16th Australasian Vertebrate Pest Conference 2014

Program and Abstracts

Management of vertebrate pest animals across the landscape

16th Australasian Vertebrate Pest Conference
Brisbane, 26-29 May 2014

Queensland Murray-Darling Committee · The Weed Society of Queensland Inc. · mla Meat & Livestock Australia · Invasive Animals Cooperative Research Centre · Queensland Government · acta · Sporting Shooters Association of Australia S.S.A.A

16th Australasian Vertebrate Pest Conference 2014

Pullman King George Square, Brisbane - 26-29 May

Management of vertebrate pest animals across the landscape

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Citation:

16th Australasian Vertebrate Pest Conference, Brisbane, May 2014

Gentle M (ed) (2014) Program and Abstracts 16th Australasian Vertebrate Pest Conference.
Pullman King George Square
Cnr Ann and Roma Sts
Brisbane QLD 4000

Disclaimer:

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Invasive Animals CRC
Level D, Building 3
University of Canberra
Bruce, ACT 2617

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INTRODUCTION

The Australasian Vertebrate Pest Conference held in Brisbane Queensland, 26-29 May 2014, is proudly hosted by Biosecurity Queensland (part of the Queensland Department of Agriculture, Fisheries and Forestry). This Vertebrate Pests Committee (VPC) conference is held triennially, with the previous conference convened in Sydney in 2011. The last time Queensland convened the conference was in 1987.

VPC is an Australasian Committee whose role is to provide coordinated policy and planning for pest animal management. Through these conferences, the VPC aims to bring people involved in pest animal management together from Australasia and elsewhere, to foster the exchange of ideas, knowledge and innovation.

The theme of the 16th conference is 'Management of vertebrate pest animals across the landscape'. The conference scientific program (Tuesday 27 – Thursday 29 May) contains presentations on control initiatives, innovative research on pest animal ecology and management, and pest animal policy. The conference is also an opportunity for networking and features a social program including the Welcome function (Monday 26 May) and Conference Dinner (Tuesday 27 May).

CONFERENCE ORGANISING COMMITTEE:

Dr Matt Gentle (Convenor)	Biosecurity Queensland
Mr Iain Jamieson	Gold Coast City Council and Weed Society Queensland
Dr Carmel Kerwick	Biosecurity Queensland
Dr Tony Pople	Biosecurity Queensland
Dr Joe Scanlan	Biosecurity Queensland

CONFERENCE SCIENTIFIC COMMITTEE:

Dr Andrea Byrom	Landcare Research, New Zealand
Dr Tarnya Cox	New South Wales Department of Primary Industries
Dr Matt Gentle (Convenor)	Biosecurity Queensland
Dr Malcolm Kennedy	Agriculture Western Australia
Dr Tony Pople	Biosecurity Queensland
Dr Andrew Woolnough	Victorian Department of Primary Industries

CONFERENCE ORGANISER:

Doreen Culliver	On Q Conference Support

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THE SOCIAL PROGRAM

Follow us on twitter @AVPC14

Monday 26 May - Welcome Icebreaker

Where: KG Bar, Ground floor, Pullman Hotel King George Square
Time: 6pm-7.30pm
Cost: $35.00 per head

Registration for the Conference will be available at this event. Delegates can enjoy canapes and drinks (beer, wine, soft drinks) for the hour and a half. This is a great opportunity to catch up with colleagues and network with other delegates attending the conference. Dress code is casual.

Tuesday 27 May - 'Rainforest & Reef' Conference Dinner

Where: Grand Ballroom, Level 2, Pullman Hotel King George Square
Time: 7pm-11.30pm
Cost: Inclusive for full registration categories (day registrants and guests $110.00)

A great night is planned for those attending. Guests will be entertained by 'Mick & G' with a floorshow by Magician Pete Booth with a special appearance by Dave Berman. Tickets for the function will be located in the plastic sleeve behind the namebadge. Dress code is smart casual but if you want to dress to the theme, Rainforest & Reef, feel free to do so and let your imagination run wild!

Wednesday 28 May - Happy Hour/Poster displays

Where: Conference Exhibit, Grand Windsor Ballroom, Level 2, Mercure Tower, Pullman King George Square
Time: 5pm-6pm

Enjoy a drink after the conference while networking with exhibitors and colleagues and perusing the posters on display.

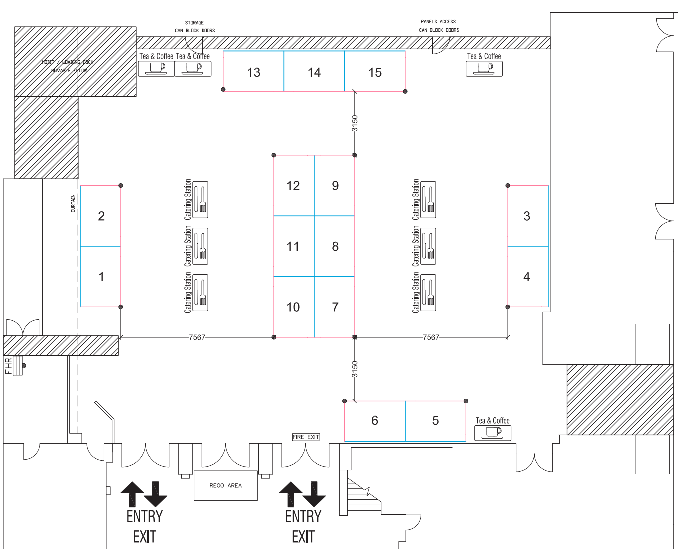
AFTER THE HAPPY HOUR: The Pullman Hotel are inviting delegates to join them in the KG Bar to watch the game!

Bar snacks will be served for one hour, starting half an hour before kick-off and all delegates attending will be offered a free drink voucher which can be redeemed during the game! What a great offer - iIf you don't have tickets to get to the game, make up a group and watch the match together, downstairs on the ground floor!

THE EXHIBITION

All catered breaks during the Conference will be held within the Exhibition area in the Windsor Ballroom.

AVPC are particularly appreciative of the support of sponsors and exhibitors at this year's conference. The committee encourages all delegates to visit the booths in the exhibition to view all displays and see what is on offer. This year, in lieu of an Exhibition Passport prize, exhibitors have been invited to donate prizes for a range of draws being held during the day within the session time slots.



Exhibitors and Booth numbers (alpha order)

Advanced Telemetry Systems Australia 9
Animal Control Technologies Australia 5,6
Animal Pest Management Services 8
Biosecurity Queensland 3
CSIRO Publishing 7
Ensystex Australasia 2
Frontier Labs 12
Invasive Animals CRC 1
Paks National 14
Sirtrack Ltd 13
Sporting Shooters' Association 4
Waratah Fencing Products 10
Wildsupply 11

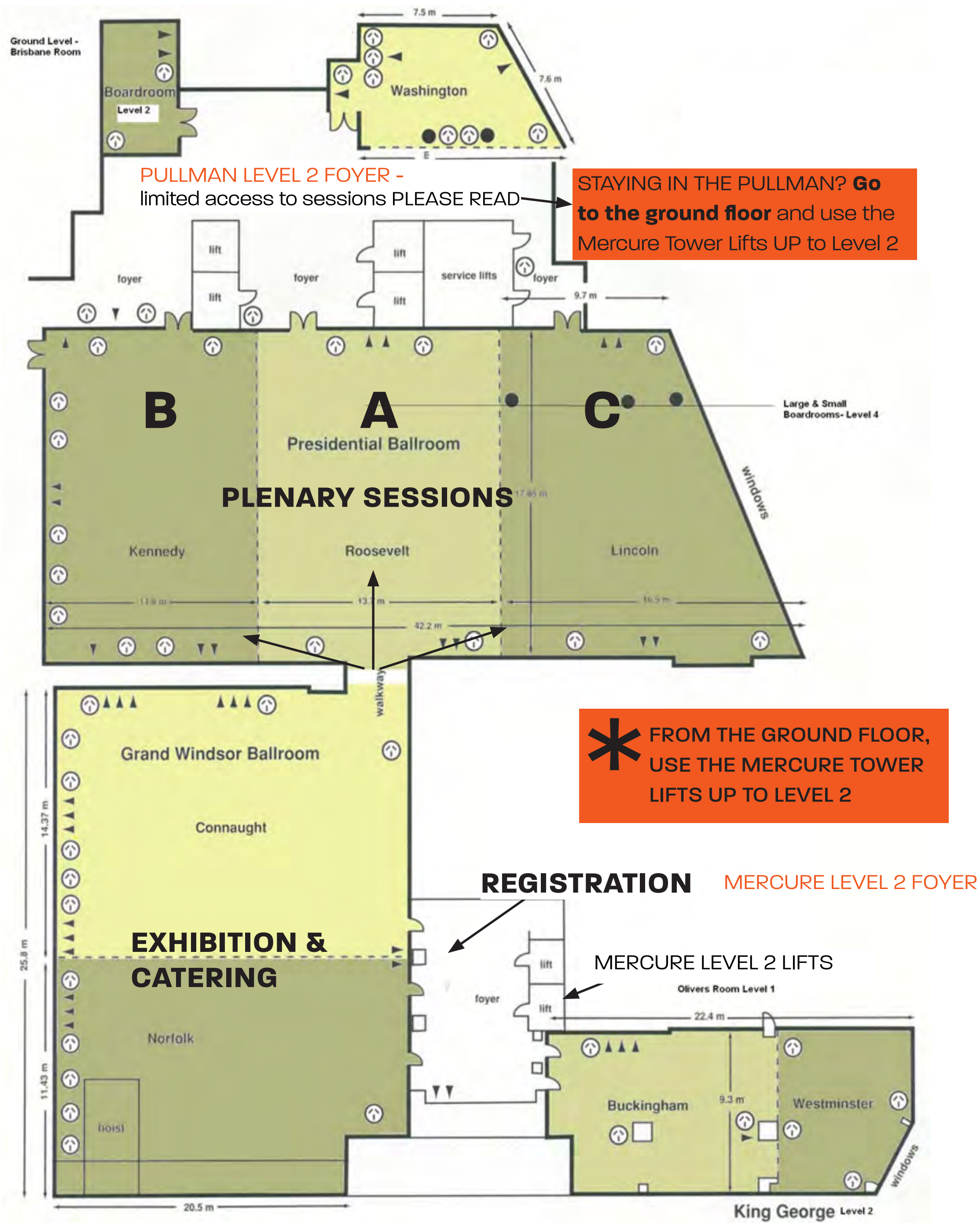
THE VENUE LEVEL 2 FLOORPLAN

To assist you find your way around, please review this page carefully to learn how you can best access the session rooms in the hotel.

The Conference sessions and the Exhibition and catering are located throughout the two hotel towers in the Pullman King George Square. All Conference sessions will be held in the Presidential Ballroom located in the Pullman Tower and exhibition and catering in the Grand Grand Windsor Ballroom located in the Mercure Tower.

1. *If you are staying in the Pullman*, **it is best if you go down to the ground floor and take the Mercure Tower Lifts from the ground floor up to Level 2**.
2. *If you are staying in the Mercure* you are in the right tower and can stop at Level 2.
3. *If you are coming into the hotel from outside*, take the Mercure Tower lifts from the ground floor up to Level 2.

Basically, to access the Conference sessions USE THE MERCURE TOWER LIFTS to Level 2.



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DAY 1 Tuesday 27 May 2014

PRESIDENTIAL BALLROOM

8:30- 8:33	Welcome - *Mr Will Zacharin, Chair of Vertebrate Pest Committee*
8:33-8:45	Welcome to Country
8:45-9:00	Official Opening - *The Hon John McVeigh, Minister for Agriculture, Fisheries and Forestry*
9:00-9:30	**Keynote**: Incursion and containment: Pests and pets, the future of vertebrate Biosecurity - *Associate Professor Phill Cassey, University of Adelaide*
9:30-10:00	**Keynote**: Staying ahead of the curve in pest animal management and innovation in an age of smaller Government and fewer land managers - *Mr Andreas Glanznig, Chief Executive Officer, IACRC*
10:00-10:30	MORNING TEA IN EXHIBIT
10:30-12:00	CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

2A INCURSION AND CONTAINMENT

CHAIR: ANDREA BYROM

10:30 Understanding the transport and introduction of vertebrates to manage invasions: reptiles in Australia
Garcia-Diaz P, Cassey P.

10:45 Inference to underpin vertebrate pest incursion management
Caley P, Barry S, Ramsey D.

11:00 Incursion pre-planning – increasing prevention and early response capability for new and emerging species
Price D, Corry M, Green M.

11:15 National Surveillance Targets: which vertebrates for Category 1 of the National Categorisation System for invasive species?
Virtue J, Diaz PG, Woolnough A, Cassey P.

11:30 St Helena Island: expanding the borders, tightening the nets
Key J, Higgins D.

11:45 Predicting bird incursions: the role of abundance, market value and species traits as drivers of the private bird trade
Vall-llosera M, Cassey P.

KENNEDY ROOM

2B LANDSCAPE-SCALE PEST MANAGEMENT

CHAIR: PETER FLEMING

10:30 Crossing the line – achieving landscape scale rabbit control despite the state border
Drew J, Matthews J, Staude N.

10:45 Overview and outcomes of the Australian Feral Camel Management project
Hart Q, Edwards, G.

11:00 The development of a Bayesian Belief Network as a decision support tool in feral camel removal operations
Harper M, Lethbridge M.

11:15 The science-based efforts of the USDA's National Rabies Management Program for controlling rabies
VerCauteren K, Gilbert A, Shwiff S, Slate D, Rupprecht C, Blanton J, Chipman R.

11:30 Canine Rabies will alter how we manage wild dogs in Australia
Sparkes J, Ballard G, Fleming P, Brown W.

11:45 New, automated pest detection and monitoring devices
Blackie H, Barrett B, Woodhead I, Irie K, Riding P, Inder S.

12:00-13:15	LUNCH AND POSTER DISPLAYS IN EXHIBIT
13:15-14:45	CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

3A INCURSION AND CONTAINMENT (CONTINUED)

CHAIR: ANDREW WOOLNOUGH

13:15 Prioritizing action for invasive alien birds and mammals in Australia
Kark S.

13:30 Smooth newts in Victoria: a new species incursion within Australia
Ward M, Kay A, Melville R.

13:45 Environmental DNA for low density species detection
Furlan E, Gleeson D, Hardy C, Duncan R.

14:00 The final needles in the haystack - Moving to Stage 3 of the Tasmanian Fox Eradication Program
Elliott C, Harris S.

14:15 Pet trade biosecurity - preventing pets becoming pests
Knegtmans J.

14:30 Starlings at an invasion front: heard but not seen
Campbell S, Woolnough A, Obolonkin V, Parsons S.

KENNEDY ROOM

3B LANDSCAPE-SCALE PEST MANAGEMENT (CONTINUED)

CHAIR: ROGER PECH

13:15 The effectiveness of integrated exotic predator control for the conservation of endangered mallee fowl (*Leipoa ocellata*) populations near Mount Hope, New South Wales
Wishart J, Meek P.

13:30 Evidence of the benefits for native mammals from sustained fox control
Robley A, Gormley A.

13:45 Southern Yorke Peninsula fox baiting for biodiversity
Rudd K, Short H, Teubner V.

14:00 Community action to tackle Indian Myna birds - what can be achieved; what is needed?
Handke B.

14:15 Assessing the efficacy of the West Australian State Barrier Fence as a barrier to wild dog movement
Kennedy M, Rose K.

14:30 Lessons in feral cat control – Can adaptive management provide the solution?
Rich M, Nolan B, Speed J, Gentle M.

14:45-15:15	AFTERNOON TEA IN EXHIBIT

DAY 1 Tuesday 27 May 2014 continued

15:15-16:45 CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

4A OPEN SESSION

CHAIR: JOHN TRACEY

15:15 Eradication of rodents and rabbits from Sub-Antarctic Macquarie Island
Springer K.

15:30 Monitoring goats and their impact on native vegetation
Harper M, Lethbridge M, Andrews L, Stead M, Shimmield J.

15:45 Eradication of black rats (*Rattus rattus*) from the Boydong Islands on the Great Barrier Reef, Queensland, Australia
Kirby P, Lindeman R, Schaper D.

16:00 Managing vertebrate pests in parks - the QPWS experience
Hodgon J.

16:15 Scavenging on wild deer carcasses by wild dogs, foxes and feral cats in south-eastern Australia
Woodford L, Moloney P, Forsyth D, Hampton J, Woolnough A, Tucker M.

16:30 Estimating density and impact of sparse rabbit populations in native vegetation
Mutze G, Jennings S.

KENNEDY ROOM

4B FERAL PIGS

CHAIR: ANDREW BENGSEN

15:15 Optimization of formulations of sodium nitrite for the lethal control of feral swine
Foster J, Cameron M, Phillips G, Eisemann J, Staples L, VerCauteren K.

15:30 Detection of feral pigs in forest habitats using an aerially deployed thermal sensor
Adams P, Rampant P.

15:45 Non-target species interaction with sodium fluoroacetate (1080) bait for controlling feral pigs (*Sus scrofa*)
Millar A, Gentle M, Leung L.

16:00 Feral pig impacts on palm forests in the Whitsunday Ranges
Nolan B, Bennison K.

16:15 Understanding population level interactions between spatial distributions of management and pig populations in the wet tropics
Fletcher C, Dryden B, Westcott D, Jones D.

19:00-LATE CONFERENCE DINNER in PULLMAN BALLROOM

DAY 2 Wednesday 28 May 2014

PRESIDENTIAL BALLROOM

8:30- 8:45 Welcome/Housekeeping - *Dr Tony Pople.*

8:45-9:15 **Keynote**: Advancing animal welfare in pest animal management: two steps forward, one step back? - *Dr Bidda Jones, RSPCA, ACT.*

9:15-9:45 **Keynote**: Eliminating feral swine in New York - leading a horse to water - *Mr Justin Gansowski, US Department of Agriculture, New York.*

9:45-10:15 **Keynote**: The impact of climate change on invasive vertebrate pests and adaptation principles and practices to manage them - *Dr Craig James, CSIRO, ACT.*

10:15-10:30 ACTA Award for Excellence in Pest Management

10:30-11:00 MORNING TEA IN EXHIBIT

11:00-12:30 CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

6A BARRIERS TO ADOPTION INCLUDING HUMAN DIMENSIONS OF INVASIVES

CHAIR: GREG MIFSUD

11:00 Effectively engaging communities in managing overabundant wildlife and associated impacts: a conservation imperative
Curtis P, Decker D.

11:15 More than factsheets - Effective community engagement is needed to achieve eradication outcomes
Elliott C, Braysher M, Marrison M.

11:30 Improving participatory approaches to managing wild dogs
Ecker S, Aslin H, , Binks B, Zobel-Zubrzycka H.

KENNEDY ROOM

6B CLIMATIC & ENVIRONMENTAL INFLUENCES ON PEST ANIMALS

CHAIR: PETER CALEY

11:00 Will climate change alter the dynamics and control of outbreaking species?
Pech R, Barron M, Tait A, Byrom A, Holland EP, James A, Tompkins D.

11:15 The influence of climate on home range of wild red deer in south-east Queensland
Amos M, Baxter G, Finch N, Murray P.

11:30 Tropical rabbits: the spread of wild rabbits in North Queensland
Elsworth P, Brennan M, Scanlan J.

DAY 2 Wednesday 28 May 2014 continued

11:00-12:30 CONCURRENT SESSIONS CONTINUED

ROOSEVELT/LINCOLN ROOMS

6A BARRIERS TO ADOPTION INCLUDING HUMAN DIMENSIONS OF INVASIVES (CONTINUED)

11:45 The human dimensions of Invasive Animals Management: program 4E1 of the Invasive Animals CRC
Alter T, Thompson LJ, Marsh J, Frumento P.

12:00 Vernacular knowledge and vertebrate pest management: is there any value in community-led interventions?
Bartel R, Marshall G.

12:15 Framing wild dog management in the context of landscape function and sustainability
Allen L, Wardell-Johnson A.

KENNEDY ROOM

6B CLIMATIC & ENVIRONMENTAL INFLUENCES ... (CONTINUED)

11:45 One step ahead - Predictive modelling of suitability and susceptibility of areas for the European wild rabbit in the Queensland Murray Darling Basin.
Macdonald V, Berman D, Marshall D, Barker J, Murray J, van Klinken R .

12:00 Where can all the pigs be found? Harnessing expert knowledge for the spatial modelling of feral pig distribution and abundance in northern Australia
Froese J, Smith C, Durr P, van Klinken R.

12:15 The cost of controlling feral pigs in temperate rainforest habitat using ground-based hunting teams
Choquenot D, Krull C.

12:30-13:30 LUNCH AND POSTER DISPLAYS IN EXHIBIT

13:30-15:00 CONCURRENT SESSIONS

ROOSEVELT ROOM

7A BARRIERS TO ADOPTION INCLUDING HUMAN DIMENSIONS OF INVASIVES (CONTINUED)

CHAIR: PAUL MARTIN

13:30 Integrating technology advances with management - the emerging role of zinc phosphide in pest control in New Zealand
Eason C, Shapiro L, MacMorran D, Blackie H.

13:45 Tools for adaptive management of forests affected by deer in New Zealand
Veltman C, Allen W, Allen R, Barker R, Bellingham P, Forsyth D, Jacobson C, Nicol S, Ramsey D, Richardson S, Todd C.

14:00 Community engagement for effective and sustainable vertebrate pest management: tools and considerations
Shuffstall W, Whitmer W, Adams L, Thompson LJ.

14:15 Using ecological research to reduce barriers to achieve effective feral pig management
Marshall D, Gentle M, Alter T.

14:30 Deep framing versus social marketing: Eliciting long-term, meaningful behaviour change in community-engaged invasive animal management
Please P, Hine D.

14:45 A conceptual framework for new invasive species management legislation in Victoria
de Milliano W, Ainsworth N, Burley J, Woolnough A.

KENNEDY ROOM

7B SOCIAL ASPECTS INCLUDING WELFARE OF PEST ANIMALS

CHAIR: BRUCE WARBURTON

13:30 Respecting Aboriginal cultural heritage while protecting the environment: landscape-scale rabbit control
Godino M, Harrison B, Farrer M.

13:45 Public perceptions about wild horses in Victoria: What do the community really think?
Brown D, Axford J, Pascoe C, Reeve C.

14:00 Managing the impacts of both pests and pest management – a feral camel experience
Gee P, Pitt J.

14:15 Quantitative assessment of animal welfare outcomes from feral camel removal methods
Hampton J, Miller C, Perry A.

14:30 Wild dog aware: Understanding the influence of media and public perception
York B, Fleming P, Hine D.

14:45 Horse control in Queensland National Parks
Dollery C.

LINCOLN ROOM

7C PRACTICAL APPLICATIONS IN MONITORING PEST ANIMALS

CHAIR: IAIN JAMIESON

Sponsored by the Weed Society of Queensland

13:30 Monitoring tools and techniques for intelligent management of vertebrate pests
Berman D, Marshall D, Garrett T, Scriven J, Morgan N, Hosie H, Zabek M.

13:45 The traps of camera traps
Meek P, Ballard G, Fleming P, Vernes K, Falzon G.

14:00 An introduction to the use of Geographic Information Systems (GIS) to visualise pest animal management issues
Calvert M.

14:15 How to collect, store and query pest animal data: A tutorial for practitioners
Allen B.

15:00-15:30 AFTERNOON TEA IN EXHIBIT

DAY 2 Wednesday 28 May 2014 continued

15:30-17:00 CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

8A BARRIERS TO ADOPTION INCLUDING HUMAN DIMENSIONS OF INVASIVES (CONTINUED)

CHAIR: PATTY PLEASE

15:30 Reducing institutional impediments to community-based invasives control
Martin P, Low Choy D, Le Gal E.

15:45 The human dimensions of invasive vertebrate pest control: innovating for effective community-wide action
Fortunato M, Smith-Herron A, Beach S, Chapman B, Ellis C, Prelog A, Theodori G, Martin P, Alter T.

16:00 Improving the effectiveness of cat management programs through sustained human behaviour change
McLeod L, Hine D.

16:15 Organisational and network learning in invasive animal management
Dickson K.

16:30 Social implications of a predator- free New Zealand
Byrom A, Greenaway A, Holland EP, Niemiec B, Warburton B.

KENNEDY ROOM

8B OPEN SESSION

CHAIR: DAVID PEACOCK

15:30 A long-term assessment of methods to reduce bird damage to fruit
Tracey J, West P, Lukins B, Saunders G.

15:45 Updated National Training Qualifications for vertebrate pest managers in Australia
Brown A, Braysher M.

16:00 Phage peptides fertility control: non-surgical sterilisation of female equids
Hall S, Aitken J, McLaughlin E.

16:15 The Balanced Scientist Program: Enhanced PhD candidate training
Buckmaster T, Sarre S.

16:30 Improving and maintaining organisational capacity in vertebrate pest management
Hurrell C, Matthews J .

17:00-18:00 HAPPY HOUR IN THE EXHIBIT / POSTER DISPLAYS

DAY 3 Thursday 29 May 2014

8:45-10:30 CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

9A BIOCONTROL DEVELOPMENTS AND APPLICATION

CHAIR: PETER ELSWORTH

8:45 **Keynote:** Biological control of vertebrate pests in Australia
Strive T.

9:15 The current status of antibodies to pathogenic and benign caliciviruses in selected rabbit populations
Cox T, Liu J, Strive T.

9:30 Identifying molecular virulence factors of Rabbit Haemorrhagic Disease Virus
Urakova N, Matthaei M, Frese M, Strive T.

9:45 Australia's rabbit history guides the search for new rabbit biocontrols: current focus on *Eimeria* and Leporid Herpesvirus-4
Peacock D.

10:00 RHDV-Accelerator: using natural selection to maintain and improve RHDV-mediated rabbit biocontrol
Matthaei M, Kerr P, Capucci L, Strive T.

10:15 The hard slog: progress towards a National Carp Biocontrol Program
Gilligan, D, McColl K.

KENNEDY ROOM

9B PERI-URBAN PEST MANAGEMENT

CHAIR: LEE ALLEN

8:45 **Keynote**: New settlers on the fringe: Demystifying peri-urban myths
Low Choy D.

9:15 Pet or Pest? An investigation of community attitudes and local government action towards cat management
Lorang M, Elliott C.

9:30 Disease prevalence and public health risks of peri-urban wild dogs
Harriott L, Gentle M, Traub R, Soares-Magalhaes R, Cobbold R.

9:45 Feral horse management amongst unexploded bombs and peri-urban people
Berman D.

10:00 The impacts and management of peri-urban wild dogs
Gentle M, Allen B, Speed J, Allen L.

10:15 Improving vertebrate pest management in peri-urban areas through technological and methodological advances
Allen B, Gentle M.

10:30-11:00 MORNING TEA IN EXHIBIT

11:00-12:30 CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

10A RABBIT IMPACTS AND MANAGEMENT

CHAIR: TARNYA COX

11:00 Experience from El Teide National Park, Canary Islands, shows that hunting to control rabbits does not meet conservation goals
Cooke B, Lopez Darias M, Luengo JLR.

KENNEDY ROOM

10B PREDATOR ECOLOGY AND MANAGEMENT

CHAIR: MALCOLM KENNEDY

11:00 Raptors vs Aliens: Can native birds of prey help control invasive species?
Glen A.

DAY 3 Thursday 29 May 2014 continued

11:00-12:30 CONCURRENT SESSIONS CONTINUED

ROOSEVELT/LINCOLN ROOMS

10A RABBIT IMPACTS AND MANAGEMENT (CONTINUED)

11:15 Reflecting on a compliance approach to rabbit control
Thorp A, Matthews J.

11:30 Refining operational practices for controlling rabbits on agricultural lands
Latham D, Nugent B, Warburton B.

11:45 Quantifying rabbit damage to pasture in Hawkes Bay, New Zealand
Perry M, Glen A, Ruscoe W.

12:00 Density-dependent effects of European rabbits on tree survival and above-ground carbon storage in a south-eastern Australian reforestation program
Forsyth D, Scroggie M, Arthur A, Lindeman M, McPhee S, Bloomfield T, Stuart I.

12:15 Application of a systems mapping tool to support community-led action on rabbit management
Adams L, Martin P, Woolnough A.

KENNEDY ROOM

10B PREDATOR ECOLOGY AND MANAGEMENT (CONTINUED)

11:15 Managing wild canids in mesic environments: Predators prey, plants and people
Fleming P. Ballard G, Morgan H, Reid N.

11:30 Population and activity responses of feral cats to wild canid control in north-eastern New South Wales
Zewe F, Ballard G, Koertner G, Forge T, Vernes K, Fleming P.

11:45 Cats, quolls and trophic cascades: are feral cats associated with declines in the eastern quoll?
Fancourt B, Nicol S, Hawkins C, Jones M, Johnson C.

12:00 Distress vocalisations in wild dogs
Nolan H, Brown W, Ballard G, McDonald P, Laegel T.

12:15 A novel approach to managing wild dogs on public land
Bretherton M, Martin S, Kingston V, Skews K, Crocos A, Lineham G, Woolnough A.

12:30-13:30 LUNCH AND POSTER DISPLAYS IN EXHIBIT

13:30-15:00 CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

11A NEW TOOLS: DEVELOPMENTS AND STRATEGIES

CHAIR: CHARLES EASON

13:30 Single or multiple-capture traps – is more always better?
Warburton B, Gormley A.

13:45 Modified Victor® Easy Set® rat traps for trapping stoats and ship rats in New Zealand: pen and field trials
Morriss G, Warburton B.

14:00 Revision of the Australian Pest Animal Strategy
Gaze I.

14:15 Density estimation from presence-absence data using spatially-explicit models
Ramsey D, Caley P, Barry S.

14:30 Developing baiting strategies for eradicating *Rattus rattus* on Torres Strait Islands
Leung L, Koh, J.

14:45 Development of re-setting toxin delivery devices and long-life lures for rats
Murphy E, Sjoberg T, Dilks P, MacMorran D, Eason C, Aylett P.

KENNEDY ROOM

11B PREDATOR ECOLOGY AND MANAGEMENT (CONTINUED)

CHAIR: BEN ALLEN

13:30 Which aerial baiting rate is better for wild dog control?
Ballard G, Fleming P, Doak S, Meek P.

13:45 Responses of two fox populations to coordinated baiting in an agricultural landscape
Bengsen A.

14:00 Assessing the uptake of ground-distributed fox baits in Western Australia
Dundas S, Adams P, Fleming P.

4:15 Assessing the impact of fox baiting on Tasmanian devils
Hughes C, Mooney N, Dickman C.

14:30 The diet of feral cats and foxes in southern Queensland
Speed J, Gentle M.

14:45 Spatial and temporal variation in the diets of wild dogs and foxes in Victoria
Davis N, Forsyth D.

15:00-15:30 AFTERNOON TEA IN EXHIBIT

15:30-16:30 CONCURRENT SESSIONS

ROOSEVELT/LINCOLN ROOMS

12A NEW TOOLS: DEVELOPMENTS AND STRATEGIES (CONT'D)

CHAIR: ELAINE MURPHY

15:30 Use of a target-specific feed structure to identify potential baiting opportunities for the control of overabundant herbivore pest species
Hunt R, Claridge A, Fleming P, Cunningham R, Russell B, Mills D.

15:45 Self-resetting traps for ground based pest control for conservation in New Zealand forests – interim results
Gillies C, Gorman N, Conn S, Crossan I, Haines M, Long J.

KENNEDY ROOM

12B OPEN SESSION

CHAIR: AL GLEN

15:30 Increasing urban abundance of an endemic New Zealand honeyeater by pest control in surrounding native forests
Innes J, Fitzgerald N, Watts C, Thornburrow D, Bartlam S, Collins K, Byers D, Burns B, Forrester G.

15:45 Mixing with Mallards: Is the integrity of the Australian Pacific black duck at risk due to hybridisation with mallards?
Taysom A, Johnson J, Guay PJ.

DAY 3 Thursday 29 May 2014 continued

15:30-16:30 CONCURRENT SESSIONS CONTINUED

ROOSEVELT/LINCOLN ROOMS

12A NEW TOOLS: DEVELOPMENTS AND STRATEGIES (CONT'D)

16:00 How effective is D-TER® animal and bird repellent in repelling brushtail possums?
Bradley G, Leung L.

16:15 Novel long-term possum control tools in New Zealand
Blackie H, Barrett B, MacKay J, MacMorran D, Inder S.

KENNEDY ROOM

12B OPEN SESSION

16:00 Understanding population dynamics of the feral horse in a coniferous environment in southeast Queensland
Zabek M, Berman D, Wright J, Blomberg S, Collins W.

16:15 Passive Activity Index: weaknesses, strengths and surprises
Allen L.

16:30-16:45 Conference Closing - *Matt Gentle, Conference Convenor*

POSTERS

1. Fabric Animal Traps - A novel animal trap design for wallabies, possums, feral cats and medium size pest browsing animals and carnivores - *Edwards I.*
2. Transport and introduction of amphibians in Australia - *Garcia-Diaz P, Cassey P.*
3. Vertebrate pest management initiatives in the Southern Ocean - *Springer K, Carmichael N.*
4. M-44 Ejector activation by red foxes (*Vulpes vulpes*) in agri-ecosystems - *Osborne E, Ballard G, Vernes K, Fleming P.*
5. Managing the risks posed by captive exotic animals via a policy-based approach - *Corry M, Kay A, De Milliano W, Woolnough A.*
6. Finding it difficult to engage media in pest control? Angry Birds and Twitter may be the answer! - *Knegtmans J.*
7. The non-pathogenic rabbit calicivirus in Queensland - *Elsworth P.*
8. Increasing the capacity of regional groups to manage vertebrate pest impacts - *Marsh J, Brown A.*
9. Novel multiple-kill control devices for feral cats - *Sjoberg T, Murphy E, Barun A, MacMorran D, Aylett P, Barret B.*
10. Understanding patterns in habitat use by free-living cats *Felis catus*: a review and implications for conservation management - *Doherty, T, Bengsen A, Davis R.*
11. Mobile device apps and real-time web-mapping of pest animals in Australia - *West P, Crawford R, O'Reilly R.*
12. Eradication efforts of feral swine in New York State - *Hojnacki D, Gansowski J.*

DISCLAIMER: This program is correct at the time of production.

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ABSTRACTS - DAY 1

Tuesday 27 May 2014

INCURSION AND CONTAINMENT: PESTS AND PETS, THE FUTURE OF VERTEBRATE BIOSECURITY

Phillip Cassey

School of Earth & Environmental Sciences and the Environment Institute,
The University of Adelaide, North Terrace SA 5005.
Email: phill.cassey@adelaide.edu.au

Australia has a mixed record at managing exotic vertebrate species. Infamous on one hand for the highly successful activities of the Acclimatisation societies and lauded on the other for its ongoing management of feral pests, particularly on islands. New vertebrate species continue to arrive in Australia, and be detected at large, but the vast majority of new incursions are exotic captive-species already in Australia, not new arrivals. New technologies for pest-removal and innovative approaches to bio-surveillance will continue to place Australia at the forefront of vertebrate pest-management.

STAYING AHEAD OF THE CURVE IN PEST ANIMAL MANAGEMENT AND INNOVATION IN AN AGE OF SMALLER GOVERNMENT AND FEWER LAND MANAGERS

Andreas Glanznig

Chief Executive Officer, Invasive Animals Co-operative Research Centre,
University of Canberra ACT 2601.
Email: andreas.glanznig@invasiveanimals.com

Maintaining landscape productivity through effective pest animal management in an age of declining public resources, fewer land managers, rising pest animal impacts and greater business uncertainty, presents large challenges for land managers.

The past decade has seen a major contraction of Australian and State government agricultural and environment budgets and extension services, and a further drop in farmer numbers by 11% over the last five years to 157,000 contributing to a 40% fall over the past 30 years according to the most recent Australian census.

The critical role of innovation to address this structural change is recognised by industry and government alike: it is one of seven themes in the National Farmers' Federation's *Blueprint for Australian Agriculture*, and identified in the national biosecurity capability audit.

In our sector, the independent evaluation of the current Australian Pest Animal Strategy (APAS) concluded that innovation to improve pest animal management over the last five years was "in large part due to the Invasive Animals CRC". Large scale collaboration across government and industry works – pure and simple. The challenge for policy makers will be to ensure that the next Australian Pest Animal Strategy charts a roadmap to maintain and nuture large-scale collaborative innovation institutions, enable industry-government pest animal management initiatives to prosper, and delivers real, measurable on-ground benefits.

UNDERSTANDING THE TRANSPORT AND INTRODUCTION OF VERTEBRATES TO MANAGE INVASIONS: REPTILES IN AUSTRALIA

Pablo Garcia-Diaz and Phillip Cassey
School of Earth & Environmental Sciences and the Environment Institute,
The University of Adelaide, North Terrace SA 5005.
E-mail: pablo.garciadiaz@adelaide.edu.au

Despite the efforts of biosecurity agencies in Australia there has been an increase in the number of new vertebrate incursions in the country during the last decade. Half of these new incursions are reptiles, and some of the species detected represent a serious threat to Australian biosecurity. Understanding the factors that affect the transport (movement of species outside their native range) and introduction (release or escape of individuals into the environment) is critical to design strategies to avoid the establishment of new species and the associated costs. We compiled a database of reptile species transported and introduced in Australia. Data were obtained from 38 sources including scientific publications, reports from environmental agencies, and classified advertisements web pages. We detected 445 reptiles transported in Australia: 211 (47.4%) are species native to Australia and 234 (52.6 %) are exotics. These species are transported via three main pathways: pet trade (161 species), zoos (340) and as stowaways (94). Transported reptiles are a taxonomic non-random sample of all extant reptiles. The number of species transported in Australia represents almost 5% of all extant reptile species. Until now, 68 (15.3% of all transported) species have been introduced outside their native ranges in Australia. Several factors such as zoogeographical realm of origin, conservation status and species attributes (body size, clutch size, colouration patterns) can influence the probability of transport and introduction. While it is important to continue biosurveillance activities for early detection of reptile incursions, additional strategies are required that directly involve the breeders and keepers of reptiles, in order to successfully prevent new invasions.

INFERENCE TO UNDERPIN VERTEBRATE PEST INCURSION MANAGEMENT

Peter Caley[1], Simon Barry[1] and Dave Ramsey[2]

[1]CSIRO Computational Informatics, GPO Box 664 Canberra ACT 2601.
[2]Arthur Rylah Institute, Department of Sustainability and Environment, Victoria,
123 Brown Street Heidelberg VIC 3084.
Email: peter.caley@csiro.au

The data available to underpin decision making when responding to vertebrate incursion events are often sparse. The observation data often arise from surveillance effort and efficacy that varies considerably in space and time. This presents challenges for making robust inference to underpin good decision making. The current models used to analyse sighting data for the purpose of estimating extinction probabilities are not robust to relaxing the assumptions regarding the observation process and how it relates to the underlying population. There is a need for statistical models that account for the inherent uncertainties in the processes that generate these data, whilst capturing all the information content it contains.

This talk will illustrate how we are developing methods that blend data and statistics with computing power to make inference on the fate of an incursion. We use the red fox incursion into Tasmania as a case study.

INCURSION PRE-PLANNING – INCREASING PREVENTION AND EARLY RESPONSE CAPABILITY FOR NEW AND EMERGING SPECIES

Dana Price[1], Melinda Corry[2], Miranda Green[1]

[1]Regulation and Compliance Group, Department of Environment and Primary Industries, 1301 Hazeldean Road, Ellinbank, VIC 3821.
[2]Regulation and Compliance Group, Department of Environment and Primary Industries, 1 Spring Street, Melbourne, VIC 3000.
Email: dana.price@depi.vic.gov.au

Pest animals have the potential to have significant negative impacts on the economy, environment, social amenity and human health. Pre-developed preparedness tools can guide action when an invasive species is detected, support rapid response to new incursions, improve response capability and ultimately increase the likelihood that new high risk species can be prevented from establishing.

The Department of Environment and Primary Industries has developed a series of pre-incursion resource documents (Pre-Plans) that aim to aid in the detection, surveillance and management of new incursions of vertebrate pests found in the wild in Victoria. There are 11 documents in the series, encapsulating a total of 22 bird species, 11 amphibian species, 48 reptile species and 28 mammal species. Each plan details the declaration status, delimitation survey methods, eradication and containment options, zoonosis risks, OHS considerations, euthanasia and disposal options and a list of expert contacts for each species.

Data on exotic vertebrates that have been intercepted at borders, seized, surrendered, stolen or detected-at-large, and on species currently kept in Victoria under permit, have been used as the basis to guide which species, or groups of species, are covered. These documents provide a resource to inform the development of detailed management plans for new exotic vertebrate incursions and are likely to have broader application in other jurisdictions.

NATIONAL SURVEILLANCE TARGETS: WHICH VERTEBRATES FOR CATEGORY 1 OF THE NATIONAL CATEGORISATION SYSTEM FOR INVASIVE SPECIES?

John Virtue[1], Pablo Garcia Diaz[2], Andrew Woolnough[3] and Phillip Cassey[2]

[1]Primary Industries & Regions South Australia, GPO Box 1671, Adelaide SA 5001.
[2]School of Earth & Environmental Sciences, The University of Adelaide SA 5005.
[2]Department of Environment and Primary Industries, 1 Spring St, Melbourne VIC 3000.
Email: john.virtue@sa.gov.au

Australia is continually at risk from the invasion, establishment and subsequent impacts of new pests and diseases, including vertebrate species. A recent ten year review of exotic vertebrate incursions and interceptions showed a wide variety of species detected at ports, held illegally and found at large in Australia (Henderson and Bomford 2011). Effective prevention, early detection, risk assessment and incursion response measures are vital to avoid establishment. A target list of species provides a basis for collaborative programs, including ongoing communications with stakeholders involved in high risk pathways.

The Incursions Working Group (IncWG) of the VPC is tasked with building national surveillance and preparedness systems for pest animal incursions. In order to progress this, the IncWG requires a list of "Alert Pests" that could concurrently be used to direct pre-border, border and post-border surveillance, and to have agreed national species response plans in place should incursions occur. Vertebrate species on such a list would not be established in Australia, pose a high pest risk, pose a likely incursion risk through a variety of arrival pathways, and intervention to prevent establishment should likely be technically feasible. The current list of National Pest Animals Alerts, developed from 2007, is not suited to the needs of IncWG as it contains a mix of species that are widely established in some parts of Australia (e.g. common myna *Acridotheres tristis*, rusa deer *Cervus timorensis*), kept under differing degrees of legislative control (e.g. ferret *Mustela putorius*, Indian ringneck *Psittacula krameri*), occur as sporadic outbreaks (e.g. red eared slider turtle *Trachemys scripta*) or are not known to occur in Australia (e.g. house crow *Corvus splendens*).

Subsequently, the IncWG has collaborated with the Categorisation Working Group of VPC to populate species in Category 1: National Surveillance of the National Categorisation System for Invasive Species (AWC and VPC 2011). The aim was to develop a nationally relevant list of "iconic" pest species covering each class of vertebrate (mammals, fish, amphibia, reptiles and birds). Selection of species for the list was informed by recent national data on vertebrate detections and analysis of risk pathways. A key challenge was relating the outcomes of varying risk assessment models to the national significance criteria of the National Environmental Biosecurity Response Agreement (NEBRA).

References:

AWC and VPC 2011. *The National Categorisation System for Invasive Species.* Categorisation Working Groups of the Australian Weeds Committee and the Vertebrate Pests Committee. http://www.feral.org.au/policy/vpc/

Henderson, W., and Bomford, M. 2011. *Detecting and preventing new incursions of exotic animals in Australia.* Invasive Animals Cooperative Research Centre, Canberra.

ST HELENA ISLAND: EXPANDING THE BORDERS, TIGHTENING THE NETS

Jill Key and David Higgins

Environment and Natural Resources Division, St Helena Island, STHL 1ZZ.
Email: Jill-key@enrd.gov.sh

St Helena Island is a UK Overseas Territory in the South Atlantic, consisting of a sub-tropical volcanic island with a total area of 420 km^2 and population of just over 4000 people. As a remote oceanic island St Helena has a high rate of endemism and is very vulnerable to the introduction of invasive species. Priority problem species include a package of cosmopolitan vertebrate pests and weeds. The South Atlantic Invasive Species Strategy and Action Plan (2010) offered sound approaches to management and under St Helena's 2001 Environment Charter there is a commitment to '*attempt the control and eradication of invasive species.*' However, multiple factors have to date limited the scope of work towards this goal. The small scale and interconnected nature of farms, biodiversity hotspots and protected areas complicates management while at the same time facilitating an integrated landscape approach, based on coordinated cross-sector action by agriculture and environment sectors. This is a new approach for the island and places high demands on the limited manpower and resources available. Other new initiatives being developed include: a national weed strategy, invasive species management plans for protected areas, a programme of post-border surveillance and monitoring, and internal biosecurity protocols to protect biodiversity hot spots and off-shore islets. To date, the island has received some level of protection from introduced species from its isolation, it has no air access and is served by a single ship which visits the island an average of 16 times a year from South Africa (6 days voyage) or Ascension Island (3 days voyage). The current biosecurity system is limited in scope, has an agricultural focus, poor facilities and no full-time staff. In 2016 St Helena faces an unprecedented change with the opening of the country's first airport. A wider range of imported produce and other risk goods will arrive, more frequently, more rapidly and from a range of different countries, threatening the effectiveness of current invasive species management as well as greatly increasing the risk of new introductions. In anticipation, St Helena is strengthening the biosecurity system, adopting a risk-based approach, and looking specifically at successful models of island biosecurity from the Pacific Islands, Australia and New Zealand.

The unique issues facing this hitherto remote island are described, and the challenges we need to address in order to effectively manage existing invasive species and mitigate the risk of new introductions are discussed.

References:

Stringer, C. and Shine. C. 2010. South Atlantic Invasive Species Strategy and Action Plan. Unpublished document, Ascension Island, 14-19 May 2009.

PREDICTING BIRD INCURSIONS: THE ROLE OF ABUNDANCE, MARKET VALUE AND SPECIES TRAITS AS DRIVERS OF THE PRIVATE BIRD TRADE

Miquel Vall-llosera and Phillip Cassey

School of Earth and Environmental Sciences, The University of Adelaide,
Adelaide SA 5005.
Email: miguel.vall-lloseracamps@adelaide.edu.au

Once a non-indigenous species has become a pest it is usually preventatively costly to eradicate or control. Therefore, stopping the arrival or release of potentially invasive species is widely considered to be the most effective management strategy. The Environment Protection and Biodiversity Conservation Act imposes an almost blanket ban on the import and export of flora and fauna in Australia. Nevertheless, the domestic trade of existing exotic species, as well as native Australian species, has continued, largely unabated. The deliberate releases or accidental escapes of these species from private collections are one of the main sources of vertebrate incursions in Australia. Given this challenge, a reliable understanding of the factors affecting preferences in animal trade may be crucial for improving our ability to prevent new incursions.

Here, we analyse the factors linked to the popularity of avian species traded in Australia. We examine the relationship between a species' market value and its abundance in the private trade, and features suggested to be related to human preferences, such as attractiveness of coloration, body size, shape, and voice. In addition, we consider traits related to the level of knowledge required for a species' handling and care, and characteristics related to the constraints of bird species for being traded in Australia.

Our prediction is that traded bird species will be distributed along a main axis of popularity, with native, small, dull, prolific and trouble-free species on one side, and exotic, large, bright coloured, and more demanding species on the other. We expect that cheap and abundant birds are more likely to be considered disposable and may have more chance of being released or escaping, than rare or expensive birds.

CROSSING THE LINE – ACHIEVING LANDSCAPE SCALE RABBIT CONTROL DESPITE THE STATE BORDER

Justine Drew[1], **John Matthews**[2], Neville Staude[1]

[1]Natural Resources South East, Department of Environment, Water and Natural Resources,
PO Box 93, Naracoorte, SA 5271.
[2]Biosecurity Victoria, Department of Environment and Primary Industries,
915 Mount Napier Road, Hamilton, VIC 3300.
Email: justine.drew@sa.gov.au

Where communities, land management units, jurisdictional variation and pest populations straddle administrative boundaries, land managers and government regulators have much more to address in planning and implementation of pest animal control programs than just the nuances of best practice. The 'Strategic Biodiversity Corridor Enhancement' project was a major cross border, multi-agency collaboration between Victoria and South Australia that has resulted in long term rabbit control across 30,000 hectares of private land and 42 km of a state border plus arterial roads.

The project demonstrates the partnerships, legislative and operational considerations required to achieve effective rabbit control at a landscape scale. The primary aim of the project was to protect valuable woodland habitat, and biolink corridors by reducing total grazing pressure. The secondary aim was to increase the adoption of best practice rabbit control in a traditional mixed farming district with historically high rabbit densities resulting in increased production and improved landscape condition.

Project challenges included delivering a short term pest animal control project that would achieve long term benefits and securing collaboration, approvals and consistent standards for rabbit control activities across the state border. The key to success was to effectively engage land managers, government agencies and community organisations with a common goal. A goal was to have a community of land managers understanding, accepting and acting on the issue and their responsibilities.

The project has resulted in greater than 95% reduction in total rabbit warrens and a reduction in rabbit densities to below one active warren entrance per hectare on infested land. Twenty properties participated in the project with 100% compliance with project requirements.

Feedback from farmers was positive, with land owners commenting that, despite the requirement to undertake synchronised warren ripping in tight time frames, the results were worth it. The community were also highly complementary of the coordinated approach undertaken by the agencies to ensure roadsides, public land and private land achieved the same biosecurity standards for rabbit control in the same timeframes.

The project, was funded by the Australian Government's Caring for Our Country program and delivered by Natural Resources South East, SA and the Victorian Department of Environment and Primary Industries. Other partners in this project include the Tatiara District Council, West Wimmera Shire Council, Telopea Downs Landcare Group and the Wimmera Catchment Management Authority.

OVERVIEW AND OUTCOMES OF THE AUSTRALIAN FERAL CAMEL MANAGEMENT PROJECT

Quentin Hart[1] and **Glenn Edwards**[2]

[1]Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture
18 Marcus Clarke Street, Canberra ACT 2601 / GPO Box 858, Canberra ACT 2601.
[2]Wildlife Use, Department Land Resource Management, PO Box 1120, Alice Springs, NT 0871.
Email: Glenn.Edwards@nt.gov.au

In 2009 the Australian Feral Camel Management Project was established with support from the Australian Government to manage the impacts of feral camels on nominated environmental sites and pastoral vegetation and soils. The project was managed by Ninti One from 2009-13 in collaboration with 20 formal partners including the camel industry and the RSPCA. Although the distribution of feral camels is over 3 million square km, the project focused on the highest priority areas covering about 30% of the total distribution and involved hundreds of landholders across a range of land tenures. It was the first Australian project to manage the impacts of a terrestrial vertebrate at this scale using conventional control techniques without the legislative support which underpinned programs such as the Brucellosis and Tuberculosis Eradication Campaign. Key achievements of the project included: the establishment of enduring landholder consent for the management of feral camel impacts across 1.3 million square km of priority management areas through commercial and/or non-commercial feral camel removal; the removal of over 160,000 feral camels and achievement of density-reduction targets at the nominated environmental assets; enhancement of the capacity of landholders and the camel industry to remove camels from the landscape; improved knowledge about feral camels, their impacts and their management. While ongoing management will still be needed, there is now a real opportunity to maintain the camel population at densities where impacts are considered minimal.

THE DEVELOPMENT OF A BAYESIAN BELIEF NETWORK AS A DECISION SUPPORT TOOL IN FERAL CAMEL REMOVAL OPERATIONS

M.L. Harper, **M.R. Lethbridge**

EcoKnowledge 130 Franklin St., Adelaide, SA 5000.
Email: mark@ecoknowledge.com.au

The removal of feral camels in Australia is complicated by the vast area over which they range, their remoteness and the changing weather conditions that constantly affect their distribution. Decision Support Systems (DSS) provide a framework in which program managers can undertake a more formal assessment of pest removal actions under different conditions, using past data and expert knowledge. The objective of a DSS in pest management is to minimise costs and optimise on-ground effectiveness. In this study we develop a Bayesian Belief Network (BBN) as a component of a landscape-scale camel DSS. BBNs provide a transparent visualisation of the components of the problem, underpinned by probability tables consisting of likelihoods and states in an uncertain environment. They enable managers to interrogate different scenarios, often consisting of incomplete intelligence data, and help seek the best course of action. We describe a novel approach of eliciting data from past camel culling operations into a BBN using a simulation algorithm. The algorithm simulates all aspects of the operation including search patterns, sightability, the time it takes to undertake the operation, fuel costs and camel densities. We verified the output of a range of scenarios from these simulations interactively with a group of experts and then using a wide range of environmental conditions we populated the states and dependencies of the final BBN. Using some hypothetical scenarios we demonstrate the BBN outputs including probabilities associated with a different number of camels removed and the associated costs.

THE SCIENCE-BASED EFFORTS OF THE USDA'S NATIONAL RABIES MANAGEMENT PROGRAM FOR CONTROLLING RABIES

Kurt VerCauteren[1], Amy Gilbert[1], Stephanie Shwiff[1], Dennis Slate[2], Charles Rupprecht[3], Jesse Blanton[4], and Rich Chipman[2]

[1]USDA/APHIS/WS National Wildlife Research Center, Fort Collins, CO.
[2]USDA/APHIS/WS National Rabies Management Program, Concord, NH.
[3]Global Alliance for Rabies Control, Manhattan, KS.
[4]Centers for Disease Control, Atlanta, GA.
Email: denise.m.blankenship@aphis.usda.gov

Management of rabies in wildlife populations is complex and provides a unique challenge for researchers and wildlife managers. Rabies virus infects the nervous system of mammals, is transmitted through the bite of infected animals, and is invariably fatal. Though human disease risk is largely mitigated in the US through pre-emptive vaccination of pets and human post-exposure prophylaxis, wildlife reservoirs pose a continuous threat. Raccoons are the primary wildlife host of rabies, followed by skunks, bats, foxes, and coyotes. Timely administration of post-exposure prophylaxis has proven nearly 100% successful in preventing rabies deaths in humans. However, the financial cost of living with wildlife rabies in the US is conservatively estimated to exceed $300 million/year. Associated impacts such as anxiety, fear, and trauma are difficult to quantify, but often manifest with rabies. Since the late-1990s, Wildlife Services (WS) has coordinated wildlife rabies management with oral rabies vaccination (ORV) as the central tactic targeting terrestrial reservoirs. Significant progress has been achieved through long-term interdisciplinary and interagency cooperation from local to continental scales. The need for effective coordination has mandated the establishment of frameworks that bring together multiple jurisdictions and disciplines from municipal, county, state, federal and international agencies; universities; and the private sector to ensure collaborative, science-based approaches to rabies management. The US National Plan for Wildlife Rabies Management and the formalization of a North American Rabies Management Plan with partners in Canada, Mexico, the Navajo Nation, and the US provide national and continental frameworks for the exchange of information; collaboration on surveillance and control; collaborative studies; and training. Here we provide an update on the status of rabies management in the US and share the research-based strategies to prevent the further spread of wildlife rabies and eventually eliminate terrestrial rabies variants from the US.

CANINE RABIES WILL ALTER HOW WE MANAGE WILD DOGS IN AUSTRALIA

Jessica Sparkes[1,4], Guy Ballard[1,2], Peter Fleming[1,3] and Wendy Brown[1]

[1] School of Environmental and Rural Sciences, University of New England, Armidale, NSW 2350.
[2] Vertebrate Pest Research Unit, Biosecurity NSW, Armidale, NSW 2350.
[3] Vertebrate Pest Research Unit, Biosecurity NSW, Orange, NSW 2800.
[4] Corresponding author email: jsparke4@une.edu.au

Canine rabies, a fatal viral zoonosis, is now less than 300 kilometres from Australia's mainland and continues to spread eastwards through the Indonesian archipelago. Rabies incursion into Australia will alter our society's perceptions of wild dog management, particularly in peri-urban areas where contact can occur between wild dogs, pets and people.

Canine rabies will not only have major implications for Australian pest animal management, but will also impact upon how Australians interact with domestic animals and native wildlife. Fear of infection may increase pressure to kill or tightly control dogs and will likely require land managers to adapt how they manage people and wild dogs in densely populated areas.

To respond to this imminent threat, we need to model how rabies will spread through Australian ecosystems so that we can develop effective rabies management plans. This will minimise reaction times and improve our chances of containing outbreaks.

Here, we present preliminary data collected to inform rabies management plans. Firstly, we use data from GPS-telemetry collars fitted to domestic and wild dogs, as well as data from camera traps, to provide insight into dog-dog and human-dog contact rates.

Secondly, we present and discuss the results from self-administered surveys focussed on dog ownership and dog bites, hunting dog movements and interactions between hunting dogs and wild dogs, all of which are vital to understand, detect and manage canine rabies when it reaches Australia.

NEW, AUTOMATED PEST DETECTION AND MONITORING DEVICES

Dr Helen Blackie[1], Mr Brent Barrett[1], Dr Ian Woodhead[2], Dr Kenji Irie[2], Mr Paul Riding[2], Mr Shane Inder[3]

[1]Centre for Wildlife Management and Conservation, New Zealand.
[2]Lincoln Agritech, New Zealand.
[3]Auckland University of Technology, New Zealand.
Email: helen.blackie@lincoln.ac.nz

Reliable detection and monitoring of pest species is a crucial component of invasive species management. However, many current techniques fall well below optimal requirements. In response to this, our multidisciplinary team has developed a new long-life field tool for automatically detecting and identifying different pest species. These systems employ a customised surface incorporating electronic technology to analyse animal footprints, gaits, stride-lengths and other physical characteristics to accurately identify interacting species. Current research has been focused on detecting key New Zealand mammalian pest species, with trials showing that these new tools can accurately identify close to 100% of rats, feral cats, mice, stoats, ferrets and brushtail possums. The technology has been designed to cope with environmental conditions encountered in the field and is a non-invasive monitoring technique which offers a cost-effective, long-life alternative compared with current labour intensive methods. Recent trials have involved leaving the devices *in situ* at various sites to examine their accuracy and probability of detection versus current methods. A simulated island reinvasion trial has also been completed, demonstrating how this new tool can work in such a scenario. Results of these new trials will be presented here.

PRIORITIZING ACTION FOR INVASIVE ALIEN BIRDS AND MAMMALS IN AUSTRALIA

Salit Kark

School of Biological Sciences, ARC Centre of Excellence for Environmental Decisions,
The University of Queensland, St Lucia 4067 QLD.
Email: salit.kark@gmail.com

This study uses decision support approaches to generate the first systematic prioritisation protocol for confronting invasive vertebrates in Australia. It tests fundamental drivers of invasion success, developing a spatially explicit information system of invasive vertebrate introductions, distribution and impacts across Australia. Using historical information, published books, papers, reports and atlas sources, we generated a spatially explicit, introduction event-based database of introduction records of birds and mammals in Australia. This allows us to examine spatial patterns of success and failure of introductions across Australia and across groups, examining spatial and temporal trends. We compare results for Australia with an earlier study we lead in Europe (Chiron et al 2009, 2010, Kark et al. 2009, Shirley and Kark 2009, 2011), disentangling the relative role of climatic, biotic and socioeconomic factors shaping invasion at a continental scale. Outcomes can help policy makers to more effectively mitigate biotic invasion threats, prioritise action and to spatially allocate efforts.

References:

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Shirley, S.M. and Kark, S. 2009. Can species traits predict impacts of alien birds in Europe? *Global Ecology and Biogeography*, 18: 450-459.

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SMOOTH NEWTS IN VICTORIA: A NEW SPECIES INCURSION WITHIN AUSTRALIA

Matt Ward[1], Adam Kay[2], Ryan Melville[1]

[1]Regulation and Compliance Group, Department of Environment and Primary Industries,
30 Little Malop Street Geelong, VIC 3000.
[2] Regulation and Compliance Group, Department of Environment and Primary Industries,
1 McKoy Street Wodonga, VIC 3690.
Email: matt.ward@depi.vic.gov.au

The smooth newt (*Lissotriton vulgaris*) is a member of the order Caudata, belonging to the family Salamandridae. The smooth newt is distributed widely throughout most of Europe and western parts of Asia. The Salamandridae family is not native to Australia, although this species has historically been present at low levels in the pet industry.

A single smooth newt was found on a construction site in Melbourne's south-eastern suburbs in 2011. The Department of Environment and Primary Industries (DEPI) conducted delimitation surveys and trace-back investigations which identified a further breeding population of 14 smooth newts in an adjacent water body. Further delimitation in 2012 captured additional smooth newts across a range of locations, confirming the presence of isolated colonies within a greater incursion area.

An evaluation of the incursion response identified ongoing challenges regarding detectability and limited targeted control options, but also highlighted many positive aspects including the value of standardised decision-making tools and collaboration with stakeholders and subject experts.

ENVIRONMENTAL DNA FOR LOW DENSITY SPECIES DETECTION

Elise Furlan[1], Dianne Gleeson[1], Chris Hardy[2], Richard Duncan[1]

[1]Institute for Applied Ecology, University of Canberra, Bruce, ACT 2617.
[2]CSIRO Ecosystem Science, Black Mountain, ACT 2601.
Email: Elise.Furlan@canberra.edu.au

Environmental DNA (eDNA) shows great potential for detecting species at low density from environmental samples. Although eDNA is an indirect method of sampling, we assume that the presence of eDNA in an environmental sample indicates the presence of a target organism in the environment. Owing to the high sensitivity and specificity of eDNA detection, positive detection of an invasive species using this method has justifiably raised alarm bells as to the likelihood of population expansion into a new environment (Jerde, Chadderton et al. 2013). However, very few studies, have attempted to understand what a negative eDNA result means in relation to a species presence or absence. This issue must be addressed if eDNA is to become a useful management tool.

I will introduce a conceptual framework to evaluate the probability of eDNA detection from an environmental sample. I will then present data from experiments on eDNA detection of invasive vertebrates from water samples and evaluate this against the detection framework. It is hoped that detection probabilities can increase the utility of this technique for natural resource managers to inform the management of invasive or endangered species.

Reference:

Jerde, C. L., W. L. Chadderton, A. R. Mahon, M. A. Renshaw, J. Corush, M. L. Bundy, S. Mysorekar and D. M. Lodge 2013. Detection of Asian carp DNA as part of a Great Lakes basin-wide surveillance program. *Canadian Journal of Fisheries and Aquatic Science,* 70: 522-526.

THE FINAL NEEDLES IN THE HAYSTACK – MOVING TO STAGE 3 OF THE TASMANIAN FOX ERADICATION PROGRAM

Craig Elliott and Stephen Harris

Tasmanian Department of Primary Industries, Parks,
Water and Environment, PO Box 46, Kings Meadows, TAS 7249.
Email: craig.elliott@dpipwe.tas.gov.au

Over ten years ago the Tasmanian Government embarked on an ambitious effort to prevent the European Red Fox establishing in Tasmania. Increased evidence of fox presence found across a wide area in Tasmania in the late 1990's through to the mid-2000's indicated an emerging threat of a dispersed fox population becoming established in the island State.

Initially, the Fox Free Taskforce (FFT) was form to investigate public sightings of foxes and undertook localised control activities from 2001 to 2006. The FFT evolved into the Fox Eradication Program (FEP) in 2006. Stage 1 of the FEP maintained a similar focus to the FFT but a major strategic change was made after a 2009 review (Landcare Research, 2009) recommended delivering a major landscape scale baiting and monitoring program under a 'precautionary' principle.

Stage 2 of the FEP involved hand baiting of approximately 450000 ha and over 2700 properties in a 2.5 year period with follow-up monitoring completed over 340000 ha. During the same period, 850 public reports of suspected fox sightings were investigated. The logistics of the operational activity, including the need to manage large amounts of operational data, was a challenge and the FEP continued to adapt and improve the management of the program. The scale and complexity of the operational activities in Stage 2 presented a number of key lessons for future eradication attempts that aim to remove a low density highly dispersed population from a large area. Effective planning remains a critical theme to these lessons and a more thorough assessment of the operating situation, prior to commencing operations, may have provided a stronger foundation from which the Stage could have been planned and delivered especially in terms of developing a strong team to deliver the program of work and achieve effective community engagement.

Circumstances, including a decrease in detection of fox evidence leading to an absence of further evidence since mid 2011, have dictated a move to Stage 3 in 2013 with resources focused on completing the landscape monitoring activities to confirm absence and undertake targeted incursion responses to destroy any remaining foxes detected as well as consolidating efforts to prepare to manage future incursions.

Stage 3 incorporates work to address knowledge gaps that remained unresolved during earlier Stages and refine the operational activity. These include achieving a better understanding of detection probabilities to determine an optimal monitoring regime; undertaking further landscape scale monitoring to support further population modelling of any detected evidence whilst also achieving an operational outcome from absence-presence data, continuing to improve DNA detection from scats including identifying predator-prey relationships and understanding the risk of different response and management options and identifying key decision points in the eradication. Further work will also be completed to determine whether there is a suitable toxicant for use in baiting peri-urban areas will also be a focus.

Whilst many complexities and challenges remain, what is regarded as the largest invasive animal eradication program ever attempted continues to provide positive signs that foxes will not be allowed to establish in Tasmania.

PET TRADE BIOSECURITY - PREVENTING PETS BECOMING PESTS

Jaap Knegtmans

Ministry for Primary Industries, New Zealand.
Email: jaap.knegtmans@mpi.govt.nz

Almost three quarters of New Zealand homes have a pet. While pets are highly valued by society, pet escapes and deliberate releases are a source of invasive species. In New Zealand strict controls apply to new introductions of pet species from overseas but of the 1500+ pet species currently in New Zealand there are limited barriers to their possession or trade. There has been an imperfect understanding regarding the legal status of these pets and the risks they pose. The National Pet Biosecurity Project is a collaborative project, involving industry and biosecurity agencies, tasked with addressing key knowledge gaps and identifying enduring ways to mitigate the biosecurity risks posed by pets. The aims, objectives and results of this initiative are discussed.

STARLINGS AT AN INVASION FRONT: HEARD BUT NOT SEEN

Campbell, S.[1], Woolnough, A.P.[1,3], Obolonkin, V.[2] and Parsons, S.[2]

[1]Invasive Species Science, Department of Agriculture and Food Western Australia,
100 Bougainvillea Avenue, Forrestfield WA 6058.
[2]School of Biological Sciences, University of Auckland,
Private Bag 92019, Auckland Mail Centre, Auckland 1142, New Zealand.
[3]Present Address: Biosecurity Division, Department of Environment and Primary Industries,
8 Nicholson Street, East Melbourne, VIC 3002.
Email: susan.campbell@agric.wa.gov.au

Detection of cryptic species using remote technology such as cameras or audio recorders can assist control programs of invasive pest animals. Remote surveillance facilitates efficient detection over large areas of potentially difficult terrain, allowing for rapid responses to new incursions.

The common starling (*Sturnus vulgaris*) has a proven invasion history in many countries and the species is firmly established in eastern Australia. However, over four decades of targeted control in Western Australia (WA) has, to date, prevented successful establishment by starlings in this State. To maintain such an achievement requires commitment to ongoing surveillance, detection and control. If left unchecked, WA's carrying capacity for starlings could be reached in a little over 50 years, costing the WA economy up to A$43.7 million annually (2011/12 dollars). However, efficiently detecting cryptic, wary starlings that are present at low density in a challenging and expansive field environment presents a significant challenge to the starling control program.

From June 2010 to June 2011 we collected over 57 600 hrs of field recordings using Song Meter (SM) units (Wildlife Acoustics) located on 12 strategic sites throughout known starling incursion territory on the south coast of WA. In conjunction, we compiled a reference library of starling calls from individuals at several locations in South Australia. From this reference library, we identified 1 991 starling syllables of varying quality and developed, tested and refined an automated detector. Our initial filter retuned a 76 % likelihood of detecting a medium-high quality single starling call. The filter algorithms were re-trained to reduce the number of false positives and the final, user-friendly interface now detects starling calls with greater accuracy and fewer false positives. The results from automated analysis of >20TB of field recording data are presented.

Given the significant economic costs that will be incurred by WA agriculture should starlings establish in this State, management of this pest species needs to continue to operate within the realm of the far 'left-hand-side' of the invasion curve. We have shown that remote audio surveillance technology could now form an integral component of the ongoing campaign against starlings, one of the world's top 100 worst invasive pests.

THE EFFECTIVENESS OF INTEGRATED EXOTIC PREDATOR CONTROL FOR THE CONSERVATION OF ENDANGERED MALLEEFOWL (*LEIPOA OCELLATA*) POPULATIONS NEAR MOUNT HOPE, NEW SOUTH WALES.

Jason Wishart and Paul Meek

Invasive Animals Cooperative Research Centre, 33 Flemington Street, Glenside, SA 5065.
Email: jason.wishart@invasiveanimals.com

Malleefowl (*Leipoa ocellata*) are a ground nesting, and primarily ground dwelling bird that were once widespread and abundant throughout much of southern Australia's arid zones. Since European settlement, their distribution and abundance has declined dramatically. They are now listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* and endangered under the *New South Wales Threatened Species Conservation Act 1995*. Numerous factors have contributed to their current conservation status such as habitat clearing, competition, inappropriate fire regimes and predation. Priddel and Wheeler (1996) reported fox predation alone accounted for up to 90% of chick and juvenile malleefowl mortality. Therefore, predation by foxes (*Vulpes vulpes*) is recognised as being a primary cause for the decline of remaining malleefowl populations, particularly in New South Wales. This study aims to develop a long term integrated exotic predator control program on connected private lands in the central mallee of western New South Wales to conserve malleefowl populations in the region. The project area adjoins the Nombinnie and Round Hill Nature Reserves where foxes are regularly baited as part of a fox threat abatement plan site plan. Several exotic introduced predators exist in the target area including foxes, feral cats (*Felis catus*) and feral pigs (*Sus scrofa*). All were strategically targeted using traditional and modern control tools. Predator abundance indices were obtained bi-annually using permanent sand plots and series of permanent camera traps. Camera traps were also positioned at malleefowl mounds to determine the number of mound visits by exotic predator species throughout the malleefowl's breeding season. The number of active/inactive malleefowl mounds present within the study area were assessed annually via aerial survey to determine the influence of integrated predator control on the areas malleefowl populations over time. The progress of the project including successes and limitations will be discussed.

Reference:

Priddel, D. and Wheeler, R. 1996. Effect of age at release on the susceptibility of captive-reared malleefowl *Leipoa ocellata* to predation by the introduced fox *Vulpes vulpes*. *Emu*, 96: 32 – 41.

EVIDENCE OF THE BENEFITS FOR NATIVE MAMMALS FROM SUSTAINED FOX CONTROL

Alan Robley[1] and Andrew Gormley[2]

[1]Arthur Rylah Institute, Department of Environment and Primary Industries,
PO Box 137, Heidelberg, VIC 3084.
[2]Landcare Research, PO Box 40, Lincoln, 7640, New Zealand.
Email: alan.robley@depi.vic.gov.au

Management agencies around the world invest considerable amounts of public funding in reducing invasive red foxes (*Vulpes vulpes*) to protect or recover native species. However the benefits of this investment are difficult to gauge, due to complex interactions when manipulating predator-prey systems.

The Glenelg Ark project was established in 2005 to facilitate the recovery of native mammal populations at risk from predation by foxes by undertaking broad scale, continuous fox baiting across large areas of state forest and national park in south-western Victoria, Australia. We investigated the benefits to three native mammal species, (southern brown bandicoot *Isoodon obesulus*, long-nosed potoroo *Potorous tridactylus*, and common brushtail possum *Trichosurus vulpecular*). We hypothesised that, given our understanding of the role predation by foxes has played in the decline and extinction of a native mammals, rates of site occupancy, colonisation and persistence of each species would be higher on sites where fox control occurred.

There has been a significant and sustained decline in fox abundance on the areas treated with fox control compared to the non-control areas. There was a significant positive effect of fox control on the occupancy of all three species, however persistence and colonisation rates varied among the three species and among sites.

This study demonstrates that foxes can be reduced and maintained at relatively low levels, resulting in potential benefits to a range of native mammals. However the positive response of native mammals is not uniform or consistent across sites suggesting that other factors are contributing to the limitation of native mammals. Land managers need to consider a wider range of management actions than simply reducing foxes in order to gain generally positive benefit to native species currently considered at risk from fox predation.

SOUTHERN YORKE PENINSULA FOX BAITING FOR BIODIVERSITY

Ken Rudd, Hannah Short & Van Teubner

Yorke Peninsula group, Dept. Environment, Water & Natural Resources
35 Frances Terrace, Kadina SA 5554.
Email: ken.rudd@sa.gov.au

The Southern Yorke Peninsula (SYP) is an important area for endangered species, including malleefowl, western whipbird, hooded plover, heath goanna, little penguin and tammar wallaby. Tammar wallabies were driven to extinction on mainland Australia in the 1930's through habitat loss and fox predation. A successful reintroduction program was commenced in 2004 when tammar wallabies were released back into Innes National Park in the Southern Yorke Peninsula in South Australia.

Foxes are common on the SYP and pose a threat to these species through predation. Fox Baiting for Biodiversity is a large scale fox baiting project being undertaken to protect endangered species on the SYP. Control of foxes is undertaken primarily by poison baiting, but den fumigation is also occasionally undertaken. We have established 687 permanent bait stations across 35,000 ha on SYP on over 30 rural holdings and 4 conservation/national parks. Baiting is carried out over two ten week baiting periods in February/March and September/October each year. With foxes exposed to 1080 baits for 20 weeks of the year, we regularly rotate the bait type used from one of four baits (two commercially- prepared baits, kangaroo meat and tuna baits).

Dietary testing of fox scats has also been carried out to give an indication of the feeding habits of the foxes.

Other observations are the sightings of three echidnas, previously thought to be extinct on Yorke Peninsula. There has also been a bush stone curlew sighting, which has not occurred in Innes for many years. There have also been several sightings of heath goannas which are listed as endangered in the region.

A major boost to the project has been received with $2,017,000 being obtained from the Clean Energy Futures Biodiversity Fund, for the Southern Yorke Peninsula Conservation Action Plan. This funding is for re-vegetation, habitat protection and weed and vertebrate pest control for the next six years.

This presentation will discuss the aims and benefits of the SYP fox baiting project thus far, and outline plans for the future.

COMMUNITY ACTION TO TACKLE INDIAN MYNAS – WHAT CAN BE ACHIEVED, AND WHAT IS NEEDED?

Bill Handke

Canberra Indian Myna Action Group Inc. c/- 6 Fanning Place, Kambah ACT 2902.
Email: handke@grapevine.net.au

Recent research findings now give a firmer scientific basis for the lived experience and understanding of the community – they show that mynas affect native bird populations and reduce their opportunities for breeding.

Many pest species require a concerted government effort to manage or control. They do not lend themselves readily to broad-scale community control activity due to their location, their characteristics or their behaviours. However, the Indian Myna control activities of the Canberra Indian Myna Action Group Inc. clearly demonstrate that mynas are one pest that is amenable to a community-action control program.

The Canberra community has now demonstrated what can be achieved by a concerted, sustained and coordinated program of community backyard trapping. This is just one model for tackling mynas: an integrated local council-community action approach is another, while local government alone is a third. Community-action can either arise as a stand-alone activity growing from collective community concern, or be facilitated and supported by local government. The local government:community integrated approach is particularly advantageous as it draws on the skills and capabilities of both parties to successfully deliver outcomes. It also represents a low cost / high impact approach for local government.

ASSESSING THE EFFICACY OF THE WEST AUSTRALIAN STATE BARRIER FENCE AS A BARRIER TO WILD DOG MOVEMENT

Malcolm Kennedy and Ken Rose

Department of Agriculture and Food, Western Australia 6000.
Email: malcolm.kennedy@agric.wa.gov.au

Temporal and spatial scale provide significant challenges to the implementation of landscape-scale pest animal control programs. These challenges also apply to assessing the efficacy of landscape-scale programs. In this paper we report on an assessment of the efficacy of a large, infra-structure based pest animal control program.

The West Australian State Barrier Fence (SBF) runs 1170km from the Zuytdorp Cliffs in the north to Jerdacuttup in the south. The SBF is composed of various sections of several 'rabbit-proof' fences initially constructed to stop the spread of rabbits. While ultimately unsuccessful in excluding rabbits the SBF has been successful in excluding emus from the agricultural region during years of emu migration. In addition, it is considered to hinder wild dog movement from the rangelands into the agricultural region.

For several decades, wild dogs were largely excluded from the agricultural region of Western Australia by effective control campaigns in the rangeland areas outside the SBF. In recent years reported wild dog activity has increased in the agricultural region, inside the SBF. The WA State Government responded to calls from producers in the agricultural region to support control of wild dogs. Recent initiatives, including the addition of a lap wire to the base of the fence and employment of doggers along the fence, have sought to improve the efficacy of the SBF as a barrier to wild dog movement from the rangelands into the agricultural region.

Evaluating the efficacy of these wild dog control measures is challenging as wild dogs can have large home ranges, occur at low densities, exhibit cryptic behaviour and their impact on production can be difficult to accurately enumerate. The spatial scale of the SBF adds an extra element of complexity to assessing the efficacy of the control measures.

Our approach to assessing the efficacy of these wild dog control measures is two-pronged. First, we undertook landholder surveys, prior to, and two years subsequent to the addition of the lap wire and contracting of doggers. The intent of these surveys were to determine if these wild dog control measures have made a difference to landholders' reported wild dog losses and their intentions, and practices, regarding small stock. Second, we have used satellite telemetry to track wild dogs captured on the rangeland side of the SBF, to determine how individual wild dogs respond to the SBF as a barrier. In this paper we report on the findings of these two approaches to assess the efficacy of these landscape-scale wild dog control measures.

LESSONS IN FERAL CAT CONTROL – CAN ADAPTIVE MANAGEMENT PROVIDE THE SOLUTION?

Maree Rich[1], **Barry Nolan[2]**, James Speed[3], Matthew Gentle[3]

[1]National Parks, Recreation, Sport and Racing, PO Box 202, Longreach QLD 4730.
[2]National Parks, Recreation, Sport and Racing, PO Box 332, Airlie Beach QLD 4802.
[3]Department of Agriculture, Fisheries and Forestry, PO Box 318, Toowoomba QLD 4350.
Email: maree.rich@nprsr.qld.gov.au

Effective pest control relies on adaptive management. This paper chronicles the Astrebla Downs National Park feral cat control project, which aimed to protect the Queensland core population of the endangered Greater Bilby (*Macrotis lagotis*). Above average rainfall from 2009 to 2011 provided ideal conditions for the native long-haired rat (*Rattus villosissimus*) to plague over much of western Queensland. Rats were able to persist for over three years in very high numbers at Astrebla Downs, greater than the 12 to 18 months observed elsewhere in the region. During the early 1990's, high feral cat numbers in the channel country were observed 18-24 months after rats started to reach plague levels. In this recent event, cats were not recorded in high numbers at Astrebla Downs until April 2012, taking approximately 30 months to reach plague levels. The number of long-haired rats fell dramatically during summer of 2012-13 (following extended periods of high temperatures) causing feral cats to 'switch' from consuming this prey to other wildlife species. Following the collapse of the rat population, dingoes were also observed to 'switch' prey consumption, with feral cats forming part of their diet.

The cat control program began in May 2012 and has included ground-based shooting teams supplemented with ground and aerial 1080 baiting, a trial aerial shoot using an R44 helicopter and some cage trapping. A combination of wildlife cameras, sand plots and spotlighting was used to monitor cat and dingo abundance during this project. The number of feral cats shot began to decline on the park in May 2013 (before the first baiting) and continued to fall after the aerial baiting activities. Dingo densities on park also increased following the rat and cat plague. However, after control actions (including aerial baiting) their numbers dropped dramatically to near pre-rat densities. Collectively, we examine available data to help determine the effectiveness of this project and provide a set of recommendations for future feral cat control programs.

ERADICATION OF RODENTS AND RABBITS FROM SUB-ANTARCTIC MACQUARIE ISLAND

Keith Springer

Tasmania Parks and Wildlife Service, PO Box 126, Moonah, TAS 7009.
Email: Keith.Springer@parks.tas.gov.au

The presence of invasive vertebrate species on sub-Antarctic Macquarie Island has had devastating impacts on the island's flora, fauna and landforms.

Previous eradication projects removed weka (*Gallirallus australis*) by 1989 and feral cats (*Felis catus*) by 2001. European rabbits (*Oryctolagus cuniculus*) have been subject to control efforts since the 1960s.

Subsequent plans to eradicate rodents and rabbits recognised that the remaining pest species could be targeted simultaneously due to commonalities in eradication methodology.

Funding of AU$24.7M was secured in 2007 for a multi-year project based on aerial baiting targeting rabbits and rodents, followed by hunting surviving rabbits with ground-based techniques. Planning commenced for a 2010 toxic bait application however this was abandoned due to shipping delays and poor weather. Concerns over non-target species mortality resulting from the limited baiting undertaken in 2010 led to renewed consideration of mitigation options. Rabbit Haemorrhagic Disease Virus (RHDV) was used in February 2011 to reduce the pre-baiting rabbit population and thus minimise toxic rabbit carcasses available to scavenging sea birds. Aerial baiting resumed in May 2011 and completed by July 2011.

The rabbit hunting phase commenced in August 2011 using hunters and dogs and is on-going, with 13 rabbits located by December 2011. Rodent detection dogs have been deployed to assist in determining rodent eradication success.

Two years after baiting, vegetation recovery is already evident and increased burrow and surface nesting sea-bird activity has been observed.

No rodents have been detected post-baiting. The estimated rabbit population has been reduced from over 150,000 to undetectable levels, leaving the project well positioned for declaring successful eradication. Successful eradication of rabbits, ship rats and house mice would make Macquarie Island the largest island worldwide to be cleared of these species.

MONITORING GOATS AND THEIR IMPACT ON NATIVE VEGETATION

M.L. Harper, M.R. Lethbridge, L.M. Andrews, M.G. Stead and J. Shimmield

EcoKnowledge, 130 Franklin St, Adelaide SA 5000.
Email: mark@ecoknowledge.com.au

The density-impact relationship of many herbivore pests has historically been difficult to measure. There is an emerging shift in funding paradigms with a need to demonstrate an improvement in vegetation from pest control operations, rather than simply reporting pest species reductions. We present a methodology that links the localised impacts of goats with goat density and activity. We test a range of vegetation condition measures, from the traditional ground cover estimates and species diversity scoring, together with indicator plant growth measures, recruitment and browsing scores. We compare these measures to broad-scale density estimates from aerial surveys, as well as localised measures of activity, including dung counts and camera traps. This project was federally funded, and the outputs include published monitoring guidelines for utilisation by land managers and NRM practitioners.

ERADICATION OF BLACK RATS (*RATTUS RATTUS*) FROM THE BOYDONG ISLANDS ON THE GREAT BARRIER REEF, QUEENSLAND, AUSTRALIA

P. Kirby, R. Lindeman, & D. Schaper

Department of National Parks, Recreation, Sport and Racing, PO Box 685, Bungalow QLD 4870.
Email: pat.kirby@nprsr.qld.gov.au

Boydong Island National Park and Little Boydong Islet are Unallocated State Land and make up 'the Boydongs'. This aggregation of two islands covers 25 hectares within the greater Denham Island Group. The far-northern Queensland section of the Great Barrier Reef, where the Denham Group NP occurs, contains some islands which support breeding and roosting sea birds and marine turtle rookeries of international and national significance. Black rats (*Rattus rattus*) were identified on the Boydongs during the mid-1980s. Impacts from non-endemic rodents upon island fauna have been documented worldwide. In 2008, the Queensland Parks and Wildlife Service introduced a state-wide system to prioritise pest initiatives for island national parks. Control efforts undertaken in 2009 using Tri-Star© bait stations with Racumin® wax blocks (0.37 g/kg coumatetralyl) provided little success due to the seasonal availability of a secondary and more favourable food source from migratory birds. In 2010 and 2011, the timing of the control effort was modified and Sure fire® wax blocks (0.05 g/kg broadifacum) were used in place of Racumin®. Significantly better results were observed. Five surveys up to July 2013 have been undertaken and no signs of black rats have been observed since the bait application in 2010. Black-naped terns (*Sterna sumatrana*) and other ground nesting sea birds have been observed nesting on these islands in large numbers post baiting. This has included the endangered Little Tern (*Sterna albifrons*) recorded roosting on the island in November 2012 leading up to their breeding season. This further suggests that the population of introduced rats on the Boydongs have been eradicated, increasing natural values of the island and reducing potential of further infestations on far northern islands.

MANAGING VERTEBRATE PESTS IN PARKS - THE QPWS EXPERIENCE

John Hodgon

Queensland Parks and Wildlife Service
PO Box 2454 Brisbane QLD 4001.
Email: john.hodgon@nprsr.qld.gov.au

The Queensland Parks & Wildlife Service (QPWS) is the largest land management agency in Queensland with responsibility for managing around 12 million hectares of protected areas and State Forests across the state. One of the chief obligations and functions in conserving and protecting the parks and forests of Queensland is reducing the impact that vertebrate pests such as feral camels, horses, pigs, cats, foxes and wild dogs on the biodiversity of these areas.

QPWS has developed and adopted a state-wide pest management system to meet these obligations. The system guides planning, on-ground activities and evaluation of progress towards pre-defined objectives, and encourages an integrated approach. Under the system QPWS has adopted the terms prevention, eradication, containment and impact reduction (asset protection) to describe strategic options for dealing with plant and animal invasions (Clarkson and Grice 2013).

As part of its broader, integrated pest management strategy, QPWS also currently has a contract with the Sporting Shooters' Association of Australia (SSAA) to carry out pest animal activities in selected protected areas across the State.

This presentation will outline the planning processes employed by the QPWS Pest Management System; discuss the range of management options used, including the role of the SSAA; and examine some successes of the past few years.

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SCAVENGING ON WILD DEER CARCASSES BY WILD DOGS, FOXES AND FERAL CATS IN SOUTH-EASTERN AUSTRALIA

Luke Woodford[1], Paul D. Moloney[1], David M. Forsyth[1], Jordan O. Hampton[2], Andrew P. Woolnough[3] and Mark Tucker[4]

[1]Arthur Rylah Institute for Environmental Research, Department of Environment and Primary Industries, 123 Brown Street, Heidelberg, VIC 3084.
[2]Ecotone Wildlife Veterinary Services, PO Box 1126, Canberra, ACT 2601.
[3]Invasive Plants and Animals Branch, Biosecurity Victoria, Department of Environment and Primary Industries, 1 Spring Street, Melbourne, VIC 3000.
[4]Melbourne Water, Upper Yarra Reservoir, Reefton, VIC 3799.
Email: luke.woodford@depi.vic.gov.au

There is concern that anthropogenic food sources may alter the behaviour and abundance of carnivores. Sambar deer (*Cervus unicolor*) are a large (130–220 kg) introduced ungulate that can be hunted throughout the year in south-eastern Australia, and hunters are not required to dispose of carcasses. We investigated how wild dogs/dingoes, foxes and feral cats utilised sambar deer carcasses during the peak hunting seasons (winter and spring) in Victoria. We placed deer carcasses at 1-km intervals along each of six transects that extended 4 km into intact forest from farm boundaries. The utilisation of each carcass by the three carnivores was estimated using remote cameras, and the rate of carcass decomposition estimated at ~14 day intervals. Foxes spent the most time at carcasses, followed by wild dogs. Feral cats spent little time at carcasses relative to foxes and dogs. For all three carnivores, time at the carcass was primarily spent feeding. Wild dog activity peaked at carcasses 2 and 3 km from farm boundaries, a likely legacy of intensive wild dog control on these farms. In contrast to wild dogs, fox activity peaked at carcasses nearest to and most distant from the farm boundary. Fox activity also peaked later in the evening compared to wild dogs. The rate of carcass decomposition was much slower in winter compared to spring. Although wild dogs and foxes fed on many carcasses, the proportion of the carcass consumed was usually low. Reasons for the low rate of deer carcass utilisation by wild dogs in our study area may include the spatially and temporally unpredictable distribution of carcasses in the landscape, the rapid rate of carcass decay in spring, low wild dog densities and the availability of alternative prey. The implications of these results for the management of deer and carnivores will be discussed.

ESTIMATING DENSITY AND IMPACT OF SPARSE RABBIT POPULATIONS IN NATIVE VEGETATION

Greg Mutze and Scott Jennings

Biosecurity SA
GPO Box 1671 Adelaide SA 5001.
Email: greg.mutze@sa.gov.au

European rabbits are a recognized threat to many Australian native plants and vegetation communities. Of particular concern is their demonstrated ability to damage sensitive species at extremely low rabbit density. However, knowledge of density-damage relationships for most species and plant communities is limited by lack of simple repeatable measures for estimating rabbit density in native vegetation. Surveys based on warren density and activity, or transect counts, are often limited by poor, changing visibility and limited vehicle access in native vegetation. Mark-recapture estimates from live-trapping programs are too complex and expensive to be used in association with most vegetation surveys. Camera traps suffer similar problems based on current technology, leaving estimates based on rabbit dung as the only common methodology that can be broadly applied in dense vegetation. Nevertheless dung-based estimates need to account for the spatial heterogeneity of dung deposition associated with the use of latrines, and rely on accurate estimates of daily dung production to provide conversions from dung density to rabbit density. We examined the pellet count in rabbit latrines as a function of broader rabbit density in order to develop a simple methodology that can be used to estimate rabbit density in sparse rabbit populations, with a particular view for use in conjunction with surveys of native vegetation condition. In addition we show how the technique can be used to develop density-damage relationships for a range of plant species and pasture communities in low density rabbit populations. It is applicable in a broad range of climatic zones and vegetation communities without prior expert knowledge of rabbit biology, and caters for survey complexity from simple community bushcare programs to complex scientific research.

OPTIMISATION OF FORMULATIONS OF SODIUM NITRITE FOR THE LETHAL CONTROL OF FERAL SWINE

Justin Foster[1], Cameron Martin[1], Greg Phillips[2], John Eisemann[2], Linton Staples[3], and **Kurt VerCauteren**[2]

[1]Texas Parks and Wildlife, Hunt, TX, USA.
[2]USDA/APHIS/WS/National Wildlife Research Center, Fort Collins, CO, USA 80521.
[3]ACTA, Somerton, VIC 3062.
Email: denise.m.blankenship@aphis.usda.gov

The potential for sodium nitrite (SN) to function and be registered as a toxicant for feral swine is being evaluated. Though a few formulations have been tried without success, there is potential. In this evaluation we assessed and compared the palatability and lethality of promising formulations of SN in a controlled, captive setting. For each candidate SN formulation, four independent groups of seven feral swine were offered treated baits following an acclimation period with non-toxic placebo baits. The number of baits consumed and feral swine killed across all formulations were assessed and compared. Here, we provide an update and present our findings to date. We also discuss our path going forward toward the US and Australian registration of a SN-based toxicant for the control of feral swine.

DETECTION OF FERAL PIGS IN FOREST HABITATS USING AN AERIALLY DEPLOYED THERMAL SENSOR

Peter Adams[1] and Paul Rampant[2]

[1]Veterinary and Life Sciences, Murdoch University, South Street, Murdoch, WA 6150.
[2]GIS Branch, Department of Parks and Wildlife, Bunbury, WA 6230.
Email: p.adams@murdoch.edu.au

Feral pigs are recognised as a threatening process to both native species and ecological communities and are estimated to cost Australia in excess of $107 million each year due to their agricultural, environmental and social impacts (McLeod 2004). Populations of these invasive pests occur in all states and territories of Australia. However accurate data on their abundance, distribution and response to control efforts is not readily available, which consequently limits the ability to accurately inform and guide appropriate management strategies. Whilst aerial surveys are widely used for assessing the abundance and distribution of pest animal populations, this method typically underestimates true abundance due to limitations associated with human observers as well as animal behaviour and the physical environment. This is of particular concern with respect to feral pigs which can exhibit cryptic behaviour. One approach to overcoming these limitations is to implement the use of thermal sensors to enhance the detection rate of target individuals. Comparison of feral pig heat signatures in a variety of settings identified that feral pigs are reliably ≥20% warmer than background environmental temperatures, making them ideal candidates for improved detection with thermal sensors. Aerial trials using a downward facing thermal sensor mounted to a fixed wing aircraft successfully detected feral pigs (in known locations) at altitudes of 170, 300 and 500 m above ground level (AGL) under forest canopy which ranged from 0-98% cover. This study provides a proof of concept for the use of aerially deployed thermal sensors to effectively detect and quantify feral pigs within a variety of landscapes, including close canopy forest habitats.

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NON-TARGET SPECIES INTERACTION WITH SODIUM FLUOROACETATE (1080) BAIT FOR CONTROLLING FERAL PIGS (*SUS SCROFA*)

Amanda Millar[1], Matthew Gentle[2] and **Luke K.-P. Leung**[1]

[a] School of Agriculture and Food Sciences, University of Queensland, Gatton, QLD 4343.
[b] Robert Wicks Pest Animal Research Centre, Biosecurity Queensland, Department of Agriculture, Fisheries and Forestry, Toowoomba, QLD 4350.
Email: luke.leung@uq.edu.au

A commonly used method for broadscale control of feral pigs in Queensland is aerial distribution of sodium fluoroacetate (1080) meat bait, but there is a concern about the potential risk of this bait to raptors, monitors and other non-target species. This study investigated the potential non-target impacts through determining the time until first approach, investigation, sample and consumption of meat bait used for feral pig control differed for non-target species, and if dying the bait green had any impact. A trial was conducted at Whetstone State Forest, southern Queensland, with green-dyed and plain 1080 meat baits monitored for eight consecutive days with camera traps. Of 60 baits laid, 92% were approached and also investigated by one or more non-target species (monitors, birds or other unknown species). The majority (85%) were sampled and 57% were consumed with monitors having slightly more interaction with plain baits than with green-dyed baits. Mean time until first approach and sample differed significantly between species with birds approaching sooner and monitor lizards sampling later than other (unknown) species. Mean time until first sampling differed significantly between colours with plain bait being sampled earlier (mean 2.19 days) than green-dyed bait (2.7 days). Another trial assessing species interactions with plain bait was completed at Culgoa Floodplain National Park, south-western Queensland. Meat baits were placed to simulate the distribution of aerially distributed baits, and monitored for 80 consecutive days with camera traps. Of 40 baits, 100% were approached, 35% investigated and 25% sampled by pigs, birds or monitors, and 25% consumed. Unexpectedly, no raptors interacted with the bait. Monitors approached, investigated (moved) and sampled the bait more rapidly than pigs or birds (crows/ravens, magpies, magpie-larks), but did not consume any entire bait. Collectively, data from the two trials demonstrate that many non-target species visit and sample 500 g meat baits. The amount sampled by birds was usually small but, on occasion, may have been enough to deliver a lethal dose. Monitors are at risk through primary poisoning, and strategies must be considered to reduce their exposure to bait. The use of green-dyed baits may be useful strategy to reduce non-target uptake, but further testing is required to determine the effect on attractiveness and palatability to feral pigs. This knowledge is used to examine the potential for non-target impacts, and if there is a need for further measures to mitigate non-target impacts.

FERAL PIG IMPACTS ON PALM FORESTS IN THE WHITSUNDAY RANGES

Barry Nolan[1], Kerrie Bennison[2]

[1]National Parks, Recreation, Sport and Racing, PO Box 5332, Airlie Beach QLD 4802.
[2] Environment Australia c/- Uluru NP PO Box 119 Yulara NT 0872.
Email: barry.nolan@nprsr.qld.gov.au

The Whitsunday Ranges area has outstanding nature conservation values. The area is at the interface between the wet tropics and more southern rainforest types. It is also a centre of endemism and a distinct sub-region within the Central Queensland Coast Bioregion. Feral pigs are common pests throughout the Whitsunday Ranges and pose significant threats to the natural values of the area by destroying endangered and endemic flora and fauna and degrading terrestrial and stream habitats. In 2003 an extensive feral pig control program was commenced which included trapping, shooting and 1080 baiting (ground and aerial) with a variety of baiting types.

Of particular concern were the impacts of pigs on the Alexandra palm (*Archontophoenix alexandrea)* forest ecosystems. The long-term survival of these habitats is at risk as feral pigs damage all juvenile life stages of the palm. Monitoring for impacts from pigs on the palm forests has been undertaken at regular intervals over the last 3 years. Four 50 m transects were established within the palm ecosystems (i.e. palm forest, perched palm forest and alluvial palm forest). These monitoring plots were established adjacent to the Whitsunday Great Walk because tracks have been shown to attract feral pigs and therefore maximum pig damage is expected to occur within the vicinity of the track (Mitchell and Mayer, 1997). Four small feral pig exclusion plots (one per transect) have been constructed to further assess the effects of pig damage.

The foliage projective cover of the understorey was assessed by the point intercept technique at 0.5 m intervals along transects. The 'units' of cover were bare ground (including rock), litter (detached organic material and dead organic material attached to a dead plant) and vegetation (including live or dead material providing it is still attached to a live plant).

Palm seedling numbers were determined from 50, 1 x 1 m quadrats on each transect. The life stage of palm seedlings (i.e. seedlings or juveniles) was recorded for each quadrat. Feral pig stomachs were collected and analysed to determine food preferences. Feral pigs were shown to extensively target palm seeds and juvenile palms through ingestion whilst also impacting on palm seedlings through their digging - to the point where no small palms were surviving. Information obtained from this project will be utilised to identify the optimum timing for control actions such as aerial or ground baiting.

Reference

Mitchell, J and Mayer, R. 1997. Diggings by feral pigs within the Wet Tropics World Heritage area of North Queensland. *Wildlife Research*, 24, 591-601.

UNDERSTANDING POPULATION LEVEL INTERACTIONS BETWEEN SPATIAL DISTRIBUTIONS OF MANAGEMENT AND PIG POPULATIONS IN THE WET TROPICS

Cameron S. Fletcher[1], Bart Dryden[2], David A. Westcott[1], Dean A. Jones[1]

[1]CSIRO Ecosystem Sciences, PO Box 780, Atherton, QLD, 4883.
[2]Terrain NRM, PO Box 1756, Innisfail, QLD, 4860.
Email: Cameron.Fletcher@csiro.au

While efficient regional and landscape scale strategies are vital for effectively prioritizing adaptation actions to most effectively manage invasive animal species, these actions must also be implemented on-ground, for individuals and local populations, in an efficient, effective, and adaptable manner. Practical management actions typically target individuals, but their importance generally lies in their accumulated population-level affects. This is significant, because actions focussed on individual management are not necessarily the most effective strategies for population-level control.

Bridging that gap requires an understanding of both how management actions impact individuals, and how those individual actions scale up to create population-level affects. We have collected detailed individual movement data using GPS collars on pigs in the Wet Tropics, and used it to parameterize an individual-based model of pig populations and management actions. The model framework allows us to estimate the population-level performance of different management strategies that remove individuals from the population as a result of spatially-distributed trapping or shooting programs. These tools are being applied to develop spatially-explicit predictions of management outcomes for adaptive management programs, and to begin building an understanding of the general rules governing the interaction between spatial distributions of management actions and populations. These general insights will provide guidelines for determining where, when and how to invest in invasive animal management at local scales. This will be based upon an understanding of the spatial dynamics of pest populations and their interaction with management, under changing climate conditions and changing management priorities at larger scales.

ABSTRACTS - DAY 2

Wednesday 28 May 2014

ADVANCING ANIMAL WELFARE IN PEST ANIMAL MANAGEMENT: TWO STEPS FORWARD, ONE STEP BACK?

Bidda Jones and Trudy Sharp

RSPCA Australia, PO Box 265, Deakin West, ACT 2600.
Email: bjones@rspca.org.au

In 2003 RSPCA Australia organised a seminar and follow-up workshop examining ‘Solutions for achieving humane vertebrate pest control’ where the need to integrate animal welfare into pest animal management was recognised by a range of participating stakeholders.

In the subsequent decade, a number of significant achievements have been made in increasing our understanding of what constitutes humane pest animal management and how to implement this, including the development of models and tools that have direct practical application for pest animal operators. The uptake of these tools has been wide-ranging with significant flow-on benefits to animal welfare. In situations where there has been significant public concern over pest animal management decisions, such as with the control of large feral herbivores, these tools have proved invaluable in demonstrating best practice and gaining community support for management activities.

At the same time, however, a number of barriers have emerged to impede the adoption of more humane practices. Concerns over the level of engagement with stakeholders, the place of animal welfare alongside other important factors affecting pest animal management decisions, and lengthy bureaucratic processes have made the journey heavy going. Indeed, the process of implementing a national agreement made in 2007 to remove a small number of designated unacceptable methods is still to be completed.

This presentation examines the steps forward and the setbacks along the way towards achieving humane vertebrate pest control, and, with the benefit of hindsight, offers some observations that might assist in future policy planning in this area.

ELIMINATING FERAL SWINE IN NEW YORK – LEADING A HORSE TO WATER

Justin Gansowski, Allen Gosser, Daniel Hojnacki, and Courtney LaMere

USDA, APHIS, Wildlife Services, 1930 Route 9, Castleton New York 12033.
Email: Justin.Gansowski@aphis.usda.gov

Feral swine were first discovered breeding in New York State in 2007. Four distinct populations of feral swine currently reside within six counties in New York. Accidental releases from enclosed shooting facilities and Eurasian boar breeding operations have allowed these animals to become established in New York. Although the population remains low within New York, the impacts of an expanding population could be enormous. Between 2008 and 2013, the New York State Department of Environmental Conservation and USDA, APHIS, Wildlife Services have removed 174 feral swine from the state. Population reduction, public education and outreach, and disease surveillance are the main components of the WS feral swine elimination program in New York. Public education and outreach was the key element that allowed the feral swine elimination program to be successfully implemented prior to the establishment of a large population of feral swine. Wildlife Services worked with government agencies and private stakeholders to develop strategies, policies and procedures to meet the goal of eliminating feral swine from New York. This coalition allowed the state of New York to pass legislation in 2013 that make it illegal to import, breed, or release Eurasian boars to the wild in New York. In addition, beginning September 1, 2015, it will be illegal to possess, sell, transport, market or trade Eurasian boars in the state.

THE IMPACT OF CLIMATE CHANGE ON INVASIVE VERTEBRATE PESTS AND ADAPTATION PRINCIPLES AND PRACTICES TO MANAGE THEM

Craig James

Leader, Managing Species and Natural Ecosystems theme,
CSIRO Climate Adaptation Flagship, CSIRO, GPO Box 1700, Canberra, ACT, 2601.
Email: craig.james@csiro.au

Most Australians (>80%) are convinced that the climate is changing either through acceptance of the scientific evidence or their direct experience. The main division in society is what is causing climate change and what to do about it. The evidence of a change is overwhelming: records for extreme high temperature and the duration of high temperatures are being broken four times more often in the last decade than are the corresponding records for extreme low temperatures. Peak rainfall intensity and the average land and sea surface temperatures have all set new extreme high records.

Change in average temperatures, increased and decreased rainfall, run-off and stream flow, and more extreme weather are some examples of the climate variables that are driving species distribution changes and ecosystem compositional change. Vertebrates, whether native species or introduced are responding to climatic drivers and will be displaced (or invade) into regions there they currently do not occur. A key question for the future is what circumstances and policy position will constitute a "pest" that requires management.

One approach to understanding the changed impact of current invasive vertebrate species is to model niche displacement based on bioclimatic and edaphic variables. This approach has the advantage that possible future distributions of individual species can be forecast and tracked. Other approaches look at the likely patterns of distribution change for entire ecosystems of species using patterns of beta-diversity already expressed in the landscape. For either method of forecasting distribution change, the recent application of the concept of rates and pathways of climatic shifts has implications for management of invasives: how fast are climatic envelopes moving, in what directions and where might we find depauperate biotic assemblages that are open for invasive species?

The burden on financial and human resources to manage pest species is usually larger than the amount of resource allocated which results in a holding pattern: lowered population size and lowered impact but rarely eradication. As species shift and ecosystems change, there will be more demands on environmental management resources. Rather than trying to react on all fronts of vertebrate pest distribution, leading to sub-optimal impacts everywhere, it will become increasingly important to become more tactical in resource allocation and operations. Advances in network optimisation have allowed us to develop rules-of-thumb for prioritising and managing pest species in different situations. Understanding how individuals move through and use the landscape lets us interpret these rules at the scale of individual pests and individual managers to guide on-ground management actions, including adaptive management options for climate change.

Animal Control Technologies Award 2014 for Excellence in Applied Pest Management

PRACTICAL PIG, FOX AND RABBIT MANAGEMENT IN THE BROCKMAN RIVER AND THE ELLEN BROOK CATCHMENTS OF WESTERN AUSTRALIA

Sue Metcalf

Chittering Landcare Centre, 175 Old Gingin Road, Muchea, Western Australia 6501.
Email: sue.metcalf@iinet.net.au

The Chittering Landcare Centre, opened in 1998, coordinates Landcare in the Brockman River and Ellen Brook catchments that contribute to the Swan River catchment. These catchments cover 2200 square km of land including high density urban areas, peri-urban small rural holdings, broad-acre farming and National Parks. Competing perspectives and needs make it difficult to coordinate control actions.

Increasing feral pig numbers in the catchments have ruined orchards and vineyards, irrigation systems, fouled waterways, destroyed areas of natural bush in reserves and increased the threat to people. In 2011, the Governor of Western Australia provided funds from the McCusker Foundation to help tackle the pig problem. The Landcare committee decided to take up the challenge and Sue Metcalf set up the program with an initial grant of $25,000.

Workshops allowed interested landholders to contribute to a pest management plan and six staff were TAFE accredited for feral animal control techniques and firearm use.

Integrated control of foxes, cats and rabbits in the area occurs in conjunction with the feral pig eradication program. Stumbling blocks that were overcome included access to 1080 poison and PIGOUT® baits in Hog Hoppers™ and issues with hunters with dogs that tended to disturb the herds causing them to scatter. The project has sought advice from a wide range of sources, has lobbied Department of Agriculture and Food Western Australia to introduce bounties on foxes and pigs for professional controllers, and to treble project funding for pig and fox management through the State NRM Office. These funds were applied to purchase traps and monitoring cameras with 162 pigs removed to date.

So far 100 foxes and 25 cats have also been eliminated through the “Red Card for the Red Fox” program.

Plans and outcomes are communicated to participants and the project is now linking more effectively with related work of the Department of Parks and Wildlife and the Department of Agriculture and Food who have agreed to collaborate with the Landcare Group in the feral pig management program in the future.

The project illustrates the technology and people issues that must coalesce for successful pest management in complex peri-urban locations.

EFFECTIVELY ENGAGING COMMUNITIES IN MANAGING OVERABUNDANT WILDLIFE AND ASSOCIATED IMPACTS: A CONSERVATION IMPERATIVE

Paul D. Curtis and Daniel J. Decker

Department of Natural Resources, Fernow Hall, Cornell University, Ithaca, New York 14853.
Email: pdc1@cornell.edu

During the last two decades in the United States, several wildlife species have become locally overabundant across vast areas of the country and created conflicts with stakeholders. For example, populations of white-tailed deer (*Odocoileus virginianus*), Canada geese (*Branta canadensis*), and coyotes (*Canis latrans*) have increased to unprecedented levels, particularly in areas with suburban and exurban development. Numerous studies in the US have shown that most people enjoy wildlife, but many temper their enthusiasm when negative impacts exceed their limits of tolerance for a species. In addition, many people, even those whose tolerance has not been exceeded, recognize the need for and expect government agencies or community leaders to manage wildlife populations and reduce negative impacts, such as damage to plants or crops, vehicle collisions, and zoonotic diseases. Citizens also expect to be involved in wildlife management decisions that directly or indirectly affect them. Lethal versus non-lethal management of animals implicated in negative human-wildlife interactions is often hotly debated, and may be a divisive issue for some communities. Consequently, human dimensions inquiry has proved valuable, if not essential, for understanding the complexity of the social context for management decisions, and for designing programs that will have strong public support. We examine case studies associated with white-tailed deer management and describe ways to gain community support for effective action. Several potential engagement models have been used, and the best approach depends on local community capacity and the political context. Key human dimensions elements for involvement in community-based management decisions will be discussed. We emphasize the importance of integrating context-relevant social and ecological information when designing sustainable programs. We also draw a connection between successfully managing human-wildlife conflicts, human-wildlife co-existence, and sustaining public support for wildlife conservation.

MORE THAN FACTSHEETS –EFFECTIVE COMMUNITY ENGAGEMENT IS NEEDED TO ACHIEVE ERADICATION OUTCOMES

Craig Elliott[1], Michael Braysher[2] and Matthew Marrison[1]

[1] Tasmanian Department of Primary Industries, Parks, Water and Environment,
PO Box 46, Kings Meadows, TAS 7249.
[2] University of Canberra, ACT 2601.
Email: craig.elliott@dpipwe.tas.gov.au

The role of active community participation is recognised by project managers as a critical factor in the success of invasive animal eradication and management projects. The principles of adaptive management are equally as important in community engagement planning as they are for the technical aspects of planning eradication operations. To take an inflexible ‘set and forget’ approach to community engagement is likely to condemn a project to failure when changes occur in the socio-political and authorising environments without a concurrent response by the project. An active supportive community, or at least key individuals within that community, can be invaluable in achieving and sustaining project objectives. Equally, motivated opponents can have a dramatic impact on the likelihood for program success. To be successful, the majority of invasive species programs need to be undertaken at a landscape scale; encountering a variety stakeholder attitudes, concerns and motivations. A common understanding between project managers and stakeholders of the project, what needs to be achieved, and how it should be undertaken is important to ensure everyone is on the ‘same page’; working together (or at least, not working in opposition) to achieve the objective of eradication.

The Tasmanian Fox Eradication Program (FEP) provides an excellent case study for lessons in managing community engagement in a large-scale eradication attempt. This program has provided a unique contradiction for its staff. While few in the Tasmanian community would welcome the establishment of foxes, continual scepticism and uncertainty within elements of the community, extending to some individuals actively opposing the effort and working to destabilise the program, has provided a challenge. Community support for eradication remains high, but the cultivation of scepticism and uncertainty presents a polarised operating environment for the FEP. Whilst an independent review of the FEP Community Engagement Strategy identified that the strategy, tools and techniques would be appropriate ‘in normal circumstances’ it has continued to be necessary for the FEP devote significant resources for issues management and community engagement.

The lessons drawn from the FEP’s experience include ensuring that adequate expertise is accessible for communications planning and analysing the socio-political environment, identifying and finding ways of addressing major issues and barriers that prevent active community support for eradication; ensuring strategies are in place to develop a knowledgeable authorising environment; and, developing and maintaining effective relationships with key stakeholders and ensuring well-informed and influential advocates, external to the project, are able to correct misinformation and represent the project in the public forum. Underpinning this is the need to ensure stakeholders have common expectations with the program as to their roles and influence over decisions relating to project’s strategic direction and operational activity.

Ultimately, the success of eradication efforts can largely come down to relationships. Without meaningful effort devoted to developing and managing relationships with key stakeholders there is unlikely to be acceptance or ownership of the program and the effectiveness of all effort will be diminished. Managers must talk ‘with’ and not just ‘to’ their stakeholders – and relying solely on a factsheet will certainly set the project on course for failure when oppositional elements emerge.

IMPROVING PARTICIPATORY APPROACHES TO MANAGING WILD DOGS

Saan Ecker, Heather Aslin, **Bill Binks** and Halina Zobel-Zubrzycka

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES),
GPO Box 1563, Canberra ACT 2601.
Email: heather.aslin@daff.gov.au

Wild dog attacks on livestock adversely affect Australia's agricultural production and agricultural communities, and the welfare of the people and livestock involved. A range of stakeholders need to be involved to effectively address these problems, and a common approach is to form multi-stakeholder groups to decide what to do in particular areas. Collective and participatory approaches to tackling complex or 'wicked' problems like managing wild dogs have been shown to be influenced by: who participates in relevant groups; how they participate, including how they plan, record and analyse their activities; and how groups negotiate and make decisions.

ABARES is conducting this study for Australian Wool Innovation Ltd. Overall, the study aims to:

- understand barriers and enablers to collective action in managing wild dogs
- understand how effective current wild dog management activities and programs are, and what contributes to making them effective
- identify options for future investment in wild dog management programs.

A literature review has been completed, highlighting some major tensions and differences of opinion that may occur among group members, as well as broader tensions in the wider community that may pose barriers to effective collaboration and participation. Tensions relate to differing views about the status of the dingo and other wild dogs; concerns about whether control techniques used are acceptable on animal welfare grounds; the nature of management structures and the respective roles of government and local communities; and the place of scientific versus local knowledge.

This study builds on recent findings by Ford-Thompson et al. (2012), using a similar approach to examine features of wild dog management groups around Australia via semi-structured interviews with group representatives. Interview questions cover:

1. how groups are led and who is involved
2. what kinds of participatory and engagement processes groups use and how they use them
3. how perspectives of different stakeholders are incorporated
4. what makes groups successful
5. what the outcomes of group actions have been—in economic, social and ecological terms.

This paper will present details of the findings from the literature review and interviews with group representatives. These phases are to be followed with in-depth case studies of selected groups in 2014. The case studies will investigate the effects of a planned intervention on the outcomes of groups' collaborative efforts.

Reference:

Ford-Thompson, A, Snell, C, Saunders, G & White, P 2012, Stakeholder participation in management of invasive vertebrates, *Conservation Biology* 26: 345–56

THE HUMAN DIMENSIONS OF INVASIVE ANIMALS MANAGEMENT: PROGRAM 4E1 OF THE INVASIVE ANIMALS CRC

Ted Alter[1], **Lyndal-Joy Thompson**[2], Jessica Marsh[3] and Paloma Frumento[4]

[1] Team Leader Project 4E1, Invasive Animals CRC, College of Agricultural Sciences, Pennsylvania State University, State College, Pennsylvania, USA.

[2] Postdoctoral Research Fellow, Invasive Animals CRC, Program 4E, University of New England, located at Building 22, University of Canberra, ACT.

[3] National Natural Resource Management Facilitator, Invasive Animals CRC, Program 4E, NSW Department of Primary Industries, Forest Rd, Orange, NSW 2800.

[4] Research Assistant, College of Agricultural Sciences, Pennsylvania State University, State College, Pennsylvania, USA.

Email: lthomps7@une.edu.au

Decades of funding into technical and scientific research for invasive animals (IA) management have produced some excellent technical solutions to individual pest animal issues, but it has become increasingly obvious that the issues being faced have important human dimensions. Frontline community engagement practitioners have a vested interest in accessing and co-developing new, informed and systematically evaluated community engagement approaches. Project 4E1 of the Invasive Animals CRC Engagement Program, 'Facilitating Collective Action' has been designed to address the collective community action dimensions of this challenge and to draw upon, and build on, the work being undertaken by the IACRC's National Natural Resource Management and Wild Dog Facilitators, as well as a range of other initiatives. It is supported by three other projects in IACRC Program 4E that focus on behaviourly effective communication (4E2), institutional analysis (4E3) and transdisciplinary research (4E4).

Frontline practitioners shouldn't be left 'holding the ball' alone when working with communities – they need access to empirically tested tools and techniques with sound conceptual foundations. The aim of Project 4E1 is to assist in building an effective and sustainable support system for community engagement for IA management at the landscape level in Australia. There are three key aspects of this approach: (1) action research with regional stakeholder partners; (2) the development of a support platform that addresses community, practitioner and policy-maker needs; (3) and the integration of research and frontline action in a way not previously experienced in Australia. This work will draw on extensive experience with the human dimensions of wildlife management in the USA through collaboration with the Pennsylvania State, Cornell and Sam Houston State Universities (see Decker et al., 2012). We will also draw on US experience in developing best practice for facilitating community-led action, E-extension resources and online tools, and creating a continuum of learning between frontline practice and academic research. This will provide practitioners with a core set of resources and support systems for facilitating effective collective action.

Key project activities focus on developing a cohort of leaders in community engagement. This involves several initiatives: (a) the development of a new course in Leadership in Community Engagement in collaboration with Penn State University, which twelve participants have already completed with consultation involving participants and key stakeholders about future iterations to occur over the next year; (b) the creation of several learning communities providing a supportive environment for practitioners across different interest areas; and (c) a Professional Doctorate program for professionals to enhance practical and theoretical understanding of the human dimensions of IA management. These elements will be monitored, evaluated and modified as necessary over the life of the project.

Reference

Decker, DJ, Riley, SJ and Siemer WF (eds) 2012, *Human Dimensions of Wildlife Management*, Johns Hopkins University Press, 2nd Edition, USA.

VERNACULAR KNOWLEDGE AND VERTEBRATE PEST MANAGEMENT: IS THERE ANY VALUE IN COMMUNITY-LED INTERVENTIONS?

Robyn Bartel[1] and Graham Marshall[2]

[1]Senior Lecturer, University of New England, Armidale, NSW, 2351.
[2]Associate Professor, University of New England, Armidale, NSW, 2351.
Invasive Animals CRC Program 4E, Facilitating Effective Community Action.
Email: rbartel@une.edu.au

Barriers to adoption of scientific knowledge and techniques continue to plague natural resource management generally and vertebrate pest management in particular. This paper will draw parallels and apply lessons learned from command and control regulation. Like vertebrate pest interventions, command and control regulation attempts to introduce new behavioural norms and management practices into pre-existing social environments, in order to affect change in biophysical environments. Command and control regulation has also experienced similar problems in failing to generate desired behavioural responses. Initiatives may be resisted for a range of reasons, including reactionary resistance, and interventions have also failed where there has been a lack of awareness and appreciation of informal norms and of practitioner, local and vernacular knowledge and practices. Where formal systems of intervention and control conflict with informal systems, not only may community confidence be undermined and therefore compliance comprised, there may also be 'crowding out' of 'folk' initiatives. This paper will analyse these reasons for failure and how they may be relevant to pest management. Some failures and barriers to adoption may be due to certain assumptions underpinning predominant intervention approaches. Firstly, the relationship between regulator and regulatee, or scientist and practitioner, may be assumed to be hierarchical, with the government or scientific body adopting a relative position of superiority to that of the community body or person. Secondly, the knowledge held by certain knowledge-holders in the relationship may also be believed, however implicitly, to be superior. This is related to the first assumption: for it is often the possession or access to scientific and technical knowledge which entitles and qualifies the regulator or scientist to their position of relative privilege in the relationship. A broadening of what counts as evidence, what is appreciated as valuable knowledge, and who are respected as knowledge-holders, may assist in reducing barriers to adoption and thereby facilitate more effective interventions. Recognising practitioner and vernacular knowledge (also known as citizen science) may also reduce reactionary resistance to change since in reframing the relationship, power relationships are also reconfigured: an intervention becomes something internal, or at least co-created, rather than external.

Adopting a proficiency model of the community, rather than a deficiency model, and going beyond public education and public participation to public-led, and co-led and co-created programmes may offer a productive way forward. Of course, for such a path to be adopted room must be made within existing systems and new supports and structures may be required. Even where evidence-based policy, policy learning and adaptive management approaches are undertaken (and these approaches remain under-utilised) there remain additional barriers. Funding and resources, scale issues and institutional structures impede existing innovation and interventions and are likely also to impede more flexible and iterative adoption of practitioner-led solutions and learning. Barriers to change may exist on the formal, as well as informal, sides of pest management. Evolving from top-down approaches to polycentric governance arrangements that adopt a nested subsidiarity framework may achieve the necessary 'vertical' redistribution of responsibility and simultaneously work to recognize the value of vernacular knowledge and empower the community, as well as facilitate greater flexibility and adaptive capacity at scale-appropriate levels.

FRAMING WILD DOG MANAGEMENT IN THE CONTEXT OF LANDSCAPE FUNCTION AND SUSTAINABILITY

Lee Allen[1], **Angela Wardell-Johnson**[2]

[1] Robert Wicks Pest Animal Research Centre, Biosecurity Queensland,
Department of Agriculture, Fisheries and Forestry, Queensland, 203 Tor Street, Toowoomba, Qld 4350.
[2] School of Social Sciences, University of the Sunshine Coast, Locked Bag 4, Maroochydore Qld 4558.
Email: lee.allen@daff.qld.gov.au

In Australia dialogue regarding the status and impact of wild dogs is framed in a paradigm that views wild dogs as serious pests. Socio-cultural and historical narratives prevent alternative paradigms for managing wild dogs from being considered. The framing of wild dogs as a 'problem' has implications for the effective management of wild dogs, but more importantly, solutions within a landscape management context will remain elusive. Dialogue on wild dogs/dingoes is currently divisive and ultimately counter-productive. This paper reviews the dialogue and circumstances surrounding the declaration of dingoes as pests and how these narratives continue to influence contemporary wild dog management. We propose an alternative paradigm, drawing on evidence that integrates dingoes within a larger landscape context. This alternative paradigm has a strong potential for improving the sustainable management of landscapes and profitability in the primary industry sector.

WILL CLIMATE CHANGE ALTER THE DYNAMICS AND CONTROL OF OUTBREAKING SPECIES?

R. Pech[1,2], M. Barron[1], A. Tait[3], A. Byrom[1], E.P. Holland[1], A. James[4] and D. Tompkins[1]

[1]Landcare Research, PO Box 69040, Lincoln 7640, New Zealand.
[2]Joint Graduate School in Biodiversity and Biosecurity, School of Biological Sciences, University of Auckland, Auckland, New Zealand.
[3]National Climate Centre, NIWA, Private Bag 14901, Wellington, New Zealand.
[4]Department of Mathematics and Statistics, University of Canterbury, Christchurch, New Zealand.
Email: PechR@landcareresearch.co.nz

Large fluctuations in primary productivity, and subsequent outbreaks of invasive vertebrates, are characteristic of many ecosystems in New Zealand and Australia. The primary drivers of outbreaks are climatic; for example, temperature in New Zealand forests and tussock grasslands, and rainfall in Australian rangelands. Modelled relationships have been used previously to predict potential effects of changes in rainfall mean and variance on the population dynamics of outbreaking species in Australia (Davis et al. 2002).

In New Zealand, there is a positive, non-linear relationship between the likelihood of high seedfall (masts) for a wide range of plant species and the difference between average summer temperatures in successive years (ΔT model; Kelly et al. 2013). The ΔT model predicts that the frequency of masts will be unaffected by gradual increases in mean temperature, but increased year-to-year variability will result in more masts. To investigate this variability a regional climate model (RCM) was downscaled to generate daily temperature data to 2099 at a 5km grid resolution across New Zealand and annual ΔT surfaces were produced. The RCM was run several times using the output from four global climate models as boundary conditions and three greenhouse gas emission scenarios (SRES B1, A1B and A2). Additional projected ΔT surfaces were generated for a much broader suite of greenhouse gas and aerosol emission scenarios using a pattern scaling approach.

These scenarios for ΔT are likely to have flow on effects for masts and subsequent outbreaks of rodents and mustelids. Tompkins et al. (2013) have predicted substantial changes will be required in the ability of management programmes to achieve effective pest control if the frequency of masts increases. Given that predation by invasive mammals is one of the most serious threats to native fauna in New Zealand, the Department of Conservation and other agencies might need to re-assess the likely long-term effectiveness of pest control strategies.

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THE INFLUENCE OF CLIMATE ON HOME RANGE OF WILD RED DEER IN SOUTH-EAST QUEENSLAND

Matt Amos[1], Greg Baxter[2], Neal Finch[1], and Peter Murray[1]

[1]School of Agriculture and Food Sciences, The University of Queensland, Gatton QLD 4343.
[2]School of Geography, Planning & Environmental Management, The University of Queensland, St Lucia QLD 4072.
Email: matthew.amos@uqconnect.edu.au

Pest managers in the future may well be forced to contend with highly variable climatic conditions. The effects of these fluctuating conditions on the ecology of vertebrate pests such as deer are not known. Our study site at Cressbrook Dam near Toowoomba in South-east Queensland saw two very different seasons in 2010 and 2011. In July 2010, relative rainfall and pasture growth for the preceding 12 months could best be described as average (Queensland Government 2013) and water levels in the dam were approaching an all-time low. Contrastingly, in July 2011 relative rainfall and pasture growth for the preceding 12 months were extremely high (Queensland Government 2013), and dam storage had exceeded 100% capacity.

We hypothesized that the differing seasonal conditions in 2010 and 2011 would allow the home range areas of wild red deer (*Cervus elaphus*) at our study site to contract in a good season (2011), compared to a poor one (2010).

Between March 2010 and March 2013, 25 deer were darted using a mixture of Xylazil 100® and Zoletil 100® and fitted with Sirtrack® G2C Wildlife GPS tracking collars. Home range analysis was conducted on recovered collars using the 95% adaptive Local Convex Hull (α-LoCoH) method via the "adehabitat" package in the program R. We conducted seasonal analysis of home range areas in the drier months of 2010 and 2011 when management was more likely to occur. Seasons were set as rut (breeding season, 22 March to 2 May) and winter (3 May to 31 October).The mean home ranges of deer groups were analysed with a paired *t*-test.

Only two (female) of the 22 recovered collars had complete data for the rut in both 2010 and 2011, and four collars (3 female, 1 male) had complete data for winter of both years. The mean home range of deer in the rut did not differ significantly for the two years ($t = 2.62$, P=0.12). However the mean home range of all four deer in winter 2010 was approximately double that of winter 2011 ($t = 2.35$, P=0.05). Likewise, when data for both the rut season and winter season were combined, the seasonal home range areas in 2010 were double those in 2011 ($t = 2.24$, P=0.04).

We conclude that seasonal conditions impact the home range areas of wild red deer in South-east Queensland during winter when food is perhaps more limiting than in other seasons. However, during the relatively short rut, behaviour was probably a more important consideration than resource availability. Pest management activities may need to be tailored to varying climactic conditions. In the case of red deer at our study site, deer inhabited much smaller home range areas in the very favourable conditions, thus making the targeting by pest management activities of specific animals much easier when seasonal conditions were favourable.

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TROPICAL RABBITS: THE SPREAD OF WILD RABBITS IN NORTH QUEENSLAND

Peter Elsworth, Michael Brennan, Joe Scanlan

Biosecurity Queensland, Department of Agriculture, Fisheries and Forestry, 203 Tor St, Toowoomba, QLD 4350.
Email: peter.elsworth@daff.qld.gov.au

The European wild rabbit (*Oryctolagus cuniculus*) in Australia holds the honour of being the fastest colonising animal anywhere in the world (Caughley 1977). Following the introduction of 13 rabbits to Winchelsea near Geelong in Victoria in 1859, rabbits had spread to the NSW border in 15 years (Stodart and Parer 1988) and the Queensland border in 30 years (Williams et al. 1995). This northward trend continued, however it was suggested that rabbits would not be able to successfully colonise regions north of the Tropic of Capricorn, primarily as temperatures would be too high for breeding. Nevertheless, by about 1980 rabbits had reached the Atherton Tablelands (Williams et al. 1995) and continue to persist throughout this region. In response to increased sightings of rabbits on the Atherton Tablelands, surveys were undertaken in 2007 and 2008. Rabbits were not found across the entire region, however local densities in isolated populations were quite high (>2 rabbits per spotlight kilometre). Warren systems were rare with most rabbits appearing to be living in above-ground harbour such as irrigation pipes and sheds. This region has suitable soils for rabbits and the high rainfall provides ample green food for most of the year. The limiting factor is the high temperatures. Rabbits have reduced breeding success when temperatures exceed 23ºC (Cooke, 1977). Average maximum temperatures across the Atherton Tablelands are only below 23ºC through winter. This suggests a very short breeding period which coincides with the driest months of the year. How then are rabbits persisting in this region when it appears that breeding opportunity is limited? To answer this question a research program has been developed to understand the ecology of rabbits in north Queensland. The application of GPS radio-tracking collars will allow, for the first time, a detailed description of how the rabbits are using the landscape. This will show the habitats that these rabbits are using, their interactions with other rabbits and if, when and how they breed. Additional monitoring of populations throughout the year will show how population dynamics fluctuate through the year. Threats to survivorship such as biological control viruses and predators will also be assessed. It is hoped that by gathering this data, an understanding of how rabbits are managing to persist and spread through this region can be gained. This in turn will allow for better informed management decisions.

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ONE STEP AHEAD – PREDICTIVE MODELLING OF SUITABILITY AND SUSCEPTIBILITY OF AREAS FOR THE EUROPEAN WILD RABBIT IN QUEENSLAND MURRAY DARLING BASIN

Vanessa Macdonald[1], Dave Berman[1], Darren Marshall[1], Janet Barker[1], Justine Murray[2], Rieks van Klinken[2]

[1]Queensland Murray-Darling Committee, PO Box 6243, Toowoomba West QLD 4350.
[2]CSIRO Ecosystem Sciences, PO Box 2583, Brisbane QLD 4001.
Email: vanessam@qmdc.org.au

Rabbit *(Oryctolagus cuniculus)* invasions are continuing to occur across the Queensland Murray Darling Basin (QMDB), despite years of rabbit management and the success of myxomatosis and rabbit haemorrhargic disease (RHD). With recovery from RHD rabbit populations are increasing and expanding their range into new areas and returning to historic areas. Tools for identification of these potential areas will help target control activities where they will be most effective. This project aims to inform land managers at a local and regional scale where the rabbit will most likely invade or re-invade in the QMDB.

The Queensland Murray Darling Committee (QMDC) and CSIRO have combined expert knowledge and spatial data to produce a tool identifying 'hot spot' areas (highly suitable areas where rabbits breed and survive best). By identifying these areas where in the landscape rabbits are most likely to invade we can target management and control, providing education and awareness, early detection and rapid response.

The model was developed using a participatory modelling approach. It involves combining ecological concepts with knowledge from research experts, management solutions with input from land managers with hands on experience in managing rabbits and spatial context in the form of spatial modelling. The model output is a series of maps of habitat suitability (ability to support high rabbit populations) and habitat susceptibility (suitable areas at risk of invasion within dispersal distance of known populations). The model shows highly suitable country across the QMDB, such as priority areas within the existing Darling Downs-Moreton Rabbit Board area for surveillance and control.

One of the strengths of this model is the ability to run different scenarios to show the impact of management and soil type on the potential for rabbits to spread. The results assist land managers to plan their investment in prevention and eradication. The model is an evolving tool that can be consistently updated with new spatial data and new ecological information.

Monitoring population densities is pivotal to a successful pest management plan. Predictive modelling provides a basis for this to be successfully achieved across large catchments effectively and efficiently. Population densities are determined by ground truthing the maps, identifying the population size in certain areas. Extrapolation across the catchment provides estimation of economic damage caused and allows prediction of the value of rabbit control using the most appropriate management strategy. Once completed the degree of success of management operations can be measured.

WHERE CAN ALL THE PIGS BE FOUND? HARNESSING EXPERT KNOWLEDGE FOR THE SPATIAL MODELLING OF FERAL PIG DISTRIBUTION AND ABUNDANCE IN NORTHERN AUSTRALIA

Jens Froese[1,2,3], Carl Smith[1], Peter Durr[2,4], Rieks van Klinken[2,3]

[1]School of Agriculture and Food Sciences, The University of Queensland, St Lucia QLD 4072.
[2]CSIRO Biosecurity Flagship.
[3]CSIRO Ecosystem Sciences, GPO Box 2583, Brisbane QLD 4001.
[4]CSIRO Australian Animal Health Laboratory, Private Bag 24, East Geelong, VIC 3219.
Email: jens.froese@uq.net.au

Feral pigs are widely distributed across Australia and cause many ecological and economic impacts, degrade sensitive environments and damage agricultural production. Their potential as a reservoir of human and animal diseases is also widely recognized. Consequently, a considerable amount of resources have been invested in the research, management and disease surveillance of feral pigs, particularly in the biosecurity 'hotspot' of northern Australia. Despite these efforts, feral pigs remain a problem. In order to target control and surveillance resources more effectively we need a good understanding of the distribution and abundance of feral pigs across the landscape.

Previous efforts at capturing such information have limitations: survey data on feral pig occurrences are patchy; broader mapping efforts are commonly based on expert estimates of feral pig occurrence and abundance per coarse land parcel or grid cell; detailed field studies on habitat use, population dynamics or movement patterns are restricted to survey transects and rarely integrated with GIS data. Predictive spatial modelling can link data to environmental conditions, thus incorporating landscape variability and adding important detail for areas where there is no information available.

This paper describes a spatial modelling approach that harnesses expert knowledge of the key ecological and environmental processes determining feral pig distribution and abundance across tropical northern Australia. In a participatory setting with a diverse group of experts (including scientists, control practitioners, landholders and field veterinarians), a process-based predictive model is developed. Proven elicitation techniques are used to minimise bias and provide robust results. A spatially-explicit estimate covering northern Queensland, derived through integration with high-resolution spatial data, is presented. Validation of spatial predictions against independently collected field data from the Laura Basin region in the wet-dry tropics and the Terrain NRM region in the wet tropics is also discussed.

The resulting spatially-explicit, process-based and carefully validated model is a tool to focus early detection surveillance strategies on high risk areas for the establishment and spread of exotic diseases. It may also help to more effectively target feral pig management on the regional scale. The model provides a state-of-the-knowledge estimate, clearly laying out assumptions on which predictions are based. As such, it can form a baseline for future monitoring efforts. Conversely, it can also be easily updated if new information (e.g. from ecological research, field surveys, other models or improved spatial data layers) becomes available.

THE COST OF CONTROLLING FERAL PIGS IN TEMPERATE RAINFOREST HABITAT USING GROUND-BASED HUNTING TEAMS

David Choquenot[1] and Cheryl Krull[2]

[1]Institute for Applied Ecology, University of Canberra, Bruce ACT 2602.
[2]Centre for Biodiversity and Biosecurity, University of Auckland, Private Bag 92019, Auckland, New Zealand 1142.
Email: David.Choquenot@canberra.edu.au

Understanding how the cost of controlling pests varies with prevailing density is a fundamental component of any bioeconomic comparison of alternative pest management strategies. The functional response (a key component of predator-prey theory) has been used to decompose variation in the time required to remove pests in order to understand how component costs of pest removal change with pest density, and to contrast relative efficiency between removal techniques, or the same technique applied in different habitats. In this study, field data collected during a 3-year ground-hunting program to control feral pigs in a temperate rainforest environment, were analysed to measure changes in hunting efficiency as pig density was progressively reduced. This analysis was used to derive a function linking cost per pig removal to prevailing pig density. The function was combined with simple population growth models to predict the ongoing cost of constraining pig populations at different densities, and used to examine the relative efficiency of different removal techniques.

INTEGRATING TECHNOLOGY ADVANCES WITH MANAGEMENT: THE EMERGING ROLE OF ZINC PHOSPHIDE IN PEST CONTROL IN NEW ZEALAND

Eason, C.T[1,2]; Shapiro, L E[2,3]; MacMorran, D[3]; Blackie, H[2,3].

[1]Cawthron Institute, Nelson, New Zealand.
[2]Centre for Wildlife Management and Conservation,
Faculty of Agriculture and Life Sciences, Department of Ecology, Lincoln University, New Zealand.
[3]Connovation Ltd, Auckland, New Zealand.
Email: charles.eason@cawthron.org.nz

In New Zealand, the control of a number of introduced terrestrial pest species is effectively conducted using sodium fluoroacetate (1080), cyanide, cholecalciferol and brodifacoum on offshore islands. Trapping is often used. In this presentation I will provide an update on vertebrate pesticide research in New Zealand and review the registration challenges that need to be addressed to enable their effective use. We believe it is important to retain and refine the use of both anticoagulant and non-anticoagulant rodenticides and explore new compounds. Whilst commonly used for mouse control in Australia, zinc phosphide was recently registered for the first time for possums, and in 2014 this registration will be extended to include rodents. Results from pen and field trials in possums and rodents will be presented. Post–registration trials with practitioners have been completed to facilitate uptake of a new tool. A low dose of cholecalciferol combined with coumatetralyl (C+C), which has the same efficacy profile as brodifacoum is being pursued, such that the acute toxin zinc phosphide can be integrated with C+C to enable long-term suppression of pest populations. To establish a strategic approach to the use of these toxins, further practitioner-led trials will be needed.

TOOLS FOR ADAPTIVE MANAGEMENT OF FORESTS AFFECTED BY DEER IN NEW ZEALAND

Clare Veltman[1], Will Allen[2], Rob Allen[3], Richard Barker[4], Peter Bellingham[3], Dave Forsyth[5], Chris Jacobson[6], Simon Nicol[5], Dave Ramsey[5], Sarah Richardson[3], Charles Todd[5]

[1]Department of Conservation, c/o Private Bag 11-052, Palmerston North, NZ.
[2] Learning for Sustainability, PO Box 30108 Barrington, Christchurch, NZ.
[3]Landcare Research, PO Box 40, Lincoln, NZ.
[4]University of Otago, PO Box 56, Dunedin, NZ.
[5]Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, 123 Brown Street, Heidelberg, VIC 3084.
[6]Sustainability Research Centre, University of the Sunshine Coast, Locked Box 4 Maroochydore DC, QLD 4551.
Email: cveltman@doc.govt.nz

Deer have colonised the wildlands set aside for conservation in New Zealand, changing the composition of plant communities in montane grasslands and forests. Intensive commercial harvesting from 1965 to 1977 suppressed deer densities but effort fell markedly after 1982 and most of the modern harvest is by non-commercial hunters. A strong focus on brushtail possum control from the mid-1990s led managers to ask whether formal deer control should be added to the restoration programme in forests. In 2003 we identified four forests with long-running possum control where two matched blocks of approximately 3,600 ha could be assigned randomly to a deer-control treatment and a non-treatment. At each site, managers and sceptical non-experts (mostly hunters) worked with us in “learning groups” (Jacobson et al. 2009) to clarify ecological and social concerns and to guide model development. We modelled growth of strongly and weakly selected tree seedlings that included competitive effects amongst vegetation components (Ramsey et al. 2012) and tested whether deer control in three of the blocks of 3600 ha generated faster seedling growth than in the well-matched non-treatment blocks. Deer density was low at the fourth site. The models best supported by the data after about five years of deer control included competitive effects from neighbouring trees and amongst plants in the forest understorey but not light nor nutrients nor deer control itself. An embedded experiment in which we altered the light regime by creating treefall gaps in beech (*Nothofagus* sp., weakly selected) forest showed both light and deer removal promoted seedling growth rates. Our protocols and models are potentially tools for other forest managers so this talk will focus on the parts of the process that caused most problems for us.

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COMMUNITY ENGAGEMENT FOR EFFECTIVE AND SUSTAINABLE VERTEBRATE PEST MANAGEMENT: TOOLS AND CONSIDERATIONS

William Shuffstall[1] , Walt Whitmer[1], Lisa Adams[2], Lyndal-Joy Thompson[3]

[1]Penn State Extension, 7B Armsby Building, University Park, PA, USA 16802.
[2]Department of Environment and Primary Industries, 1 Spring Street, Melbourne, VIC 3000.
[3]Invasive Animals CRC Program 4E, University of New England, Armidale, NSW 2351.
Email: Wcs2@psu.edu

Engaging landholders and community groups has long been an element of invasive animal management in Australia and the United States. Community engagement for effective and sustainable invasive animal management provides a unique opportunity for community institutions (government and non-government organizations) and individuals (landholders and other stakeholders such as animal trappers) to build ongoing and enduring relationships. It also provides an effective framework to address a wide range of community-related issues including agreement on: the importance of, and priorities for pest management; the level of management required; the types of pest control tools; the techniques to be used; the strategies for applying control measures; marshalling resources (information, human and financial resources); and deciding what changes are needed over time.

The US and Australian experience suggests that effective community engagement for invasive animal management requires:

- increasing community residents' and leaders' awareness and understanding of impacts on the community's environment, economy and social well-being to a level sufficient to motivate action;
- encouraging community residents and leaders to act within the context of their community in a coordinated and strategic manner;
- helping community residents, leaders and invasive animal professionals to use their knowledge and to co-create new knowledge and understanding about managing invasive animals given local conditions;
- creating regular opportunities for people to engage each other in meaningful dialogue about how they can work together; and
- developing institutional and political capacity to allow ongoing, meaningful and enduring dialogue between stakeholders.

There are significant differences between how engagement is approached in Australia and the US, suggesting substantial opportunity for shared learning. Elements of community engagement, core principles for effective community engagement and engagement tools and techniques will be discussed. Opportunities for learning and improving practice in both countries will be identified.

USING ECOLOGICAL RESEARCH TO REDUCE BARRIERS TO ACHIEVE EFFECTIVE FERAL PIG MANAGEMENT

Darren Marshall[1], Matthew Gentle[2], Ted Alter[3]

[1]Queensland Murray Darling Committee, PO Box 6243 Toowoomba, QLD 4350.
[2] Robert Wicks Pest Animal Research Centre, Biosecurity Queensland,
Department of Agriculture, Fisheries and Forestry, Queensland, 203 Tor Street, Toowoomba, QLD 4350.
[3]Penn State University, 204 Armsby, University Park, PA USA, 16802.
Email: darrenm@qmdc.org.au

Feral animal control in southern Queensland is an ongoing challenge to land managers.

While there are significant resources being invested in this issue, there is often little measurable reduction in feral animal numbers or the impact they have on the environment, production or human and domestic livestock health. Effective and practical tools are available to land managers to control feral animals in the landscape, but these tools often remain under- or poorly utilised. The major challenge is to engage citizens and communities sufficiently to enable these tools and knowledge to be used for effective control of feral animals.

It is generally advisable to employ multiple control methods to ensure that all animals are susceptible to control. Techniques should also be implemented in a coordinated manner, over a large enough area to minimise 'edge-effects' and therefore, potential for reinfestation through immigration from surrounding, uncontrolled areas. This approach is important for longer-term, effective control and represents an even larger challenge. How do we get a community to work together in a timely, coordinated manner to reduce feral animal numbers and the impact they have? The challenge is to effectively engage citizens and communities to enable these tools and knowledge to be used successfully.

In conjunction with Origin Energy, Santos GLNG and the Queensland Murray Darling Committee in Southern Queensland, we aim to facilitate effective community action through applied research to influence land managers to participate in coordinated control. We believe there is significant value in bridging the gap between research and extension to encourage greater participation in feral pig control. We will examine an innovative approach that aims to improve the participation of citizens and communities in coordinated, feral pig management, using applied science to achieve social change.

This project will use innovative research techniques to investigate feral-pig movement ecology during control operations to gather scientific data whilst also creating a strong interface for community ownership and change. This presentation will discuss an integrated scientific and community engagement approach, and discuss the implications for improved feral pig management in southern Queensland.

DEEP FRAMING VERSUS SOCIAL MARKETING: ELICITING LONG-TERM, MEANINGFUL BEHAVIOUR CHANGE IN COMMUNITY-ENGAGED INVASIVE ANIMAL MANAGEMENT

Patty Please[1] and Donald W. Hine[2]

[1] IA CRC Program 4, University of New England, Armidale, NSW, 2350.
- based at Griffith University – Nathan Campus, Nathan, QLD 4111.
[2] IA CRC Program 4 – Team Leader Project 4E2,
School of Behavioural Cognitive and Social Sciences, UNE, Armidale, NSW 2350.
Email: pplease@une.edu.au

Behavioural science offers a number of theories, principles and concepts to enhance effective communication, impact on decision-making and promote changes in behaviour. Social marketing has proven to be an effective strategy for eliciting pro-environmental behaviour in many domains (McKenzie-Mohr *et al*., 2012). Community-based social marketing is currently being trialled in Australia to enhance community participation in invasive animal management.

Recent critiques suggest that although a social marketing approach can be effective and suitable in some contexts, it sometimes may produce unintended negative effects by reinforcing world-views that are incompatible with sustainable lifestyles and sound environmental management (Corner & Randall, 2011; Crompton, 2010). For example, repeatedly targeting individuals and communities with messages that emphasize the financial benefits of specific management strategies, a common social marketing strategy, may inadvertently reinforce a highly individualistic "what's in it for me" mind-set that will undermine the on-going adoption of sound management strategies when incentives are no longer present. This is particularly problematic for *bigger-than-self* problems, such as invasive animal management, that will require a shift away from rational self-interest to coordinated collective responses based on the recognition and acceptance of a common cause.

In this presentation we contrast social marketing with *deep framing* (Lakoff, 2010), a complementary or alternative approach to behaviour change. This involves developing values-based communication strategies based on narratives and metaphors designed to activate self-transcendent mindsets that are more compatible with collective community responses to environmental problems. We discuss the strengths and limitations of both approaches and present examples of potential applications to invasive animal management.

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A CONCEPTUAL FRAMEWORK FOR NEW INVASIVE SPECIES MANAGEMENT LEGISLATION IN VICTORIA

Jan-Willem de Milliano, Nigel Ainsworth, John Burley and Andrew Woolnough

Department of Environment and Primary Industries,
1 Spring Street, Melbourne, VIC 3000.
Email: will.demilliano@depi.vic.gov.au

Invasive species have the potential to have significant negative impacts on the economy, the environment, social amenity and human health. Victoria uses a risk-management approach to reduce the effects of invasive species threats. This is achieved via the use of a combination of legislation and policy tools. A mix of tools is appropriate because they vary in their effectiveness in achieving different specific goals. Victoria's generalised invasion curve (prevention, eradication, containment and asset protection) is at the heart of this system to ensure the State is well-positioned to meet future biosecurity challenges.

Whilst many of Victoria's key strategies and policies relating to invasive species reflect a modern approach to biosecurity, based on risk-management principles as the basis for government involvement and investment, our legislation has not maintained pace with the breadth and nature of change in the biosecurity sphere. The expansion of overseas trade and travel, changing land use and demography, as well as changing consumer preferences and expectations, have all contributed to a recognition that existing Victorian invasive species legislation is no longer sufficient to respond appropriately to the range of challenges that can arise in managing terrestrial and aquatic invasive species.

New invasive species management legislation is proposed to enhance Victoria's ability to prevent new high-risk invasive species from establishing, eradicate high-risk invasive species already present, contain and reduce the spread of established species and manage the impacts of invasive species that are already widely present in Victoria. The proposed legislation will provide the necessary flexibility, range of tools and powers to efficiently and effectively respond to biosecurity threats posed by a broad range of taxonomic groups, and achieve greater alignment to both national and Victorian biosecurity policy.

This paper will outline the conceptual framework underpinning the new invasive species management legislation that is proposed for Victoria.

RESPECTING ABORIGINAL CULTURAL HERITAGE WHILE PROTECTING THE ENVIRONMENT: LANDSCAPE-SCALE RABBIT CONTROL

Malinda Godino[1], Brett Harrison[2], Mark Farrer[3]

[1]Regulation and Compliance Group, Department of Environment and Primary Industries, 110 Natimuk Road, Horsham, VIC 3400.
[2]Regulation and Compliance Group, Department of Environment and Primary Industries, 78 Henna Street, Warrnambool, VIC 3280.
[3]Regulation and Compliance Group, Department of Environment and Primary Industries, Shire Hall Barkly Street, Ararat, VIC 3377.
Email: malinda.godino@depi.vic.gov.au

The application of best practice management techniques can sometimes expose conflicts between statutory frameworks with competing priorities. In Victoria all land owners and land managers have legislative responsibilities to control European rabbits and protect aboriginal cultural heritage. These responsibilities are a requirement of the *Catchment and Land Protection Act 1994* and the *Aboriginal Heritage Act 2006* respectively. Conflicts between these regulatory frameworks may increase the risk of non-compliance and cause organisational reputation damage.

Rabbit management in Victoria is informed by the state-wide Biosecurity Strategy and Catchment Management Authority Regional Catchment Strategies (RCS). These strategies outline how high value economic, environmental and social assets can be best protected from the impacts of declared widespread invasive species. At a regional scale the RCS is used to prioritise government and private/public partnership investment. The Department of Environment and Primary Industries (DEPI) administers the regulatory provisions of the *Catchment and Land Protection Act 1994*, which is the legal instrument used for rabbit compliance.

During 2012-13 DEPI implemented the Lake Hindmarsh rabbit compliance project in western Victoria. The aim of the project was to achieve long-term rabbit control over 15,000 hectares to protect high value environmental assets along the Wimmera River biolink corridor and to consolidate the $1.4 million dollar investment already made by 160 land owners and land managers along the Wimmera River. Compliance was used as a tool to ensure benchmark targets for rabbit control were met.

In planning rabbit management projects, DEPI is guided by its ‘Keerna – Indigenous Partnership Framework’. ‘Keerna’ aims to improve opportunities for indigenous Victorians in primary industries and is underpinned by the values and behaviours of trust, respect and mutual understanding. During project planning, initial consultation with Aboriginal Affairs Victoria (AAV) identified that much of the land adjoining Lake Hindmarsh contained areas of aboriginal cultural sensitivity. In response to these findings DEPI initiated further consultation with AAV and the local registered aboriginal party, Barengi Gadjin Land Council, to mitigate the risk of damage to culturally sensitive areas during rabbit control operations.

Consultation resulted in a number of community engagement, operational and process improvements that reduced the risk of damage to Aboriginal cultural heritage across the project area. Dialogue and agreement with the traditional owners was central to the success of the project. This work demonstrates that respecting cultural values should not impede good pest animal management.

PUBLIC PERCEPTIONS ABOUT WILD HORSES IN VICTORIA: WHAT DO THE COMMUNITY REALLY THINK?

Daniel Brown[1], Joanna Axford[1], Charlie Pascoe[1] and Stuart Reeve[2]

[1]Parks Victoria, 46 Bakers Gully Road, Bright, VIC 3741.
[2]Micromex Research, 10/1 Bounty Close, Tuggerah, NSW 2259.
Email: daniel.brown@parks.vic.gov.au

The management of wild horses throughout Australia is a contentious issue. Managers can be confronted with strong views from interest groups about the methods of, and even need for, population management. However, the views of the broader public are often unclear. Parks Victoria conducted an investigation of the general publics' knowledge and perceptions of wild horses and their management to inform the development of management plans for wild horse populations in the State.

A telephone survey of 800 residents showed that the community generally has limited knowledge and awareness of wild horses and their management in Victoria. Survey respondents generally had positive views of wild horses and, importantly, many did not view wild horses as a pest species. Respondents were generally unaware of the environmental impacts of wild horses and had limited knowledge of wild horse management techniques and strategies. Nevertheless, respondents were receptive to being informed about wild horses and, after being presented with information about populations and impacts, were more supportive of management to limit population size and growth.

Mustering and fertility control were the control methods favoured by the majority of respondents, while shooting was the method least supported.

The lack of community awareness and understanding of wild horses and their impacts in Victoria hinders the effectiveness of community debate on the need for population management. However, the increase in support for population control, following the provision of basic information on populations and impacts, has important implications for future management of this sensitive issue.

MANAGING THE IMPACTS OF BOTH PESTS AND PEST MANAGEMENT – A FERAL CAMEL EXPERIENCE

Philip Gee and John Pitt

Rural Solutions SA, Primary Industries and Regions SA, 12 Tassie Street, Port Augusta, SA, 5700.
Email: phil.gee@sa.gov.au; john.pitt@sa.gov.au

There are many social impacts that can be attributed to feral camels. These include impacts associated with road accidents and damage to pastoral infrastructure, community infrastructure and cultural sites. There can also be conflict between neighbours or sections of communities with differing attitudes to feral camel management. Equally, there may be secondary social impacts associated with the control methodologies themselves and an effective management program may also need to address these.

The feral camel is widely perceived by the environmental sector to be a pest, but to some remote aboriginal communities it can represent a lifeline to much needed employment and income. To these communities the need for management may be well recognised so the challenge for the environmental sector is to achieve its desired conservation outcomes alongside the social and economic aspirations also sought by the communities. Clearly a partnership approach is required without which the environmental sector risks disengagement, limited access and possibly the creation of perverse outcomes such as maintenance (sustainable harvest) of the feral herd.

A Removal Assistance (RA) model to underpin such a partnership was developed in South Australia and implemented throughout the life of the Australian Feral Camel Management Project (AFCMP) to accommodate the social, economic and environmental aspirations of indigenous landholders in the remote Anangu Pitjantjatjara Yankunytjatjara Aboriginal (APY) Lands. The RA model is essentially a targeted incentive payment which rewards landholders for every female feral camel removed from the landscape and dispatched to abattoir slaughter. An effective verification and auditing system was developed and implemented to ensure probity and best practice animal handling was adopted by landholders at all times. Over the life of the project it was found that the RA model was effective in encouraging commercial removal while preventing a number of perverse outcomes, particularly selective mustering of male camels or release of female camels back into the wild. Many lessons were learnt and new risks became apparent, but where social and economic considerations are essential in obtaining effective feral camel management at a landscape scale, then the RA model should be considered as an option in the management tool kit.

QUANTITATIVE ASSESSMENT OF ANIMAL WELFARE OUTCOMES FROM FERAL CAMEL REMOVAL METHODS

Jordan Hampton[1, 2], Corissa Miller[1], and Andrew Perry[1]

[1]Ecotone Wildlife Veterinary Services, PO Box 1126, Canberra 2601 ACT.
[2]Murdoch University, 90 South Street, Murdoch 6150 WA.
Email: j.hampton@ecotonewildlife.com

The Australian Feral Camel Management Project (AFCMP) was initiated in 2009 to provide a coordinated national approach for the management of feral camels (*Camelus dromedarius*). Aerial shooting and live removal (mustering and trucking) were the primary control methods used under the AFCMP to achieve target densities around nominated environmental assets in a relatively short timeframe. To ensure best practice, a process of ongoing verification and feedback was implemented to assess compliance with model national standard operating procedures (SOPs). Quantitative assessment frameworks were developed to allow verification of animal welfare outcomes.

Aerial shooting was assessed at seven field sites and live mustering at one field site from 2011-2013. Shooting assessments were based on modifications to protocols used to benchmark killing methods for the whale harvesting industry. Live removal assessment was based on modifications to protocols used to assess the road transport and abattoir slaughter of domestic livestock. For helicopter shooting, ante-mortem observations were used to elucidate parameters relevant to duration of suffering, namely time to death (TTD), and instantaneous death rate (IDR). Post-mortem inspections were performed to assess wounding rate (WR), and the location and number of bullet wound tracts. Live removal was assessed through quantifying key parameters, including mortality rate, 'collapse rate', 'electric prod use rate' and body condition score of animals.

For aerial shooting, ante-mortem data revealed a mean TTD of 4 ± 15 (mean ± s.d.) seconds and mean IDR of 83% (n=192). Post-mortem data (n=715) revealed WR was 0.4% and hence killing efficacy was 99.6%. Inspected camels displayed 2.4 ± 0.9 bullet wound tracts, with the relevant SOP specifying a minimum of two shots per animal. Seventy-five percent, 63% and 35% of animals were shot at least once in the thorax, cranium and cervical spine, respectively, with 98% of animals shot at least once in one of these target zones. Within each social group, camel carcasses were found 28 ± 33 metres apart (n=703). Live removal data revealed that during mustering, mortality rate was 0.2% and collapse rate was 1.2% (n=500). At the point of loading onto trucks (n=187), electric prod use rate was 69%, collapse rate was 13% and 2% of animals had a body condition score < 1/5.

This study demonstrated that quantitative analysis can be used to assess animal welfare outcomes for lethal and non-lethal wildlife management methods. Helicopter shooting was associated with a very short duration of suffering through adherence to SOPs. Live removal operations were less tightly regulated and we were not able to measure several aspects relating to duration and intensity of suffering. Non-lethal wildlife control techniques are often assumed to be inherently more humane than lethal methods but our data questions that assumption in the context of feral camel management. The transparent verification process presented here also had benefits for training shooters, auditing performance and improving relationships with animal welfare groups and funding agencies. We recommend the application of rigorous quantitative assessments for wildlife management practices for which animal welfare outcomes remain contentious.

WILD DOG AWARE: UNDERSTANDING THE INFLUENCE OF MEDIA AND PUBLIC PERCEPTION

Bernadette York[1,2], Peter Fleming[1] and Donald Hine[2]

[1]NSW Department of Primary Industries, Forest Rd, Orange, NSW 2800.
[2] Behavioural Cognitive & Social Sciences, University of New England, Armidale, NSW 2351.
Email: bernadette.york@dpi.nsw.gov.au

In June 2011 when the Australian Government banned live export of cattle to Indonesia a clarion call was blasted across the country to local livestock industries and others working in areas affected by animal welfare issues. The government's response was largely due to public outcry over footage aired on the Australian Broadcasting Commission's Four Corners program. Public perception was the likely influence which led to the Australian Government's decision to cease the live export trade: a minority animal rights group was able to influence public perception and global trade using the media.

Animal rights and animal welfare groups represent differing opinions, the former proposing animals should have similar rights to people, the latter focussing on animal behaviour and management so *'that animals under human care or influence are healthy, properly fed and comfortable and that efforts are made to improve their well-being and living conditions. In addition, there is a responsibility to ensure that animals which require veterinary treatment receive it and that if animals are to be destroyed, it is done humanely*' (Department of Agriculture 2007).

The management of dingoes and other wild dogs poses animal welfare, production, economic and social issues, directly affecting livestock producers and those who come in contact with wild dogs. Conservation of the iconic Australian dingo is also the subject of public attention. All these issues are widely and variously reported in the media, both reflecting and influencing public opinion. As the live trade case showed, public perception can play a significant role in dictating what can and cannot be done in the management of animals in Australia.

Concentrating on media representations and coverage of wild dog issues in Australia this paper investigates current media coverage using content analysis to examine existing media representations and the perceptions reflected. This media analysis is contributing to a larger study which will explore audience attitudes to and perceptions of wild dogs using psychological profiling techniques to segment the audience so that messages and communication can be tailored to fit. Based on these studies, an extension of the results will explore the use of, and instigate, art projects to create new spaces to communicate wild dog issues.

This research is being undertaken as part of the Invasive Animals Cooperative Research Centre's Program 4 'Facilitating effective community action', which encompasses a wide range of projects examining the human dimensions of invasive animal management, and the project 'Co-management solutions for wild dogs in agri-ecosystems: predators, prey, plants and the triple bottom line'.

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HORSE CONTROL IN QUEENSLAND NATIONAL PARKS

Colin Dollery

Queensland Parks and Wildlife Service, PO Box 2066, Cairns QLD 4870.
Email: colin.dollery@nprsr.qld.gov.au

The management of feral horses, particularly where lethal methods are employed, is a controversial issue that tends to incite strong responses from many sectors of the community. However, aerial shooting is accepted as the most effective and humane way of dealing with large populations of horses ranging across extensive areas (Jones and Coleman 2006). The release of a discussion paper in 2004 by the Humane Vertebrate Pest Control Working Group (HVPC Working Group 2004), led to the preparation of a suite of standard operating procedures (SOP) addressing the control of many pest species, including one dealing with aerial shooting of horses. An early version of this SOP (Sharp and Saunders 2005) was used by Queensland Parks and Wildlife Service to inform the development of control strategies aimed at achieving a sustained reduction in the population density of feral horses in Carnarvon National Park in Central Queensland to address the impacts described by Weaver (2008). The success of that program has led to the operating procedures developed there being adopted state-wide.

In recognition of the sensitive nature of the task and the importance of maintaining the highest standards of animal welfare, QPWS has refined and modified the operating procedures. The additional components include a requirement for two helicopters working in tandem in all but open, sparsely-wooded country and a veterinary audit of all aspects of the shooting program.

The planning of control operations and priority setting is supported by feral horse impact monitoring programs. The success of this approach is discussed with examples drawn from four years of a five year control program at Oyala Thumotang National Park (CYPAL) in central Cape York Peninsula.

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MONITORING TOOLS AND TECHNIQUES FOR INTELLIGENT MANAGEMENT OF VERTEBRATE PESTS

[1]**David Berman**, [1]Darren Marshall, [1]Tom Garrett, [1]John Scriven, [1]Nathan Morgan, [1]Holly Hosie, [2]Magdalena Zabek

[1]Queensland Murray Darling Committee, Toowoomba, QLD 4350.
[2]University of Queensland, School of Veterinary Science, Gatton QLD 4343.
Email: dave@ozecological.com.au

Vertebrate pest animals cause environmental and economic damage. Many pest species also have positive impacts. Intelligent management of vertebrate pests involves actions that minimise the damage and maximise the positive impacts. Such management requires the accurate monitoring of population density and levels of impact. Unfortunately this can be difficult and expensive and is often done poorly or not at all. It is common for pest animals to be "controlled" (trapped, shot or poisoned) with no idea of the reduction in population size, let alone the reduction in damage achieved. This paper discusses potential new or improved options for monitoring vertebrate pest density.

Movement-sensing cameras have become very useful tools for vertebrate pest management. Users often set the cameras to take a photograph when triggered by animal movement within approximately 15 m of the front of the camera. The time-lapse option on these cameras is not often used but may reduce the bias associated with camera angle or height and variability of movement sensing. Cameras can be set to photograph areas over two hectares at regular intervals. Each photograph is a measure of the actual density of visible pest animals or wildlife at that place. A camera set in this way provided a good estimate of the density of a known number of domestic horses in a paddock. Also, in the field, time lapse photography provided reasonable density estimates for feral horses. Since the distance viewed by movement-sensing cameras at night is limited, we tried thermal imaging cameras filming through the night and we were able to distinguish feral pigs from other animals up to 300 m away. Sniffer dogs are being tested as a method for monitoring secretive and very low-density pest species such as cats and rabbits. Small quadcopters/drones mounted with video or thermal imaging cameras are also being considered as a means to survey rabbits, feral pigs or feral horses.

The techniques discussed here have the potential to improve estimates of vertebrate pest density, even when density is very low. This is important because for some species it is necessary to reduce the population to very low levels to achieve an acceptable level of damage. Estimating the actual number of individual pests at both low and high density provides us with greater ability to monitor the success of control activities and assign economic benefits. Further work is required to develop these techniques so that they are easy to use and provide accurate measures of the success of vertebrate pest control activities.

THE TRAPS OF CAMERA TRAPS

Paul D Meek[1,2,3], Guy Ballard[1,2,3], Peter Fleming[1,2,3], Karl Vernes[1] and Greg Falzon[1]

[1] University of New England, Armidale NSW 2351
[2] Invasive Animals CRC, Canberra ACT 2601
[3] NSW Department of Trade and Investment, Vertebrate Pest Unit, Orange NSW 2800
Email: paul.meek@invasiveanimals.com

The adoption of camera trapping as a data collection method in wildlife research and monitoring has occurred at warp speed. The attraction of pictures and videos of animals, new insights into behaviour, reduced field time and reduced costs of surveys has driven this rapid uptake. In pest management, camera traps are used to monitor the presence of the majority of Australian fauna pests and in recent times as a tool for measuring the success of control programs. Like every tool used in scientific sampling, there are constraints, traps and challenges to overcome before the benefits can be reaped. Contemporary camera traps have not been designed to detect fast small-medium sized animals like those pests found in Australia and New Zealand. As such we suggest that there are many practitioners using them who are not aware of the limitations and the care needed when using these devices to detect species from rat to dog size. To this end we have been investing considerable effort into attempting to unravel the mysteries of these devices, to understand their limitations and to maximise their use through appropriate choice of models, optimum placement, orientation and settings. It is our objective to test the numerous applications of using camera traps in wildlife investigations, to validate their accuracy and effectiveness, to develop best practice, to compare and contrast methods, to share our findings, convey our knowledge through training and contribute towards the refinement of survey techniques through robust assessment. We will present our perspective on the traps of camera traps, the advantages and some of our findings based on the last five years of research.

AN INTRODUCTION TO THE USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) TO VISUALISE PEST ANIMAL MANAGEMENT ISSUES

Moya Calvert

Invasive Plants and Animals Research, Biosecurity Queensland, Ecosciences Precinct
GPO Box 267, Brisbane QLD 4001.
Email: moya.calvert@daff.qld.gov.au

Regional councils often collect a lot of information about pest animals, which is an underutilised and potentially valuable resource for gaining a deeper appreciation of issues surrounding pest management. While the data is often used for internal reporting purposes, it can be used to make more informed and reliable decisions about how, when and where to control pest animals; this in turn creates efficiencies and improves control measures for the organisation.

Pest animal sightings, incidents and other data were recently collated from several Local Government Authorities in south-east Queensland. Data were visualised in a Geographic Information System using several techniques: 3D mapping, animation and graphic effects. The intent of visualisation is to highlight issues that are not immediately apparent when the data is viewed conventionally (e.g. as a table, or graphically). Visualising these issues may provide sufficient information to assess current management practices, but is also an important step in developing research questions or hypotheses for further, more detailed analyses.

The results indicate that GIS can be used to display data using more dynamic and expressive techniques which are immediately understandable and interpretable. This presentation will provide the audience with a better knowledge of what is possible with GIS using pre-existing data.

HOW TO COLLECT, STORE AND QUERY PEST ANIMAL DATA: A TUTORIAL FOR PRACTITIONERS

Benjamin L. Allen

Robert Wicks Pest Animal Research Centre, Biosecurity Queensland,
Department of Agriculture, Fisheries and Forestry, PO Box 102, Toowoomba, QLD 4350.
Email: benjamin.allen@daff.qld.gov.au

A wide range of people from students to local and state government agencies regularly collect large amounts of data on pest and other animals. Understandably, data collection and storage is often designed with single issues in mind, such as a simple log of pests captured and destroyed, a list of public complaints, or records of animals photographed during remote-camera exercises. To generate simple internal reports, these data are often queried for *where*, *when* or *how many* animals, which can take a substantial amount of time. While current data collection and storage practices may seem sufficient to address these single issues, slight modification to data collection and storage practices can dramatically improve the quality of data collected and reduce query times. Such modifications can therefore provide better information to managers faster, freeing-up staff time for other frontline tasks. Standardising data storage practices can also greatly assist cross-jurisdiction data-sharing between agencies which can help improve pest management across the landscape.

This tutorial uses camera-trapping data collected by local governments to demonstrate how to improve the collection, storage and querying of animal (pests and wildlife) monitoring data. The following topics are discussed:

- Designing camera monitoring programs to answer different ecological or management questions
- Arranging *Excel* spreadsheets to optimize data querying
- Simple formulas and subtle (but critical) differences in numerical values
- Error checking
- Simple data querying using pivot tables
- Constructing appropriate graphs and figures
- Basic statistics to validate/quantify your observations

The aim of the tutorial is to provide a brief 'start to finish' overview of how remote cameras can be deployed, how their data can be entered into spreadsheets, and how that data can be used to generate reliable results (including figures and tables) for use in internal reports or for sharing with other organisations.

REDUCING INSTITUTIONAL IMPEDIMENTS TO COMMUNITY-BASED INVASIVES CONTROL

Paul Martin[1], Darryl Low Choy[2] and Elodie Le Gal[3]

[1] Australian Centre for Agriculture and Law, University of New England, Armidale, NSW 2351.
[2] Urban and Environmental Planning section of Griffith School of Environment, Griffith University, Nathan QLD 4111.
[3] Australian Centre for Agriculture and Law, University of New England, Armidale, NSW 2351.
Email: elegal2@une.edu.au

In professional practice, those seeking to control pest animals face many practical impediments. They may have to deal with communities and landowners who are against pest control methods or ignorant of the issues. Pest management programs are generally under-resourced, and the processes of securing funds are tortuous. Front-line people also have to manage potential legal liability risks, and compliance obligations. The rules (e.g. pesticide use regulations, biodiversity conservation laws, animal health and welfare laws, land tenure arrangements, land use laws) and their administration are complex and fragmented.

The challenges to successful pest management approaches also differ with geographical location. For example, due to low-population densities in rural and remote Australia, community engagement strategies will often have limited effect. In peri-urban areas, pest control is made difficult by multiple land uses, community attitudes and laws that restrict conventional control practices.

Understanding institutional issues around funding, regulatory matters, program coordination and performance, staffing and the like is important because they determine whether pest management programs are successful or not. The Program 'Facilitating Effective Community Action' of the Invasive Animals CRC is focused upon identifying the high priority issues that impede effective action, and advancing reforms that will reduce these impediments. This paper will identify the major impediments to effective control, and discuss strategies that may be available to reduce these impediments and strengthen institutional supports for action.

Among the issues to be examined are financing mechanisms, harmonization and regulatory coordination, and enforcement. Particular attention will be given to peri-urban issues, which present particular institutional impediments and complications.

It is hoped that the paper will serve as a catalyst for further collaboration between policy researchers and those working at the 'front line' of invasive control.

THE HUMAN DIMENSIONS OF INVASIVE VERTEBRATE PEST CONTROL: INNOVATING FOR EFFECTIVE COMMUNITY-WIDE ACTION

Michael Fortunato[1], Autumn Smith-Herron[1], Sarah Beach[1], Brian Chapman[1], Colter Ellis[1], Andrew Prelog[1], Gene Theodori[1], Paul Martin[2], Theodore Alter[3]

[1] Sam Houston State University, [2] University of New England, [3] Penn State University.
Email: fortunato@shsu.edu

Impressive technological and managerial advancements continue to be made in combating vertebrate invasive pests, using a scientific approach to continuing improvement. However, research on pest management organizations in Australia has revealed a lack of a scientific approach to improving participation in vertebrate pest control across affected communities. Based upon this research and further dialogue, we propose that social and institutional innovation is required that goes beyond the technological control of pests. What is needed is a scientific approach to achieving effective community-wide action, improving the efficacy and diffusion of new technologies. The presentation presents a multi-national collaboration for studying issues of pest control and public participation: The University of New England (Armidale, New South Wales), Penn State University (University Park, Pennsylvania), Sam Houston State University (Huntsville, Texas), and Cornell University (Ithaca, New York). The collaborators will present four potential research areas addressing ways to better achieve more effective citizen involvement in controlling pest animals.

Risk perception and preparedness. This research explores perceptions of risk regarding invasive species, how these perceptions could facilitate or prevent collective action, and how risk communication could play a role in triggering community action.

"Hold-outs" and boosting public engagement. Non-participation by landholders significantly reduces the effectiveness of management techniques. This research would explore the attitudes behind non-participation, identify important social and institutional barriers to participation, and develop approaches to improve participation.

Developing new techniques for citizen science. Empowering community members with basic scientific training and mobile technologies ought to improve the monitoring of pest species, and the motivation of people to participate in pest species control. We argue that incorporating different perspectives on the role and power of the community may lead to better, locally appropriate techniques.

Examining the contribution of invasive species management to social theory. Pest species management is a mirror of many fundamental issues of community action in modern society. We suggest that a scientific approach to improving pest species management and community engagement can provide important insights that can be applied in fields as diverse as public health, education and social justice.

Our presentation will consider new methods being used within these research areas, and results from interviews with vertebrate pest stakeholders in Australia and the state of Texas. We will consider any common themes in the Australia-U.S. experience. Proposed outreach and educational programs based on these findings will be discussed.

IMPROVING THE EFFECTIVENESS OF CAT MANAGEMENT PROGRAMS THROUGH SUSTAINED HUMAN BEHAVIOURAL CHANGE

Lynette McLeod[1] and Donald W. Hine[2]

[1]IACRC Program 4, School of Behavioural Cognitive and Social Sciences, UNE, Armidale, NSW 2350.
– based at NSW Department of Primary Industries, Orange, NSW 2800.
[2]IACRC Program 4 – Team Leader Project 4E2, School of Behavioural Cognitive and Social Sciences, UNE, Armidale, NSW 2350.
Email: lmcleod6@myune.edu.au

Cats are one of the major pest animals in the Australian environment, but are also a valued pet species (Denny and Dickman 2010). In recent years cat-specific legislation and 'responsible cat owner' programs have been introduced in most states and territories to restrict the reproductive and predation potential of owned domestic cats. Nation-wide pest management programs and 'best practice' principles have been developed to target feral populations, and to a lesser extent, semi-owned domestic and stray cats, to control the impacts of these pests. The challenge remains to successfully integrate these principles into everyday practices; a process requiring sustained human behavioural changes.

There are many theories of human behaviour change described in the literature that have been developed in order to show how behaviours change, and can be changed over time. Various frameworks and models have been developed incorporating behavioural models with the theoretical knowledge of behaviour change to guide the planning of behavioural change interventions (Darnton 2008). This project will investigate the potential of one of these applied models, community-based social marketing (McKenzie-Mohr 2000), to determine its practicality in developing interventions to improve the effectiveness of cat management programs. Key influential human behaviours that can improve the effectiveness of the various cat management programs will be identified, and used to develop intervention strategies to elicit behavioural change and/or encourage new behaviours. These strategies will then be tested using randomised control trials.

This project is part of a larger research component of the Invasive Animal Cooperative Research Centre (IACRC) which is developing 'best practice' communication strategies by evaluating behavioural sciences approaches to create interventions to engage, educate and change attitudes and behaviours towards pest management.

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ORGANISATIONAL AND NETWORK LEARNING IN INVASIVE ANIMAL MANAGEMENT

Katrina Dickson

PhD Student, The Australian Centre for Agriculture and Law,
University of New England, Armidale, NSW, 2351.
Email: kmcdon20@myune.edu.au

Every year in Australia invasive animals result in extensive damage to natural ecosystems, threats to human and animal health and significant agricultural production losses. Technical solutions have been advancing, however attention to human dimensions, such as community engagement, effective communication and knowledge transfer has been limited. While adaptive management has been applied to the technical aspects of invasive animal control, albeit inconsistently, transformative learning has not been explored in the human dimensions.

This presentation will elaborate on my proposed PhD research, which will test and add to our knowledge of transformative learning in human dimensions in invasive animal control. The term "transformative learning' was described by Pahl-Wostl (2009), as triple-loop social learning which as well as questioning actions, and guiding assumptions, more deeply considers the whole system, such as regulatory frameworks, management structures and governance norms and values.

The need for my PhD research has been identified by the Invasive Animal CRC's Program 4E, Community Engagement. Martin and Verbeek (2012) recommended continuous research and learning about the human dimensions of invasive animal control in their review, and my participation as an interviewer supported this finding. My PhD is intended to supply practical recommendations such as policy interventions, tools and practices which will enable improved capacity for learning in the human dimensions.

This presentation will review the current literature on transformative learning and will introduce case studies which may identify practices, methods and tools transferrable to transformational learning in the Australian NRM (invasive animal) system. My PhD will interrogate the formal NRM system including legislation, policies, guidelines, strategic plans, evaluation, and alignment of motivations and rewards. The formal system will be compared with the informal system, using case studies and key informant interviews in Australia and the US to determine what happens in practice, for example how communities are engaged, how communication occurs, and the degree to which reflective learning presently occurs, and could potentially occur. This will enable a better understanding of how transformative learning may be applied within the current and future NRM (invasive animal) context, and include an assessment of the drivers of, and constraints to transformative learning in NRM; the institutional arrangements which may support or hinder transformative learning; and the potential characteristics of such a learning system, including roles of information technology, social media, peer to peer learning, use of experts, and formal versus informal learning.

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SOCIAL IMPLICATIONS OF A PREDATOR-FREE NEW ZEALAND

Andrea Byrom[1], Alison Greenaway[2], E Penelope Holland[1], Becky Niemiec[1], Bruce Warburton[1]

[1]Landcare Research, PO Box 69040, Lincoln 7640, New Zealand.
[2]Landcare Research, Private Bag 92170, Auckland Mail Centre, Auckland 1142, New Zealand.
Email: byroma@landcareresearch.co.nz

‘Predator-Free NZ’ has been discussed in many guises since the eminent physicist Sir Paul Callaghan laid down his challenge in February 2012. The concept has the potential to motivate public interest in New Zealand’s native biodiversity, and to generate a greater awareness of the impacts of predators on native biota. Conversely, ‘scaling up’ to areas of the mainland envisioned by Sir Paul may generate much public opposition and debate, and for a multitude of reasons.

We need to articulate what we actually mean by ‘Predator-Free NZ’, and preferably express that in terms of desired outcomes (e.g. conservation of native biota over a percentage of the landscape, international branding and reputation, and so on). We have many of the pieces of the puzzle required to achieve such an ambitious goal. The challenges are:

- technical (e.g. development of new and improved traps and toxins for the target species),
- social (e.g. some pest control tools generate public opposition),
- ecological (e.g. detecting reinvasion by pests into controlled areas),
- financial (e.g. applying pest control across vast areas of the landscape needs to be cost-effective and using financial instruments to incentivise business and industry involvement),
- policy-related (e.g. multiple agencies will need to be involved), and
- logistical (e.g. large teams of experienced pest control personnel may be required).

Putting all these pieces of the puzzle together to achieve the desired outcomes is the real challenge for Predator-Free NZ. In this talk I will attempt to address the challenge, and extend any potential lessons learned to the Australasian context.

A LONG-TERM ASSESSMENT OF METHODS TO REDUCE BIRD DAMAGE TO FRUIT

John Tracey[1, 2], Peter West[1], Brian Lukins[1] and Glen Saunders[1]

[1]Vertebrate Pest Research Unit, NSW Department of Primary Industries, 1447 Forest Rd Orange NSW 2800.
[2] Environment Department, University of York, York YO10 5DD, UK.
Email: john.tracey@dpi.nsw.gov.au

Birds are well known pests of fruit and other horticultural crops, and a variety of methods are routinely used to reduce their damage. However, there are surprisingly few studies that evaluate their efficacy in relation to damage. In addition these are rarely, if ever, replicated sufficiently in time and space to account for the natural variability in bird crop systems.

We evaluate the efficacy of netting, shooting and scaring in reducing damage across 101 orchards and vineyards over seven years. Linear mixed models were used to test for the effects of these treatments when used either individually or in combination, on percent bird damage across 185 property year records.

One-hundred and forty bird species were observed in vineyards and orchards of the Orange region of NSW, of which 29 native and 7 introduced species damaged fruit. Starlings were the most common pest (70.4%, mean density 419± 112 starlings/ km^2). Netting was the most effective treatment in reducing damage, but birds breached nets through holes or gaps and consumed fruit through netting, with damage as high as 56 ± 4.8% recorded under netting. Shooting (20.5± 3.8%) was not as effective as netting (10.7 ± 2.8%), but less than a third of the cost ($538 vs $1,903/ha/property) and had 13% lower damage compared to nil treatments (33.2 ± 5.6%). This was likely to be a result of scaring birds away from the crop, as the number of birds shot was unrelated to damage caused and the numbers shot were low in relation to population size (35.0 ± 7.9%). However, scaring with electronic devices and visual deterrents had no measurable effect on bird damage, indicating that although birds may respond initially to scarers, they quickly acclimatise to new stimuli that do not pose a physical threat. Property size was significant in the final model with smaller crops more susceptible to damage, but crop type (grapes, cherries, apples and pears) and control effort had no affect on damage.

We recommend changes to routine management of pest birds and emphasise the importance of pursuing fundamental knowledge of commonly used pest management practices.

UPDATED NATIONAL TRAINING QUALIFICATIONS FOR VERTEBRATE PEST MANAGERS IN AUSTRALIA

Annette Brown[1, 2] and Mike Braysher[2, 3]

[1]NSW Department of Primary Industries, Forest Rd, Orange, NSW 2800.
[2]Invasive Animals Cooperative Research Centre, University of Canberra, ACT 2601.
[3]University of Canberra, ACT 2601.
Email: annette.brown@dpi.nsw.gov.au

Vertebrate pest management in Australia continues to evolve in response to land use changes, shifting community attitudes and advancing technologies. The increasing demands and complexity of this profession requires employees with expertise in a broad range of disciplines. The Australian Pest Animal Strategy (APAS) recommends that best practice management of vertebrate pests should focus on reducing damage rather than the number of individual animals, using a strategic and integrated approach that incorporates the best available knowledge, tools and skills. To help achieve this, Australia's vertebrate pest management training qualifications under the national Vocational and Education Training (VET) system have recently been updated to align with the APAS. Industry engagement and consultation during the scoping phase of this project has highlighted a number of reasons why people who work in pest management jobs are not undertaking training to obtain nationally recognised qualifications. Barriers to formal educhallation include employers who are unwilling to release staff for periods of training, a lack of available training courses and skilled trainers in the industry (especially in rural and regional areas), workers with university qualifications who lack practical field skills, workers who are employed on short-term contracts with no secure career path, and a general preference for competency-based short courses for professional development. This paper will explain the motivation behind Australia's qualifications and training review, and how the review proposes to overcome some of the problems with current training programs. These issues are not unique to Australia and we also explore how other countries facing similar challenges are addressing the continuing education needs of vertebrate pest management professionals.

PHAGE PEPTIDES FERTILITY CONTROL: NON-SURGICAL STERILISATION OF FEMALE EQUIDS

Sally Hall[1], John Aitken[1] and Eileen McLaughlin[1]

[1]Priority Research Centre for Reproductive Science,
University of Newcastle, Callaghan, NSW, 2308.
Email: sally.e.hall@uon.edu.au

Feral horses *(Equus caballus)* are a significant pest species in Australia, responsible for soil erosion across agricultural lands and the loss of native fauna populations. Over the last 20 years, feral horse populations in Australia have risen twenty percent per annum, where the current population is estimated at 400,000 brumbies, predominantly located in central and northern Australia. Methods developed to combat this outbreak have been unsuccessful in reducing numbers, and aerial shooting, the most effective method currently practiced, has been banned in certain parts of Australia. Consequently, another mechanism of feral horse management needs to be developed to reduce population numbers.

Our proposed strategy to control feral horse populations is to develop pharmaceutical reagents that will destroy the finite germ cell population in the ovary, thereby rendering the animal instantaneously and irreversibly infertile. Female mammals are born with a finite supply of germ cells in the ovarian cortex and as these cells are unable to be replicated, the store can be exhausted, leaving the animal unable to produce offspring. Using ovary cell specific phage peptides, coupled to cytotoxic molecules, we can target these germ cells and induce apoptosis, leaving the animal unable to produce offspring. This novel technique has been investigated in other mammals where folliculogenesis is well understood, however in the horse, a less well characterised system, more research needs to be done.

Cytokines are well-known to drive folliculogenesis in mammalian systems, and thus our approach to characterising equine folliculogenesis is through members of the JAK/STAT and SCF/c-kit signalling pathways. Real time PCR, immunohistochemistry and immunoblotting have been used to identify changes in gene and protein expression during follicular development. The localisation of these proteins in the equine ovary provides a basis for the visualisation of the primordial follicle pool in the horse and allows the reproductive lifespan of the animal to be estimated. These can be used as biomarkers to assist in developing a novel technique for non-surgical sterilisation of female equids.

THE BALANCED SCIENTIST PROGRAM: ENHANCED PHD CANDIDATE TRAINING

Tony Buckmaster[1], **Stephen Sarre**[1,2]

[1] Invasive Animals Cooperative Research Centre, University of Canberra ACT 2617.
[2] Institute for Applied Ecology, University of Canberra ACT 2617.
Email: anthony.buckmaster@canberra.edu.au

The Invasive Animals Cooperative Research Centre (IA CRC) is funded under the Commonwealth Government CRC program and committed to train at least 24 PhD students over three cohorts. The Balanced Scientist Program was developed by the IA CRC with the specific aim of producing exceptional multi-skilled industry-ready PhD graduates. In addition to their specialised PhD research experience, these graduates will have gained professional, strategic and vocational skills in research leadership and management, stakeholder and community engagement and have developed contacts, collaborations and networks beyond those gained during a traditional research-based doctoral program.

There are several crucial elements to the Balanced Scientist Program. Foremost of these is the placement of students within industry, both government and non-government, to work in programs that contribute to the overall goals of the parent organisation. Students are under the supervision of at least one industry-based professional in addition to their university-based primary academic supervisor.

The second crucial component of the program is that students are trained in areas of leadership, management, business and entrepreneurial skills that complement and enhance their research training in their chosen field. These skills are selected in conjunction with the students and their supervisors and are placed within a detailed learning plan that guides their 80 days of additional training over four years. To ensure that their ability to produce an exceptional research thesis is not compromised through undertaking this added training, the Balanced Scientist Program funds an additional six months of full scholarship for the students.

Twenty nine PhD students participated in the Balanced Scientist Program of which 27 have already submitted theses for marking. Twenty four of those students have had their doctorate conferred giving a current completion rate of 83%. This is expected to rise to an overall completion to conferral of doctorate rate of 96%. This exceptional completion rate is far higher than the national average for PhD completion of 60%, the average completion rate of CRCs at 64% and the average completion rate for the Group of Eight universities of 68%.

The Balanced Scientist Program, in additional to increasing the completion rate of PhD students, has allowed graduating students to better prepare for the industry workplace, develop networks before graduation, improve employment prospects and match research efforts with industry priorities.

IMPROVING AND MAINTAINING ORGANISATIONAL CAPACITY IN VERTEBRATE PEST MANAGEMENT

Caleb Hurrell[1], John Matthews[2]

[1]Regulation and Compliance Group, Department of Environment and Primary Industries,
Corner Fenwick Street and Little Malop Street, Geelong, VIC 3220.
[2]Regulation and Compliance Group, Department of Environment and Primary Industries,
915 Mount Napier Road, Hamilton, VIC 3300.
Email: caleb.hurrell@depi.vic.gov.au

Maintaining organisational capacity in vertebrate pest management is an essential component to effectively and efficiently deliver evidence-based best practice on-ground programs. In Victoria, the Department of Environment and Primary Industries (DEPI) is responsible for developing and regulating biosecurity standards for agriculture and the natural environment on behalf of the broader community. Management programs for declared widespread vertebrate pests are informed by legislative frameworks, supported by sound science and implemented by technically competent staff.

The recipe for successful vertebrate pest management at a landscape scale consists of the timely and accurate application of appropriate best practice control techniques and landholder participation. It is also heavily reliant on organisational capacity – specifically, the technical knowledge and skills of staff to competently and consistently assess, regulate and advocate best practice vertebrate pest management with an ever-changing demographic of stakeholders.

DEPI regularly reviews the knowledge, skill and resource capacity of the organisation to deliver government priorities, including reviewing recruitment and training strategies and standards. The current DEPI science-based recruitment strategy has strengthened and underpinned organisational knowledge and enhanced business capability, including improvements to science, strategy and project management to inform decisions and direction in pest management.

In support of this strategy and to ensure technical skills in best practice vertebrate pest management are actively fostered in DEPI staff, a nationally accredited training program in best practice vertebrate pest management has been developed specifically for Victorian needs. The program addresses a need to improve and maintain critical technical skills and create a succession plan to ensure the knowledge and skills necessary for compliance-based vertebrate pest management in Victoria can be maintained into the future.

Staff at all levels have been encouraged to participate in the program. Benefits of the program have been experienced by both field staff and managers, who now have improved skills in developing on-ground management strategies and assessing, regulating and advocating best practice vertebrate pest management. Participation in the program has also recently expanded to include staff from other natural resource management agencies, who have indicated a strong desire to improve their organisational knowledge in vertebrate pest management.

ABSTRACTS - DAY 3

Thursday 29 May 2014

BIOLOGICAL CONTROL OF VERTEBRATE PESTS IN AUSTRALIA

Tanja Strive[1,2]

[1]CSIRO Ecosystem Sciences, Clunies Ross St, Black Mountain, ACT 2601.
[2]Invasive Animals CRC, University of Canberra, ACT 2617.
Email: Tanja.Strive@csiro.au

Australia is unique in that it uses viruses to successfully control an invasive vertebrate pest species – the European rabbit. The introduction of Myxoma Virus (MYXV) in 1950 and later Rabbit Haemorrhagic Disease Virus (RHDV) in 1995 has resulted in estimated benefits of >$70 billion AUD to Australia's agricultural industries, plus innumerable benefits to biodiversity. Arguably the main challenge in maintaining effective biological control is the ongoing 'arms-race' between any pathogen and its vertebrate host. In the case of MYXV host-pathogen co-evolution led to virus attenuation and the development of genetic resistance, and consequently a reduced impact on rabbit populations. In contrast, rapid attenuation of RHDV has not been observed in the 18 years since its release, although genetic resistance to RHDV has recently been described in some Australian rabbit populations.

To provide alternative control tools, for more than two decades the Invasive Animals CRC and its predecessor, the Vertebrate Pest Control CRC, have explored a variety of biocontrol options for a number of pests. Aiming at reducing pest populations to sustainable levels while at the same time addressing issues of strict species-specificity and animal welfare, research conducted by the previous CRC largely focussed on developing recombinant viruses to control the fertility of mice, rabbits and foxes.

In contrast, current research again focusses on classical biological control, targeting rabbits and carp. Koi herpesvirus is being developed as the first ever biological control tool for a freshwater pest species. The RHD Boost project has been assessing additional strains of RHDV sourced from Europe and Asia for their potential to complement the existing Australian field strains. The RHD Accelerator project is developing novel platform technologies for the targeted natural selection of improved RHDV variants, while the Bioprospecting initiative is on the lookout for alternative rabbit pathogens, all aiming at supplementing the tool kit available to sustainably manage rabbit populations.

THE CURRENT STATUS OF ANTIBODIES TO PATHOGENIC AND BENIGN CALICIVIRUSES IN SELECTED RABBIT POPULATIONS

Tarnya Cox[1], June Liu[2], Tanja Strive[2]

[1] Vertebrate Pest Research Unit, NSW DPI, Forest Road, Orange NSW 2800.
[2] Ecosystem Sciences, CSIRO.
Email: tarnya.cox@dpi.nsw.gov.au

Rabbit numbers throughout Australia have reportedly been on the increase since 2003. In an effort to maintain the benefits of the initial release of Rabbit Haemorrhagic Disease Virus (RHDV), a research project (RHD-Boost) was established to investigate overseas strains of RHDV for their potential to complement the existing Australian RHDV strain in the biological control of rabbits. As a part of that wider researcher project we investigated the demographic and serological status of rabbit populations at some of the original sites from the 1996-8 post-release monitoring period. We investigated the presence and prevalence of antibodies to both RHDV and the benign rabbit calicivirus RCV-A1, which offers partial protection to infection by RHDV. Seven of the original 26 intensive monitoring sites where RHDV was originally released in 1996 were monitored four times over one year from April 2011 to February 2012. Of the 496 rabbits 64% (319) had a positive serological response. Of these 82% had antibodies to RHDV, 65 % had antibodies to RCV-A1 and 47% had antibodies to both viruses. The probabilities that an animal would fall within each of four categories (Clean: no antibodies, RHDV: antibodies to RHDV only, RCV: antibodies to RCV-A1 only, Both: antibodies to both RHDV and RCV-A1) differed across sites, but did not differ significantly across seasons within sites, suggesting that there was no seasonal effect of either virus within the sampling period. Three of the sites Erldunda (NT), Muncoonie (QLD) and Sterling (WA) differed significantly to all other sites with a higher proportion of rabbits classified as Clean. Hattah (VIC) differed significantly with all other sites in the proportion of rabbits classified as RHDV only. Rabbits in populations with RCV-A1 antibodies were significantly more likely to be positive to RHDV. The results indicate that the antibody levels to both RHDV and RCV-A1 differ considerably between rabbit populations in Australia. Such information is important when working towards releases of possible additional strains of RHDV, and to subsequently monitor their impact post-release.

IDENTIFYING MOLECULAR VIRULENCE FACTORS OF RABBIT HAEMORRHAGIC DISEASE VIRUS

Nadya Urakova[1,2,3], Markus Matthaei[1,2], Michael Frese[3] and Tanja Strive[1,2]

[1]CSIRO Ecosystem Sciences, Clunies Ross St, Black Mountain, ACT 2601.
[2]Invasive Animals CRC, University of Canberra, ACT 2617.
[3]Faculty of Education, Science, Technology and Mathematics,University of Canberra, ACT 2617.
Email: nadezda.urakova@csiro.au

The European rabbit (*Oryctolagus cuniculus*) is one of the worst vertebrate pest species in Australia causing ongoing severe damage to the environment. In 1996, rabbit haemorrhagic disease virus (RHDV) was released in Australia to control feral rabbits at a landscape scale. Initially the virus dramatically reduced rabbit numbers and has kept populations low for over a decade. However, recent evidence suggests that rabbits are now becoming resistant to the original RHDV strain in some parts of Australia, and that the virus in turn may evolve to maintain relatively high levels of virulence. More research into the resistance mechanisms in rabbits and into the virulence mechanisms of the virus is urgently needed to better understand the ongoing evolutionary process and to address the problem of waning RHDV effectiveness. However, this is going to be a challenging task given that rabbit caliciviruses cannot be grown in cultured cells, which makes molecular biology studies difficult.

Recently, we have discovered a benign rabbit calicivirus (RCV-A1) in Australia. RCV-A1 does not cause any disease in rabbits, but its genetic organisation is almost identical to that of the lethal RHDV. This discovery provides an opportunity to systematically compare two complementary sets of closely related genes and encoded proteins: one from the extremely pathogenic RHDV and the other from the completely benign RCV-A1.

The aim of this approach is to identify the viral components critical for the high virulence of RHDV. This will not only enhance the general understanding of calicivirus biology, but may also help to improve the use of RHDV as a biocontrol agent for the ongoing effective management of rabbit populations.

AUSTRALIA'S RABBIT HISTORY GUIDES THE SEARCH FOR NEW RABBIT BIOCONTROLS: CURRENT FOCUS ON *EIMERIA* AND LEPORID HERPESVIRUS-4

David Peacock

Biosecurity SA, Adelaide, SA 5000.
Email: david.peacock@sa.gov.au

Australia's management of its pest population of rabbits has been extraordinarily benefited by the successful introductions of myxomatosis in 1950 and rabbit haemorrhagic disease virus (RHDV) in 1995. Both viruses initially reduced rabbit numbers in many areas by up to 95% and so far have saved agricultural industries c. $70 billion (Cooke *et al.* 2013). However, as expected with pathogen/host relationships, the viruses changed and genetic resistance developed in the rabbits allowing their numbers to recover, albeit to levels lower than those before the virus releases.

In the search for additional biological control agents for the pest rabbits, it is important that we have a better understanding of the genetics and micro-fauna of the rabbits present in Australia. This comprehensive spatial knowledge is critical in determining if, and where, potential biocontrol agents are already present in Australia, and the genetic landscape that will strongly influence biocontrol efficacy.

Australia's rabbit population arose from a number of locations and possibly origins (Peacock and Abbott 2013), with genotype variability reported from Sydney (Phillips *et al.* 2002) and likely present at other locations. Such variability may be influencing the efficacy of RHDV and should influence efficacy of any new biocontrols.

Pathogens of current biocontrol focus are *Eimeria* and leporid herpesvirus-4 (Henzell *et al.* 2008), however *Eimeria intestinalis* and *E. flavescens* are described from south-west Western Australia, but not from other mainland regions (Hobbs and Twigg 1998), and proposing their translocation to other regions to assist rabbit management requires confirmation of their absence.

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RHDV-ACCELERATOR: USING NATURAL SELECTION TO MAINTAIN AND IMPROVE RHDV-MEDIATED RABBIT BIOCONTROL

Markus Matthaei [1,2], Peter Kerr [1,2], Lorenzo Capucci [3] and Tanja Strive [1,2]

[1]CSIRO Ecosystem Sciences, Clunies Ross St, Black Mountain, ACT 2601.
[2]Invasive Animals CRC, Bldg 3, University of Canberra, Bruce, ACT 2617.
[3]IZSLER, Instituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna, 25124 Brescia, Italy.
Email: Markus.Matthaei@CSIRO.au

Rabbit haemorrhagic disease virus (RHDV) is widely used in Australia and New Zealand to control populations of the European Rabbit (*Oryctolagus cuniculus*), one of Australia's worst invasive vertebrate pest species. Following its release in 1996, RHDV had a devastating impact on the naive rabbit population across most of the continent. However, rabbits surviving the infection become part of an immune breeding population due to the development of a strong antibody response that protects them from further infection. While natural outbreaks of RHDV still occur regularly, wild rabbit populations now show a varying degree of population immunity that limits the impact of RHDV. To maintain efficient RHDV-mediated rabbit biocontrol, a virus different enough to avoid this antibody-mediated immunity would be highly desirable.

To achieve this, we will employ the virus' intrinsic ability to quickly adapt to changing circumstances. This ability results from the error-prone replication of viral genomes that generates an immense variety of slightly different viruses each round of replication. By sequentially passaging a recent RHDV field isolate in rabbits that also received a well-defined and increasing amount of RHDV-specific antibodies, natural selection processes will give rise to variants able to overcome the applied antibodies. Doing this stepwise with different antibodies in a directed and optimised manner, our aim is to select sufficiently different virus variants that are able to infect field rabbits that are immune to existing strains.

We are currently developing the protocols necessary to carry out this selection in rabbits, as well as the methods to monitor selection efficiency and to map the genetic marker(s) we are selecting for. If successful, the RHD Accelerator platform will enable us to continuously select for RHDV variants that avoid existing protective antibodies in rabbits at the time of their release, which will significantly improve our ability to manage feral rabbit populations sustainably.

THE HARD SLOG: PROGRESS TOWARDS A NATIONAL CARP BIOCONTROL PROGRAM

Dean Gilligan[1] & Kenneth McColl[2]

[1] Batemans Bay Fisheries Centre, Freshwater Ecosystems Research, Department of Primary Industries, PO Box 17, Batemans Bay, NSW 2536.

[2] AAHL Fish Diseases Laboratory, CSIRO-Australian Animal Health Laboratory, Private Bag 24, Geelong, VIC 3220.

Email: dean.gilligan@dpi.nsw.gov.au

Evaluations of Cyprinid herpesvirus-3 (CyHV3) (formerly known as Koi herpesvirus) as a potential biological control agent for common carp in Australia continue at the high level bio-secure facility located at CSIRO's Australian Animal Health Laboratory. Testing has shown that Australian carp are highly susceptible to the C07 strain of CyHV-3. The CSIRO have now tested susceptibility of 13 native fish species (representing a broad range of Australian freshwater fish Orders), introduced rainbow trout and a representative mammal, bird and crustacean. Tests of reptiles, amphibians and a few additional fish species are yet to be undertaken. So far, no species other than carp has shown any evidence of infection. This concurs with international experience that CyHV-3-induced disease is entirely specific to common carp. The virus appears to be both effective and safe and represents a viable bio-control option for common carp in Australia (and probably New Zealand). Federal and state governments have been briefed on the Invasive Animals Cooperative Research Centre's current carp bio-control development program in preparation for submission of formal applications under the Biological Control Act, Quarantine Act/Environmental Protection and Biodiversity Conservation Act and Australian Pesticides and Veterinary Medicines Authority Act. These applications require detailed summaries of the pest status of carp and currently available carp control options, biological and epidemiological data on CyHV-3 (including details and results of the testing program), details of viral production, efficacy, safety, trade, occupational health and safety etc., as well as proposed release and monitoring and evaluation strategies and details of inter-jurisdictional collaboration. The New South Wales Department of Primary Industries is currently compiling these data and preparing applications for submission in 2014. Other activities being undertaken to support/advance the program are: preparation and testing of freeze-dried virus; sequencing the genome of the C07 strain; epidemiological modelling of potential release strategies; compilation/collection of international data on the effects of CyHV-3 on wild carp populations; compilation/collection of benchmark data on carp densities and their environmental impacts; and, development of costings and funding proposals for a staged national carp bio-control program.

NEW SETTLERS ON THE FRINGE: DEMYSTIFYING PERI-URBAN MYTHS

Professor Darryl Low Choy

School of Environment, Griffith University, QLD 4101.
Email: d.lowchoy@griffith.edu.au

In recent decades, vast tracts of former rural lands beyond the limits of cities and urban centres, have been transformed by processes more closely aligned to urban values than to the traditional rural ones they were displacing. Contrary to popular belief that these areas are still essentially rural in function and character, Australian research into this peri-urbanisation process has identified new settlement patterns inhabited by a typology of the new settlers, many with no prior experience of non-urban living.

The research has also highlighted the essential drivers behind the peri-urbanisation processes which acknowledge that whist amenity motives have been strong in this relocation process, there are a wider range of drivers that have consequently influenced the resultant settlement and land use patterns.

These emergent peri-urban settlements, inhabited by this wave of new settlers, demands fresh new approaches to their engagement, planning and management, particularly in the land use and natural resource management fields.

The peri-urban forms that have and continue to emerge in these fringe areas are essentially defining a new settlement frontier that defies understanding through conventional planning and natural resource management theories. This paper will utilise this research to demystify a number of peri-urban myths that have emerged unchallenged in planning and natural resource management circles.

PET OR PEST? AN INVESTIGATION OF COMMUNITY ATTITUDES AND LOCAL GOVERNMENT ACTION TOWARDS CAT MANAGEMENT

Meg Lorang[1], Craig Elliott[2]

[1] Kingborough Council, Locked Bag 1, Kingston, TAS, 7050.
[2] Tasmanian Department of Primary Industries Parks Water and the Environment,
PO Box 46, Kings Meadows, TAS 7249.
Email: craig.elliott@dpipwe.tas.gov.au

Felis catus, the domestic cat is the most popular pet worldwide today. Since their arrival in Australia, cat numbers have grown to reach an estimated 2.65 million owned cats and 18 million feral cats Australia-wide. The impact of cats on Australia's native animal species has been well documented. Free-roaming or unconfined domestic pet cats also represent a significant source of neighbour aggravation and complaints to Councils, provide breeding stock for stray and feral cat populations, and spread of cat-borne diseases. Despite decades of attempts to raise awareness about the need for responsible cat ownership, the majority of cat owners continue to allow their cats to roam freely. Local and state governments are under increasing pressure from the community to implement tighter controls on roaming cats. In response to this pressure, Tasmania recently introduced State administered cat control legislation. Measures contained in the *Cat Management Act 2009* focus on providing livestock producers in rural areas with formal rights to control cats on their land but the Act contains very limited provisions for the control of domestic or owned cats in a suburban setting.

To understand why cat owners continue to allow their cats to roam and to assist in determining an appropriate response for their community, Kingborough Council, in southern Tasmania, conducted a review of bylaws currently in use by local councils across Australia to control pet cats. A community attitudes survey was then used to assess attitudes towards cat management issues, using the results of the bylaw review to frame questions regarding potential control measures.

Control measures included restricting the number of cats permitted per household, compulsory cat registration, council planning provisions requiring confinement, 'cat at large' or nuisance animal provisions to prevent roaming cats, cat prohibited areas and 'last cat' policies. Results of the survey indicated extremely high levels of support in the community from both cat owners and non-cat owners for the introduction of various compulsory cat control requirements.

This work has informed Kingborough Council's strategy to cat management. It is recognised that relying solely on voluntary compliance from cat owners to confine pet cats will not be effective. Further investigation into the reasons behind the failure of large numbers of cat owners to control their cats responsibly is required and will form a part of ongoing work in Tasmania.

DISEASE PREVALENCE AND PUBLIC HEALTH RISKS OF PERI-URBAN WILD DOGS

Lana Harriott[1], Matthew Gentle[2], Rebecca Traub[1] Ricardo Soares-Magalhaes[3], Rowland Cobbold[1]

[1]School of Veterinary Science, University of Queensland, Gatton QLD 4343.
[2] Robert Wicks Pest Animal Research Centre, Biosecurity Queensland, 203 Tor Street, Toowoomba QLD 4350.
[3]School of Population Health, University of Queensland, Herston QLD 4006.
Email: l.harriott@uq.edu.au

A growing human population and the expansion of built up areas into surrounding bushland has seen an increase in wild dog populations within urban communities. Recently, data has shown that wild dogs traverse within a very close distance to houses, frequently visit household backyards, and use common and highly populated areas such as school grounds and parklands (Allen *et al*., 2013). Such close geographical proximity to these locations increases the likelihood of wild dog - human interactions and also the opportunity for humans, and particularly children, to be exposed to wild dog faecal material and vector-borne diseases. There are numerous microorganisms that can be found in the faecal material of wild dogs and these can be transmitted either directly, through close contact with the dogs themselves or indirectly, through contamination of the environment. Ectoparasites of wild dogs may also act as vectors for pathogens that are infectious to humans. These can include different species of bacterial, parasitic and virusal pathogens, of which some may have serious implications for human health. Although we are aware that wild dogs are capable of harbouring potentially zoonotic pathogens, their prevalence and any associated risk factors remains largely unknown and unexplored. The role of wild dogs in the maintenance and transmission of pathogens with public health significance needs to be investigated to determine the scale of the problem and if management action is required.

Prevalence data on targeted zoonotic diseases amongst wild dogs is currently being collected utilising faecal samples, blood samples and whole dog carcasses provided from council management programs within north-eastern New South Wales and south-eastern Queensland. Necropsy, microbiological and molecular methods are being utilised for detection and identification of pathogens. Information collected from necropsy will be further integrated with geographical information to assist in the quantification of risk factors and the public health effect of diseases carried.

Results from these investigations will lead to more informed management programs for wild dogs in peri-urban areas, and to further encourage responsible pet ownership.

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FERAL HORSE MANAGEMENT AMONGST UNEXPLODED BOMBS AND PERI-URBAN PEOPLE

David Berman

Ozecological Pty Ltd.
Email: dave@ozecological.com.au

The feral horse population at Greenbank Military Training Area appeared to have reached a critically high level in 2005. The horses were generally in poor condition and had been seeking food outside the training area. This posed considerable risk to the horses themselves and people traveling on roads in the area. Access by people to half of the 50 square kilometre training area was prevented due to the presence of unexploded bombs. The training area is situated within 24 kilometres of the centre of Brisbane amongst many peri-urban equestrian enthusiasts.

Before control operations commenced, a steering committee was formed involving all interest groups to determine the methods to be used. All horses were to be captured and those considered suitable were to be offered to community members for domestication. Horses considered unsuitable for domestication were to be euthanised at the site of capture.

In 2005, 22 horses were trapped by Mark Goullet (Ferals Out) and removed from the population. A further 30 horses were removed in 2006 and three mares were radio-collared. In 2007, 19 horses were removed and two more were radio-collared. In 2008, the remaining 13 horses known to be in the training area were removed. There have been no reports of horses in this area since.

Mark-recapture and distance-sampling methods were used to estimate the population size regularly throughout the operation and dung counts were used to monitor distribution. Eight of the last remaining horses were uncollared and were rarely seen in areas where they could be caught. As expected, the uncollared horses formed stable social groups with collared horses during late 2007. The radio-collars improved our ability to find and capture the remaining horses.

Eighty-four horses were removed from the Greenbank Military Training Area in three years. Forty of these were re-homed. Considerable emphasis was placed on finding homes for all horses that were suitable. Most of these were young horses but older horses that showed suitable temperament were also re-homed. This was an extremely important part of the project. To gain support of the public it is essential to show that as many horses find new homes as possible. The proximity of the work to the centre of Brisbane means there was an increased risk that horse protectionists could have opposed and prevented the operation.

The Greenbank Military Training Area is not suitable for horses, particularly if they are left to increase uncontrolled. Unmanaged, this population would have continued to pose a risk to people traveling in vehicles, and would have increased in numbers until they suffered from lack of food. These unmanaged horses also had the potential to harbour exotic horse diseases that could damage the valuable southeast Queensland domestic horse industry. Feral horses should no longer be a problem at Greenbank Military Training Area.

THE IMPACTS AND MANAGEMENT OF PERI-URBAN WILD DOGS

Matt Gentle, Ben Allen, James Speed and Lee Allen

Robert Wicks Pest Animal Research Centre, Biosecurity Queensland, Department of Agriculture, Fisheries and Forestry, 203 Tor Street, Toowoomba, QLD 4350.
Email: matthew.gentle@daff.qld.gov.au

Peri-urban areas are regions surrounding cities, towns and built-up areas that usually contain a mixture of land uses including residential, commercial, and rural-residential (Low Choy 2007). Pest animals have become increasingly prevalent within such fragmented landscapes. The presence and impacts of wild dogs (*Canis lupus dingo* and their hybrids) are increasingly being felt by producers and residents of towns and outer suburbs throughout the more populated areas of eastern New South Wales and Queensland. Preliminary movement studies indicate that wild dogs readily utilise peri-urban landscapes, and roam in close proximity to residential homes, schools and recreation areas (Allen et al. 2013). Typically, wild dogs in regional areas are associated with impacts such as maiming or killing domestic stock and wildlife. In contrast, peri-urban environs appear to suffer from a greater range of impacts, partly reflecting the greater diversity of the land uses and residents, but also the increased human:wild dog interactions. However, there remains a general paucity of data relating to the type and level of impacts from wild dogs in such communities. Understanding impacts is crucial to determining the problem, and formulating and monitoring appropriate management strategies. Managing wild dog impacts is essential, but can be challenging given conventional control options are limited in peri-urban environs (DEEDI 2011). An improved understanding of the application and efficacy of current control measures will help in the uptake of new control technologies.

This presentation uses data collated from local governments and other sources to discuss the distribution, range and intensity of impacts caused by wild dogs in peri-urban areas. This work is part of an Invasive Animals CRC research project (delivered in conjunction with Biosecurity Queensland, NSW Department of Primary Industries and various Local Governments), to document the nature, distribution and impact of peri-urban wild dogs; investigate their ecology and movements, and test alternative management approaches in peri-urban environments.

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IMPROVING VERTEBRATE PEST MANAGEMENT IN PERI-URBAN AREAS THROUGH TECHNOLOGICAL AND METHODOLOGICAL ADVANCES

Benjamin L. Allen and Matt Gentle

Robert Wicks Pest Animal Research Centre, Biosecurity Queensland, Department of Agriculture, Fisheries and Forestry, PO Box 102, Toowoomba, QLD 4350.
Email: benjamin.allen@daff.qld.gov.au

Management of vertebrate pests in peri-urban areas is complicated by diverse stakeholder attitudes and priorities, limited control options and deliberate or inadvertent interference from people. These issues can lead to poor application of pest monitoring and control practices, and ultimately poor data quality and management outcomes. Pest managers in peri-urban areas often have substantial human resources devoted to pest management, which is advantageous. However, workload, funding and other constraints typically limit the effort that can be spent monitoring and controlling pests. Fortunately, slight adjustments to common pest monitoring practices and the adoption of technological advances can dramatically improve the performance, data quality and practical value of pest monitoring and control. In this study, we identify and discuss three practical ways in which canid pest (dingoes/ wild dogs, stray dogs and foxes) management can be improved in peri-urban areas, using examples from coastal Australian cities.

GPS-tracking collars fitted to wild dogs can be a useful tool for identifying daytime resting places, den sites and environmental movement bottlenecks used by wild dogs. Understanding the characteristics of these sites can assist development of targeted control practices. Knowledge of movements also facilitates appropriate scaling of control operations whereby control can be applied at scales relevant to the target animal or impact.

The standardised deployment of remote trail-cameras can identify not only relative abundance trends of pest and native animals, but can also highlight the timing of animal activity and interactions between species. Understanding animal activity times can assist in developing wild dog control strategies that minimise the risk of interference by humans, domestic dogs or foxes.

The standardised handling of data obtained from remote cameras, GPS-collars or other wildlife monitoring efforts can facilitate data sharing within and between organisations. Such practices have the potential to yield data of far greater inferential value and facilitate mutually beneficial collaborations. Simple adjustments to data handling practices can also dramatically reduce the data handling time required by practitioners, freeing up time for other frontline tasks.

Rather than an ad hoc or observation-based approach to wild dog control, adoption of new technology and fine tuning of data capture and handling practices can permit a more streamlined evidence-based approach to management of the animal and the impact. We will discuss the accrued benefits from these advances as available to the agencies involved and highlight potential applications to other stakeholders interested in the management of vertebrate pests in peri-urban areas.

EXPERIENCE FROM EL TEIDE NATIONAL PARK, CANARY ISLANDS, SHOWS THAT HUNTING TO CONTROL RABBITS DOES NOT MEET CONSERVATION GOALS

Brian Cooke[1], Marta Lopez Darias[2] and Juan Luis Rodriguez Luengo[3]

[1]Institute for Applied Ecology, University of Canberra, Canberra 2601.
[2]Instituto de Productos Naturales y Agrobiologia (CSIC), San Cristobal de La Laguna, Tenerife, Canary Islands, Spain.
[3]Servicio de Biodiversidad, Gobierno de Canarias, Santa Cruz de Tenerife, Canary Islands, Spain.
Email: Brian.Cooke@canberra.edu.au

In some Australian states it is considered politically expedient to allow hunters into national parks to control mammalian pests. Such decisions contradict several major principles of pest control. It is obvious, for instance, that such decisions are usually made without considering whether hunters can remove enough pests to drive populations down and achieve conservation goals. Instead, actions seem to be based on the simplistic notion that killing a few pests 'must do some good'. Nonetheless, there are few practical examples available from Australia to show why such thinking is flawed. We can, however, draw on experiences from other countries where introduced vertebrate pests are a problem in national parks and see whether hunting is a potential solution. A good example is provided by experiences in El Teide National Park on Tenerife, one of the Canary Islands. El Teide is one of the 12 natural treasures of Spain and has been a world heritage site since 2009. It also hosts over 2.8 million visitors annually so its management is of considerable importance both economically and culturally. Rabbits were introduced to the Canary Islands possibly 450 years ago by Spanish colonists and a significant hunting industry has persisted since. However, the vegetation of these isolated islands is as unique as that of the Galapagos Islands and many endemic plant species and ecosystems have been severely compromised by rabbits. The arid, high altitude ecosystem that surrounds El Teide volcano and associated ancient caldera is no exception. Signs of rabbits are common in most of the area and even common shrub species show typical rabbit 'browse-lines' 50 cm above the ground. Long-term research shows that grazing (largely by rabbits) is changing the vegetation into a virtual monoculture where one plant species which fortuitously had chemical defences against rabbits is now at an advantage. Yet these changes are on-going despite the fact that almost 4000 hunters, along with their dogs, currently enter the park each year. We analysed annual data on rabbit counts and numbers of rabbits taken over almost 20 years and found that despite increasing numbers of hunters the off-take of rabbits rose only slowly. The number of rabbits bagged per hunter actually fell significantly as more hunters took part. More to the point, the off-take of rabbits was demonstrably far below the number needed to off-set annual recruitment. The data make it clear that, even in countries such as Spain where there are large numbers of hunters, and a well-developed hunting culture, hunting is not a reliable way of meeting conservation goals such as protecting plant ecosystems. The time and effort spent in administering hunting permits would be far better spent on more effective direct action to reduce rabbits.

REFLECTING ON A COMPLIANCE APPROACH TO RABBIT CONTROL

Alex Thorp, John Matthews

Regulation and Compliance Group, Department of Environment and Primary Industries,
915 Mount Napier Road, Hamilton, VIC 3300.
Email: alex.thorp1@depi.vic.gov.au

In 1995 the Victorian Government implemented a compliance-based approach as a strategy to achieve long-term control of European rabbits across the state. This was the first time the Victorian Government had utilised the provisions of the *Catchment and Land Protection Act 1994* at a landscape scale in order to ensure that land owners and managers acted on their legal responsibilities to control established pest animals and as leverage to support community led action. The approach focuses on nil-tenure management, using all of the available tools including education, incentives and enforcement.

The Rabbit Action Plan (RAP) Project was established to assess the success of this approach and to identify areas for improvement. The project consisted of two components: the reassessment of properties that had previously been exposed to compliance; and a land owner/manager survey designed to identify drivers and barriers to achieving long-term rabbit control.

Properties involved in the project were randomly selected from the Glenelg-Hopkins catchment in south-west Victoria. Historical infestation and property assessment records were analysed from a total of 100 properties across project areas that received compliance between 1996 and 2012. On-ground property audits were conducted to establish current infestation levels in order to measure the change in rabbit abundance and warren density and condition since previous assessment or intervention. A survey was conducted of all 100 property owners/managers to identify drivers and barriers to participation in best practise rabbit control and to gauge the influence that the compliance approach had on land owners'/managers' attitudes and actions in rabbit management. Information gathered by the project will be used to guide future compliance activities and investment.

REFINING OPERATIONAL PRACTICES FOR CONTROLLING RABBITS ON AGRICULTURAL LANDS

A. David M. Latham, Graham Nugent and Bruce Warburton

Landcare Research, PO Box 69040, Lincoln 7608, New Zealand.
Email: lathamd@landcareresearch.co.nz

Rabbit abundance has reached pre-rabbit haemorrhagic disease (RHD) levels in some parts of New Zealand. They are negatively impacting stocking rates and environmental values, and threatening the economic viability of farms in rabbit-prone areas. Although research to improve the effectiveness of the RHD virus continues, aerial poisoning using 1080 or pindone is currently the only practical method available to farmers for controlling rabbits at high densities. This method, however, is expensive and can cost up to $140 per hectare for 1080, and even more for pindone. High costs result primarily from the high bait sowing rates used and the best-practice requirement to broadcast bait as uniformly as possible to obtain complete coverage of the treated area. We compared the efficacy of strip sowing bait at an overall reduced sowing rate but not a reduced bait density within the treated area, with broadcasting, in two regions in New Zealand, during winters 2011–2013. Preliminary results suggest that the two strategies produce comparable reductions in rabbit numbers. Although some costs of control are fixed (e.g. site inspections and permits), we estimate that strip sowing bait can reduce per hectare control costs by 20–40%.

QUANTIFYING RABBIT DAMAGE TO PASTURE IN HAWKES BAY, NEW ZEALAND

Mike Perry[1], Al Glen[2] and Wendy Ruscoe[2, 3]

[1]Landcare Research, Private Bag 11052, Manawatu Mail Centre, Palmerston North 4442, New Zealand
[2]Landcare Research, PO Box 69040, Lincoln 7640, New Zealand
[3]Institute for Applied Ecology, University of Canberra, ACT 2601, Australia
Email: perrym@landcareresearch.co.nz

Rabbits in New Zealand damage pasture and native vegetation (Scroggie *et al.* 2012), and support inflated numbers of invasive predators (Cruz *et al.* 2013). However, few studies have measured the biological and economic impacts of rabbit grazing in New Zealand. We aimed to assess the impact of various rabbit densities on farmland in the eastern North Island.

In October 2012, 45 rabbit monitoring sites were established on Opouahi Station, a sheep and cattle grazing property in Hawkes Bay. Rabbits are abundant in the area, supporting high predator numbers that constantly invade a neighbouring conservation reserve. Based on spotlight counts, sites were designated as having low, medium or high rabbit densities (n = 15 sites in each category). No rabbit control was conducted during the course of the experiment.

Each site had four 250 x 250 mm plots. One plot was surrounded by a cage that excluded all grazers, and one plot had a cage that excluded livestock but not rabbits. The other two plots were un-caged experimental controls. All plots were clipped to sample the dry weight and composition of pasture. Sampling was repeated four times at approximately monthly intervals to measure pasture growth.

Here we present the effect of rabbit grazing on pasture growth and composition, and examine the relationship between rabbit density and impacts. Our results will allow farm managers to make informed decisions on when rabbit control becomes economically viable.

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DENSITY-DEPENDENT EFFECTS OF EUROPEAN RABBITS ON TREE SURVIVAL AND ABOVE-GROUND CARBON STORAGE IN A SOUTH-EASTERN AUSTRALIAN REFORESTATION PROGRAM

David M. Forsyth[1], Michael P. Scroggie[1], Anthony D. Arthur[2], Michael Lindeman[1], Steven R. McPhee[3], Tim Bloomfield[4] and Ivor G. Stuart[5]

[1]Arthur Rylah Institute for Environmental Research, Department of Environment and Primary Industries, 123 Brown Street, Heidelberg, VIC 3084.
[2]Australian Bureau of Agriculture and Resource Economics and Sciences, Department of Agriculture, Canberra, ACT 2601.
[3]Agricultural Technical Services Pty Ltd., 48 Warooka Road, Yorketown, SA 5576.
[4]Port Phillip and Westernport Catchment Management Authority, PO Box 2435, Sunbury, VIC 3429.
[5]Kingfisher Research, 20 Chapman Street, Diamond Creek, VIC 3089.
Email: dave.forsyth@depi.vic.gov.au

Reforestation is widely advocated as a solution to multiple global change problems, including biodiversity loss and climate change. However, browsing by invasive species may reduce the survival and/or growth of trees, compromising the effectiveness of reforestation programs. We conducted a field experiment to investigate the impacts of a widespread invasive herbivore, the European rabbit (*Oryctolagus cuniculus)*, on three native tree species (Manna Gum, Drooping Sheoak and Golden Wattle) planted in a landscape-scale reforestation program on private property near Bacchus Marsh, Victoria. Following exclusion of livestock by fencing, 180 trees were planted in each of ten experimental 1-ha units, with rabbit-proof exclosures (tree guards) erected around half of the trees on each unit. Five randomly-selected experimental units were subjected to sustained rabbit control. Rabbit density, and tree survival and growth, were monitored quarterly for 21 months in each experimental unit. Finally, we estimated above-ground carbon storage in a random sample of trees that had survived to the end of the experiment. Tree survival was better explained by rabbit density than by whether or not the unit was subjected to rabbit control: tree survival was highest at low rabbit density and declined with increasing rabbit density, with <5% of trees planted outside exclosures surviving for 21 months at high rabbit densities. However, even trees exposed to low (but non-zero) densities of rabbits had lower survival rates relative to trees from which rabbits had been completely excluded by exclosures. The density-dependent decline in tree survival with increasing rabbit density and reduced biomass of trees exposed to even low densities of rabbits resulted in a strong decline in above-ground carbon biomass with increasing rabbit density. These results demonstrate that rabbits can severely impact the outcome of reforestation programs in south-eastern Australia and highlight the importance of excluding rabbits (or at least controlling them to very low densities) in order to increase the survival rates and biomasses of trees planted in reforestation programs.

APPLICATION OF A SYSTEMS MAPPING TOOL TO SUPPORT COMMUNITY LED ACTION ON RABBIT MANAGEMENT

Lisa Adams[1], Paul Martin[2] and Andrew Woolnough[1]

[1] Department of Environment and Primary Industries, 1 Spring Street, Melbourne, VIC 3000.
[2] University of New England, Armidale, NSW 2351.
Email: lisa.adams@depi.vic.gov.au

A National Rabbit Facilitator (NRF) has been appointed by the Invasive Animals Cooperative Research Centre to support community led action on rabbit management. A part of this role is to investigate how groups with responsibilities for rabbit management work together, how this impacts front line action, and where there is scope for change to enable more effective community action.

We are using a systems approach (Martin and Verbeek, 2006) to understand how the various aspects of rabbit management are linked. The NRF is working with community, government and business stakeholders, initially in Victoria, to develop a state-wide rabbit management systems map. The map deliberately focuses on the human dimensions of rabbit management to clarify the groups involved, how decisions on rabbit management are being taken and what factors influence these decisions, how information on rabbit management is generated and used, and what we know about resourcing rabbit management – where the resources come from, how they are applied and to what effect?

The rabbit management systems map will provide the basis for dialogue among the stakeholders on issues and opportunities for rabbit management, options for system changes to better enable community led action on rabbits, and how these options might be progressed.

We anticipate that this systems approach could result in reforms to the financing and administration of rabbit control works, compliance and quality assurance strategies, and community support programmes.

The systems mapping tool and its application to rabbit management in Victoria will be discussed.

Reference:

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RAPTORS *VS* ALIENS: CAN NATIVE BIRDS OF PREY HELP CONTROL INVASIVE SPECIES?

Al Glen

Landcare Research, PO Box 69040, Lincoln 7640, New Zealand.
Email: glena@landcareresearch.co.nz

Much recent research has focused on interactions between terrestrial predators, such as wild dogs, foxes, cats, and their prey. Avian predators, which occur throughout Australia and New Zealand, are often overlooked in these studies. A recent meta-analysis showed less than 20% of Australian studies on predator interactions included raptors and/or reptiles as well as mammals (Glen in press). However, many birds of prey have similar diets to those of terrestrial predators, and could compete with them for prey. Some raptors also kill invasive birds and mammals, including invasive predators such as stoats, weasels, cats and foxes.

In New Zealand, native falcons are being used to control pest birds in vineyards (Kross *et al.* 2012), but could native birds of prey also assist ecological restoration by reducing the impacts of a much wider range of invasive predators or herbivores? While some raptor species, (e.g. harriers in New Zealand; black kites in Australia) may thrive in highly modified environments, others (e.g. New Zealand falcons, wedge-tailed eagles) may be suppressed by human persecution and/or habitat modification. Restoring populations of these species may benefit agriculture and biodiversity by helping to suppress invasive animals.

I summarise evidence for effects of native raptors on invasive species in Australia and New Zealand, and report preliminary results from a study in New Zealand's South Island, where native falcons, harriers and owls coexist with a range of invasive predators and prey.

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MANAGING WILD CANIDS IN MESIC ENVIRONMENTS: PREDATORS, PREY, PLANTS AND PEOPLE

Peter J. S. Fleming [1,2], Guy Ballard [2,3], Helen Morgan[2] and Nick Reid[2].

[1]Vertebrate Pest Research Unit, Biosecurity NSW, NSW Department of Primary Industries, Orange, NSW 2800.
[2]School of Environmental and Rural Sciences, University of New England, Armidale NSW 2351.
3Vertebrate Pest Research Unit, Biosecurity NSW, NSW Department of Primary Industries, University of New England, Armidale NSW 2351.
Email: peter.fleming@dpi.nsw.gov.au

Wild dog numbers and distribution have been increasing over much of north eastern NSW during the past 15 years. They are having significant social and economic impacts on livestock producers and local communities. Concurrently, pressure is brought to bear on producers by the wider community to reduce lethal control of wild dogs (and dingoes in particular) because of their iconic status and environmental benefit through speculated effects of trophic cascades, which, although untested, are already affecting management decisions.

Consequently, a collaborative 4-year experiment, funded by the Invasive Animals CRC, is investigating the effects of lethal control of wild canids on population dynamics and interactions between predators (wild dogs, red foxes, feral cats and spotted tailed quolls), their prey and the vegetation that the prey eats and finds cover in. The project provides a framework for associated studies, including the socio-economics of wild dog predation and societal attitudes to wild canids and their management. Other ecological, social and technological research hangs off the design framework. Here, we introduce the objectives, design, personnel, logistics and progress of the project.

POPULATION AND ACTIVITY RESPONSES OF FERAL CATS TO WILD CANID CONTROL IN NORTH-EASTERN NEW SOUTH WALES

Frances Zewe[1], Guy Ballard[1,2], Gerhard Koertner[1], Trent Forge[1], Karl Vernes[1] and Peter Fleming[1,3]

[1] Environmental and Rural Science, University of New England, Armidale, NSW 2351.
[2] Vertebrate Pest Research Unit, NSW Department of Primary Industries, University of New England, Armidale, NSW 2351.
[3] Vertebrate Pest Research Unit, NSW Department of Primary Industries, Orange Agricultural Institute, Orange, NSW 2800.
Email: fzewe@myune.edu.au

The productive ecosystems of north-eastern New South Wales support sympatric populations of wild dogs, foxes, feral cats and spotted-tailed quolls. How feral cats co-exist with these other predators in such areas is not known.

This research aims to address two key questions. Firstly, it aims to assess the impact of 1080 baiting for wild canid control on feral cat activity and abundance. To address this, we are fitting GPS-VHF collars to cats at paired treatment (1080 baiting for wild dog control) and nil-treatment sites. These sites span an altitudinal gradient from the agri-ecosystems of the New England Tablelands to lowland, coastal areas. We are also using camera traps to conduct a capture-recapture study of feral cats.

Secondly, we seek to determine how cats and spotted-tailed quolls interact in north-eastern New South Wales. Cats and spotted-tailed quolls are similarly sized and therefore may compete directly or indirectly for food and shelter. We hypothesise that the effect of competition in cat and spotted-tailed quoll interactions will be dependent on several habitat variables, including resource availability and predictability. Here we present preliminary data on activity patterns and habitat use by feral cats in north-eastern New South Wales.

CATS, QUOLLS AND TROPHIC CASCADES: ARE FERAL CATS ASSOCIATED WITH DECLINES IN THE EASTERN QUOLL?

Bronwyn Fancourt, Stewart Nicol, Clare Hawkins, Menna Jones and Chris Johnson

School of Biological Sciences, University of Tasmania, Hobart, TAS 7001.
Email: Bronwyn.Fancourt@utas.edu.au

The eastern quoll (*Dasyurus viverrinus*) is extinct on the Australian mainland, with Tasmania its last refuge. However, numbers in Tasmania are declining rapidly, with statewide populations declining by more than 50% over the past 10 years. Preliminary investigations have suggested a possible negative association between feral cats and eastern quolls. Feral cats are potentially a four-pronged threat to eastern quolls through predation, competition for resources, fear exclusion and the spread of diseases such as toxoplasmosis. However, cats and quolls have lived together in Tasmania for over 100 years without negative population impacts, so why would they have waited until now to make their move?

While Tasmania has largely escaped many of the mammal extinctions and declines suffered on the Australian mainland, marsupial dynamics in Tasmania are changing rapidly and new threats are emerging. The Tasmanian devil (*Sarcophilus harrisii*) is in steep decline due to the spread of the fatal Devil Facial Tumour Disease. Devil declines may be allowing mesopredators such as feral cats to be released from competitive pressure, leading to possible spatial and temporal shifts in activity and potentially an increase in abundance, which in turn could threaten quolls and other species.

Given the possible trophic cascades that may be occurring, we investigated possible associations between eastern quolls and feral cats by asking two questions:

1. Is toxoplasmosis associated with eastern quoll declines?
2. Is feral cat activity negatively associated with eastern quoll activity?

Eastern quoll populations were screened for the seroprevalence of *Toxoplasma*-specific IgG antibodies, with seroprevalence 5 times higher at sites with declining quoll populations, and a significant negative association between seroprevalence and number of quolls captured. However, survivorship did not differ between seropositive and seronegative individuals, suggesting that eastern quoll populations are not limited by toxoplasmosis. Higher seroprevalence at declining sites, however, is a signal of an increased exposure to feral cats, suggesting increased predation, competition or exclusion may be associated with quoll declines. Remote camera surveys confirmed higher feral cat densities at sites where quolls were declining. However, activity patterns were more complex, with activity times of cats and quolls varying with carnivore community structure. The possible implications of these changes in spatial and temporal activities will be discussed.

DISTRESS VOCALISATIONS IN WILD DOGS

Huw Nolan[1], Wendy Brown[1], Guy Ballard[2], Paul McDonald[1], T. Laegel[1]

[1]School of Environmental and Rural Science, University of New England, Armidale NSW 2351.
[2]New South Wales Department of Primary Industries, Armidale NSW 2351.
Email: hnolan2@myune.edu.au

Acoustic location and identification technologies have the potential to be valuable tools for ecologists and ethologists, enabling animals in remote environments to be located and identified (Huetz and Aubin 2012). Because the acoustic properties of the environment influence sound propagation, some mammals adjust the usage and/or structure of their vocal signals accordingly. We tested if wild dogs similarly adapted calls to suit their environment. We analysed spectral (such as frequency and amplitude) and temporal (such as call length) components of vocalisations recorded from trapped individuals. Dogs were trapped at three markedly different sites: New England, NSW, characterised by thick eucalyptus forests and gorges; the Sunshine Coast, Queensland, characterised by high levels of anthropogenic noise and low lying cane fields; and the desert of WA characterised by low spinifex vegetation and a sandy substrate. While data collection is ongoing, we have early indications that the structure of wild dog vocalisations differs across sites. Understanding the differences in vocalisations of wild dogs in varying environments is vital to the success of remote acoustic monitoring and improved wildlife management.

Reference:

Huetz, C. and Aubin, T. 2012. *In* Sensors for ecology - Towards integrated knowledge of ecosystems. Le Galliard, J-F., Guarini, J-M. and Gaill, F. (eds). Centre National de la recherche scientifique (CNRS), Paris. pp.83-98.

A NOVEL APPROACH TO MANAGING WILD DOGS ON PUBLIC LAND

Michael Bretherton[1], Simon Martin[1], Vaughan Kingston[1], Ken Skews[2], Andrew Crocos[1], Glenn Lineham[1] & Andrew Woolnough[1]

[1]Regulation and Compliance Group, Department of Environment and Primary Industries.
[2]Bring Sheep Back to Ensay Group, Ensay, Gippsland.
Email: Michael.Bretherton@depi.vic.gov.au

The most effective way of reducing the impact of wild dogs is through sustained control programs with all land managers working together across private and public land. This is the approach pursued by the Victorian Government.

For public land managers, wild dog control competes with other land management priorities, limited resources and the scale of tracts of land requiring management. The challenge for public land managers is ensuring that appropriate wild dog control is undertaken in partnership with local communities. A group of landholders in the Gippsland region of Victoria came up with the idea of empowering local community groups to control wild dogs on public land. Whilst simple in concept, the implementation of the idea was complex.

The process for community groups gaining approval to conduct wild dog control on public land included:

- ensuring that participants in the community groups had appropriate endorsements (i.e. a valid 1080 user endorsement) and adhered to the appropriate codes, standards, labels and other guiding documents;
- creating a register of volunteers (ensuring endorsements and serving as a tool for indemnity); and
- gaining authority to undertake control activities on public land by the participants on the register of volunteers.

Community groups were supplied with an information package by the Department of Environment and Primary Industries that clearly outlined the roles and responsibilities of all parties. The package included information on how to meet accreditation requirements, comply with codes of practice and standard operating procedures, meet work, health and safety obligations, and how individuals would be protected through liability and insurance arrangements.

Like many new initiatives, this novel approach encountered a number of challenges that needed to be overcome to enable its implementation. The community groups have since successfully undertaken wild dog control on public land, whilst fulfilling all their requirements and obligations. The success of this initiative in Gippsland has led to implementation in other areas of Victoria. Importantly, this initiative represents how a public-private partnership can achieve a common objective.

SINGLE OR MULTIPLE-CAPTURE TRAPS – IS MORE ALWAYS BETTER?

Bruce Warburton and Andrew Gormley

Landcare Research PO Box 69040, Lincoln, New Zealand.
Email: warburtonb@landcareresearch.co.nz

Trapping to control possums, rodents, and mustelids is expensive because most traps only capture a single animal and require frequent checking to clear and reset. As a consequence, multiple-capture traps have recently become available, but are more expensive (NZ$150–$170) than single-capture traps (NZ$9–$30). Deciding what is the most cost-effective option requires an understanding of how many captures a trap might have at a single site over the time between checks. Although multiple-capture traps seem a good idea when pest densities are high, when there are few animals (as is the case when pests are being maintained at low densities), spending scarce operational funds on traps that can kill 10–20 individuals might not be justified. Using an individual-based simulation model to determine the maximum number of captures that any one trap site might have indicated that for possums, ship rats, and stoats, the most cost-effective option might be to use 2-3 cheap single capture traps at a site rather than a single expensive multiple-capture trap.

MODIFIED VICTOR® EASY SET® RAT TRAPS FOR TRAPPING STOATS AND SHIP RATS IN NEW ZEALAND: PEN AND FIELD TRIALS

Grant Morriss and Bruce Warburton

Landcare Research, Lincoln 7640, New Zealand.
Email: morrissg@landcareresearch.co.nz

In New Zealand stoats (*Mustela erminea*) and ship rats (*Rattus rattus*) are targeted by trapping to mitigate their predation impacts on native wildlife. Available traps, especially for stoats, are expensive, and for community groups with limited funding, allocating a high proportion of their budget to purchasing traps restricts the area they can place under control. Consequently, there is a need for a low-cost alternative that also meets the killing performance requirements of the National Animal Welfare Advisory Committee trap-testing guidelines. A cheap snap-back trap (Victor® Easy Set® rat trap) was modified by changing the treadle trigger to a pull trigger and addition of a plastic shroud to consistently direct and align the approach of animals to the front of the trap. These traps, in vertical and horizontal sets, were tested with both stoats and ship rats. During each test the trap had to render 10 of 10 animals irreversibly unconscious within 3 minutes. The modified trap passed with both species in both trap sets. All stoats were struck across the head whereas rats were struck either on the head or neck with all animals found to be irreversibly unconscious when first monitored. The modifications were used to develop commercial add-ons to standard snap-back traps which were then field tested over the 2013–14 summer. The results of initial development and pen testing and subsequent field testing will be presented.

REVISION OF THE AUSTRALIAN PEST ANIMAL STRATEGY

Ian Gaze

Weeds and Pests Section, Department of Agriculture
18 Marcus Clarke Street, Canberra ACT 2601.
Email: Ian.Gaze@daff.gov.au

The current Australian Vertebrate Pest Strategy was developed by the Vertebrate Pests Committee (VPC) and endorsed by the then Natural Resource Management Ministerial Council in 2007. The Strategy was reviewed during 2012-13, and the review made a number of recommendations for a revised Strategy. These included garnering greater stakeholder interest and ownership of the Strategy. The development of the Intergovernmental Agreement on Biosecurity also has implications for the new Strategy. This session will outline the Committee's approach and direction for a revised Strategy, prior to its release for public consultation.

DENSITY ESTIMATION FROM PRESENCE-ABSENCE DATA USING SPATIALLY-EXPLICIT MODELS

Dave Ramsey[1], Peter Caley[2] and Simon Barry[2]

[1]Arthur Rylah Institute, Department of Environment and Primary Industries, 123 Brown St, Heidelberg, VIC 3084.
[2]CSIRO Mathematics, Informatics & Statistics, GPO Box 664, Canberra ACT 2601.
Email: david.ramsey@depi.vic.gov.au

Many methods for sampling vertebrate pests are based on detection/non-detection (presence/absence) data. Usually, such data are subject to analysis to estimate the probability of occupancy for a sample location, corrected for imperfect detection (occupancy analysis). While estimates of occupancy are useful in many contexts they are still a fairly crude representation of the dynamics of the population. Indeed, many problems in vertebrate pest ecology require estimates of population density or abundance (e.g. harvest quotas, disease/damage thresholds). Traditionally it has been assumed that it is difficult or impossible to estimate animal density from presence/absence data unless certain restrictive assumptions were made or supplementary information was collected. However, previous studies have estimated local population density from presence-absence data assuming a functional relationship between detection probability p and local density N, the so-called Royle/Nichols (RN) model (Royle and Nichols 2003). This estimator requires a similar design to traditional occupancy study that assumes independence between sample units. That is, individuals detected at a particular sample unit cannot be detected at other sample units. If animal home ranges overlap multiple sample units then estimates of population abundance using this model are biased high. This is a particular risk in studies of animals with large home ranges, such as many carnivore species. Here we extend models for density estimation for presence/absence data to situations where sample locations are not independent. The model assumes that individuals can be detected at multiple sample units producing spatially correlated detections. A spatially-explicit model of the detection process is then fit to the correlated detection data using Approximate Bayesian Computation methods as well as conventional likelihood-based Markov Chain Monte Carlo methods. The model contains parameters for home range size, individual detection probability and population density. As the model is spatially-explicit, a by-product of the estimation process is the likely locations of home range centres within the sampled area. We report on the performance of the new model using simulation and illustrate its use with a practical example estimating the abundance of foxes in the Grampians national park from remote camera surveys.

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DEVELOPING BAITING STRATEGIES FOR ERADICATING *RATTUS RATTUS* ON TORRES STRAIT ISLANDS

L. K.-P. Leung, J. J.-M. Koh

School of Agriculture and Food Sciences, University of Queensland, Gatton, QLD 4343.
Email: luke.leung@uq.edu.au

Exotic rodents are an important threat to island biodiversity. Little is known of the population ecology of *Rattus rattus* on islands in Australia. This knowledge is useful for developing strategies to prevent eradication failures. This study aims to determine (1) the home range and population response of *R. rattus* to the initial phase (two weeks) of an experimental baiting campaign; (2) the consumption of wax block baits during this initial phase; (3) the palatability of wax block with Bitrex (Ditrac) and without Bitrex (X-Verminator) to rats; (4) whether or not elevating the bait station will affect bait take by invertebrates and rats; and (5) the palatability of loose grain bait (Mouse-Off) versus wax block bait to rats and invertebrates. The study was conducted in the human inhabited area of Poruma Island, Queensland in early 2011. Two bait trials, Ditrac (0.05 g brodifacoum kg^{-1}) versus X-Verminator (0.05 g brodifacoum kg^{-1}) bait and Mouse-off (0.05 g bromadiolone kg^{-1}) versus X-Verminator bait were conducted. The first trial was also used as the initial baiting phase and the population response to this was assessed by pre- and post-baiting live-trapping and radio-tracking. X-Verminator should be used in eradications of *R. rattus* on Poruma and other similar islands because this bait was found to be 4.5 times more palatable than Ditrac with bitrex. Baiting also significantly increased the proportion of juveniles, decreased the overall body condition of the population and the home range area. This suggests that younger, weaker individuals are excluded from consuming the bait by stronger, more dominant individuals at this initial baiting phase. The reduction in home range size was possibly due to the effects of toxicosis. Ants removed a daily average of 1.35 g/bait station of X-Verminator and this rate of removal may compromise the availability of bait to eradicate rats. Elevating the bait stations did not have any effect on bait take by the ants or rats. The proximity of the bait station to ant nests appeared to affect the rate of bait take by ants and this relationship should be exploited to minimize bait take by ants.

DEVELOPMENT OF RE-SETTING TOXIN DELIVERY DEVICES AND LONG-LIFE LURES FOR RATS

Elaine Murphy[1,2], Tim Sjoberg[2], Peter Dilks[2], Duncan MacMorran[3], Charles Eason[1,4], Paul Aylett[3]

[1]Centre for Wildlife Management and Conservation, Department of Ecology, Lincoln University, NZ.
[2]Department of Conservation, Private Bag 4715, Christchurch, NZ.
[3]Connovation Ltd, Auckland, PO Box 58613, Manukau, Auckland NZ.
[4]Cawthron Institute, Private Bag 2, Nelson, Nelson, NZ.
Email: Elaine.Murphy@lincoln.ac.nz

Introduced rats continue to have a major impact on biodiversity around the world, and improved control techniques are required to avoid further extinctions. We are trialling re-setting toxin-delivery systems (Spitfires) targeting a range of predators, including rats. The Spitfire works by firing a paste containing a toxin on to the belly of rats as they pass through a tunnel. The device then resets. When the rats groom the paste from their fur, they ingest the toxin. Each Spitfire is capable of approximately 100 doses and is fitted with a counter and a delay mechanism. 1080 has been trialled in a Spitfire and 6/6 wild Norway rats (*Rattus norvegicus*) and 8/9 ship rats (*R. rattus*) died. Pen trials are continuing to increase sample size and field trials are planned for 2014. Zinc phosphide, cholecalciferol and C+C (cholecalciferol + coumatetralyl) are also being investigated as alternative toxins for the Spitfire.

Resetting devices that are expected to work for long periods without being serviced also require long life lures. We are investigating pheromone and prey-scented lures with captive ship and Norway rats in outdoor enclosures. The volatile components of the most attractive lures will then be analysed using headspace sampling and gas chromatographic analysis.

The long-term, effective control of introduced rats will require a range of toxins with different modes of action, and will rely on a number of different delivery systems.

WHICH AERIAL BAITING RATE IS BETTER FOR WILD DOG CONTROL?

Guy Ballard,[1,5], Peter Fleming,[2,5], Sam Doak[3] and Paul Meek[4,5]

[1] Vertebrate Pest Research Unit, NSW DPI, Armidale, NSW, 2351.
[2] Vertebrate Pest Research Unit, NSW DPI, Orange, NSW, 2800.
[3] NSW National Parks & Wildlife Service, Walcha, NSW, 2354.
[4] Vertebrate Pest Research Unit, NSW DPI, Coffs Harbour, NSW, 2450.
[5] School of Environmental & Rural Sciences, University of New England, NSW, 2351.
Email: guy.ballard@dpi.nsw.gov.au

In 2009, the Australian Pesticides and Veterinary Medicines Authority (APVMA) reduced the maximum aerial baiting rate for wild dogs to 10 baits per km. This new rate is equal to 25% of the maximum rate permitted up to 2009 and less than 10% of historic aerial baiting rates.

Over four baiting seasons, from 2010 to 2013, we trapped and then fitted GPS-VHF collars to wild dogs in order to assess the effectiveness of three baiting rates: 0, 10 and 40 baits per kilometre. Using our knowledge of >120 wild dogs' exposure and survival, as well as activity data from camera trapping transects, we discuss the relative efficacy of the three aerial baiting rates for achieving wild dog control.

RESPONSES OF TWO FOX POPULATIONS TO CO-ORDINATED BAITING IN AN AGRICULTURAL LANDSCAPE

Andrew Bengsen

NSW Department of Primary Industries, Locked Bag 6006, Orange NSW 2800.
Email: andrew.bengsen@dpi.nsw.gov.au

Introduced predators, such as the red fox (*Vulpes vulpes*), are often subjected to lethal control programs to reduce their impacts on economic or conservation resources. It is generally assumed that these programs reduce the local density of the target species, but the effects of routine control programs conducted by private landholders are seldom tested. Other effects of control programs on predator populations, such as changes in structure and function, are also rarely examined.

I evaluated the effects of two poison baiting programs conducted by local fox baiting groups in the Goonoo region of central New South Wales, in winter 2012 and autumn 2013. The programs aimed to reduce fox abundances over large areas of mixed agricultural land in order to curtail predation on lambs and to support other actions to protect mallee fowl. I used camera trap surveys to monitor changes in the abundance of foxes at monitoring stations before and after baiting, and tracked the fate and landscape use behaviour of 19 GPS-collared foxes. I also examined the importance of spatial coverage of baits in relation to fox home ranges.

Plotting of actual and simulated home ranges graphically illustrated the benefits of coordination among neighbours for exposing a meaningful proportion of the target population to baits. Nonetheless, nearly 70% of the foxes using baited properties were estimated to have survived baiting, and neither baiting program induced a detectable decrease in fox abundance at monitoring stations. All collared foxes that were killed by baits died within four days of baits being deployed, even when baits were distributed twice in one season. There are several possible causes for the high estimated survival rate. The short latent period for those collared foxes that were killed by baits suggests that insufficient baiting intensity or a high prevalence of bait shyness would be important hypotheses to test in future.

Some foxes shifted the geographic centre of their short-term (7 day) home ranges after baiting, further highlighting the importance of co-ordinating control activities among neighbouring properties. Changes in landscape use by surviving foxes could also have implications for monitoring programs that rely on activity indices rather than estimates of absolute abundance or density. These may also be relevant to other programs aiming to detect changes in populations of territorial animals subjected to lethal control.

Co-ordination among neighbours is critical to the success of lethal control programs aiming to reduce the density and impacts of foxes in mixed agricultural landscapes. However, even where it is impossible to increase the number of landholders participating in co-ordinated programs, substantial improvements in fox control could be achieved by improving bait encounter and consumption on those properties that do participate.

ASSESSING THE UPTAKE OF GROUND-DISTRIBUTED FOX BAITS IN WESTERN AUSTRALIA

Shannon J. Dundas, Peter J. Adams and Patricia A. Fleming

School of Veterinary and Life Sciences, Murdoch University, South St, Murdoch WA 6150.
Email: S.Dundas@murdoch.edu.au

Ground-baiting for foxes in Western Australia is an important management technique for biodiversity rich areas that are not adequately covered under Western Shield (aerial baiting program run by the Department of Parks and Wildlife). For example, riparian areas inhabited by the quokka (*Setonix brachyurus*; an endemic habitat specialist macropod listed as Vulnerable) are ground-baited monthly. Over 9 months, we monitored fox baits distributed in seven of these sites. Baits remained in the environment for an average of only 2.26 ± 2.17 nights after deployment (min 0, max 15 nights). This effectively limits the protective benefit of this baiting program to approximately 10% of the time. Partial bait-take by non-target species was frequently observed and could be an issue if foxes ingest baits with sub-lethal doses of 1080 and learn to avoid baits. Results of this study will be discussed in terms of implications for the conservation of native species in Western Australia.

ASSESSING THE IMPACT OF FOX BAITING ON TASMANIAN DEVILS

Channing Hughes[1], Nick Mooney, and Christopher Dickman[1]

School of Biological Sciences, University of Sydney, NSW.
Email: nhug7059@uni.sydney.edu.au

The recent introduction of red foxes (*Vulpes vulpes*) to Australia's island state of Tasmania represents a significant ecological and economic threat. In response, the Tasmanian Government is conducting a fox eradication program across much of the state, using Foxoff®, a bait containing the poison sodium fluoroacetate (commonly known as 1080). The bait is potentially attractive to native Tasmanian carnivores as well as to foxes. Of particular concern is the endangered Tasmanian devil (*Sarcophilus harrisii*), which is already at risk from an emergent infectious disease, Devil Facial Tumor Disease.

We report the results of a two-year before-after-control-impact (BACI) study of Tasmanian devil populations at four sites in north-western Tasmania — two poison-treatment sites that were baited midway through the study, and two control sites that were never baited. We monitored the four populations (a total of nearly 400 individuals) through a series of capture-mark-recapture (CMR) surveys. Population size, demographic makeup, and animal condition were compared between treatment and control sites. Preliminary results suggest that fox baiting had no negative impact on devil populations. Final results will be available by the time of conference.

THE DIET OF FERAL CATS AND FOXES IN SOUTHERN QUEENSLAND

James Speed and Matthew Gentle

Robert Wicks Pest Animal Research Centre, Biosecurity Queensland, Department of Agriculture, Fisheries and Forestry, Queensland, 203 Tor Street, Toowoomba, QLD 4350.
Email: james.speed@daff.qld.gov.au

Feral cats (*Felis catus*) and red foxes (*Vulpes vulpes*) are widely recognised as having a direct impact on wildlife through predation. Numerous dietary studies from southern areas of Australia have identified introduced animals such as the European rabbit (*Oryctolagus cuniculus*) often represent a large proportion of the diet of foxes and feral cats. However, little is known about diet composition in rabbit-free areas of southern Queensland. The analysis of →280 stomachs from cats and red foxes taken from agricultural areas of the Southern Brigalow belt, in south-eastern Queensland, indicate that cats prey heavily on mice (*Mus musculus*), followed by birds then other mammals. Foxes also preyed upon mice, with invertebrates and carrion also making up a significant proportion of their diet, while these were virtually absent in the diet of cats.

This paper will present data on the diet of cats and foxes in fragmented cropping and grazing lands from southern Queensland, where rabbits are absent. We shall compare the diet of cats and foxes, and discuss the relative importance of prey items to each species. Finally, we shall discuss how this contributes to our broader understanding of fox and feral cat ecology, and consider the implications for managing the impacts of these two pervasive predators.

SPATIAL AND TEMPORAL VARIATION IN THE DIETS OF WILD DOGS AND FOXES IN VICTORIA

Naomi Davis[1] and David Forsyth[2]

[1]Department of Zoology, The University of Melbourne, VIC 3010.
[2]Arthur Rylah Institute for Environmental Research, Department of Environment and Primary Industries, 123 Brown Street, Heidelberg, VIC 3084.
Email: ndavis@unimelb.edu.au

There is increasing evidence that the abundance of carnivores is at least partly determined by food availability. Hence, understanding variation in the diets of carnivores will enable the consequences of factors that alter food availability (e.g. culling of prey or the establishment of new prey) to be explicitly considered by managers. We collated published and unpublished literature and data on the diets of wild dogs and foxes in Victoria. Our review indicates that a large number of mammal species are consumed by wild dogs, but the bulk of the diet consists of a few medium-sized native marsupials (e.g. average frequency of occurrence was 27% for the swamp wallaby and 20% for the common wombat). European rabbits and sheep were commonly consumed by wild dogs (27% and 8% average frequency of occurrence, respectively), however, the frequency of other introduced mammal species in their diet is generally low (average frequency of occurrence <1%).

The diet of foxes consists largely of small mammals, particularly European rabbits. Native mammals comprise a smaller component of the diet of foxes, although Phalangeridae are commonly consumed. A number of wild dog and fox prey species not recorded in the Victorian literature were recorded in unpublished diet data, including numerous small native marsupials and the introduced hog deer.

Preliminary analysis indicates spatial variation in the diets of wild dogs and foxes in Victoria. For wild dogs, the most commonly occurring prey items recorded in East Gippsland, North Central and North East Victoria were native swamp wallaby, common wombat and possum species. In the North East, introduced sambar deer and European rabbits were commonly recorded. As well as swamp wallaby and common wombat, cattle and birds were commonly consumed in West and South Gippsland. Cattle were also commonly recorded in Central Victoria along with other introduced and native mammals, birds and insects. Insects were common prey in the Mallee region, followed by sheep, western grey kangaroo and rabbit. Native possums were one of the most common prey items recorded in the diet of foxes for all regions considered except the Mallee and North East Victoria.

For foxes, insects were common prey items except in East Gippsland. Introduced rabbits were common prey items in West and South Gippsland, the Mallee, Central and North East Victoria. Birds were common prey in Central Victoria and also in West and in South Gippsland where native swamp wallaby were also commonly consumed. The introduced house mouse was a common component in the diet in the Mallee and North East Victoria. Reptiles and sheep were also commonly consumed in the Mallee while native bush rats were commonly consumed in the North East. Seeds were common in the diet of foxes in North Central Victoria, where introduced sambar were also recorded in the diet. Herbage was a common component of the diet of foxes. The implications of these results for the ecology and management of wild dogs and foxes in Victoria will be discussed.

USE OF A TARGET-SPECIFIC FEED STRUCTURE TO IDENTIFY POTENTIAL BAITING OPPORTUNITIES FOR THE CONTROL OF OVERABUNDANT HERBIVORE PEST SPECIES

Rob. J. Hunt[1], Andrew W. Claridge[1,2], Peter J. S. Fleming[3], Ross B. Cunningham[4], Benjamin G. Russell[5] and Douglas J. Mills[1].

[1]National Parks and Wildlife Service, Queanbeyan, NSW 2620.
[2]University of New South Wales, Canberra, ACT 2600.
[3]Vertebrate Pest Research Unit, Biosecurity NSW, Orange, NSW 2800.
[4]The Australian National University, Canberra, ACT 0200.
[5]National Parks and Wildlife Service, Hurstville, NSW 2220.
Email: rob.hunt@environment.nsw.gov.au

Negative impacts associated with overabundant pest herbivore species are legally well accepted, with feral goats (*Capra hircus*) listed as a key threatening process under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Additionally, herbivory and environmental degradation caused by feral goats and deer are listed as key threatening processes in New South Wales under Schedule 3 of the *Threatened Species Conservation Act 1995*. Despite these listings, control techniques for these species are limited, particularly when compared to the number of techniques available for other pest species. To redress this deficiency we trialled a feed structure exploiting differences in limb morphology (foot size/structure) between native macropods (kangaroos/wallabies) and introduced ungulates (feral goats/deer) to allow select access to attractants. In a field situation, these feeders allowed for a high level of target selectivity. Commercially available livestock salt blocks were found to be highly attractive to the target species. Evaluation of potential toxicants identified a humane and rapid-acting agent that may be presented within the structure. Ongoing field trials continue to identify the potential for further development of this target selective, humane and cost efficient method as an additional technique for controlling overabundant herbivore pest species.

SELF-RESETTING TRAPS FOR GROUND BASED PEST CONTROL FOR CONSERVATION IN NEW ZEALAND FORESTS – INTERIM RESULTS

Craig Gillies, Nic Gorman, Stephen Conn, Ian Crossan, Matthew Haines and Jenny Long

Department of Conservation, Science & Capability Group, Private Bag 3072, Hamilton NZ.
Email: cgillies@doc.govt.nz

We will report on a series of field trials of the Goodnature Ltd A12 resetting trap for controlling brushtail possums (*Trichosurus vulpecula*) and the A24 resetting trap for rats (*Rattus rattus* and *R. norvegicus*) and stoats (*Mustela erminea*) in New Zealand forests. Our initial short-term, small-scale pilot trials of the devices showed that both the A12 and the A24 resetting traps appeared to kill the target animals quickly and humanely. We then proceeded to longer-term, operational-scale trials of the traps. The operational-scale trials of the A12 possum traps were conducted between November 2011 and June 2013 at Trounson Kauri Park in Northland and in the Te Urewera National Park. WaxTag® and trap-catch indices of possum abundances indicated that populations of this pest were reduced to acceptable levels in Trounson Kauri Park but not in the Te Urewera site. About 40% of the A12s purchased for the possum trials suffered mechanical failures (mostly slow gas leaks) during the testing period. Operational scale trials of the A24 traps to target stoats started in September 2012 in the Te Urewera National Park and at the Rotoiti Nature Recovery Project at Nelson lakes. Tracking tunnel indices of abundance indicated that, despite a high rate of mechanical failure of the early versions of the traps, stoat populations were suppressed at both sites during the first spring and summer of these trials. The rat control trials of the A24 started in August 2012 in the Onepu block in Northern Te Urewera and at Boundary Stream in the Hawkes Bay. Tracking tunnel indices of rat abundances indicated that populations of this pest were not suppressed to acceptable levels at either site during the first trial season. We suspect this was because the long-life auto-lure was not strongly attractive to rats and/or due to a high rate of mechanical failure of the devices early in the trials. We believe that the auto-lures (for all the target pests), and the mechanical reliability of the devices themselves, still require further refinement and testing before the full potential of these self-resetting traps can be realised. The Goodnature Ltd team worked hard to develop solutions to the mechanical problems we discovered, and made many incremental changes to their trap designs throughout our trials. We will be working with the Goodnature team over the next two years to further evaluate the latest versions of the traps and the new long-life auto-lures they have recently developed.

HOW EFFECTIVE IS D-TER® ANIMAL AND BIRD REPELLENT IN REPELLING BRUSHTAIL POSSUMS?

Bradley Gale and **Luke Leung**

School of Agriculture and Food Sciences, University of Queensland, Gatton, QLD 4343.
Email: bradley.gale@uqconnect.edu.au; luke.leung@uq.edu.au

The common brushtail possum (*Trichosurus vulpecula*) is abundant in suburban areas and causes damage to garden plants by browsing. Chemical repellents are widely available to repel animals but little is known of their effectiveness. This study aimed to test the efficacy of D-TER® animal and bird repellent (Lorac Australia Pty Ltd) in repelling the species from consuming a highly palatable food (apple) and a moderately palatable food (carrot). The repellence was based on difference in consumption between a treatment feed station and control feed station 3 m apart within the same site.

The experiment was conducted in two suburbs in Brisbane over two periods. Two feed stations were placed 3 m apart at each site. Each feed station was provisioned with apple and carrot each evening at dusk over a 10 day pre-treatment period and a 5 day treatment period. D-TER® was applied to one of the feed stations (treated) at the site for the treatment period. The other feed station was used as the control feed station.

For both food types, change in mean daily percentage consumption differed significantly between the treated and control feed stations. Carrot consumption was reduced by 29.9% and 7.5% at the treated and control feed stations, respectively. Apple consumption increased by 6.87% and 67.8% at the treated and control feed stations, respectively.

The results indicated that D-TER® was effective in repelling brushtail possums from both food types. However, D-TER® was effective in decreasing the mean daily percentage consumption from the pre-treatment period to the treatment period for carrots but not apples. A plausible explanation for this is that apples have a higher palatability than carrot. These findings indicate that consumers using D-TER® will notice a reduction in damage caused by brushtail possums to moderately palatable food sources but not highly palatable food sources. Consumers may be less convinced by the repellent effect of D-TER® on highly palatable food sources because the effect was merely suppressing brushtail possums from increasing consumption over time.

D-TER® does have repelling properties against the brushtail possum in suburban gardens. However, the strength of the repellent effect of D-TER® is influenced by the palatability of the food source to be protected. Future trials may evaluate the effectiveness of D-TER® in repelling brushtail possums from feeding on even less palatable food such as foliage and seedlings.

NOVEL LONG-TERM POSSUM CONTROL TOOLS IN NEW ZEALAND

Helen Blackie [1,2], Brent Barrett [1], Jamie MacKay [1],
Duncan MacMorran [2], Shane Inder [3]

[1] Centre for Wildlife Management and Conservation, [2] Connovation Ltd, [3] Auckland University of Technology
Email: helen.blackie@lincoln.ac.nz

Brushtail possums continue to present a substantial threat to the New Zealand environment and economy. Current control methods are able to substantially reduce possum numbers in the short term but immigration and in situ breeding allow populations quickly recover. Control must be repeated every few years to maintain the low population densities required for conservation gains and to limit the spread of bovine tuberculosis. Therefore, the next step in possum control is to develop devices that are able to attract and kill possums over long periods of time, with minimal input and maintenance. The 'Possum Spitfire' has been designed in collaboration with Connovation Ltd to help us reliably achieve long-term possum control. It is species-specific, lightweight, robust, and has the capacity to dispense a measured dose of toxin to over 100 possums before servicing. The device incorporates a long-life attractant and will operate for at least one year. During this presentation we will describe the development process and report on the latest field trial results for this new control tool.

INCREASING URBAN ABUNDANCE OF AN ENDEMIC NEW ZEALAND HONEYEATER BY PEST CONTROL IN SURROUNDING NATIVE FORESTS

John Innes[1], Neil Fitzgerald[1], Corinne Watts[1], Danny Thornburrow[1], Scott Bartlam[1], Kevin Collins[2], Dave Byers[2], Bruce Burns[1,3] and Guy Forrester[4]

[1]Landcare Research, Private Bag 3127, Hamilton 3240, New Zealand.
[2]Waikato Regional Council, Private Bag 3038, Waikato Mail Centre, Hamilton 3240, New Zealand.
[3]School of Biological Sciences, University of Auckland, Private Bag 92019, Auckland 1142, New Zealand.
[4]Landcare Research, PO Box 40, Lincoln 7640, New Zealand.
Email: innesj@landcareresearch.co.nz

Observations during 1999-2004 suggested that tui (*Prosthemadera novaeseelandiae*) visited Hamilton City (New Zealand) and surrounding rural properties only during March to October, outside the nesting season. From 2004 onwards, we captured and banded 51 adult tui and fitted radio transmitters to 41 in central Waikato urban and peri-urban areas to verify where they were nesting and to determine nesting success. Fourteen tui moved 5-23 km from urban areas to surrounding native forests at the onset of nesting, but successfully fledged young were found in only four (29%) of fourteen unmanaged nests we located. Most nests were preyed on by ship rats (*Rattus rattus*), swamp harriers (*Circus approximans*) and brushtail possums (*Trichosurus vulpecula*). Mammal pest control commenced in two forests where tui nested in 2007 and expanded to seven sites by 2010. Pest control was highly effective, reducing ship rats to mean 2.7% tracking rate and brushtail possums to mean 1.2% residual trap catch in subsequent tui nesting seasons. Biennial urban bird counts since 2004 and public reports documented that tui abundance and distribution increased significantly in Hamilton City after 2008, initially in 'green' areas (parks and gullies) in winter. Then, in the 2012-13 summer, tui also increased significantly in green areas in November, indicating nesting in Hamilton rather than returning to natal sites; some were also counted in residential areas in November for the first time. These results confirm previous studies showing that tui move widely in winter; that they readily cross pasture in the absence of forest corridors; and that they will inhabit urban areas year-round. Our results suggest that provided adequate food is available, effective control of ship rats and possums can rapidly (1-4 years) increase tui visits and nesting within 20 km of managed sites, enabling recolonisation of urban habitats by this iconic taxon.

MIXING WTH MALLARDS: IS THE INTEGRITY OF THE AUSTRALIAN PACIFIC BLACK DUCK AT RISK DUE TO HYBRIDISATION WITH MALLARDS?

Alice Taysom, Joshua Johnson & Patrick-Jean Guay

School of Engineering and Science, Victoria University, Melbourne VIC 8001.
Email: alice.taysom@live.vu.edu.au

The threat that hybridisation with Mallards (*Anas platyrhynchos*) poses to many dabbling duck species is one that is commonly overlooked. Introduced Mallards have interbred with the Pacific Black Duck (*A. superciliosa*), to the extent that the New Zealand subspecies is now considered endangered. In Australia, introduced Mallards are typically of domestic origin and were originally believed to be restricted to urban areas. The degree of hybridisation between Mallard and the Pacific Black Duck is currently unknown, largely because hybrid backcrosses are difficult to visually identify. A technique using microsatellite markers was established to genetically identify hybrids. This system utilises nine markers that were tested on putatively pure Pacific Black Ducks and domestic Mallards. Assignment tests, performed with the program Structure, had a 99% likelihood that specimens of a known species (Mallard or Black Duck) were assigned to the correct group. The marker set was used to test the rate of hybridisation throughout Australia. Assignment tests on 372 specimens from six Australian states showed that the likelihood that individuals were of Mallard origin was <1% in Victoria, Queensland, South Australia and New South Wales, 3% in Tasmania and 16% in Western Australia. This result suggests that hybrids are not common, but are increasing in areas of Tasmania and Western Australia. Furthermore, Western Australia samples were collected from urban areas, whereas all other samples were from rural regions. This also supports the theory that hybrids may be more prevalent in urban areas where Mallards are more common. The results of this study indicate that while the overall rate of hybridisation is low in rural areas, preventative action in the form of eradication is still required to avoid the same diminishing fate as the New Zealand Black Duck.

UNDERSTANDING POPULATION DYNAMICS OF THE FERAL HORSE IN A CONIFEROUS ENVIRONMENT IN SOUTHEAST QUEENSLAND

Magdalena A. Zabek[1], David M. Berman[2], John Wright[1], Simon Blomberg[3], Wynne C. Collins[1]

[1] University of Queensland, School of Veterinary Science, Gatton QLD 4343.
[2] Queensland Murray-Darling Committee, Toowoomba, QLD 4350.
[3] University of Queensland, School of Biological Sciences, St Lucia QLD 4072.
Email: m.zabek@uq.edu.au

Numerous concerns have been raised by government agencies, private landholders and the general public about feral horse (*Equus caballus*) presence in the Australian ecosystems. There is a lack of collective solutions on the management of this overabundant species. Dobbie & Berman (1993) proposed that successful management of feral horses in the Australian landscape can be achieved by (1) establishing the impacts of feral horses on the environment, economy or society, and (2) commissioning a detailed scientific study into population distribution and dynamics. These findings should be made available to the interest groups, and community involvement should be sought before management action is implemented.

The objective of this study was to characterize the most vital parameters of a feral horse population in order to propose a long-term management plan. The study was conducted in 2011-2013 on a population of feral horses in a coniferous environment in south-east Queensland, and was focused on establishing population density and abundance, reproduction status, survivorship and annual growth rate. Robust and multi-state, mark-recapture population models were used to characterize population demography, and to estimate annual fecundity (F=0.21), survival (S=0.92) and finite rate of population increase (λ=1.05). Distance sampling of feral horse dung was used to estimate animal density in low density (1.61 horses/km^2, 95%CI 1.04-2.51) and high density (3.18 horses/km^2, 95%CI 2.07-4.87) areas, and enabled estimation of the total number of horses (n=1600, 95%CI 1175-2398) in the forest of a size of 880 km^2.

The results were comparable to parameters obtained for other populations with a limited food supply (Dawson & Hone 2011), and rate of population increase was lower than the maximum reported for populations under the most favourable conditions (Wolfe 1980). We believe this study demonstrates the value of understanding the ecology of feral animals, and will encourage future managers and government organizations to cooperate in the formulation of the appropriate feral horse management programs in Australia.

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PASSIVE ACTIVITY INDEX: WEAKNESSES, STRENGTHS AND SURPRISES

Lee Allen

Robert Wicks Pest Animal Research Centre, Biosecurity Queensland,
Department of Agriculture, Fisheries and Forestry, Queensland, 203 Tor Street, Toowoomba, Qld 4350.
Email: lee.allen@daff.qld.gov.au

This paper reviews the performance and uses of the Passive Activity Index (PAI) for detecting difficult-to-observe species and species at low densities. The PAI is a rapid, inexpensive method of monitoring trends of a large variety of species over large areas when applied appropriately but can be prone to bias, loss of sensitivity and misinterpretation if used unwisely or under unfavourable circumstances. Weaknesses, strengths and surprises, discovered over years of applying the PAI, are discussed.

POSTERS

FABRIC ANIMAL TRAPS – A NOVEL ANIMAL TRAP DESIGN FOR WALLABIES, POSSUMS, FERAL CATS AND MEDIUM SIZE PEST BROWSING ANIMALS AND CARNIVORES

Dr Ivo Edwards

Maydena, Tasmania
Email: ivo.edwards@skymesh.com.au

These traps are of a single size and comprise a collapsible skeletal aluminium and steel frame covered by strong nylon fabric. Trapped animals are contained in semi-darkness in a large space with only soft fabric to impact against. The trap design and deployment method is the culmination of 10 years of research effort to develop a humane and economic alternative to 1080 poison for pest possums and wallabies in Tasmania. The trap has potential applicability world-wide as a humane, effective and economical trap for normally trap shy medium sized pest browsing animals and carnivores.

The traps are a whole new concept in animal traps, not just a variation of a cage or leg hold trap. They are:

- Open on 3 sides and top when set. Minimal entry needed to trigger trip mechanism great for catching the most trap wary animals
- Super humane with only soft fabric for animals to impact against and contained animals in bag like structure in semi-darkness
- Trip weight adjustable via a simple screw
- Very easy to set and adjust
- Peg provided to anchor to ground.
- Very tough yet light weight at 3.5 kg
- Collapse flat when sprung for easy transport and storage
- Strong nylon fabric covering readily replaced
- Free for 30 day trial period

Euthanasia of trapped animals is an increasingly contentious issue and examination aids for trapped animals is an integral component of humane trapping. Animals caught in these traps can be practically euthanised by various techniques. Manual stunning through the fabric with a special stunning hammer is a simple equivalent to a captive bolt pistol as used by abattoirs. Alternative methods are to transfer trapped animals to a net for shooting at close range, or for examination, medical treatment, sterilisation or contraceptive provision prior to unharmed release. Chemical euthanasia is the preferred option, but unfortunately impractical in many situations.

It is critical for high catch-efficiency to get target animals accustomed to entering traps before actually setting traps to catch them. Locked open traps loaded with grain food can be used for free feeding browsers if they are not needed continually to trap animals. Simple animal feeders are a cheaper alternative and are designed to look like a trap opening. They can be loaded with food for 1 - 2 weeks to attract animals to a site before setting traps. Animals can be enticed to where it is convenient to trap them and multiple traps can be set around each feeder for just 2 - 3 nights before moving traps to the next feeder a few hundred metres away.

The nylon fabric used in these traps is too hard for the sharpest animal claws, but can be damaged by teeth of Tasmanian devils, various rats and mice, bullets, and wear and tear over time. The traps are designed for easy and cheap fabric replacement by slipping a prepared replacement over the frame and attaching it with cord or cable ties.

We have demonstrated success using these traps for catching Tasmanian wallabies, possums and feral cats and invite trials by research workers for other pest animals. Our special interest is on economic aspects of pest animal control, not just technical success. To this end we believe the deployment techniques used to trap animals to be of equal to greater importance than the technical trap design aspects.

TRANSPORT AND INTRODUCTION OF AMPHIBIANS IN AUSTRALIA

Pablo García-Díaz and Phillip Cassey

School of Earth & Environmental Sciences and the Environment Institute,
The University of Adelaide, North Terrace SA 5005.
Email: pablo.garciadiaz@adelaide.edu.au

Emergent invasive amphibians represent a potential serious threat to Australian biosecurity. Recent research on amphibian invasions has focused on the factors that affect the likelihood of establishment, while the patterns of transport and introduction of this group remains poorly studied. We collated a database of transported (outside their native range) and introduced (released or escaped from captivity) amphibians in Australia from different sources (scientific publications, reports of environmental agencies and web pages of classified advertisements). This is the first study to quantitatively address the transport and introduction stages of amphibian invasions. We found 97 species transported via two main pathways: trade (71 species) and stowaway (38 species). Nineteen species (19.6% of transported) have been introduced in the Australian environment and four (21.1% of introduced) were considered as established. Transported species were a taxonomic and geographic non-random sample of extant amphibians, whereas introduced species were a random sample of transported species. We analysed the influence of several factors on the probability of transport and introduction. Transported amphibians via trade and stowaway pathways have large native ranges (usually > 100 km^2), whose longitudinal and latitudinal mid-points are located mainly through Australia, Asia. The likelihood of introduction increases for species transported via both pathways. Our results suggest that the availability of amphibians to be captured, bred and kept in captivity strongly affects the probabilities of transport and introduction. Management of the risk of new amphibian introductions requires the continued vigilance by agencies involved in biosurveillance as well as the inclusion of the people involved in the pet trade.

VERTEBRATE PEST MANAGEMENT INITIATIVES IN THE SOUTHERN OCEAN

Keith Springer, Noel Carmichael

Tasmania Parks and Wildlife Service, PO Box 126, Moonah, TAS 7009.
Email: Keith.Springer@parks.tas.gov.au

The Southern Ocean circles the globe in the land-scarce latitudes between 45° and 60° South, and encompasses the southern regions of the Pacific, Atlantic and Indian Oceans. Continental landmasses border or protrude only slightly into the Southern Ocean from Africa, South America and Australia. Islands dotted around the Southern Ocean form important breeding locations for sub-Antarctic and Antarctic wildlife species. The islands were heavily exploited for marine mammals during the 19th and 20th centuries, and vertebrates were introduced to the majority of sub-Antarctic islands either deliberately (usually for food) or accidently.

Many have become 'invasive' and have caused extensive environmental damage to island ecosystems, especially to native vegetation (from herbivores) and birdlife (from predators). On islands with both invasive herbivores and predators, impacts on flora and fauna are often exacerbated by interactions between them.

Several countries have eradicated invasive vertebrates from islands they manage, including the United Kingdom, France, South Africa, Australia and New Zealand. Species targeted typically include rodents *Rattus spp, Mus musculus*, domestic cats *Felis catus*, European rabbits *Oryctolagus cuniculus* and ungulate species including goats *Capra hircus*, cattle *Bos taurus* and sheep *Ovis aries*. Current eradication projects are underway or planned on some sub-Antarctic islands including Macquarie, Gough, Marion, Antipodes and South Georgia. Previous operations on other islands have successfully removed invasive species, with resultant recovery of natural biota. Recent eradication successes demonstrate feasibility of increasingly complex operations and encourage further ambitious endeavours in the region, where many opportunities for vertebrate pest management remain.

M-44 EJECTOR ACTIVATION BY RED FOXES (*VULPES VULPES*) IN AGRI-ECOSYSTEMS

Evelyn Osborne[1], Guy Ballard[1, 2], Karl Vernes[1] and Peter Fleming[1, 3]

[1] School of Environmental & Rural Sciences, University of New England, NSW, 2351.
[2] NSW Department of Primary Industries, Armidale NSW 2351.
[3] NSW Department of Primary Industries, Orange, NSW 2351.
Email: eosborn4@myune.edu.au

M-44 ejectors are a long-awaited addition to the techniques currently available for control of wild canids in Australia (Marks & Wilson 2005). In the northern tablelands of NSW, wild dogs (*Canis lupus dingo, C.l. familiaris* and hybrids) and red foxes (*Vulpes vulpes*) are significant agricultural pests.

As a 'new' technique, local land managers are eager for any information that will enhance the performance of M-44 ejectors as control tools.

In this paper, we report the results of a field trial that aimed to determine if particular landscape variables were associated with relatively greater probabilities of activation of M-44s by target animals, than others.

MANAGING THE RISKS POSED BY CAPTIVE EXOTIC ANIMALS VIA A POLICY-BASED APPROACH

Melinda Corry[1], Adam Kay[2], Jan-Willem de Milliano[1] and Andrew Woolnough[1]

[1]Department of Environment and Primary Industries, 1 Spring Street, Melbourne, VIC 3000.
[2] Department of Environment and Primary Industries, 1 McKoy Street Wodonga, VIC 3690.
Email: melinda.corry@depi.vic.gov.au

Pest animals have the potential to have significant negative impacts on the economy, the environment, social amenity and human health. In Victoria, there are laws that regulate the importation, keeping, breeding and trading of pest animals. These laws aim to protect the State from these potential threats. The Department of Environment and Primary Industries (DEPI), on behalf of the Victorian Government, is responsible for minimising the threat posed by pest animals that may be brought into, kept and/or sold in Victoria.

DEPI has developed and implemented a suite of policy principles to improve response times of client interactions, reduce red tape, and support a consistent approach to information provision and decision making. The policy principles are based on the Vertebrate Pests Committee '*Guidelines for the Import, Movement and Keeping of Non-indigenous Vertebrates in Australia*'. The paper demonstrates how these policy principles intend to manage the import, keeping and selling of pest animals in non-statutory zoos in Victoria. Importantly, these policy principles have been developed in consultation with the end-users.

FINDING IT DIFFICULT TO ENGAGE MEDIA IN PEST CONTROL? ANGRY BIRDS AND TWITTER MAY BE THE ANSWER!

Mr Jaap Knegtmans

Ministry for Primary Industries, New Zealand.
Email: jaap.knegtmans@mpi.govt.nz

Think outside the box when engaging public in pest control. When the standard media release failed to generate enough media interest for our red-vented bulbul response, we went back to the drawing board. Working closely with our communications team, a different approach was trialled with great success. This poster will outline how playing on the popular Angry Birds phenomenon, and social media such as Twitter made this response a real talking point in the public arena. Ensuring a biosecurity campaign relevant to today's society can be key to its success or failure.

THE NON-PATHOGENIC RABBIT CALICIVIRUS IN QLD

Peter Elsworth

Biosecurity Queensland, Department of Agriculture, Forestry and Fisheries, 203 Tor St, Toowoomba, QLD 4350.
Email: peter.elsworth@daff.qld.gov.au

Two biological control viruses, namely myxomatosis and rabbit haemorrhagic disease virus have been released in Australia for the control of rabbits. While both releases were initially very successful, both had some problems with their continued effectiveness. One problem with RHDV was that it was never as effective in cooler-wetter parts of Australia (Henzell et al. 2002). Initial monitoring of the spread of RHDV showed some rabbits possessed cross-reacting antibodies to the ELISA test for RHDV, even though the virus was not present in those populations (Cooke et al. 2002, Nagesha et al. 2000). This gave rise to the theory that there was a non-pathogenic calicivirus in those populations. In 2009 this virus was isolated and named rabbit calicivirus-A1 (Strive et al. 2009). Since then this virus has been shown to provide temporary cross-protection against RHDV (Strive et al. 2013). The recent development of a serological test (Liu et al. 2012) has allowed testing of historical samples which so far has shown RCV-A1 to be present in cooler-wetter parts of Victoria, NSW and the ACT. In Queensland, the virus was shown to be historically present at Whetstone (near Inglewood) and the Eidsvold/Munduberra area. More recently it has been shown to be present at Stanthorpe. Due the protection this non-pathogenic virus provides against RHDV, an understanding of the presence and prevalence of RCV-A1 is essential for management of rabbits in Queensland. Release of RHDV is still widely used as a control tool, and if the RCV-A1 is present then this may not be the most effective management technique.

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INCREASING THE CAPACITY OF REGIONAL GROUPS TO MANAGE VERTEBRATE PEST IMPACTS

Jessica Marsh[1, 2] and Annette Brown[1, 2]

[1]Invasive Animals Cooperative Research Centre, University of Canberra, ACT 2601.
[2]NSW Department of Primary Industries, Orange, NSW 2800.
Email: jessica.marsh@dpi.nsw.gov.au

The Australian natural resource management (NRM) structure was developed in 2004 and is comprised of 54 regions. Since their establishment, each NRM organisation has developed the ability to play a critical role in vertebrate pest management, education and awareness. However, each region works in relative isolation, and constantly endures reform at all levels due to staff reductions, varied focus of expertise, funding fluctuations, 'top down' prioritisation of targets, ever-changing partnerships with stakeholders and large government-induced structural changes. Managing these reforms whilst working to improve the state of our natural resources is difficult for regional groups, and with many competing priorities the capacity for groups to implement effective invasive animal management is reduced. Experience over time shows a lack of informative monitoring and evaluation of regional pest animal programs, which commonly results in discontinued management and reduced community engagement levels.

To help build this capacity and maintain effective programs and resilient communities, the Invasive Animals Cooperative Research Centre has implemented a national facilitator model to improve pest management at a broad scale. It aims to provide specialist support to NRM and other regional groups to help develop the knowledge and skills required to counteract the impacts of pest animals on agricultural production and biodiversity. With an ongoing reduction in extension services across many sectors, and using a state based example to demonstrate, the facilitator model may provide the answer to promoting best practice pest management across landscapes and across tenure.

The presentation will discuss this national facilitator model and incorporate experiences and knowledge from the Penn State University 'leadership and community engagement program'. This will facilitate comparison of front-line practitioner activities from the United States and Australia, helping to highlight different approaches to similar problems. We provide recommendations for successfully engaging with communities and creating effective, community-led pest management programs.

NOVEL MULTIPLE-KILL CONTROL DEVICES FOR FERAL CATS

Sjoberg, T.[1,2], Murphy, E.[1,2], Barun, A.[1], MacMorran, D.[3], Aylett, P.[3], Barret, B[1].

[1]Centre for Wildlife Management and Conservation, Department of Ecology, Lincoln University, NZ.
[2]Department of Conservation, Private Bag 4715, Christchurch, NZ.
[3]Connovation Ltd, PO Box 58613, Manukau, NZ.
Email: tim.sjoberg@Lincolnuni.ac.nz

Feral cats (*Felis catus*) represent a significant threat to endangered species and are one of the most damaging predators worldwide. Current cat management is labour intensive, costly and restricted to single kill traps, live capture, shooting or toxins. The focus of this research is to investigate cat behaviour around a novel multiple-kill control device (Spitfire). The Spitfire delivers a known amount of toxic paste onto a cats belly area that is licked off while grooming. Different versions of the Spitfire are being developed to target different pest species in NZ – they all use the same basic firing mechanism, but have different housings and a range of different toxins. The cat Spitfire will deliver PAPP (para- aminopropiophenone) to the cat's belly. PAPP has been developed as a vertebrate toxin in New Zealand and Australia to protect endemic species from invasive predators and is currently registered for use in NZ for feral cats and stoats. Recent pen trials found that 3/3 feral cats died from ingesting PAPP sprayed onto their stomach fur. Cats are compulsive groomers and spraying their belly with a toxin is providing a novel pathway for toxin ingestion, rather than poison meat baits which degrade rapidly within the environment.

Feral cats are notoriously hard to control and much of this research has focused around Spitfire housing. All housing models have been developed to increase cat interaction rates while reducing non-targets from entering, models differ in length, height, wire mesh attachments and ramps leading up to raised housing models. Of these, several of these housing prototype models have been field evaluated with positive results.

UNDERSTANDING PATTERNS IN HABITAT USE BY FERAL CATS FELIS CATUS: A REVIEW AND IMPLICATIONS FOR CONSERVATION MANAGEMENT

Tim S Doherty[1] *, Andrew Bengsen[2], Robert A Davis[1]

[1] School of Natural Sciences, Edith Cowan University, 270 Joondalup Drive, Joondalup, WA 6027.
[2] NSW Department of Primary Industries, Locked Bag 6006, Orange, NSW 2800.
* corresponding author: t.doherty@ecu.edu.au

Feral cats have a wide global distribution and cause significant damage to native fauna. Reducing their impacts requires an understanding of how they use habitat and which parts of the landscape should be the focus of management. We reviewed 24 experimental and observational studies conducted around the world over the last 35 years that aimed to examine habitat use and selection by feral cats. Our aims were to: (i) summarise the current body of literature on habitat use and selection by feral cats in the context of existing ecological theory and (ii) identify important commonalities in research findings that might help improve the future management and research on feral cat impacts. We found that feral cats exploit a diverse range of habitats including but not limited to arid deserts and shrublands, fragmented agricultural landscapes, glacial valleys, temperate and sub-Antarctic islands and a range of forest and woodland types. Inferences explaining cat habitat use included prey availability, predation/competition and shelter availability, but the strength of evidence used to support these inferences was low, with most studies being observational or correlative. Future studies on this topic will benefit from employing an experimental approach and collecting data on prey and other predators. Effective management of feral cat populations could target high-use areas, such as dense habitat and linear features. Larger predators can spatially exclude cats from certain habitats and integrated management of native predators and introduced prey may aid biodiversity conservation and management.

MOBILE DEVICE APPS AND REAL-TIME WEB-MAPPING OF PEST ANIMALS IN AUSTRALIA

Peter West[1,2], Rebecca Crawford[1] and Rachel O'Reilly[1]

[1]Vertebrate Pest Research Unit, NSW Department of Primary Industries, Forest Road, Orange, NSW 2800.
[2]Invasive Animals Cooperative Research Centre, Building 22, University of Canberra,
University Drive South, Bruce, ACT 2617.
Email: Peter.west@dpi.nsw.gov.au

Enhancements in mobile device, web-mapping and digital platform technologies have greatly supported improvements in the way we engage with land managers and gather real-time information on pest animals across the Australian landscape. Mobile mapping and communication tools, such as social media, also offer an effective and timely method of communicating pest animal threats among pest stakeholders.

The FeralScan (*www.feralscan.org.au*) citizen science initiative of the Invasive Animals CRC has proven to be highly successful in engaging the Australian public in actively recording evidence of pest animals, their impacts and control activities. FeralScan provides a free web-based mapping facility for landholders, community groups, and local government and pest control professionals. Anyone can use FeralScan to record information on pest animals in their local area, and share that data with others to better target pest animal problems. It hosts a series of species-based portals and now contains over 25,000 community records of pests and their impacts. FeralScan provides people with up-to-date information which can be used to improve on-ground decision-making and targeted pest control.

FeralScan also offers a new mobile-optimised website allowing field-based recording of pest information without users having to return to a desktop PC or laptop. New community-networking tools are expected to further support participants to work cooperatively on pest animal problems.

Complementing FeralScan is a new Field Guide to Pest Animals of Australia App. Currently available for Apple-device users; this app contains species information, photographs, maps, audio calls, control information and resources for 53 of Australia's pest animal species. The App links to web-resources (such as PestSmart) to increase the accessibility of new tools and technologies to stakeholders Australia-wide. The App has proven to be very popular, with over 6,500 downloads since mid-2013.

These projects put new platform technology directly into the hands of landholders and communities. They bring innovation to pest management by integrating datasets, increasing accessibility of real-time pest animal data, and increasing connectivity of end-users with pest control information.

ERADICATION EFFORTS OF FERAL SWINE IN NEW YORK STATE

Daniel Hojnacki and Justin Gansowski

USDA, APHIS, Wildlife Services, 1930 Route 9, Castleton, NY 12033.
Email: Justin.Gansowski@aphis.usda.gov

Feral swine are a non-native invasive species found throughout the United States, with an estimated population of 5 million individuals. Accidental and intentional releases from enclosed shooting facilities and domestic swine operations have allowed these animals to proliferate across the landscape. Feral swine cause large-scale ecological, agricultural, and property damage along with the threat of disease. First discovered breeding in New York State (NY) in 2008, four distinct populations of feral swine currently reside within the state. Although the population remains low within NY, the impacts of an expanding population could be enormous. USDA-APHIS Wildlife Services (WS) estimated that feral swine have accounted for $1,002,677 in damage and management efforts combined, although much of the damage remains undocumented. Between 2008 and 2014, New York State Department of Environmental Conservation and WS have removed 178 feral swine from the state. In 2013, WS personnel performed feral swine management on 26,399 acres of private and public lands. New York State recently passed new legislation immediately banning breeding, transporting, and intentionally releasing Eurasian Boars onto the landscape, while banning possession by 2015. With new legislation and utilizing aerial surveillance operations to assist in detecting feral swine, eradication in NY is a foreseeable goal. Population reduction is only one component to the WS feral swine program, which also involves public education and disease surveillance.

The impacts of feral swine on the landscape, current efforts to eliminate feral swine, and future feral swine management in NY will be presented.

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