishment in dense shade and higher light environments, dispersal up to 500 m into the rainforest and thousands of seedlings controlled to date, highlight the invasive capacity of these species under local conditions. Similarly, clidemia has proven a persistent, elusive and resource-demanding eradication target in the seven years since its discovery. These biological characteristics and the difficulties in preventing reproduction in tropical forested environments suggest that should more (or larger) infestations of these species be detected, eradication on a national scale would be increasingly less likely.

Limnocharis field studies

We found that a small proportion of limnocharis seedlings can take only 23 days to produce a flowering stalk under field conditions in north Queensland. Mature fruits can form on flowering stalks in a minimum of 23 days, giving a minimum of 46 days for limnocharis reproduction under glasshouse conditions. Limnocharis could therefore produce thousands of seeds per flowering stalk in less than two months, with plantlets also likely to form on the flowering stalks. Both propagule types could readily be dispersed by water. This information was incorporated into the limnocharis eradication program, resulting in an increase in the frequency of visits to all naturalised limnocharis populations, thereby removing the risk that any plants missed in one survey could mature before the next survey.

Funding

CRC for Australian Weed Management

Queensland Government

Logistical support

National Four Tropical Weeds Eradication Program

National Siam Weed Eradication Program

Expected completion

June 2009

9 Ecology of Wet Tropics weeds

Objective

Increase our understanding of the ecology of key Wet Tropics weeds, in order to improve their management.

Staff

Melissa Setter (Leader), Stephen Setter, Michael Graham and Katie Patane (CWTA)

Collaborators

CRC for Australian Weed Management

Cairns Regional Council

National Siam Weed Eradication Program

National Four Tropical Weeds Eradication Program

Australian Maritime College, Marine Modelling Unit

CSIRO Sustainable Ecosystems, Atherton

Rationale

Weeds have the potential to degrade the high environmental, social, cultural and economic values of the Wet Tropics of Queensland. This project aims to develop a sound ecological knowledge of priority Wet Tropics weeds as needed to improve weed management strategies for this important bioregion.

Methods

Field, shade house and laboratory experiments are underway on a number of weed species, including pond apple (*Annona glabra*), harungana (*Harungana madagascariensis*), hymenachne (*Hymenachne amplexicaulis*), Siam weed (*Chromolaena odorata*), miconia (*Miconia calvescens*), clidemia (*Clidemia hirta*), mikania (*Mikania micrantha*) and tobacco weed (*Elephantopus mollis*).

Specific studies include:

Hymenachne and harungana—seed longevity

Seeds are placed in mesh bags in the field at 0 cm, 2 cm and 10 cm in the soil profile and retrieve them after set periods of time to test their germination ability and viability status in the laboratory. Results indicate how long the seed bank of these species persists and provide information about dormancy periods. We recently tested hymenachne and harungana seeds after eight years of burial.

Siam weed—documentation of eradication effort

An isolated infestation of Siam weed is used to quantify the resources (hours of labour involved for survey and control, and the volume of herbicide used) required for eradication. We monitor the rundown of plants, seedling emergence and the soil seed bank in conjunction with this.

Miconia—timing of flowering and fruit maturity

We have monitored five miconia trees since 2005 to assess timing and volume of fruit production, which had not been previously well documented under Australian conditions. Pre-flowering panicles are securely bagged with fine mesh; we then record the time for formation of flowers, immature berries and mature berries. As berries mature, we remove the panicles and count the number of berries.

Clidemia—post-damage survival and reproduction

Hand-pulling is one of the most commonly used methods for clidemia management. We simulate the impact of inefficient hand-pulling on clidemia by cutting mature plants in the shade house at both ground level and 10 cm and monitor the subsequent survival rate and age to reproduction.

Pond apple—seedling mortality and age to reproduction

We have established a field experiment to determine the survival and time to reproduction of pond apple seedlings.

Pond apple—WONS project

We recently undertook a large project funded by WONS to cover a number of gaps in our knowledge of pond apple ecology. Specific areas of research included seed germination and viability studies, timing and quantity of fruit production, seed predation by insects, and dispersal by animals and water. We also commissioned the Marine Modelling Unit of the Australian Maritime College to investigate the potential movement of pond apple fruits and seeds via ocean currents.

Photo 1. Experimentalist Michael Graham checks a pond apple fruit trap near the Russell River.

Photo 2. Experimentalist Katie Patane retrieves seeds for germination testing during the seed longevity and buoyancy experiment on pond apple.

Progress

Hymenachne and harungana—seed longevity

After eight years burial, hymenachne still had some viable seed at each depth tested. Overall, an average of 12% was still viable, which was not substantially less than the previous six-year sampling (13% viability). Unfortunately this was the last sample, so we are unable to document the full rundown of the seed bank. Observing the trends, though, it seems as if some seed could persist for several more years.

Harungana appears to have quite a persistent seed bank as well, especially when buried. After eight years, seeds buried at 2 cm displayed approximately 24% viability, and those buried at 10 cm still had a viability of approximately 72%. No viable seeds remained at 0 cm (surface), but at the previous test time of six years even those seeds were approximately 6% viable.

Note that for both species, these results pertain to the experimental field conditions; seed persistence may differ under other conditions.

Siam weed—documentation of eradication effort

In July 2003, we collected baseline data on all individuals (approximately 1000 plants), and have been sampling the soil seed bank, recording seedling emergence, and monitoring the efficacy of kill and re-treatments since then. Prior to treatment there was a seedling density of over 4000 seedlings ha^{-1} in the core infestation area; five years later this has reduced to none. We have documented the number of hours spent searching for and controlling the plants to date, as well as the volumes and costs of chemicals used to treat this infestation.

Miconia—timing of flowering and fruit maturity

Data to date indicate that, if the time when flowering is first noted is taken as time zero, it takes approximately:

- six weeks for immature (green) fruit to appear
- 17–19 weeks for mature (purple) fruit to appear
- 20–21 weeks until the majority of fruit appears mature (purple).

We are unsure as to the possible viability of seeds in the immature fruit, so control programs are best advised not to allow fruiting at all if possible. Preliminary counts showed an average of 300 fruits per panicle (range 13–1141) and about 190 seeds per fruit.

Clidemia—post-damage survival and reproduction

Clidemia plants cut at 10 cm recovered quickly, flowering in five days, and fruiting after 86 days. Plants cut at ground level flowered after a minimum of 194 days and fruited after 294 days. Whether cut at ground level or 10 cm, clidemia displayed a high tolerance to damage, with an overall survival rate of approximately 97.5%.

Pond apple—seedling mortality and age to reproduction

Approximately 90% of seedlings died after three years. The earliest time to reproduction has been recorded as 3.5 years (this plant was 2.5 m high with a 70 mm basal diameter). Monitoring is ongoing.

Pond apple—WONS project

The project is completed and the final report submitted. Some of the key findings include:

- Pond apple seed appears to have an inherent ripening or maturation period, which could not be accelerated, after fruit drop.
- Germination occurred across a range of temperatures from approximately 17 °C to 37 °C. Interestingly, germination was higher than anticipated at the lower end of this range. This suggests that pond apple may do better in cooler climates than previously thought.
- Seed production varied greatly with seasonal conditions and habitat, and was as high as 8 million seeds ha^{-1} in dense infestations.
- Pond apple's fruiting peaks during December–April.
- Pond apple displays yellow or senescent leaves during June–August, which assists in locating plants. This is also often a good time of year for control activities to ensure maximum site access (dry season) and to prevent fruiting.
- Insect damage was observed in the field at three locations—the insect was isolated in the laboratory and identified as *Coccotrypes carpophagus*. Our studies suggest that this seed-boring weevil is reducing the available seed bank of pond apple to some extent, but is unlikely to be actively pursued as a biocontrol agent due to its large host range, including some commercial species.
- We found that agile wallabies disperse viable seeds away from infestations. In contrast, some rodent species destroy pond apple seeds that they consume.
- In a laboratory study we found that seeds can remain floating and retain some viability after two years in either fresh or saline water.

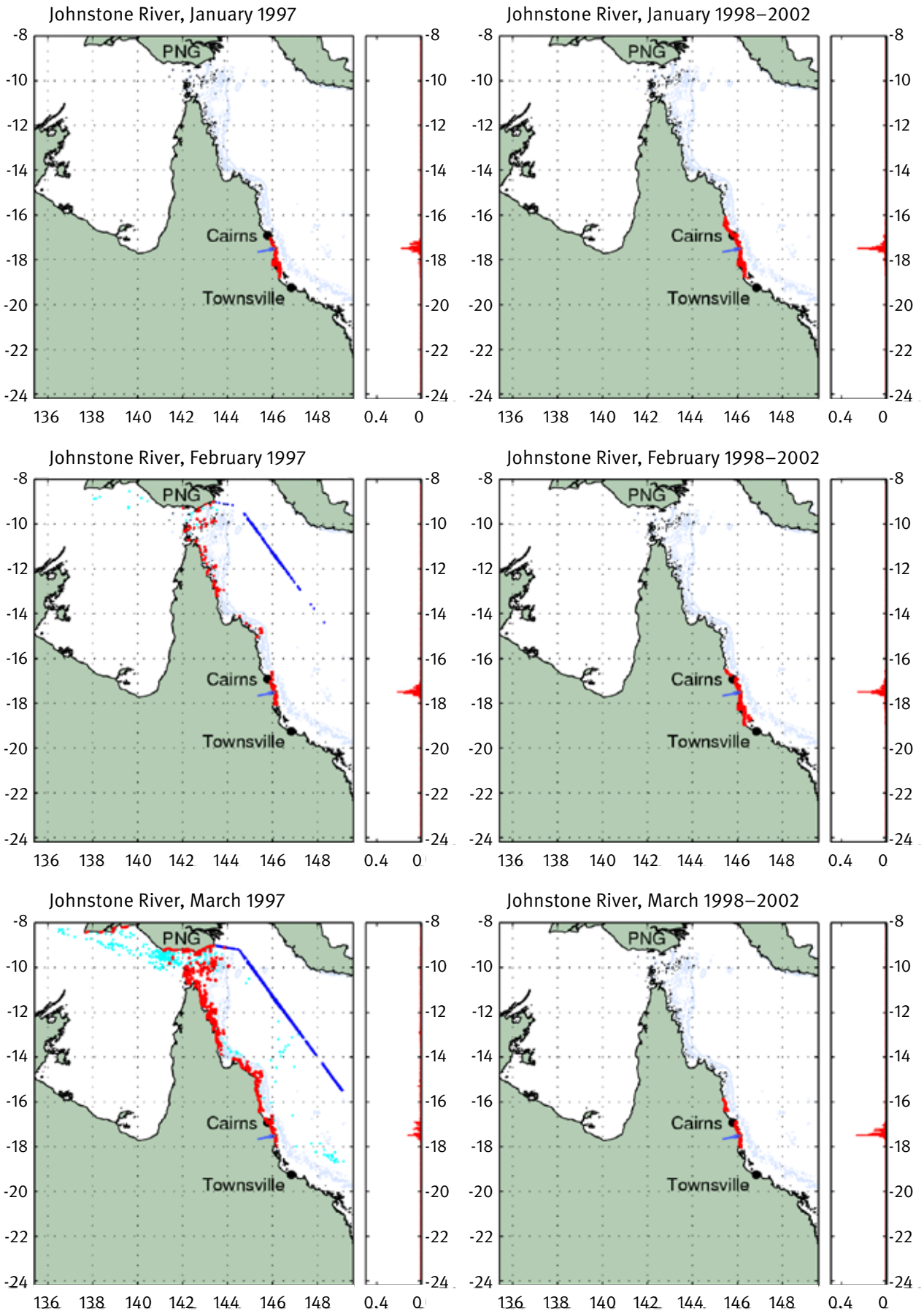

Figure 1. This figure shows that pond apple seeds can move either north or south from their point of release, and up to Papua New Guinea under extreme conditions, such as Tropical Cyclone Justin in 1997. This example is for the Johnstone River (blue arrow); similar maps are available for all studied rivers. Beached seeds (red), still active (cyan), lost seeds (blue).

- Ocean dispersal modelling showed that, depending on prevailing conditions:
  - Seeds could move in either direction along the coast.
  - Most seeds would beach within three months.
  - Most seeds would beach within 100 km of release point.
  - Some seeds could be transported up to 1300 km.

A full report is being prepared which will present modelled results (likely direction, distance and proportion of seed spread) for each of the 16 studied rivers. It will note river systems and conditions likely to cause furthest distribution. It will also highlight the existing path of movement of pond apple seeds from the Queensland coast to the Torres Strait and Papua New Guinea, as well as the potential path of movement to the Northern Territory, if pond apple is allowed to infest rivers on the western coast of Cape York.

Funding

Natural Heritage Trust—WONS

National Four Tropical Weeds Eradication Program

Land Protection Fund

Queensland Government

Logistical support

CRC for Australian Weed Management

WONS Program

National Four Tropical Weeds Eradication Program

Expected completion

The project is ongoing, with different experiments expected to require between one and 11 years to complete.

10 Water weed management

Objectives

Improve the efficiency and ecological sustainability of aquatic weed control programs by understanding basic biology of high-risk aquatic weed species and their function in the aquatic ecosystem.

Staff

Amanda Dimmock (AFRS)

Collaborators

The project is a partnership between community environmental groups and local governments.

Rationale

To lessen the economic and environmental impacts of aquatic weeds, we need to improve our understanding of their biology and ecology. Ideally, this would lead to the identification of relatively small modifications in weed management practices that would have large effects on weed populations.

This research aims to assist resource managers to understand and manage aquatic weeds more effectively through two approaches: (1) providing information about the ecological and biological mechanisms which regulate aquatic plant growth and community development and (2) providing data on the biology of targeted species that will allow intervention at vulnerable stages of their growth or development in order to achieve management aims.

Methods

In controlled experiments, we will determine impacts on water quality and quantity (including evapotranspiration) of aquatic weeds and native species. Further investigations involve manipulation experiments to identify vulnerable stages of the life cycle for targeted control, as well as triggers to population explosions.

We will undertake detailed investigations of the biology of high-risk populations of the worst aquatic weed species (declared and emerging exotic species) in Queensland. Topics will include factors such as dispersal (vegetative and seed), survival strategies (including response to loss of aboveground biomass and drought) and vulnerability of different life history stages.

We will use these data to develop species/ecosystem models that assist integrated control programs by predicting problems requiring intervention. Data will also inform the most ecological and efficient control options.

Progress

Collection of specimens of both declared species and those newly emerging in Queensland waters has commenced. We are currently setting up a floating weeds trial that will include water hyacinth (*Eichhornia crassipes*), salvinia (*Salvinia molesta*) and water lettuce (*Pistia stratiotes*), in comparison with the native species azolla (*Azolla* spp.) and duckweed (*Spirodela* spp.).

Trials on life cycle and vulnerabilities for control of submerged species include cabomba (*Cabomba caroliniana*), parrot's feather (*Myriophyllum aquaticum*), dense waterweed (*Egeria densa*) and dwarf rotala (*Rotala rotundifolia*), compared with native species.

Emergent species that will be investigated for dispersal capabilities and life history stages to target for control include hygrophila (*Hygrophila costata*), senegal tea (*Gymnocoronis spilanthoides*), kidneyleaf mudplantain (*Heteranthera reniformis*) and sagittaria (*Sagittaria platyphylla*).

Funding

Land Protection Fund

Queensland Government

Expected completion

Ongoing

11 Mimosa (*Mimosa pigra*)

Objectives

- Study seedling emergence and seed bank dynamics of Mimosa pigra growing at Peter Faust Dam, Proserpine, to assist in the eradication of this species.
- Investigate fire and chemical options for mimosa control.
- Evaluate herbicides for control of melaleuca regrowth in areas infested with mimosa.

Staff

Joseph Vitelli and Barbara Madigan (TWRC)

Rationale

In February 2001, the first infestation (~100 plants) of mimosa in Australia outside the Northern Territory was found at Peter Faust Dam, near Proserpine in central coastal Queensland. Mimosa is a WONS and a declared Class 1 plant in Queensland. Originating from Central America, mimosa poses a major threat to the integrity of northern Australia's wetlands, reducing biodiversity and affecting primary production. In the Northern Territory, it has formed impenetrable, nearly mono-specific thickets over 800 km^2, while in Queensland it is found over 80 ha of land bordering the Proserpine water supply. Queensland's cane fields, cattle grazing areas and wetlands are all at risk of mimosa invasion.

With mimosa invasion no longer just a threat but a reality in Queensland, a stakeholder group consisting of DPI&F, SunWater, Whitsunday Regional Council, Mackay Whitsunday Natural Resource Management Group, Canegrowers Proserpine, Whitsunday Catchment Landcare, Proserpine Irrigators Committee and local landholders was formed in 2001 to work together to eradicate the Peter Faust Dam infestation. On-ground control efforts involving both manual removal and chemical control began in April 2002. One of DPI&F's contributions is to provide research on the biology and control of mimosa at Peter Faust Dam to aid in the eradication efforts. This includes advising on the timing of site revisits to ensure plants are detected and controlled prior to setting seed and predicting how long the eradication effort needs to continue.

Methods

Mimosa is intensively studied at Peter Faust Dam, especially on the peninsula known as Point 10. Massive seedling germination occurred across this peninsula as the water level in the dam decreased from April 2001, when mimosa was first detected. The area studied starts at the 65% water storage capacity level and extends to the middle of the creek bed. This area includes the closed canopy mimosa infestations (known as the core areas) and individual mimosa plants scattered across the peninsula.

Seedling emergence and seed bank

We record annual seedling counts in a 5 m grid pattern across the peninsula and take soil cores annually from different areas for seed bank studies. We also test the viability of recovered seeds.

Control of melaleuca regrowth

The recruitment of three melaleuca species (*Melaleuca leucadendra, M. quinquenervia* and *M. viridiflora*) at Peter Faust Dam is hindering the detection and control of mimosa. We grow these three species in pots at TWRC and apply 14 herbicide treatments using the spray gantry to simulate aerial application at 200 L ha^{-1} in a complete double overpass.

The treatments are:

- triclopyr/picloram (Grazon* DS Herbicide) at 1500/500 and 3000/1000 g ha^{-1}
- tebuthiuron (10% formulation) at 4000 and 8000 g ha^{-1}
- 2,4-D/picloram (Tordon* 75-D Herbicide) at 2250/562.5 and 4500/1125g ha^{-1}
- hexazinone (Velpar® L Herbicide) 4500 and 9000 g ha^{-1}
- fluroxypyr (Starane* 200 Herbicide) at 600 and 1200 g ha^{-1}
- metsulfuron (Brush-Off® Brush Controller) at 72 and 144 g ha^{-1}
- imazapyr/glyphosate (Arsenal® Xpress Herbicide) at 1500/1500 and 3000/3000 g ha^{-1}
- a control.

Progress

Seedling emergence and seed bank

An 86% decline was recorded in the soil seed bank in the core infested area from 2002 to 2007. Soil seed viability remains high at 99%. 2008 rainfall events have seen dam levels rise to 67%, inundating the core area. Receding water levels should result in a massive germination event and an accelerated soil seed bank decline. Soil seed bank depletion studies are continuing.

Control of melaleuca regrowth

Preliminary results indicate that stem dieback on *Melaleuca quinquenervia* and *M. viridiflora* is averaging 72% using the herbicides metsulfuron (77%), 2,4-D/picloram (75%), hexazinone (70%) and imazapyr/glyphosate (67%). The difference in dieback between these species is not significant. *M. leucadendra* dieback, on the other hand, is averaging only 35%. The trial is still in progress.

Funding

Queensland Government

Mackay Whitsunday Natural Resource Management Group

Australian Government (Defeating the Weed Menace Program)

Expected completion

2010 (subject to funding availability)

Part 3 Pest animal management

1 Best practice baiting—dispersal and seasonal movement of wild dogs (*Canis familiaris*)

Objectives

- Identify the source of current wild dog problems inside the wild dog barrier fence by monitoring the movement of wild dogs in non-baited areas within the barrier fence.
- Identify how far dispersers travel from uncontrolled areas to determine the optimum width of buffers.
- Discover the cause of increased dog activity during the April and May mating season so as to predict the most effective time to bait to prevent re-colonisation.
- Study the movement of wild dogs on and around sheep properties.

Staff

Lee Allen (Leader) and Damian Byrne (RWPARC)

Rationale

Wild dog predation of livestock continues to inflict significant economic hardship for graziers and contributes to the demise of the sheep industry throughout Australia. Loss of sheep producers is a cause for concern in rural communities struggling to maintain the viability of town businesses, services and amenities. While many stakeholders contribute considerable financial resources to wild dog management programs, wild dog problems show no sign of abating. Opinions differ regarding the source of the wild dogs and whether the wild dog barrier fence and baiting programs are effective.

Wild dog studies undertaken by DNR&W and DPI&F over the last decade have demonstrated that one or two baiting programs per year on single properties of 400–2000 km^2 can increase the number of calves killed and the frequency of years during which predation loss occurs, compared to losses on non-baited properties. Monitoring studies also show there is a peak in wild dog activity in April–May each year that gradually declines to around October. This peak in activity was observed in north Queensland, Capricorn and the Hervey Bay coast, south-west and central-west Queensland, and is reported in the Pilbara of Western Australia. Heightened activity is thought to be associated with mating (late May), and we believe April–May is a significant peak in yearling dispersal that has a major influence on the outcome of wild dog control programs and predation.

This project seeks to discover the source of wild dog problems and improve wild dog management. The proposed studies are the result of lengthy consultations, initiated by 14 local government stakeholders, to resolve the wild dog problems inside the barrier fence. These studies are designed to assist managers to determine the dimensions of buffer areas around non-baited areas, predict the most effective time to bait and better understand the behaviour of wild dogs and livestock predation.

Methods

Wild dogs are trapped in padded-jaw traps and fit them with satellite collars in 'hot spot' areas within the wild dog barrier fence: Yuleba State Forest (east of Roma), Angelalla Creek catchment (between Morven and Charleville) and Kumbarilla State Forest (south-west of Dalby) and in central-west Queensland (Blackall area). We believe yearlings are the animals most likely to disperse from their natal area and re-colonise after baiting. We monitor the daily movements of these animals for up to 10 months, then recover and redeploy the collars.

From location data we identify and calculate the core areas and territory boundaries of collared individuals. We also use these data to calculate the distance travelled per day and the time of day when animals are active in different seasons. Daily locations will detect extra-territorial movements, eventual dispersal and/or mortality if the animal is destroyed in control programs.

In addition, we capture, satellite collar and release up to five wild dogs of any weight or age in sheep country around Blackall, central-west Queensland. We closely monitor and observe these animals to document their breeding success and movement within and around sheep properties—including sheep predation on adjacent properties where these animals traverse.

This research is conducted under an animal ethics permit, PAEC 051105.

Progress

Between 2006 and 2008, we have trapped 53 wild dogs; 49 of those were collared and/or ear-tagged and monitored for a combined total of › 200 months. 13 collared animals died within two months of capture: three were killed by poison baits, five were shot to recover failed collars, one was shot harassing livestock and four died of unknown causes. One adult male had his collar torn off. Of the remaining animals monitored, 14% (n = 5), all yearling males, have made one or more long distance dispersal moves of › 100 km from their capture location.

Twelve of 22 wild dogs (or 55%, seven males, five females), captured within state forests or national parks either incorporated adjacent pasture or cultivation land in their territories (n = 5), dispersed onto grazing properties recently baited for wild dogs (n = 3) or expanded their territories to include properties recently baited and/or rearing sheep (n = 4).

Movement data, compared between mating (mid March–end of May), whelping (mid July–end of August)

and pup rearing seasons (September–November), suggest wild dogs actively avoid travelling on roads after the mating season. Reduced activity on roads explains why wild dog activity declines rapidly after autumn and remains low even after the annual breeding season. The mean distance travelled per day by males and females (14.5 km) varied little between autumn and summer but, surprisingly, was approximately 25% greater (17.7 km) during whelping in winter than during mating and pup rearing. While both genders have noticeable peaks in activity at dawn and dusk/early evening, males are less active during the day and more active through the night than are females. Females, particularly adults, cover large areas beyond their winter/spring territory boundaries during mating season, while beta males appear territorial and heavily patrol roads and travel ways.

Seven collared dogs lived adjacent to rabbit-proof or dog-proof netting fences and three collared dogs had dispersal movements that intersected with and/or followed netting fences for › 200 km. One dispersing dog escaped through a hole in a netting fence. In spite of approximately 10 opportunities, none negotiated grids to escape through the fences.

Photo 1. Releasing satellite collared dingo #39 from a property near Charleville. This dog moved over 400 km into northern New South Wales.

Baiting effectiveness

Of three wild dogs collared on sheep properties near Blackall in June 2007 (three weeks after a 1080 baiting program), two were subsequently discovered to be a breeding pair. They successfully raised a litter of pups in an inaccessible, thickly vegetated location between two properties and also survived a subsequent 1080 aerial-baiting program in October 2007 intended to destroy them. We are unable to determine the fate of the offspring. DNA samples from 2007 suggest the wild dogs around Blackall are closely related and inbred, indicating a limited gene pool exists and local breeding, rather than immigration, is occurring.

A 1080 ground-baiting program at the Charleville study site in May 2008 did not kill any of the 10 yearling dogs that were collared three weeks earlier. However, we believe that six collared dogs and several of their associates have succumbed to poison bait during 2006 and 2007 when forest lessees or adjoining landholders baited.

Funding

Natural Heritage Trust (through Bureau of Rural Sciences)

Desert Channels Queensland

Queensland Murray Darling Committee

South West Natural Resource Management

EPA/QPWS

DNR&W

Fourteen shire councils in south-west Queensland

Expected completion

December 2008

2 Feral pig (*Sus scrofa*) impacts on freshwater ecosystems

Objectives

- Use a number of ecological indicators found in freshwater habitats as a guide to quantifying feral pig impacts on elements of biodiversity.
- Conduct large-scale, 'learning-by-doing' manipulative experiments to describe the feral pig abundance/impact system so that management strategies can be developed.

Staff

Jim Mitchell and Bill Dorney (TWRC)

Collaborators

James Cook University—Australian Centre for Tropical Freshwater Research

DEWHA

Rationale

Environmental impacts of feral pigs have not been studied intensively and very little quantitative information is available on the ecological impacts feral pigs cause throughout Australia. There is a distinct lack of information on a number of threatened ecosystems and, in particular, there is a scarcity of information relating to seasonal freshwater habitats in the dry tropics. This study aims to assist in answering questions relating to feral pig impacts on this unique habitat.

Photo 1. Feral pigs digging up freshwater lagoons in Lakefield National Park.

Methods

The research site is situated at Lakefield National Park—specifically the area surrounding the New Laura ranger station (15.175 °S, 144.3480 °E).

There are two studies:

Ecological impact of feral pigs on biodiversity

Exclusion fencing consisting of feral pig netting around six ephemeral lagoons and billabongs was constructed. Six unprotected lagoons with similar attributes (surface area, depth etc.) act as experimental controls. We obtain ecological indices at two-month intervals, dependent on weather conditions, over the dry seasons of three consecutive years and compare measurements from fenced and unfenced lagoons. The sequential measurements of these ecological indicators as the lagoons draw down give a guide to the consequences of feral pig impacts on biodiversity and a guide to the timing of recovery from these impacts if the level of impact is reduced.

Relationship of ecological impact to feral pig density

Aerial shooting is used to artificially manipulate the population density of feral pigs around selected large lakes in the area to enable the quantification of feral pig damage in sites that have varying pig abundance levels. There are three treatments based on the relative abundance of pig populations on each lake (i.e. Caulders Lake—low pig population, Jacks Lake—medium pig population and North Kennedy Lake—high (normal for this area) pig population). We describe the pig population levels from a series of abundance indices derived at two-month intervals during the survey period. For each lake, we conduct a systematic ecological sampling regime for the ecological indicators to determine the influence of pig abundance on these indicators.

Progress

All fencing is complete. Sampling commenced in August 2007. All of the lagoons have been sampled twice in 2007 and twice in 2008. Aerial shooting around the lakes has destroyed over 400 pigs to date. Population monitoring and water sampling of the lakes is continuing.

Photo 2. Bill Dorney collecting biological samples in Lakefield National Park.

Funding

Queensland Government

DEWHA

Logistical support

EPA

Expected completion

2010

3 Development of a cyanide bait for monitoring feral pigs (*Sus scrofa*)

Objectives

- Develop an effective formulation of cyanide for feral pig control to incorporate into current and potential bait substrates.
- Develop a delivery technique for baits containing cyanide.
- Demonstrate the efficacy of the bait on captive feral pigs and, if successful, undertake preliminary field trials to test efficacy.
- Conduct preliminary determinations of the delivery techniques for other species, specifically foxes.

Staff

Matt Gentle (Leader) and David Aster (RWPARC)

Collaborators

Duncan McMorran, Paul Aylett and Charlie Eason (Connovation Ltd)

Rationale

Feral pigs pose a significant threat to livestock producers and public health as carriers of endemic and exotic diseases. Improved techniques for feral pig control, disease surveillance and sampling would be beneficial for exotic disease contingency planning and managing the impacts of this serious vertebrate pest.

Toxins currently registered for use in Australia have long latent periods, making them unsuitable for disease surveillance purposes. The use of potassium cyanide as a fast-acting feral pig toxin appears promising. Presumably, when presented in bait form to feral pigs, cyanide would result in carcasses located close to the location where baits are consumed. This would be ideal for examining and collecting carcasses for disease sampling and generating population indices, especially for species (such as feral pigs and foxes) targeted with poison baits. This project aims to test the means of cyanide delivery for application to feral pig management, and to assess the technique for application to other species, particularly foxes.

Methods

Feral pigs are trapped from wild populations in the Inglewood and Yelarbon districts of south-western Queensland and transported to RWPARC, Inglewood. All pigs are conditioned to the holding facilities for at least seven days. Pigs are maintained on a diet of commercial pig grower pellets, with water provided *ad libitum*.

We present feral pigs with prototypes of each product to determine the nature and level of consumption. Initially, this involves testing non-toxic bait packages to determine if the product is consumed and the nature and level of consumption. A bait 'package' consists of a delivery product (or capsule) encased within the bait substrate. Pigs are presented with non-toxic versions of the package for sufficient periods to encourage their consumption of the toxic package when presented. We test toxic versions of the capsule for lethality only when the majority of pigs consuming the bait substrate also consumed the delivery product (the capsule designed to carry the toxin).

We conduct fox trials on three properties in the Inglewood district to investigate potential cyanide formulations. Bait stations are baited with sweetened condensed milk to encourage visitation and consumption by foxes before cyanide bait is added. We use remote cameras and spoor identification to confirm the identity of the animal that visited the plot and consumed the bait.

This research is conducted under an animal ethics permit, PAEC 050702. The APVMA approved the supply and use of cyanide in field-testing of products (permit PER 8998).

Progress

We completed a total of seven pen trials on feral pigs using a variety of bait packages and cyanide formulations (powder, paste and liquid). Despite success in habituating feral pigs to consuming the non-toxic baits, many pigs rejected or only partially consumed the toxic bait. It appears difficult to disguise the cues associated with cyanide, given its apparent distinctive smell and taste. Whether an acceptable presentation can be achieved with the current encapsulation and formulation technology is uncertain. Additionally, the inconsistent mortality of animals, even when large doses were ingested (e.g. › 50 mg kg^{-1}), suggests that feral pigs may be more resistant to cyanide than originally envisaged. Lastly, the relatively long period before unconsciousness and death in this study suggests that cyanide may not have the significant advantages to animal welfare as seen in other species (e.g. foxes).

Pigs' apparent tolerance to cyanide, perhaps due to metabolic processes adapted from dietary cyanide exposure, may provide sufficient justification to question the applicability of cyanide as a toxin for these feral animals. In addition, it appears difficult to deliver a sufficient dose of cyanide without rejection of the bait material. Due to these issues no suitable presentation method has been developed to date and no field testing has been done. Given these difficulties, we have ceased testing any further cyanide packages on feral pigs until these issues can be overcome.

We offered buried encapsulated potassium cyanide paste covered with sweetened condensed milk to wild foxes on three field sites. A total of 33 cyanide baits were taken or uncovered by foxes, and 30 of these baits were rejected or expelled by foxes. Recovered cyanide baits were found within 3 m of the bait station. We obtained a total of four fox carcasses from 199 cyanide bait nights, with carcasses found in the range 0–16 m, with an average distance of 7.3 m from the bait station. Although cyanide was highly effective when consumed by foxes, frequent rejection of the bait during the trials

suggests that foxes were deterred by the taste or effect of cyanide. We found desiccation of bait material to be a plausible reason why foxes were readily able to expel the cyanide baits. Improvements in presentation, palatability and delivery of these baits are needed to help mask the taste or effect of the cyanide and improve the technique.

Photos 1a and 1b. Fox visiting and removing bait during the field trials.

Funding

Queensland Government

Bureau of Rural Sciences

Expected completion

This project was completed in July 2008.

4 Effective 1080 meat baiting for feral pigs (*Sus scrofa*)

Objectives

- Assess the amount of 1080 in meat baits required to kill feral pigs.
- Investigate the longevity of 1080 and substrate for pig meat baits.
- Undertake a field assessment of the efficacy of feral pig baiting using a quantitative biomarker to assess multiple bait uptake by feral pigs.

Staff

Matt Gentle (Leader), James Speed, Peter Elsworth (RWPARC), Jim Mitchell, Bill Dorney (TWRC) and Bob Parker (AFRS)

Rationale

Feral pigs are baited with 1080 meat baits for broad scale reduction and the technique is recommended in the event of an exotic disease outbreak. Significant amounts of 1080 bait are used each year in Queensland for the management of feral pigs. However, current baiting practices have varied and often limited success. This may be due to variations in bait uptake because of bait density, bait location or seasonal conditions. The overall low level of success may be a result of pigs consuming insufficient bait to receive a lethal dose. It is therefore essential to have a greater understanding of the number of baits feral pigs consume during a bait campaign. This information, when combined with the lethal dose required, will indicate whether the poor levels of reduction are due to insufficient toxin or failure of feral pigs to consume bait. We also need to determine the period of toxicity for 72 mg 1080 meat baits to ensure that baits contain lethal amounts for feral pigs but do not offer a long-term hazard to non-target animals.

Methods

A toxicity trial using penned animals was conducted so that results could be compared with those from previous trials. To avoid differences in the susceptibility of penned feral pigs compared to free-ranging feral pigs, we undertake additional experiments to assess the effect of factors such as a varied diet and pig activity on the toxicity of 1080.

To estimate the longevity of baits, 72 mg 1080 baits are presented in the field for specific periods before collection and checking for 1080 concentration. This is done in a sample of Queensland environments that represent areas where aerial baiting occurs.

Aerially baiting with non-toxic meat baits that contain a quantitative biomarker (Rhodamine WT) is undertaken. This enables estimation of bait uptake in free-ranging pigs and take a shot sample of the population within days of bait distribution. A blood sample is removed from each individual and analysed for the presence and concentration of the biomarker, providing estimates of the proportion of the population that consumes bait, and the number of baits that is consumed.

This research was conducted under an animal ethics permit, PAEC 040803.

Progress

See *Technical highlights 2006–07* for detailed results from the toxicity trials, bait degradation trials and aerial baiting trials. We calculated that 4.15 mg kg^{-1} of bait material is required to target feral pigs effectively (to achieve a lethal dose for 90% of pigs (LD_{90})). When converted to the number of 72 mg baits required for a lethal dose (Figure 1), this highlights that feral pigs with › 20 kg bodyweight may need to consume more than one meat bait to receive a lethal dose of 1080. This may help to explain some of the poor reductions reported from aerial baiting with 1080 meat baits. Increasing the bait density typically used in aerial baiting campaigns may help to achieve higher levels of population reduction.

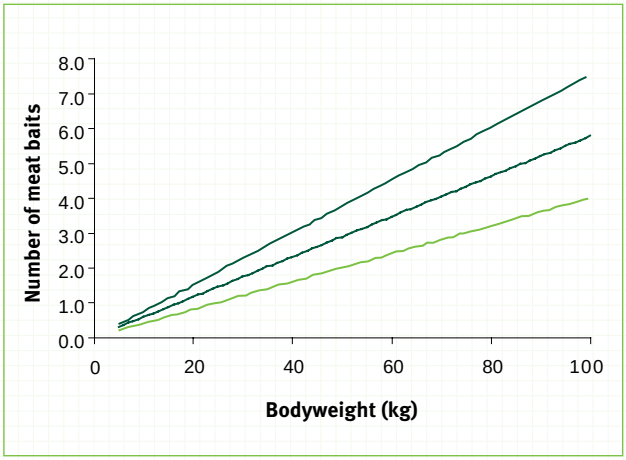

Figure 1. The number of 72 mg meat baits required to kill a feral pig of given bodyweight (kg) based on the calculated LD_{90} and 95% confidence intervals.

Funding

Queensland Government

Bureau of Rural Sciences

Expected completion

This project was completed in July 2008.

5 Assessing the role of harvesting in feral pig (*Sus scrofa*) management

Objectives

- Survey landholders in the western Darling Downs to determine the distribution of pig damage, its perceived cost and the control methods employed.
- Estimate the density–impact relationship for pigs damaging grain crops.
- Quantify the effectiveness of commercial and recreational harvesting in managing feral pig populations.

Staff

Matt Gentle (Leader), James Speed, Aaron Prendergast and Annette Blair (RWPARC)

Collaborators

Queensland Murray Darling Committee

Safe Food Production Queensland

AQIS

Game and meat processors

Rationale

Pest managers often encourage commercial and recreational harvesting of pigs because this is essentially a 'free' reduction in pest density. However, the reduction in numbers may provide minimal damage mitigation and may be inappropriately allocated in space and time. Additionally, more effective control (e.g. baiting) may not occur because of the perception that harvesting is effective or because pigs are valued for recreational use (i.e. hunting). Until now, Australian governments have been passive observers in the commercial use of pest animals. A better approach may be to pursue markets actively and subsidise harvests in unprofitable areas or at unprofitable times. Other, non-commercial control methods will be required to reduce pest densities below those possible through harvesting alone. The relationship between pest impact (production or environmental) and pest density needs to be known to determine the optimum mix of harvesting and non-commercial control and to guide decision-making by pest managers. Bioeconomic modelling can reveal how best to integrate harvesting with conventional control methods.

This project aims to assess the impact of commercial and recreational pig harvesting over strategic areas of the Queensland Murray Darling Basin. This is a critical component of an ongoing program by the Queensland Murray Darling Committee to coordinate the control of feral pigs, foxes and feral cats in the region. The broad outcomes of the project will provide an evaluation of the impacts of commercial and recreational pig harvesting compared to a coordinated control program, particularly in relation to crop damage. The project will quantify the impacts of feral pigs on crops and will provide

new knowledge, expertise and strategies on best practice to optimise the management of feral pigs and other pest animals. This will provide vital information on the feasibility, cost-effectiveness and logistical requirements for the implementation of a broader control program for the region.

Methods

Landholders were surveyed using a combination of phone and postal surveys. In addition to identifying hot spots of damage and areas with little control, the survey facilitates the selection of study areas for more intensive assessments of damage and density. Importantly, these surveys also raise awareness of the project throughout the rural community.

We estimate both lost grain production and pig density using a combination of helicopter surveys, aerial photography and ground assessments. Pig damage and pig density is estimated on six study sites, predominantly grain-cropping properties. Study areas encompass a range of pig densities. These are monitored at least twice during the maturation of the crop—post-emergence and just prior to harvest. The aerial pig-density surveys are conducted using a four-seater helicopter (Robinson-44) flying along pre-determined transects through each study area. We complete two surveys at each site.

Pig damage is assessed using a variety of methods, including aerial survey, aerial photographs/ satellite images, and ground assessments. Where possible, we assess damage remotely to minimise the need for intensive ground assessments. A sample of patches assessed remotely is also assessed from the ground to correct the aerial estimates. We estimate the level of damage by assessing the yield within each damaged patch compared to the yield in an adjacent, undamaged crop area.

The initial aerial survey is undertaken when pigs are recognised as actively using crop areas. We monitor a sample of the patches of damage recorded during this stage to determine the effect of early damage on yield. The final damage survey is undertaken just prior to harvest.

To monitor feral pig harvesting, we record the harvest offtake of pigs at each site to determine the harvest rate. This requires the cooperation of the individual harvesters, the game industry and Safe Food Production Queensland. We also monitor other control activities undertaken at each site through discussions with the landholders.

This research is conducted under an animal ethics permit, CA 2007/09/211.

Photo 1. Harvested feral pigs in refrigerated storage.

Progress

The landholder survey (n = 280) has largely been completed and data are currently collated. Initial results indicate that 80% of landholders suffer damage to grain crops from feral pigs and 16% suffer › 5% damage. This level of damage would equate to a significant economic loss.

The methodology used to assess damage to field crops has, by necessity, been altered from that originally envisaged. The original methods relied on recording feral pig damage remotely through aerial surveys. The preliminary helicopter and ground surveys suggested that damage is difficult to quantify from the air. Therefore, more intensive and time-consuming ground-based surveys are required to collect damage data. We surveyed a total of 23 paddocks during the summer cropping season, with a total of 5272 ha of sorghum crops assessed. A mean of $19 ha^{-1} was lost due to feral pig damage. These intensive assessments will continue to determine feral pig damage to crops (predominately wheat) in the winter cropping season.

Photo 2. Aerial surveys undertaken to measure pig density.

We have completed aerial surveys on all six study sites. The density of feral pigs is relatively low, possibly due to periods of prolonged drought, with all sites having < 1 pig km^{-2}.

Data from feral pig harvesters continue to be collected, with considerable numbers of pigs harvested from within our study sites.

Funding

Queensland Government (Blueprint for the Bush)

Queensland Murray Darling Committee

Expected completion

June 2009

6 Evaluating monitoring techniques for feral cats (*Felis catus*) and foxes (*Vulpes vulpes*) in south-east Queensland

Objectives

Investigate current techniques for determining population densities of cats and foxes and improve these monitoring techniques where possible. The project is divided into three parts:

- Capture and release cats/foxes with radio collars for analysis of spatial movements and collection of mark/recapture data.
- Monitor the distribution and abundance of cats/foxes using spotlight counting, track plots and visitation at scent stations.
- Determine the effectiveness of ground shooting to remove cats and foxes.

This pilot project is undertaken as part of the 'Assessing the role of harvesting in feral pig management' project (page 50).

Staff

James Speed (Leader) and Matt Gentle (RWPARC)

Rationale

The ability to census and monitor a pest animal species is vital for its successful management. Without reliable information on abundance and distribution, it is difficult to evaluate the magnitude of the problem, the impacts of the pest species and the effectiveness of control programs.

Recently, there has been a push to standardise monitoring techniques for cats in Australia (draft threat abatement plan for feral cats). The density of the species and the characteristics of the habitat being monitored can greatly influence the logistics of different monitoring techniques as well as the reliability of results. Additionally, there have been no broad scale assessments of the effectiveness and efficiency of ground shooting of predators as a control technique.

This project aims to investigate the viability of different techniques for monitoring feral cats and foxes in southern Queensland. It also aims to investigate the role of ground shooting as a control technique.

Methods

Feral cats and foxes are trapped and fitted with radio collars and release them. Where possible, animals are fitted with a GPS collar. Each collar has a download rate of one point every five minutes for a 24-hour period then off for six days before repeating the cycle. This helps to determine how feral cats utilise the environment as part of their everyday activities.

Trapping continues until sufficient animals (~20) are radio-collared and released. After this, landholders are encouraged to control foxes and cats through

ground shooting. This helps us to determine the effectiveness of shooting as a control technique by determining the proportion of animals removed, through changes in the indices of abundance and the mortality of collared feral cats and foxes. A bounty system may be used to encourage landholders to target as many animals as possible.

We undertake spotlight counts and track plot counts on defined transects to monitor the abundance of feral cats and foxes. These transects follow roads and fence lines and attempt to incorporate as many of the representative habitat types available as possible. Spotlighting is performed from a slow-travelling vehicle (10–15 km h^{-1}), recording the number of animals seen. In track plot counts, a swathe of loose soil across the road is checked for animal tracks and re-raked on a daily basis. Additional activity techniques investigated include active activity plots (using visual and olfactory lures) and road drags. We monitor all techniques for at least three consecutive nights.

This research is conducted under a DPI&F animal ethics permit, CA 2007/09/214.

Progress

To date, we have completed spotlighting at 120 km of transects at 'Crowder's Creek' site and recorded 21 foxes and one cat. We have also run an active plot trial (252 plot nights), resulting in the detection of 17 foxes and one cat. Trapping has been undertaken to capture and mark animals for further research. At this point, we have trapped and radio collared 14 foxes and four cats. Two of the cats have been fitted with GPS collars.

Funding

Queensland Government

Queensland Murray Darling Committee

Expected completion

June 2009

7 Adaptive management of rabbits (*Oryctolagus cuniculus*)

Objectives

- Improve the measurement of rabbit impacts and the effectiveness of rabbit control programs.
- Establish landholder-driven, scientifically monitored rabbit control programs.
- Use these as demonstrations to promote the use of effective rabbit control.

Staff

David Berman (Leader), Michael Brennan, Peter Elsworth and James Speed (RWPARC)

Collaborators

Mark Ridge (Darling Downs–Moreton Rabbit Board)

Rationale

In 1950, the biological control agent, myxoma virus, reduced rabbit numbers dramatically across Australia. While myxomatosis still suppresses rabbit populations over much of their former range, within 10 years there were signs that populations were recovering. By the 1960s rabbit numbers had returned to extremely high levels in the best areas for rabbits while in other areas they did not recover at all.

In 1996, rabbit haemorrhagic disease virus (RHDV) spread across Queensland and reduced rabbit numbers by at least 70%. This, combined with myxomatosis, currently suppresses rabbit populations by probably over 90% below the pre-1950 levels. However, there are signs that rabbit populations are recovering now from RHDV as they did from myxoma virus. We have reports of rabbits in areas where a problem was not previously evident. Rabbits may be developing, or have developed, a genetically based resistance to RHDV and/or the virus may be developing less virulent strains.

Most disturbing is an increase in the number of rabbit outbreaks within the Darling Downs–Moreton Rabbit Board area, where rabbits were not allowed to establish and where native plants and animals and agriculture were protected from the impact of rabbits for over 100 years since they arrived in Queensland.

Rabbit control using biological agents or poison, without destruction of warrens, generally provides only a short-term reduction in numbers. Areas where warrens are destroyed have remained virtually free of rabbits for up to at least 20 years. For long-term control, therefore, we must destroy rabbit breeding places (e.g. warrens, holes under concrete slabs).

The initial rapid reduction in rabbit numbers after arrival of RHDV in all parts of Queensland did not occur on Bulloo Downs, a large cattle station in south-west Queensland. For three years after the arrival of RHDV, rabbit numbers remained high. With this apparent failure of the biological control agents, a scientifically monitored rabbit control program was initiated.

An experiment was established in 2001 to measure the cost and effectiveness of warren ripping on Bulloo Downs. By 2002 we had demonstrated that warren ripping controlled rabbits and there were benefits to native plants and animals as well as cattle production. The benefits of effective rabbit control to biodiversity and agriculture need to be properly measured also in south-east Queensland using techniques similar to those used at Bulloo Downs. Measuring these benefits and demonstrating methods used for control are essential to encourage landholders to control rabbits.

Methods

We have established scientifically monitored rabbit control programs at Bulloo Downs and in and around the Darling Downs–Moreton Rabbit Board area to:

- Demonstrate the importance of targeting control activities in key breeding places (source).
- Measure the cost of eradication of small, isolated rabbit populations.
- Measure the benefits of rabbit control to biodiversity, agriculture and pastoralism.

Establishing scientifically monitored programs driven by landholders is an excellent way to demonstrate the techniques and encourage rabbit control. These programs show the best techniques, the benefits of controlling rabbits and the dangers of doing nothing.

Bulloo Downs

Surveys of warren activity and spotlight counts are conducted annually to measure the long-term success of the rabbit control program at Bulloo Downs.

Darling Downs–Moreton Rabbit Board area

After surveying a number of sites throughout south-east Queensland, we selected a suitable site at Cottonvale, on the southern edge of Warwick Shire. This site has a high concentration of rabbit warrens within 500 m of the Darling Downs–Moreton Rabbit Board area (on the unprotected side of the rabbit proof fence). Breaches in the fence have allowed some rabbits into the rabbit-free area but they have not established warren systems there; these animals live in log piles. Soil type, landform and land use are similar on both sides of the fence. The site is ideal for measuring the differences in pasture and biodiversity caused by rabbits. We mark all warrens and log piles with steel posts and record the number of active and inactive burrows. We also establish rabbit-proof and cattle-proof (with rabbit access) exclosures to identify the impact of rabbits and separate this from that caused by cattle, and further distribute sand plots to count rabbit tracks and predator tracks throughout the site. Once the differences are measured between lightly infested and heavily infested areas, we destroy all warrens and measure the rate and extent of recovery of pasture and biodiversity.

Progress

Bulloo Downs

Bulloo Downs has had seven consecutive years of below average rainfall. Drought conditions and destruction of the rabbits' drought refuge have combined to reduce rabbit numbers by over 99%.

Darling Downs–Moreton Rabbit Board area

Measurements are currently underway inside (clean side) and outside (dirty side) of the rabbit-proof fence. The absence of warrens from the 'clean side' shows clearly that the fence is effective in preventing rabbits from establishing warren systems. Preliminary results indicate that the 'dirty side' is characterised by a high number of warrens, a high density of rabbits, fewer pasture species and a low macropod activity (Figure 1).

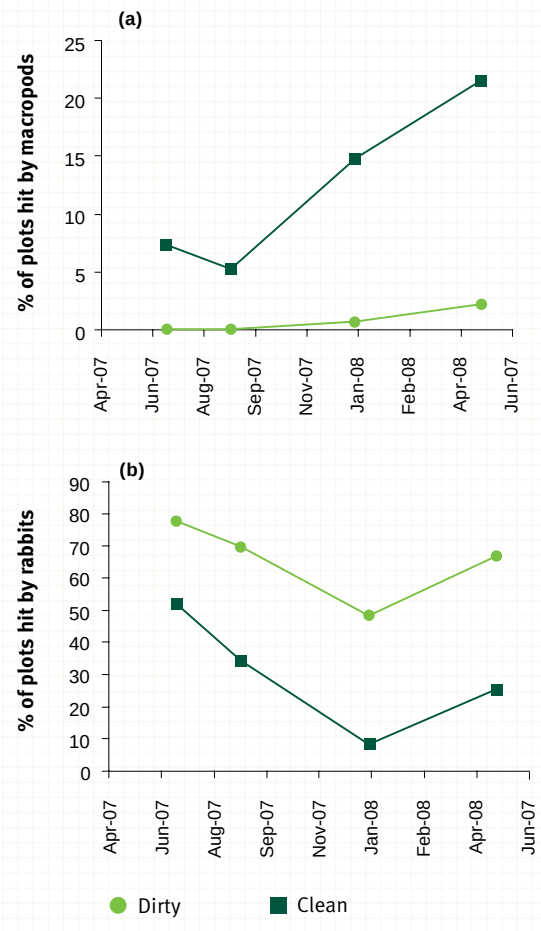

Figure 1. (a) Macropod activity was greater on the 'clean side' of the rabbit proof fence where (b) rabbit activity was low.

Future work will determine whether the rabbit populations are viable in the absence of warrens. Information on reproduction and survival of rabbits in warrens and log piles of varying degrees of complexity will be collected. This will allow better targeting of the source of rabbits during control operations.

Funding

Land Protection Fund

IACRC

Australian Wool Innovation

Logistical support

Darling Downs–Moreton Rabbit Board

Expected completion

Ongoing

8 Resistance to RHDV in Australian rabbits (*Oryctolagus cuniculus*)

Objectives

- Develop a test protocol for determining resistance to RHDV in rabbits.
- Test rabbits from around Australia to determine if resistance is developing and to what level it has developed.
- Explore reasons behind variation in any resistance seen between populations.
- Test field strains of RHDV to compare virulence and effectiveness against the original release strain.
- Explore interactions between RHDV and the new enteric rabbit calicivirus (eRCV) discovered in Australian rabbits.

Staff

Peter Elsworth, David Berman, David Aster and Robert Thomson (RWPARC)

Collaborators

Brian Cooke (IACRC)

Steve McPhee (Department of Primary Industries, Victoria)

Greg Mutze, Ron Sinclair and John Kovalivski (Department of Water, Land and Biodiversity Conservation, South Australia)

Tanja Strive (CSIRO)

Rationale

Rabbit haemorrhagic disease (RHD) has been a successful tool in the control of rabbits throughout Australia. It caused a great reduction in rabbit numbers on initial release and continues to keep numbers low in many areas. Concerns have been raised about RHD's continuing efficacy as numbers of rabbits are increasing in some areas. Rabbits started showing resistance to myxomatosis about 10 years after its initial release and it has now been 12 years since RHDV was released. Rabbits are a major pest of agricultural and natural systems and if they were to return to the numbers present pre-RHD, they would once again have a devastating effect. Establishing the current status of rabbit resistance to RHDV will allow decisions to be made on the direction of future management programs and research priorities for new control tools.

Methods

Young rabbits have been collected from 15 sites around Australia (Qld: Inglewood, Bulloo Downs, Townsville and Diamantina Lakes National Park; SA: Turretfield, Gum Creek and Coongie Lakes National Park; Vic: Hattah/Kulkyne National Park, Bendigo, Bacchus Marsh and Yambuck; NSW: Michelago, Valpine and Oaky Creek; NT: Alice Springs).

Once tested to establish that animals have not had previous exposure to RHDV, they are acclimated to the laboratory at RWPARC Inglewood. When grown to full adult age (13 weeks old) they are challenged with a small oral dose of RHDV (Figure 1). The chosen dose level has been shown to infect 65% of fully susceptible domestic rabbits and is considered to be a 'field' realistic dose. We record infection rate, mortality rate and survival time for each group of rabbits. We then compare populations back to the infection rate of fully susceptible domestic rabbits to establish if resistance is present. Rabbits that survive the trial without being infected are re-challenged intra-muscularly with the same dose. Again, we record infection rate, mortality rate and survival time. This allows for examination of the mode of resistance shown by the rabbits.

Field-strain virus is obtained from the Turretfield area in South Australia. Virus has been collected from this area every year since RHDV was released. The Department of Water, Land and Biodiversity Conservation, South Australia is currently performing phylogenetic analysis to establish how much the virus may have changed over time. Virus is standardised using ELISA titration and real-time RT-PCR. A series of challenge tests against a standard line of rabbits allows comparison of various field strains against the original release strain of RHDV.

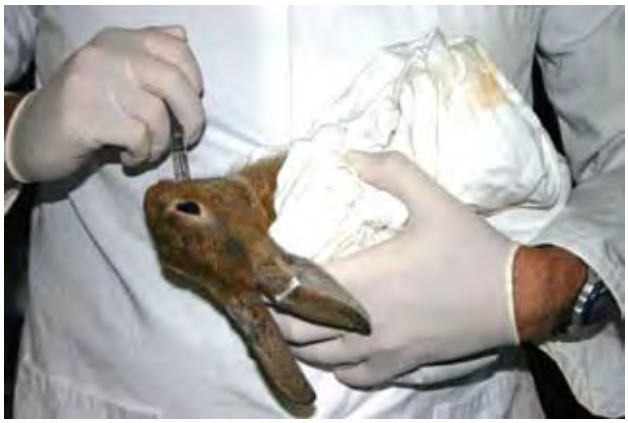

Photo 1. Adult rabbits are orally administered a small dose of RHDV to test for resistance to the virus.

Progress

A challenge protocol has been developed and completed tests on rabbits from all 15 sites. However, blood serum testing is still in progress for five sites to establish infection rates.

We have determined resistance to varying degrees across the populations (Table 1). The emergence of resistance to RHDV is of great concern for the continuing use of RHD as a control tool in managing rabbits. We are currently undertaking explorations into the differences between the populations in an effort to explain the varying rates of resistance seen.

For the 10 sites where complete data are available, resistance was highest at sites with medium level rainfall (300–600 mm). Survival times for rabbits succumbing to RHD have been no different to those seen in trials soon after RHDV release, and there are no significant differences among the populations.

This demonstrates that rabbits are not overcoming the disease by lengthening the period between infection and disease to allow a greater immune response. Infection rates by intra-muscular administration were similar to those by oral administration at most sites. This indicates that the mode of resistance is not at the mucosal barrier, as virus delivered straight into muscle is not increasing the rate of infection.

We will perform trials at RWPARC Inglewood during the next 12 months to explore the virulence of eRCV (a non-lethal calicivirus present in the rabbit population) and any impact it has on infection by RHDV. We will also test field strains of RHDV for virulence in comparison to other field strains and the original release strain of RHDV.

Rabbit population	Proportion of rabbits infected
Bacchus Marsh (central Vic)	0.00*
Hattah (north-west Vic)	0.14*
Gum Creek (central SA)	0.18*
Turretfield (south SA)	0.21*
Inglewood (south Qld)	0.22*
Michelago (NSW/ACT border)	0.25*
Valpine (east NSW)	0.42
Bendigo (central Vic)	0.46
Yambuck (south-west Vic)	0.64
Domestic rabbits	0.65
Bulloo Downs (south-west Qld)	0.73

Table 1. Level of resistance shown by 10 populations of rabbits. (Values show the proportion of animals infected after challenge with RHDV; * = Populations that are significantly different from the domestic rabbits [$p < 0.05$, two-tailed Fisher's exact test], indicating resistance to the virus.)

Funding

IACRC
Australian Wool Innovation
MLA

Logistical support

Department of Primary Industries, Victoria
Department of Water, Land and Biodiversity Conservation, South Australia
University of Canberra
Low Ecological Services
Centrogen
Townsville Field Training Area
EPA

Expected completion

June 2009

9 Effective and safe rodent management

Objectives

- Evaluate the potential of various overseas registered rodenticides for their use in Australian broadacre cropping.
- Evaluate and enhance best practice management of mice (*Mus domesticus*) in crops.
- Refine the current mouse plague predictive model.

Staff

Peter Cremasco (Leader), David Aster (RWPARC) and Bob Parker (AFRS)

Collaborators

Bell Laboratories, Inc.

Animal Control Technologies Australia

Grain farmers

Rationale

Currently, there is only one rodenticide registered for use in crops. Grains industry stakeholders are concerned that if zinc phosphide were to be withdrawn, there would be no registered chemical to control rodents in this situation. There are several acute toxins and anticoagulants registered overseas, as well as unregistered Australian formulations, that could potentially be registered for use under Australian cropping conditions for the control of rodents.

This project was developed to evaluate each of the compounds under laboratory and field conditions for their potential for Australian registration through the APVMA.

Methods

The evaluation of potential rodenticides involves the following:

- laboratory toxicity
- relative palatability
- residue levels
- field efficacy
- non-target evaluation.

We collect data for the evaluation of best practice mouse management at the same time, and at the same sites, as data for refinement of the plague predictive model. This involves an assessment of current mouse density indicators, as well as an assessment of the biological and environmental variables at each site. In addition, prior to the assessment of mouse indices, we collect information from landholders concerning various management practices used.

Progress

Laboratory toxicity

Four alternative toxin formulations were evaluated against the current registered in-crop rodenticide. One rodenticide was excluded from further evaluation, due to poor performance in the laboratory.

Relative palatability

The palatability of all tested candidate toxins is comparable to that of the current registered product.

Residue levels

We exposed representative summer and winter cereals, oilseeds and legumes grown in a glasshouse to megadoses of the candidate chemicals. Testing showed no detectible residues in the grain or plant material. Development of an appropriate residue testing procedure has revealed some interesting chemical aberrations in some of the candidate chemicals when exposed to heat or sunlight. As a result of these findings, we undertook further laboratory toxicity trials, using bait subjected to field exposure. Toxicity of the aged material to captive mice was shown to be sufficiently acceptable to warrant field testing.

Field efficacy

Field trials have not commenced due to the lack of appropriate APVMA trial permits. One permit application was refused due to lack of sufficient minimum residue level data on mammal species. Two more permit applications are still under consideration. Due to project time constraints, it is unlikely that field trials will commence during this project's life. Non-target evaluation, which was part of the proposed trial applications, is also unlikely to proceed.

Data collection for best practice mouse management and development of the plague predictive model is proceeding concurrently with routine monitoring.

Funding

Grains Research and Development Corporation

Queensland Government

Logistical support

RWPARC and AFRS staff: pot trial establishment and mice care

Bell Laboratories, Inc. and Animal Control Technologies Australia staff: assistance with trapping during field trials

Expected completion

March 2009

Part 4 Research services

1 Pest management chemistry

Objectives

- Provide advice on the use, impact and environmental toxicology of vertebrate pesticides and herbicides to support their effective and responsible use to manage pest animal and weed populations.
- Manufacture and monitor the quality of chemical pest control products used to manage pest animal and weed populations.
- Undertake chemical ecology research and analysis on pest populations.

Staff

Bob Parker, Tanya Hutchins, Liz Hutchinson, Claire McNeal, Sean Muller, Lesley Ruddle, Dennis Webber and Alyson Weier (AFRS)

Rationale

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

Methods

In this project we provide chemical advice and support to pest management in Queensland, and undertake toxicological and eco-toxicological investigations relating to the use of vertebrate pesticides. We maintain a laboratory and formulation facility at AFRS and also make use of facilities at other research stations and field sites.

We carry out tests using appropriate methodology dictated by the client and the research direction. The laboratory operates within a quality assurance framework and maintains analysis methods for a range of vertebrate pesticide and herbicide formulations.

Progress

Eco-toxicology

Currently only one rodenticide formulation is registered for the control of mice in crops. In another project ('Effective and safe rodent management', page 57) work is undertaken to identify and evaluate alternative rodenticide formulations for use in this situation. Crop residue studies on two candidate formulations containing zinc phosphide and bromethalin as active ingredients have been completed. These studies were conducted using a series of pot trials on winter and summer crops. No residues of the two candidate formulation actives were found in wheat, chickpea, sorghum and sunflower grown in five soil types with bait applied at 100 times the rate envisaged for actual crop use. Bromethalin in the bait was found to degrade rapidly when exposed to sunlight, which is a possible factor in rapidly reducing residue levels in the crop after baiting. Additional studies were also conducted on the environmental stability of cholecalciferol, another rodenticide.

Forensic toxicology

Metaldehyde, the active ingredient in snail bait, has been added to the laboratory's profile of tests. Metaldehyde poisoning in dogs has some similar symptoms to 1080 poisoning and an antidote is not available. Introduction of this test allows further differential diagnosis in suspected 1080 and strychnine poisoning cases.

Over the year the laboratory performed 69 investigations relating to possible fluoroacetate poisoning, 32 relating to possible strychnine poisoning, 12 relating to possible anticoagulant poisoning and 4 relating to possible metaldehyde poisoning. Most investigations related to domestic dogs and cats; however, there were some also involving wildlife (macropods). Our laboratory also conducted total iodine analysis on a range of samples relating to animal health.

Formulation chemistry

During the year the formulation facility produced 250 L of 1080 concentrate for use in Queensland for the preparation of baiting solutions and rabbit bait. This was supplemented with a further 60 L of 1080 pig bait solution and 60 L of 1080 dog bait solution.

The Department maintains a strong testing program to ensure sodium fluoroacetate baiting in Queensland meets agreed standards. Testing of post preparation sodium fluoroacetate solutions and meat baits continued across the year. Additional testing of sodium fluoroacetate and rodenticide formulations was undertaken for industry.

Funding

Land Protection Fund

Queensland Government

Expected completion

Ongoing

2 Chemical registration: providing tools for invasive pest control

Objectives

Ensure that pesticides used for invasive plant and animal control are available and meet Australian regulatory requirements.

Staff

Bob Parker and Margie Cohn (AFRS)

Rationale

As a result of the strategic review of Invasive Plant and Animal Science this project was set up under the 'Research Services' umbrella to undertake chemical registration and permit activity in relation to the Invasive Plants and Animals program. Biosecurity Queensland currently holds a range of permits for the use of pesticides to control invasive plants and animals. The need for permits has increased as pesticide registrants focus primarily on crop protection with consequent greater economic returns, rather than environmental protection. This means that registered chemicals are less likely to be available for controlling invasive plant and animal species.

Methods

When obtaining registrations or permits for pesticide use we follow set guidelines laid down by the APVMA. The volume of information required varies depending on whether the chemical is already registered or allowed for another use, or is a new pesticide. Depending on the chemical and application, information may be required relating to: the chemistry and manufacture of the pesticide; its toxicology, including its metabolism and kinetics; likely crop and environmental residues; occupational health and safety, associated both with its manufacture and its use; its impact on the environment; its efficacy and safety in use and whether there are trade implications associated with the intended use.

While DPI&F has primary responsibility for some pesticides, such as sodium fluoroacetate (1080), our focus is on obtaining off-label permits for registered chemicals already in the market place. As a consequence, investigations are normally restricted to likely crop and environmental residues, impact on the environment, and efficacy and safety in use relating to the use of a given pesticide in a new situation or for a new pest. Project staff work with other scientists to ensure data are available to address these issues and that any studies conducted for regulatory purposes meet APVMA requirements and guidelines.

Progress

During the past year the following permits were renewed or obtained:

- permit for the use of Presto 001® Granular Ant Bait for the control of the yellow crazy ant (*Anoplolepis gracilipes*)
- permit for the use of Termidor® Residual Termitacide for the control of *A. gracilipes*
- permit for the use of S-Methoprene for the control of *A. gracilipes*
- permit for the use of Confidor® 200 SC Insecticide and other registered products containing 200 g L^{-1} imidacloprid for the control of the lantana biocontrol agent Aconophora compressa on the ornamental plant fiddlewood (*Citharexylum spinosum*)
- permit for the use of 600 g kg^{-1} metsulfuron methyl for controlling alligator weed (*Alternanthera philoxeroides*)
- amendment of the environmental weeds permit to add Grazon* Extra Herbicide to the product list and to change the class of people who can use the permit
- permit for the use of Grazon* DS and Access® Herbicide for the control of coral cactus (*Cylindropuntia fulgida* var. *mamillata*).

APVMA's final 1080 review was released in January 2008. With changes to labelling and the imposition of new conditions of registration, APVMA is satisfied that the continued use of products containing 1080 is unlikely to cause significant harm to non-target animals or the environment. However, the report also concluded that in the absence of evidence to the contrary, the use of meat baits for feral pig control cannot be supported. This is due to concerns for the non-target impacts of meat baits containing 72 mg of 1080. However, the use of 1080 in meat baits for feral pig control is considered a vital component for the integrated management of feral pigs in Queensland. Therefore, DPI&F is currently conducting non-target impact monitoring of baits to ascertain whether there are significant population impacts outside the target species (particularly to birds of prey and goannas). To date, studies have identified that only a few of the potential non-target species take feral pig meat baits and new trials are in the planning stage to determine the overall impact.

Funding

Queensland Government

Land Protection Fund

Expected completion

Ongoing

A Appendixes

1 Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ABC	Australian Broadcasting Corporation
ACT	Australian Capital Territory
AFRI	Arid Forest Research Institute, India
AFRS	Alan Fletcher Research Station
APVMA	Australian Pesticides and Veterinary Medicines Authority
AQIS	Australian Quarantine and Inspection Service
ARC-PPRI	Agricultural Research Council—Plant Protection Research Institute, South Africa
CABI	CAB International
CMI	Composite match index
cpSSR	Chloroplast microsatellites
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CWTA	Centre for Wet Tropics Agriculture
DEWHA	Department of the Environment, Water, Heritage and the Arts, Commonwealth Australia
DNA	Deoxyribonucleic acid
DNR&W	Department of Natural Resources and Water, Queensland
DPI&F	Department of Primary Industries and Fisheries, Queensland
DSMA	Disodium methylarsonate
ELISA	Enzyme linked immuno sorbent assay
EPA	Environmental Protection Agency, Queensland
eRCV	Enteric rabbit calicivirus
ETM+	Landsat Enhanced Thematic Mapper
FPC	Foliage projective cover
GPS	Global positioning system
IACRC	Invasive Animals Cooperative Research Centre
IFGTB	Institute of Forest Genetics and Tree Breeding, India
LD	Lethal dose
LSD	Least significant difference
MLA	Meat and Livestock Australia
MSMA	Monosodium methylarsonate
NRMMC	Natural Resource Management Ministerial Council
NRMSC	Natural Resource Management Standing Committee
NSW	New South Wales
NT	Northern Territory
PNG	Papua New Guinea
PVA	Population viability analysis
Qld	Queensland
QPWS	Queensland Parks and Wildlife Service
QUT	Queensland University of Technology
RHD	Rabbit haemorrhagic disease
RHDV	Rabbit haemorrhagic disease virus
RT-PCR	Reverse transcriptase-polymerase chain reaction
RWPARC	Robert Wicks Pest Animal Research Centre
SA	South Australia
SE	Standard error
SLATS	Statewide Landcover and Trees Study
TM	Landsat Thematic Mapper
TWRC	Tropical Weeds Research Centre
UK	United Kingdom
UQ	The University of Queensland
Vic	Victoria
WA	Western Australia
WONS	Weed(s) of National Significance

2 Herbicides and pesticides

Name	Active ingredient(s)	Concentration	Manufacturer
1080	sodium fluoroacetate	various < 0.3 g kg^{-1}	Biosecurity Queensland
1080 Concentrate	sodium fluoroacetate	180 g L^{-1}	Biosecurity Queensland
1080 pig bait solution	sodium fluoroacetate	36 g L^{-1}	Biosecurity Queensland
1080 dog bait solution	sodium fluoroacetate	6 g L^{-1}	Biosecurity Queensland
Access®	triclopyr + picloram	240 g L^{-1} + 120 g L^{-1}	Dow AgroSciences Australia Ltd
Amicide® 625	2,4-D	625 g L^{-1}	Nufarm Australia Ltd
Pestmaster® Aqua-Tech® Glyphosate 360	glyphosate	360 g L^{-1}	Triox Pty Ltd
Arsenal® 250	imazapyr	250 g L^{-1}	Nufarm Australia Ltd
Arsenal® Xpress	Imazapyr + glyphosate	150 g L^{-1} + 150 g L^{-1}	Nufarm Australia Ltd
Basta®	glufosinate-ammonium	200 g L^{-1}	Bayer CropScience Pty Ltd
Brush-Off®	metsulfuron methyl	600 g kg^{-1}	DuPont (Australia) Ltd
Confidor® 200 SC	imidacloprid	200 g L^{-1}	Bayer CropScience Pty Ltd
Daconate®	MSMA	800 g L^{-1}	Crop Care Australasia Pty Ltd
DSMA Clear	DSMA	220 g L^{-1}	Barmac Industries Pty Ltd
EZ-Ject™ Copperhead Herbicide Shells	imazapyr	835 g kg^{-1}	Ez-Ject Inc
EZ-Ject™ Diamond-back Herbicide Shells	glyphosate	835 g kg^{-1}	Ez-Ject Inc
Flame®	imazapic-ammonium	240 g L^{-1}	BASF Australia Ltd
Glean®	chlorsulfuron	750 g L^{-1}	DuPont (Australia) Ltd
Grazon* DS	triclopyr + picloram	300 g L^{-1} + 100 g L^{-1}	Dow AgroSciences Australia Ltd
Grazon* Extra	triclopyr + picloram + aminopyralid	300 g L^{-1} + 100 g L^{-1} + 8 g L^{-1}	Dow AgroSciences Australia Ltd
Hotshot*	aminopyralid + fluroxypyr	10 g L^{-1} + 140 g L^{-1}	Dow AgroSciences Australia Ltd
Lantana 600	dichlorprop	600 g L^{-1}	Agricrop Pty Ltd
Lontrel*	clopyralid	300 g L^{-1}	Dow AgroSciences Australia Ltd
Organic Interceptor™	pine oil	680 g L^{-1}	Certified Organics (Aust) Pty Ltd
Presto 001®	fipronil	0.01 g kg^{-1}	BASF Australia Ltd
Roundup®	glyphosate	360 g L^{-1}	Nufarm Australia Ltd
Sencor® 480 SC	metribuzin	480 g L^{-1}	Bayer CropScience Pty Ltd
Starane* Advanced	fluroxypyr	333 g L^{-1}	Dow AgroSciences Australia Ltd
Starane* 200	fluroxypyr	200 g L^{-1}	Dow AgroSciences Australia Ltd
Termidor®	fipronil	100 g L^{-1}	BASF Australia Ltd
Tordon* DSH	triclopyr + picloram	200 g kg^{-1} + 100 g L^{-1}	Dow AgroSciences Australia Ltd
Tordon* Granules	picloram	20 g kg^{-1}	Dow AgroSciences Australia Ltd
Tordon* 75-D	2,4-D + picloram	300 g L^{-1} + 75 g L^{-1}	Dow AgroSciences Australia Ltd
Velpar® L	hexazinone	250 g L^{-1}	DuPont (Australia) Ltd
Vigilant®	picloram	43 g kg^{-1}	Horticulture and Food Research Institute of New Zealand
No trade name, special formulation	tebuthiuron	100 g kg^{-1}	Dow AgroSciences Australia Ltd

Note: ™, ® and * all denote a registered trademark.

3 Staff listings

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Bill Palmer	PhD, MAgrSc, BRSc, QDAH	Principal Entomologist
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4 Publications

Journal articles

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5 Presentations

Conference presentations

Gosper, C.R. 2007. *The role of fruit traits of bird-dispersed plants in invasiveness and weed risk assessment.* Ninth International Conference on the Ecology and Management of Alien Plant Invasions. Perth, Western Australia. September.

Manners, A., Palmer, W.A., Dhileepan, K., Hoskins, N. and Walter, G.H. 2008. *The ecological principles that underpin host testing for weed biocontrol – lessons from the release of* Aconophora compressa *against lantana.* Australia and New Zealand IOBC Biocontrol Conference. Sydney, New South Wales. 10–14 February.

McFadyen, R.E. and Palmer, W.A. 2008. *Classical biocontrol: possible even for weeds with congeneric native species?* Australia and New Zealand IOBC Biocontrol Conference. Sydney, New South Wales. 10–14 February.

Palmer, W.A. 2008. *Weed biocontrol in 2008 – where are we?* Australia and New Zealand IOBC Biocontrol Conference. Sydney, New South Wales. 10–14 February.

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Posters

Elsworth, P. 2007. *Are rabbits developing resistance to RHDV?* Corroboree. University of Canberra, ACT. July.

Lockett, C.J., Robinson, M., Pukallus, K., Dhileepan, K. and Palmer, W.A. 2008. *Impact of* Chiasmia assimilis, *an introduced weed biological control agent on prickly acacia* (Acacia nilotica *ssp.* indica) seedlings. Australia and New Zealand IOBC Biocontrol Conference. Sydney, New South Wales. 10–14 February.

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Workshops

Day, M.D. 2008. *Biological control of weeds in Queensland.* DPI&F Entomology Professional Development Workshop. Gympie, Queensland. May.

Gentle, M. 2008. *Feral pig research in southern Queensland: an update.* Biosecurity Queensland feral pig research review. AFRS Sherwood, Queensland. March.

Parker, R.W. 2008. *APVMA 1080 review.* Vertebrate Pesticide Regional Coordinators Workshop. Emerald, Queensland. June.

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Parker, R.W. 2008. *1080 bait and solution quality assurance update.* Vertebrate Pesticide Regional Coordinators Workshop. Emerald, Queensland. June.

Treviño, M. 2007. *Biological control of cat's claw creeper.* Weed Warriors Workshop. Boonah and Rathdowney Primary Schools, Brisbane, Queensland. 12 September.

Vogler W.D. 2007. *Bellyache bush ecology and management.* Bellyache Bush Workshop. AFRS Sherwood, Queensland. July.

Vogler, W.D. 2007. *Understanding grader grass ecology for improved management.* Weedy Grasses Workshop. Darwin, Northern Territory. October.

Vogler, W.D. 2007. *Northern Gulf Resource Management Group Project Prioritization Workshop.* Mareeba, Queensland. December.

Vogler, W.D. 2007. *Burdekin Dry Tropics Prioritization and Logic Workshop.* Townsville, Queensland. December.

Vogler, W.D. 2008. *Northern Regional Natural Resource Management Groups Project Alignment Workshop.* Cairns, Queensland. January.

Forums

Allen, L. 2008. *Training workshop on wild dog management, trapping and monitoring.* Capricorn Pest Management Group. Rockhampton, Queensland. May.

Berman, D. 2007. *Rabbit research.* Stanthorpe Shire Council Meeting. Stanthorpe, Queensland. September.

Berman, D. 2008. *Feral scientists: ecology and successful pest management.* Capricorn Pest Management Group Meeting. Rockhampton, Queensland. February.

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6 List of species

Common name	Scientific name
alligator weed	*Alternanthera philoxeroides*
American rat's tail grass	*Sporobolus jacquemontii*
azolla	*Azolla* spp.
balloon vine	*Cardiospermum grandiflorum*
balloon vine	*Cardiospermum halicacabum*
bellyache bush	*Jatropha gossypiifolia*
bellyache bush jewel bug	*Agonosoma trilineatum*
bellyache bush leaf-feeding moth	*Xylesthia* sp., *X. pruniramiella*
bellyache bush stem-boring weevil	*Cylindrocopturus jatrophae*
bellyache bush rust fungus	*Phakopsora jatrophicola*
bower of beauty vine	*Pandorea jasminoides*
cabomba	*Cabomba caroliniana*
camphor laurel	*Cinnamomum camphora*
Captain Cook tree (yellow oleander)	*Cascabella thevetia*
cat's claw creeper	*Macfadyena unguis-cati*
cat's claw creeper leaf-sucking tingid	*Carvalhotingis visenda*
cat's claw creeper leaf-tying moth	*Hypocosmia pyrochroma*
Ceylon spinach	*Basella alba*
chromolaena (Siam weed)	*Chromolaena odorata*
clidemia	*Clidemia hirta*
coral cactus	*Cylindropuntia fulgida* var. *mamillata*
dense waterweed	*Egeria densa*
duckweeds	*Spirodela* spp.
dwarf rotala	*Rotala rotundifolia*
echeveria	*Echeveria* spp.
feral cat	*Felis catus*
feral pig	*Sus scrofa*
fiddlewood	*Citharexylum spinosum*
florestina	*Florestina tripteris*
fox	*Vulpes vulpes*
giant Parramatta grass	*Sporobolus fertilis*
giant rat's tail grass	*Sporobolus pyramidalis*
giant rat's tail grass	*Sporobolus natalensis*
golden guinea flower snake vine	*Hibbertia scandens*
grader grass	*Themeda quadrivalvis*
guioa	*Guioa semiglauca*

Common name	Scientific name
harungana	*Harungana madagascariensis*
hygrophila	*Hygrophila costata*
hymenachne	*Hymenachne amplexicaulis*
kalanchoe	*Kalanchoe blossfeldiana*
kidneyleaf mudplantain	*Heteranthera reniformis*
lantana	*Lantana camara*
lantana	*Lantana urticifolia*
lantana	*Lantana nivea*
lantana	*Lantana horrida*
lantana	*Lantana strigocamara*
lantana	*Lantana hirsuta*
lantana budmite	*Aceria lantanae*
lantana herringbone leaf-mining fly	*Ophiomyia camarae*
lantana mirid	*Falconia intermedia*
lantana rust	*Puccinia lantanae*
lantana rust	*Prospodium tuberculatum*
lantana stem-sucking bug	*Aconophora compressa*
large-leaf privet	*Ligustrum lucidum*
limnocharis	*Limnocharis flava*
Madeira vine	*Anredera cordifolia*
Madeira vine leaf beetle	*Plectonycha correntina*
Madeira vine leaf beetle	*Phenrica* sp.
melaleuca	*Melaleuca quinquenervia*
melaleuca	*Melaleuca leucadendra*
melaleuca	*Melaleuca viridiflora*
miconia	*Miconia calvescens*
miconia	*Miconia nervosa*
miconia	*Miconia racemosa*
mikania butterfly	*Actinote anteas*
mikania butterfly	*Actinote thalia pyrrha*
mikania rust	*Puccinia spegazzinii*
mikania vine	*Mikania micrantha*
mimosa	*Mimosa pigra*
monkey rope vine (silk pod vine)	*Parsonsia straminea*
mother-of-millions	*Bryophyllum* spp.
mother-of-millions	*Bryophyllum delagoense*
mother-of-millions weevil	*Osphilia tenuipes*
mother-of-millions weevil	*Alcidodes sedi*
mouse	*Mus domesticus*
Parramatta grass	*Sporobolus africanus*
parrot's feather	*Myriophyllum aquaticum*
parthenium	*Parthenium hysterophorus*

Common name	Scientific name
parthenium clear-wing moth	*Carmenta ithacae*
parthenium stem-galling weevil	*Conotrachelus albocinereus*
parthenium summer rust	*Puccinia melampodii*
pond apple	*Annona glabra*
prickly acacia	*Acacia nilotica* ssp. *indica*
prickly acacia leaf-feeding geometrid	*Chiasmia assimilis*
prickly acacia noctuid	*Cometaster pyrula*
rabbit	*Oryctolagus cuniculus*
sagittaria	*Sagittaria platyphylla*
salvinia	*Salvinia molesta*
seed-boring weevil	*Coccotrypes carpophagus*
Senegal tea	*Gymnocoronis spilanthoides*
Siam weed (chromolaena)	*Chromolaena odorata*
silk pod vine (monkey rope vine)	*Parsonsia straminea*
sporobolus leaf fungus	*Nigrospora oryzae*
sporobolus leaf smut	*Ustilago sporoboli-indici*
sporobolus stem wasp	*Tetramesa* sp.
tobacco weed	*Elephantopus mollis*
velvety tree pear cactus	*Opuntia tomentosa*
water hyacinth	*Eichhornia crassipes*
water lettuce	*Pistia stratiotes*
white moth vine	*Araujia sericifera*
wild dog	*Canis lupus familiaris*
wild tobacco	*Solanum mauritianum*
yellow crazy ant	*Anoplolepis gracilipes*
yellow oleander (Captain Cook tree)	*Cascabella thevetia*
white lippia	*Lippia alba*