Alternate and Cost-Effective Methods to Control Flying Feral Vermin

Novel, Non-Lethal Bird Control Technology

A report for

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Executive Summary

Magpie geese have been a major problem on farms in Northern Australia for many years. As far back as the failed Humpty Doo Rice project in the 1960s at Fogg Dam in the Northern Territory, magpie geese have been known to destroy crops. More recently, these geese have become a major pest for fruit and vegetable farmers in Northern Australia. Managing on-farm bird numbers and minimising crop damage has come at a significant cost and the common deterrent strategies employed have yielded mixed results in their effectiveness.

This report examines alternative and new deterrent strategies and technologies currently in use (or currently being trialled) around the world with the purpose of identifying those that could assist Northern Australian farmers. Fourteen different deterrent strategies or technologies, categorised into six groups, were examined.

1. Visual deterrent - Laser & UV Light technology

Agrilaser® and UV light from Lite Enterprises are both long range silent visual deterrents, which work by shining the light to disturb and deter birds. Agrilaser® is already on the market, while the UV light technology is still under development. Both were shown to be effective at moving birds - in particular, the author has found Agrilaser® to be effective in dispersing magpie geese and other birds.

2. Drone technology - "Robird" by Clear Flight Solutions

While drones are not new in the Australian agriculture and horticulture sectors, the Robird studied is. The Robird is a robotic life-like drone bird and come in two models (the Peregrine Falcon and Eagle). The Robird mimics the bird of prey it is modelled on and has shown to be effective in the Netherlands (where it was developed) to move problems birds from industrial and horticulture sites. Presently the Robird is not available for purchase but the services of the developer can be engaged.

3. Auditory deterrents – SonicNets, Bird Gard, Scarecrow, HyperSpike® and latest pyrotechnics products by RocketMan

Of the five auditory deterrents studied, the Sonic Nets technology shows the greatest potential. It works by hijacking the sound wavelength target bird species communicate at,

inhibiting their ability to communicate with each other. This sound occurs as a low level hum to the human ear, making the technology particularly attractive to small horticulture farms in parts of rural Northern Australia experiencing urban encroachment. The other technologies explored, Scarecrow, Bird Gard, HyperSpike® and pyrotechnics, are shown to be effective, but a disadvantage is the large noise/sound they emit.

4. Chemical deterrents (non-lethal) – Avian Control® and Avipel® Shield

Two non-lethal chemical deterrents were assessed in this study tour. Due to the discomfort experienced following contact with the chemicals, the birds learn to avoid the treated crops and locations. Both chemical deterrents were demonstrated to work effective although only Avian Control® is approved for use as a bird deterrent on horticultural crops by the Environmental Protection Agency (US). An emergency permit is granted for the use of Avipel® Shield in some US states as there has been a report that residuals of the chemical is found in the produce of some crops. If either chemical is to be registered for use in Australia, careful consideration of safety implications on humans, animals and the environment should be considered and/or investigated.

5. Natural Predators – The Dog and Falconry Box

Natural predators are some of the most effective and safest deterrents available. Employing the natural predatory instincts of mans best friend, the dog, has shown to be a quick and effective method to disperse birds at airports overseas and in Australia. With appropriate training, the farm dog's instincts can be harnessed for a similar purpose in the horticulture industry. In addition to the dog, there is also a successful and innovative research project using falconry boxes to attract wild birds of prey (American Kestrels) to hunt and breed on cherry farms to manage starling numbers. The same trial should be considered, provided the predators of magpie geese can be attracted to nest successfully in installed boxes.

6. Environment Modification - altering the environs to discourage bird landings

The strategies studied in this area, such as the resurfacing of an airport grass ways with asphalt or bird resistant grass, is least applicable to the horticulture industry. While they have successfully managed/reduced bird numbers in the aviation industry, it is impractical, for example, to resurface an entire farm with asphalt.

Key Recommendations

The strategies and technologies studied here are likely to have some level of success on their own, but birds (magpie geese) will habituate, so while these methods will work in the beginning, they may lose effectiveness over time. It is therefore abundantly clear that a multi-pronged approach to managing magpie geese (and bird pest) dispersion should be considered.

- Further analysis and testing on the use of visual deterrents and Robird (or other drone technology) as a quieter option for Northern Australia where urban encroachment places restrictions on permitted noise levels.
- Undertake a feasibility study and seek advice of a dog trainer/behaviourist with wildlife management experience in training dogs to assist with managing bird numbers on farms.
- Initiate discussions with falconry box researchers in replicating the study in Northern Australia using native birds of prey.
- Undertake a feasibility study by trialling the two chemical deterrents identified in this project on horticulture crops grown in Northern Australia.
- A number of the technologies are still at the proof of concept stage, so working with developers on trials to evaluate their effectiveness in Northern Australia could be a possibility.

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Foreword

I am an agronomist working at Tropical Primary Products, a family-run tropical fruit orchard established by my parents, based approximately 50km south east of the Darwin's central business district (NT, Australia). The tropical fruits grown on our orchard include mangoes, jackfruit, durian, pomelo, chempadak, water-apples as well other small trial crops. We run an active breeding mango breeding program with the variety "TPP1" being our first commercialised mango.

My family and I migrated from Malaysia in 1987 to establish our first farm on 16 hectares of vacant farmland. We have since expanded to over 200 hectares of farming land. I completed my Bachelor of Agriculture Science at the University of Adelaide and returned in 2009 to work full-time on the family farm. Over the years, I have served as board director for a number industry groups such as the Australian Mango Industry Association, NT Farmers Association and the NT Mango Industry Association.

Our story with magpie geese began in the mid-1990s when we started growing annual and perennial crops. We noticed that every year as the waterfowl hunting season began, we would find magpie geese flocking to our farm, and that of our neighbours, for safe refuge from the nearby conservation park, Lambells Lagoon, where hunting is permitted. Exacerbating the problem is that the hunting season was beginning earlier each year despite lobbying by farmers and advisement of environmentalists.

As the urban sprawl extended towards the rural area, concerns about noise and safety led to a firearm ban on farms in the late 2000s. Prior to the firearm ban, it was permissible to kill magpie geese. Following the ban, we had to find non-lethal methods to disperse these birds.

Over time my family has seen magpie geese evolve to meet the environment. Historically, they would eat fallen fruit but over the 15 years they have learned to perch on, and eat fruit directly off the trees. In addition to crop losses, we and other farmers have reported damage caused by the birds to irrigation systems as they try to source fresh water. With every year that passes, the problems caused by these magpie geese seem to increase, yet my farming colleagues continue to battle these birds in what appears to be a losing war.

In 2015, I was awarded a Nuffield Scholarship to research non-lethal and cost effective methods to controlling flying vermin, including magpie geese. I began researching and learning about innovative technologies such as drones, lasers, bird communication inhibitors and palate deterrents for birds. Through these study tours, I aimed to bring back technologies and strategies that may be trialled and adapted to manage bird and flying vermin invasion on farmlands in the NT (and more broadly Northern Australia), with a particular focus on magpie geese.

In April 2016, a group of concerned farmers, myself included, met with representatives from Charles Darwin University and the NT Department of Primary Industry and Fisheries. After years of campaigning, we secured funding through the Mango Levy and Horticulture Innovation Australia to study the impact of migrating magpie geese on farmlands in Northern Territory. This was a very much welcomed development.

With the generous support of the Nuffield Scholarship fund, my travels have taken me to amazing places such as United Kingdom, France, United State of America, Germany, Czech Republic, Poland, Kenya, South Africa, The Netherlands, Belgium and New Zealand. I met inspirational farming personalities, from owners of companies to farmers who have developed novel, unusual and smarter methods to farm efficiently. Farming practices around the world may be different and farming in each area comes with its own challenges, however what is similar is that as primary producers, we work together to feed the nine billion people of the world.

Acknowledgments

I would like to thank my parents, for giving me time and support to complete this scholarship and taking over my job on the farm while I was away on my study tours.

To my sisters, Shoo Lin and Shoo Peng, thank you from the bottom of my heart for editing my report and for your constant encouragement and support to complete my report.

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I would like to thank the following people and companies for their generous time in meeting me in person:

- Steinar Henskes and Corné Sweep - Bird Control Group
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- Piper and Brian Edwards - Cherry Capital Airport
- Megan Shave and Dr Catherine Lindell - Michigan State University
- Gib Rokich - Salt Lake City Airport
- Kimber Finney - Bird Gard
- Simon de Bono - The RocketMan
- George Archibald and Anne Lacy - International Crane Foundation
- Delegates and vendors of - 2016 Bird Strike USA Conference

And finally, to Warren Hunt (NTDPI), thank you for encouraging me three years ago to do a Nuffield Scholarship. It is done now!

Abbreviations

^{0}	Degree
%	Percentage
A$	Australian Dollar
APVMA	Australian Pesticide and Veterinary Medicine Authority
ATV	All Terrain Vehicle (Quadbike)
cm	Centimetre
db	Decibel
EPA	Environmental Protection Agency
FOB	Foreign Object (airport term)
hz	Hertz
kg	Kilogram
khz	Kilohertz
lbs	Pounds (Weight)
m	Metre
mm	Millimetre
mW	Milliwatt
nm	Nanometre
NT	Northern Territory
QLD	Queensland
s	Second
US	United State of America
US$	US Dollar
UV	Ultraviolet
W	Watts
WA	Western Australia

Objectives

This report sets out to investigate non-lethal, cost effective bird control techniques and technologies used in agriculture, horticulture and aviation industries around the world. It is hoped that cheaper, effective technologies could be found and easily adapted for farmers in Northern Australia.

The study tour will assess novel technologies and strategies that are not currently used in other NT farms. Specifically, the following technologies or strategies will be evaluated:

- Visual deterrents such as laser technologies - to determine effectiveness and suitability against bird pests in airfields and orchards.
- Realistic drones, particularly the birds of prey drones - to determine their mode of action and effectiveness in dispersing smaller birds from airport, waste management and orchards.
- Novel sound deterrents technologies and how they work to deter pest birds.
- Natural predators such as falconry and dogs that might be effective in scaring bird pests.

Introduction

Magpie geese (Anseranas semipalmata) have been a major problem on farms in Northern Australia for many years. As far back as the failed Humpty Doo Rice project in the 1960s at Fogg Dam[1] in the Northern Territory, magpie geese have been known to destroy crops (The Rice Trial, 2016). In recent years, these geese have become a major pest for fruit and vegetable farmers in Northern Australia, including to the family business of the author of this report. Managing on-farm bird numbers and minimising crop damage has come at a significant cost, with the common deterrent strategies employed yielding mixed results in their effectiveness. With this in mind, the author of this report embarked on an overseas study tour to identify innovative deterrent strategies that could assist Northern Australian farmers. The outcomes of this study tour is of particular importance to the long-term, sustainable expansion of the horticulture industry if the re-emphasis of making Northern Australia the "food bowl of Asia"[2] is to succeed.

Figure 1: Magpie geese on farmland (Photo: NT Field and Game)

[1]"The Humpty Doo Rice Project was inspired by grand visions of taming a new frontier, settling northern Australia and supplying rice to Asia." However, the project failed and it was largely blamed on the Magpie Geese. In reality it was also due to a number of other reasons including an unfamiliar environment which did not support the farming methods and machinery of America employed, poor choice of rice variety. (http://www.ricetrail.com.au/)

[2] First floated in the 1960s

About the Bird: Magpie Geese

Magpie geese (*Anseranas Semipalmata*) are a species of waterbird widespread across northern Australia, from Broome in WA to Ayr in Queensland. With a life span of up to 30 years, magpie geese often congregate in large flocks (Blaze, 2004) in their natural habitat of waterways and wetlands. The bird is predominantly black and white in colour with a long black neck and head. The bird's underpart is white with black edges on the underwing. Their bill, legs and feet are orange. Unlike most waterfowl, magpie geese have strongly clawed toes that are only partly webbed. Females are slightly smaller than males. (Birdlife Australia, n.d.)

Figure 2: Magpie goose taking off at Fogg Dam (Photo: Paul Thomsen/ Djambalawa at English Wikipedia)

The Problem and the Study

Each year, the commencement of waterfowl hunting season presents a major challenge for farmers in the Northern Territory. Coinciding with the Territorian mango season (generally from late September to November), the waterfowl hunting season sees magpie geese threatened in their natural habitat. They mass migrate from their natural habitats to find "safe havens" for shelter and food, often at nearby farms. The expansion of the horticulture industry in the Northern Territory and increasing numbers of birds landing on farms are anecdotal evidence for the escalating damage to horticulture crops. In the mango industry, farmers have estimated damage of up to 20 per cent of their annual crops (Personal Communication with Martina Matzner, 2015).

Studies on winged vertebrate pest have focussed predominantly on small flying vertebrate pest such as parrots, honeyeaters, cockatoos, and crows, however there are very few studies into the impact of magpie geese invasion of horticultural land, specifically on orchards, fruit trees and the environs. However, what is known is that these geese have evolved over the years from feeding on grass at the ground level to attacking fruits, both at the ground and at tree level.

In the past, farmers with a firearm licence can manage the mass migration from the commencement and for the duration of the hunting season by shooting. Today, this is no longer a deterrent option for many farmers due to urban encroachment. The increasing population density, due to the increasing attraction of living in a rural setting, has resulted in hunting ban many farming regions for safety reasons and noise management. Since the hunting ban, farmers are reporting an increase in magpie geese numbers, with birds roosting in the native trees adjacent to farms and orchards at night instead of returning to their natural habitat, resulting significant damage to crops.

Figure 3: Magpie geese perching on a tree (Photo: Han Shiong Siah)

Despite trailing various strategies to manage magpie geese invasions, some of which are particularly costly. there have been mixed successes; at times, farmers seem to be fighting a losing battle. For this farmer, on-farm strategies have included gas cannons, horns and sirens, Agrilasers® and employing staff on all-terrain vehicles (ATVs) to chase the birds from sunrise

to sunset. The latter, in particular, is very expensive due to Australia's high labour at $21 per hour or more. Notwithstanding, there is also the cost of fuel.

Bird deterrent techniques studied in NT have focussed on small birds, such as rainbow lorikeets and cockatoo, but not magpie geese. These studies included trialling physical and chemical deterrents and have yielded mixed results. The use of loud audio disturbance devices (gas cannons, horns and blank shotgun bullets) may be initially effective but loses effectiveness within days when the birds learn that the noise neither injures nor kills. Netting of the entire farm is highly effective but costly to both build and maintain.

Based on these existing studies and anecdotal reports from farmers, there is some urgency to identify bird deterrent techniques and technologies that are more effective and cost-effective in support of the farmers and the horticulture industry in Northern Australia. Understanding this urgency, this study explores best practice bird deterrent techniques from different industries around the world that could be introduced to assist farmers with the management of magpie geese in Northern Australia. Pertinent to this study is that these strategies or technologies must be both (a) effective in impact and cost (b) suitable to the Northern Australian climate, and (c) easily and quickly disseminated.

Specifically, this study examines different deterrent strategies that fall within the following categories:

- Sight and visual deterrent
- Drone/robotic bird technology
- Auditory deterrents
- Chemical deterrents (non-lethal)
- Natural predators
- Environment modification

The study involves travel to regions that are similarly affected by native bird invasions, to major metropolitan centres and airfields where bird behaviour and deterrents have been used successfully to reduce bird numbers, and to universities and companies at the forefront of developing new bird deterrent technologies and techniques. The locations and details of the study tour are listed in Figure 4.

Country/ Region	Date	Companies and Deterrent Technology Studied
The Netherlands	15/6/2015 - 25/6/2015	• Bird Control Group, Delft, The Netherlands - Agrilaser • Clear Flight Solution, Enschede, The Netherlands – Robird • Royal Netherlands Airforce, Eindhoven Airport.
United States of America	12/5/2016 - 9/6/2016	• Piper, K9 Airport Dog, Traverse City, Michigan – animal assisted deterrent • Megan Shave, PhD, Traverse City, Michigan – Falconry Box • Avian Control Inc, Detroit, Michigan – Chemical Deterrent • Salt Lake City Airport, Utah – Airport Habitat Modification. • Bird Gard, Sister, Oregon – Audio Deterrent
New Zealand	4/6/2016 - 9/6/2016	• The Rockman Man, Dunedin, New Zealand – Pyrotechnic • Zespri, Mount Maunganui, New Zealand.

United States of America	5/8/2016 - 16/8/16	• Bird Strike USA Conference, Chicago
		  ○ Ultra Electronic – HyperSpike – Directional Audio Control
		  ○ PGG Wrightson Turf – Avanex – Bird Deterrent Ryegrass
		  ○ MidStream Technology – Sonic Net – Audio Deterrent
		  ○ Lite Enterprise – UV Light Barrier – Light Deterrent
		  ○ Margo Supplies Limited – paintball – Bird Deterrent
		• International Crane Foundation, Baraboon, Wisconsin – Chemical Deterrent

Figure 4: Details of the study tour

It is also hoped that this study will highlight the magnitude and urgency of the magpie geese problem in Northern Australia and encourage not only reactive but also pre-emptive actions. This may include a long-overdue longitudinal and empirical study on their impact upon the horticulture sector of Northern Australia[3], and the establishment of applied research centres in support of farmers and the horticulture industry in Northern Australia. Applied research run within these centres may consider examining the region's challenges such as, but not limited to, the management of pests and vermin. These strategies are particularly important if the touted idea of turning Northern Australia into the "Food Bowl of Asia" is to succeed.

This report will present findings of the different types of deterrent technologies and strategies assessed during this study, and make recommendations on which are suited for Northern Australia and the way forward in introducing or trialling their effectiveness.

[3] A study by Charles Darwin University have since commenced in 2016

Chapter 1: Visual Deterrents

Visual and auditory deterrents together are effective and one of the fastest methods to disperse flocks of birds (Beason, 2004). Auditory deterrents will be discussed in Chapter 4. Visual deterrents work on the principle that birds fear unknown approaching danger, be this light, laser beams or drones, and to evade approaching danger, they fly away (Bird Gard, 2016).

Commercial visual deterrents rely upon novelty to elicit alarm (Inglish, 1980) and if the technology is unpredictable, the target birds will not habituate.

Lite Enterprises

Interview subject: Donald Ronning (Lite Enterprise, USA); 16/08/2016

Lite Enterprises produces a combined visual and auditory bird deterrent solution employing ultraviolet (UV) light. The concept of this technology is the use of UV light at specific wavelengths to cause discomfort – known as the "glare point"- to the birds, resulting in flight.

A trial has been undertaken on Red Tail Hawks, in which UV light was used to create a light barrier in a selected zone. The hawks are then directed to fly towards the light, with results showing the birds would suddenly change direction as they reached a certain distance and alter their flight path away from the path of the UV light (Ronning, 2016).

These findings were supported by the results of a recent separate study on caged cowbirds. In this study, a number of wavelengths of UV light were shone at caged cowbirds, with increased alertness recorded when the birds were exposed to light wavelengths of 470nm. Light at this wavelength occur as a blue light to humans. To the cowbirds, their response/reaction to possible collision with a remote-controlled plane under this wavelength was twice as fast compared to other light wavelengths (Doppler et al, 2015). However, researchers not have yet been able to source commercially available UV light at the correct wavelength.

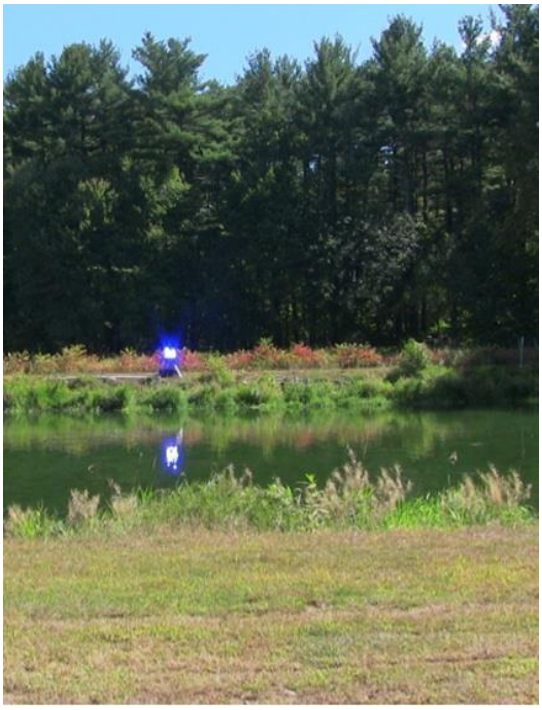

Figure 5: UV Light over a fishery (Photo: Lite Enterprises website)

Based on Lite Enterprises' UV studies, a new prototype is currently under development with hopes to begin trials on planes towards the end of 2016. The prototype is a standard aircraft light (PAR46) that is being converted to emit light over four different wavelengths, from visible light spectrum to the invisible UV spectrum (Ronning, 2016). If the trial is successful, the technology could perhaps be adapted for bird deterrence use on farms.

Laser Technology by the Bird Control Group

Interview subjects: Steiner Henskes & Corne Sweep (Bird Control Group, The Netherlands); 17/06/2015

"We provide solutions to keep birds at a safe distance from commercial activities"

-- Bird Control Group --

Laser is a new and non-lethal technology currently used for bird controls. The Bird Control Group is an industry leader in the development of bird deterrent laser technology with their products used today by a number of industries ranging from aviation to aquaculture and agriculture sectors. Under the "Agrilaser®" brand, the Group has developed three primary products for the agriculture sector: Agrilaser® Automatic, Agrilaser® handheld and Agrilaser® Lite (Bird Control Group, n.d.).

The technology works by appealing to the survival instincts of birds. A laser beam is pointed at, or near, the birds, making them believe there is something foreign – a potential threat – nearby, therefore causing them to take flight. This technology is designed with bird behaviour in mind. Birds cannot habituate to the laser as the beam pointed at or near them always varies

(*i.e.* controlled by humans therefore not always in the same place, nor at set intervals). Moreover, the refraction from laser to nearby materials such as leaves, branches, ground and grass, causes a danger sensation for the birds.

Green laser at 532nm wavelength was most effective to deter birds after extensive study and experimentation with a range of laser colours[4]. All Bird Control Group lasers are rated at Class 2M[5] and do not cause eye or skin damage within aversion response[6] time, meaning their products are classified as safe to the handler and targeted birds.

As with the use of most laser technology, safe handling is always a major concern and many countries, including Australia, have laws and regulations governing the use of high-powered lasers[7]. Consequently, with general safety. laws and regulations in mind, there is a maximum emission wavelength to which lasers are manufactured. From personal experience with Agrilasers®, lasers become ineffective under full sunlight. Companies making these types lasers deterrents are now adapting and modifying their laser technology to work better in brighter environments. Figure 6 summarises the three available Agrilaser® products manufactured by the Bird Control Group.

[4] In my discussion with the Bird Control Group, red laser was also found to be effective for deterring birds, but it requires 50 times more power than green

[5] "Visible, safe for accidental exposure (< 0.25 s) providing optical instruments are not used." (see http://www.lasermet.com/resources/class_table.php)

[6] "Closure of the eyelid, eye movement, pupillary constriction, or movement of the head to avoid an exposure to a noxious or bright light stimulant. In this standard, the aversion response to an exposure from a bright, visible, laser source is assumed to limit the exposure of a specific retinal area to 0.25 s or less." (see https://www.lia.org/evaluator/glossary.php)

[7] "According to federal law in Australia, any hand-held, battery operated laser with a power emission above 1mW is considered a dangerous weapon, and written consent must be obtained prior to possessing/importing such a laser pointer. However, according to an Australian Customs fact sheet, laser diodes, modules and other laser equipment above 1mW is legal to import". This site includes state-by-state breakdowns. (http://www.ozlasers.com/australian-laser-laws)

	Agrilaser® Lite	Agrilaser® Handheld	Agrilaser® Automatic
Description	Handheld and mobile Similar to a small hand torch Product viewed was 2nd generation	Handheld and mobile Similar to a large hand torch Product viewed was 2nd generation	Automatous device with pre-set time and pattern that the user programs Can be set to operate over three time-slots and up to 16 different zone or patterns Can be roof mounted or mounted at a user-determined height (e.g. mounted on stacked produce bins) Can be solar powered
Weight	180 grams	760 grams	NA
Range	Up to 1,000 metres	Up to 2,500 meters	Ability to provide full 360° coverage of the farm/area
Energy Consumption	2 watts	4 watts	4 watts
Image:			

Figure 6: Agrilaser® Products. Source: Interview with the Bird Control Group

The Bird Control Group has expanded into the aviation sector with similarly products (Aerolasers®) designed for airfield and airports to manage flocking of small birds and raptors. The new range of products, the Horizon Safety System, are modifications of Agrilaser® with an extra enhancement, which limits the reach of laser beams to no greater angle of 15° above the horizon. This safety measure eliminates the risk of lasers being accidentally pointed at aircrafts in the air and may be an important addition for some parts of Northern Australia where there are regular military (air) exercises. With the current generation of Aerolaser® being more powerful and effective than the current generation of Agrilaser®, there are plans to update the Agrilaser® with the more powerful Aerolaser® light.

Comments and Summary

A key deterrent for birds is the fear of an approaching unknown foe or a known predator, also known as visual deterrent. The two technologies assessed under this category include one that is available and one at the development stage.

Laser technology has improved substantially since it was first used on our farm in 2013; it was considered an effective option due to its long range (up to 2,500m) and mobility. Whereas first generation Agrilaser® products lose their effectiveness between dawn and dusk, the new generation products can be operated under daylight conditions, a necessity on a clear, cloud-free day in Northern Australia. If the cost of the technology is not a limiting factor, the pre-programmed automated technology and 360° area coverage, makes the Agrilaser® Automatic a beneficial addition to the bird/geese deterrent strategies already employed in Northern Australia.

Harnessing the UV light spectrum is a novel approach for deterring flying pests. The pilot study presented by Lite Enterprises has shown that birds may have an aversion to ultraviolet light and blue light with wavelengths of approximately 470nm but this technology is still at its infancy; more work is required to establish if different birds, including magpie geese, might react at the same or different wavelengths.

Chapter 2: Drone Technology

Drone technology has improved rapidly over the last few years and is now employed by a wide range of industries. In farming, drones have been used in Australia for visual photographic inspection of crop health and productivity, pest management (*i.e*. integrated pest and weed management), to rounding up dairy cows (Landline, 2013 & Landline, 2015). The question for this study is what drone technology, or similar, is available for the management of birds numbers on Northern Australian farms, in particular the magpie geese?

Robirds were subsequently identified, resulting in a visit to its developer, Clear Flight Solutions, an innovative robotic company from Enschede in the Netherlands specialising in creating realistic looking robotic bird and drones, primarily for bird control and (industrial) inspections. (Clear Flight Solutions, n.d.)

Robirds

Interview Subjects: Nico Nijenhuis &Remko De Jongh (Clear Flight Solutions, The Netherlands); 19/06/2015

Robirds are unique, remotely controlled robotic birds of prey that are realistic in appearance, movement and weight. Clear Flight Solutions, with the support of Twente University, have developed two Robird models, the Peregrine Falcon and the Eagle. The Falcon is able to chase away birds up to 3kg while the Eagle can chase away birds of any type (Clear Flight Solutions, 2015).

Figure 7: Nico Nijenhuis with Clear Flight Solution's Peregrine Falcon Robird (Photo: Han Shiong Siah)

Clear Flight Solutions' first prototype Robird was successfully tested at a waste management field, with an active waterway nearby where birds flocked to find food. Within a week into trialling Robird, the problem bird (gull) population reduced significantly by 95 per cent (Nijenhuis, 2015). Subsequently, the Robird has been used to manage starling infestation on a blueberry farm in the Netherlands (Clear Flight Solutions, n.d.).

A key advantage of a Robird as a bird deterrent technology is its ability to mimic its real-life counterpart. Extensive pilot training, including understanding the behaviour of the birds that it mimics, is required in order to get the maximum benefit out of the Robird.

An important factor that must be considered is the Robird is a drone-based technology and there will be laws and regulations governing its operation. At the time of this interview Dutch drone laws, for example, require all commercial drones in the Netherlands to be registered. Operation of these drones also require a minimum of three personnel: a trained pilot, an observer and a payload officer. Therefore, any introduction of the Robird into Australia will require comprehensive and up-to-date understanding of Australian Drone Laws[8] beforehand. A detailed list of advantages and disadvantages is presented in Figure 8.

Advantages	**Disadvantages**
Two models (Peregrine Falcon & Eagle) therefore have the ability to control birds of different sizes Mimics the real-life counterparts Shown to be effective in controlling birds in the Netherlands RoBird do not get tired or become uncontrollable like real counterpart. Battery can be hot swapped in a matter of minutes.	Local (national & state laws) governing commercial drones Untested in Australia Not available for purchase presently Costly to engage in Clear Flight Solutions' services ($1000 a day) Operators require extensive training Battery life of 20 minutes; Clear Flight Solutions indicates that birds of prey do not normally fly for more than a few minutes

Figure 8: Robird advantages and disadvantages

At the time of the interview for this report, (19/06/2015) Robirds were not available for sale as they were still in the early stages of development. The company instead provides services including bird control at US$1000 a day. The company plans to manufacture the Robirds for sale in the future. While the list price is yet to be determined, it is expected to cost around

[8] https://www.rpastraining.com.au/casr-101-uav-drone-legal-or-illegal

US$30,000. Clear Flight Solutions has expressed interest in coming to Northern Territory to trial Robirds on magpie geese but this study would require funding.

Comments and Summary

Life-like drones such as the Robird are a novel and successfully tested technology that could potentially replace birds of prey currently used to scare bird pests. The initial set-up cost is high but may be a more reliable and useful alternative to natural predators. The technology was designed and tested for the Northern Hemisphere but not fully tested in all conditions, such as the hot and humid climates of Northern Australia, or the target bird pest - the magpie geese The current prototype is effective on smaller birds but may not be against magpie geese.

An alternative to a natural living predator is a drone predator such as Robird (discussed in an earlier section of this conclusion) and the Goosinator drone. Another alternative to drone predators are natural predators such as the domesticated dog and birds of prey and this will be discussed in Chapter 2.

Chapter 3: Auditory Deterrent

"By exploiting natural bird behaviour, [auditory] products create a hostile environment that is unattractive to birds".

-- Scarecrow Bio-Acoustics Systems –

Auditory deterrents are another method to disperse flocks of birds and together with visual deterrents, are one of the fastest ways to do so. Robert C. Beason , from the USDA Wildlife Services writes that for sound deterrent to be effective, the sound must be (1) loud enough to be audible, (2) within the frequency that the birds ear can detect and (3) be a biologically relevant message to encourage the birds to depart (Beason, 2004). For this study tour, five auditory deterrents, working on these some of these principles, were assessed for their ability to the management of flocking bird pests. These were manufactured by (a) Scarecrow Bio-Acoustics Systems, (b) Bird Gard, LLC (c) Hyperstrike, (d) SonicNet and (e) pyrotechnics (The Rocketman). A summary of each technology is presented in the following sections.

Scarecrow Bio-Acoustics Systems

Interview subjects: Martin Vink & Loc Hoogenstein (Royal Netherlands Air Force, The Netherlands) 23/06/2015

"Scarecrow", manufactured by Scarecrow Bio-Acoustic Systems, is a digitised auditory deterrent using the distressed calls of birds to simulate a hostile environment. Distressed bird calls signals to the flock that attack is imminent and warns the flock to flee. Scarecrow is used by airfields, National Park authorities, Port Authorities, Nuclear Power Stations, Shopping Centres and Schools. (Scarecrow Bio-Acoustics Systems, n.d.). The company has a large bank of digitised distressed bird and birds of prey calls. (Scarecrow Bio-Acoustics Systems, 2007).

During this study tour, the Scarecrow Bio-Acoustic System Ultima was observed in action at the Eindhoven Airport, Netherlands. The Ultima model studied comprises two speakers mounted on the top of the vehicle and a central tablet computer control fitted inside the vehicle. The user selects from a list of the bird distress or birds of prey calls based on the bird type being dispersed. The volume is then adjusted to tailor to the flock size of birds to be dispersed. At the touch of a button, the bird call will be played over the speaker to scare away the flock. An additional feature of the Ultima model is its capability to record the following details; the number of birds in the flock, the location where the system was operated, the bird call selected and the effectiveness of the chosen parameters. Each of these data points can be

downloaded and analysed by Scarecrow Bio-Acoustic System or the airport's wild life management (Scarecrow Bio-Acoustics Systems, 2007).

Figure 9: Scarecrow Ultra (Photo: Han Shiong Siah)

Bird Gard

Interview Subject: Kimber Finney (Bird Gard LLC, USA); 31/05/2016

Bird Gard LLC, has a similar product line as Scarecrow Bio-Acoustic Systems Ltd that exploits the avian's fear of attack and the frequencies they are capable of hearing. The majority of birds can hear sound frequencies between 1kHz and 4kHz, with few birds having an upper limit of greater than 10kHz (Beason, 2004). Large birds such as geese have a lower frequency of 100hz to 8khz (Finney, 2016). Ultrasonic auditory deterrents (20kHz) are available but are generally ineffective as birds have worse hearing then humans and thus it is not assessed in this study.

Bird Gard claims that their loudest device, the Bird Gard Super Pro Amp, is capable of emitting up to 125db from 20 speakers, with the sound travelling outwards from the centre to a diameter limit of 365 metres (Bird Gard, n.d.). The key to the success of this system is the built-in microprocessor that plays a randomised combination of bird distress calls and bird of prey calls, thereby reducing the ability for the birds to habituate to the device (Bird Gard, n.d.).

Bird Gard confirmed that it does not currently have the distress calls of magpie geese in their library nor could it be confirmed whether distress calls of the Canadian geese is adequate to disperse magpie geese but that the cries of the bald eagle might be suitable. Bird Gard suggest that the NT horticultural industry might like to record the magpie geese's distress call by capturing a live geese and obtain a full six seconds of the distressed bird's call on a full spectrum microphone. The recording would then be remastered by an audiologist from the company and could be added to their library (personal communication with Kimber Finner, 2016).

Ultra Electronic

Interview subject: Katelyn Waters (Ultra Electronics UK); 10/08/2016

An alternative to Scarecrow Bio-Acoustic and Bird Gard LLC's technology is Ultra Electronics' recently launched HyperSpike® HS-10 (Ultra Electronics SSI, 2016). Marketed at the military, law enforcement, infrastructure and life safety industries, HyperSpike® is a range of acoustic hailing devices (or speakers) capable of directionally emitting in excess of 140dB of sound. The device has been used effectively for long-range crowd control, ship-to-ship communication and wildlife management.

During this study tour, two models of HyperSpike® devices were examined and a comparison of the features are described in Figure 10.

	HyperSpike® HS-10	**HyperSpike® HS-14**
Sound emitted	144dB	148dB
Communication range from speaker	750 m	1500 m
Angle of sound beam	15 º	12 º
Frequency range	Unknown	300 Hz - 8 kHz,
Weight	15lbs	37lbs
Advantage	Portable	Longer communication range Sound beam is more focussed with target angle being smaller.

Figure 10: HyperSpike® Model comparison Source: Ultra Electronics USSI (http://www.ultra-hyperspike.com/Products)

As Ultra Electronics' HyperSpike® is not specifically tailored for bird dispersal, recordings of bird distress calls are unavailable. Custom recorded bird distress calls or cries from birds of prey may be loaded onto the device via a memory card. A farm in Northern Territory has used this technology with some success, although the device is reported to be loud and must be used with care around houses.

SonicNets collaboration

Interview Subject: Samuel McClintock (Midstream Technology, USA); 10/08/2016

A new player in the auditory deterrent arena is SonicNets, developed from the research of Professor Mark Hinders and Professor John Swaddle of The College of William and Mary of Williamsburg (Virginia, US) in understanding bird behaviour. The product is currently at the early stages of being commercialised through Midstream technologies, also of Williamsburg.

Unlike Scarecrow, Bird Gard and HyperSpike®, SonicNets technology does not broadcast distress sound or predatory at high dB. Instead, the device, a speaker known as a parametric array, emits a focussed low beam of sound at the same frequency target birds communicate at. This is not only uncomfortable for the target birds to linger in the vicinity, but also disrupts their communication about ripened food. To humans, this low level frequency is audible as a low hum.

Figure 11: Sonic Net Parametric Array Speaker (Photo: Han Shiong Siah)

The key to the success of SonicNets' system is the identification of the correct frequency at which the target birds communicate (Swaddle et al, 2016). A recording of the target bird is required and the sound engineer will need to identify the correct frequency that interferes with the target birds' communication (McClain, 2014).

A pilot study of the technology at in the College's aviary showed a reduction of captive starlings foraging for food by up to 46 per cent (Mahjoub et al, 2015) and field studies showed that use of SonicNets reduced birds population in airways by up to 82 per cent (Swaddle et al, 2016). This apparatus is not known to have been deployed outside of the US, but installation of the prototype is planned for an aquaculture farm in Far North Queensland when a waterproof model of the parametric array speaker becomes available.

In the process of developing this technology, Hinder and Swaddle were awarded the Grand Challenges Exploration fund. This prize is funded by the Bill and Melinda Gates Foundation to recognise and encourage innovative approaches to combating world's toughest and persistent global health and development challenges (Kennedy, 2012). The award recognises this technology as an affordable solution that could be adopted in combating food loss to birds.

RocketMan (Pyrotechnics)

Interview Subject: Simon De Beno (RocketMan New Zealand); 06/06/2016

Using pyrotechnic-based deterrents to manage wildlife is not new and should not be disregarded as new innovative technology such as SonicNets are introduced into the market. Pyrotechnic deterrents have been used in the NT horticulture industry for decades as part of the arsenal of deterrent strategies. In fact, the NT Park and Wildlife Commissions had for years distributed Bird Frite®, a pyrotechnic-charged cartridge developed by the Australian Government and manufactured by Chemring Pty Ltd (Victoria, Australia) for the management of birds on airfields and orchards, until the cessation of its production and sale in 2014 for safety and fire hazard concerns (Issacs, 2014)[9].

While still in use, Bird Frite® was commonly used as a magpie geese deterrent, including on the author's farm. The advantage of Bird Frite® was that the cartridges were compatible with an unmodified 70mm chambered shotgun. The explosion of the cartridge is loud (approximately 145db) and takes place approximately 100m from the shooter, close to the target bird flock. (Farm Show Magazine, 1989)

With Bird Frite® products no long available or manufactured, a new product, the Shell Cracker Cartridge, was introduced as a direct replacement. It has a reduced fire hazard rating and like Bird Frite®, it can be also launched from a 12-gauge shotgun. The reach for fired cartridges was estimated to be between 90 and 120 metres, emitting sound at 110db and is capable of exploding within 10 metres of the target (RocketMan, 2016).

Nevertheless, pyrotechnics remains a viable bird deterrent strategy. This led to a visit to an industry leader in the latest pyrotechnic wildlife management/deterrent, New Zealand based RocketMan. Owned by Mr Simon De Beno who has 25 years' experience working with explosives in the mining, construction and outdoor industry sector, RocketMan is a company

[9] It was distributed as part of NT Parks and Wildlife's Birds harassment and destruction program/permit free of charge

that specialises in the next generation pyrotechnics used in aviation, agriculture and horticulture industries of Australia and New Zealand. Mr De Beno says his products are safer, more predictable and reliable. (Interview with Simon De Beno, 06/06/2016)

RocketMan supplies five types of pyrotechnic projectiles, mostly for the aviation sector, but some may be adaptable for the agriculture/horticulture industry. The product range includes both the pyrotechnics cartridges and the launching devices (see Figure 12).

	Bird-Banger	**Screamer-Siren**	**Whistler**	**Shell Cracker**	**CAPA**
Cartridge size	15mm	15mm	15mm	12 gauge	18.6mm
Material	Biodegradable cardboard enclosed	Biodegradable cardboard enclosed	Biodegradable cardboard enclosed	Cardboard enclosed, 12-gauge	Polycarbonate outer sheath, 18.6mm
Range	Short	Medium	Medium	Medium	Long range
Distance reached before explosion	30-40m	Up to 90m	Up to 90m	90 to 120m	Up to 450m after 7s silent ascension.
Recommended launcher	RocketMan launchers	RocketMan launchers	RocketMan launchers	Used with 12-gauge shot gun	18.6mm CAPA launcher
Maximum sound emitted	120dB at 10m	Not available	Not available	110dB at 10m	150dB at 10m
Type of noise disturbance	Loud audible bang	High-pitched screeching	High-pitched whistling	Loud audible bang	Built-in rocket motor is silent on discharge and cartridge detonates without detection.
Price	A$3	A$3	A$3	A$5	A$35

Figure 12: Rocket Man Products Source: Rocket Man Cartridges http://www.therocketman.co.nz/products/cartridges)

Some of the key advantage of RocketMan's products are:

- Most cartridges are made from biodegradable cardboard casing (Bird Banger, Screamer Siren and Whistler) and cold to touch following discharge, making them safe to use in high fire risk environments (DeBeno, 2016).
- One of its launchers, the Rocketman RG300, might be the most useful as it can be loaded with up to ten 6mm calibre blanks to initiate the cartridges, thus reloading the blanks between firing cartridges is not required. This launcher is also affordable at A$500 with each cardboard cartridge costing about A$3 each.

- The Screamer Sirens and Whistler cartridges are designed to create maximum disturbance to deter pest birds, therefore loading a mixed combination of both cartridges may guard against bird habituation.
- The RocketMan CAPA cartridge can also be considered for bird deterrence, however this long range pyrotechnic is a rocket propelled cartridge and requires a specialised launcher. While CAPA Cartridge is primarily used in airfields where a vehicle cannot get to the location of the birds quick enough, it may be able to disperse larger flocks of magpie geese from distance. At A$35 each, the CAPA Cartridge is used sparingly, even on runways (DeBeno, 2016).

Figure 13: RocketMan Pack shown at Dunedin Airport (Picture: Han Shiong Siah)

During this study tour, demonstrations of RocketMan products were observed at two horticulture fruit farms in the Alexandra region of New Zealand's South Island. The RocketMan 15mm cardboard cartridges are routinely used as part of both farms' active bird harassment strategy. Both farms also disperse bird pests using vehicles, lasers, an automated octocopter drone[10] with sound deterrent capacity, and as a last option, lethal kill. Simon De Beno say there is no silver bullet for the bird problem, and a combination of technology will help reduce bird habitation.

In Australia, a possible disadvantage of using pyrotechnic deterrents for horticulture producers is the requirement of the operator to hold a firearm licence and the company to have a corporate licence. This includes RocketMan's launchers and cartridges. More specifically, a 'H' (handgun) Class Licence will be required to operate RocketMan's launchers. In New Zealand, the same licensing and regulations is not required.

[10] Type of drone with eight engines

Comments and Summary

Used in combination, visual and auditory deterrents are the quickest way to disperse flocking bird pests. The auditory deterrents assessed in this study tour include audio devices that play the calls of birds of prey and birds in distress (Scarecrow Bio-Acoustics System and Bird Gard), devices that play noises of harassment loudly (HyperSpike®), devices that block the frequencies that target birds communicate at (SonicNets Technology) and pyrotechnic devices combining sight, sound and the element of surprise (RocketMan).

In theory any one of these techniques can work but are untested against magpie geese in Northern Australia, and for some technologies, more work is required before the technology could be tested. For example, neither Scarecrow, Bird Gard nor HyperSpike® have the calls of distressed magpie geese in their library and this would take time to prepare. SonicNets, purported to be an affordable technology, is promising as it blocks the channels of communications between pest birds rather than broadcast noise files, thereby reducing bird flocking. However, the product is still in development as the communication frequency for magpie geese is still to be established. The pyrotechnics technology (RocketMan) is a suitable alternative due to its combined elements of visual and sound deterrent, although gun safety regulations in Australia make it more difficult, but not impossible, to trial this technology.

Chapter 4: Chemical Deterrents

Chemical deterrents used in the horticulture sector are typically sprayed on the produce and may be classified as primary or secondary repellents via their modes of action. A primary repellent elicits a sensory response by altering the taste, smell or irritant properties of the produce following contact. A secondary repellent effects a physiological response, typically following ingestion, thereby teaching the target organisms to avoid the sprayed produce or location (Cowan et al, 2015). The first report of chemical repellent use against birds, both lethal and non-lethal, was recorded by the early European settlers in the US of Native Americans using Extracts of *Vaeratrum. Spp* (Benson, 1966). In recent times, there has been a push for non-lethal chemical deterrents to be used in primary production.

This section describes the study of two chemical deterrents: (1) Avian Control®, by Avian Enterprises LLC (US) and (2) Avipel® Shield by Arkion Life Science (US).

Avian Control®

Interview subject: Jon Stone (Avian Enterprises LLC, USA); 24/05/2015

Avian Control® is a liquid repellent based on methyl anthranilate (methy 2-aminobenzoate), a naturally occurring compound found in flowers and fruits such as jasmine, acacia, gardenia, hyacinth, concord grapes and orange blossom (Vogt, 1992) and is considered generally safe as a food additive for use as grape flavouring.

The first generation of methyl anthranilate, "Rejex-it", was developed by PMC Specilates to manage Canadian Geese infestation and approved for use by the American Environmental Protection Agency (EPA) in 1994[11], however there has been reports of mixed successes (Eisenmann et al 2011). Avian Control® is a one of six EPA-registered variant of methyl anthranilate repellent and was successfully registered in 2010 (EPA, 2011).

Methyl anthranilate acts on the trigeminal nerve associated with taste and smell, located in the head of the bird, causing a pain response. While the affected bird recovers after departure from the sprayed area or produce, it is also conditioned to associate the location with

11 EPA review of methyl anthranilate as a chemical repellent.
(https://www3.epa.gov/pesticides/chem_search/cleared_reviews/csr_PC-128725_8-Jun-94_012.pdf)

discomfort and does not return. Acute toxicity to this compound is slight in aquatic fish and invertebrates, and negligible in animals, avian and humans due to the minimal dosages used.

Typically, Avian Control® is sprayed as a dry or wet mist on fruit and vegetables, farmland, turf, airfields, and effects irritations via three modes of action; exposure via ingestion (of the fruit produce or via preening), touch (even through the feet) and/or inhalation of misted molecules. Despite company claims that birds do not develop tolerance to Avian Control®, a representative of the company indicated that some young starving birds would endure the discomfort to forage on treated grounds and feast on treated crops (Stone, 2016).

Application of the deterrent on grapes, berries and stone fruit should occur before the start of the picking season and needs to be reapplied weekly or every two weeks when there is no rain, as the product is not resistant to heavy downpour (Avian Control, 2016)

Figure 14: One Gallon of Avian Control (Source: Avian Enterprise website)

The manufacturer claims that Avian Control® cost $12.50 USD per acre to apply, and has been reported to reduce grape fruit loss to birds from between 37 per cent to 87 per cent (Avian Control®, 2016). However, cost is variable depending on the application strategy of the end user and may be as high as $150/ gallon (Stone, 2016).

In 1993, the effect of methyl anthranilate on deterring rainbow lorikeet from rambutan crops was investigated in Northern Territory and while it was effective, the subsequent effects on the crops were unsatisfactory. Rambutan husks treated with the chemical darkened and became aesthetically unpleasant; the effect was hastened under direct sunlight. It is of note that an earlier formulation of methyl anthranilate was used, and a repeat of the study using Avian Control® should be considered to determine if there is reduced phytotoxicity to plants and produce. (Marcsik, 1997)

Avipel® Shield Technology

Interview subjects: George Archibald & Anne Lucy (International Crane Foundation, USA); 13/08/2016

Avipel® Shield is another non-lethal bird deterrent that is currently used to mitigate bird damage on crops. The active ingredient (9,10-anthraquinone) is found in aloe vera, rhubarb and greater plantains and sennas. In its natural form, 9,10-anthraquinone has a laxative effect (Xing and Soffer, 2001). Birds eating treated seeds suffer digestive distress and quickly learn to avoid the location where the treated seeds are sowed (Avipel® Shield, 2016).

Avipel® Shield is a water insoluble product and is sold in powder and liquid form. Seeds are coated with the chemical prior to sowing, with early trials indicating the liquid formulation was more successful at coating grass and corn seeds than the powder format (Lacy, 2016). Typically, sweet corn seeds are coated in a hopperbox containing the liquid repellent prior to sowing.

Figure 15: Maize Trials with Avipel (Photo: Avipelshield website)

In a collaborative study between the International Crane Foundation (Wisconsin) and Arkion Life Sciences, the effects of Avipel® Shield treatment as a deterrent against sandhill crane was studied. Cranes were eating newly sown corn seed and seedlings (up to 7cm high) and historically, crop damage reduction was managed by shooting. Farms sown with untreated seed suffered greater damage compared to farms sown with treated seed, which were largely left untouched by the cranes. (Lacy, 2016). Cranes eating treated seeds exhibit similar avoidance behaviours as birds encountering Avian Control® and its variants (Lucy, 2010), possibly due to discomfort induced in the trigeminal nerve although Lacy suggested that this might be associated with UV rays emitted by 9,10-anthraquinone that interferes with the "glare point" of these birds' eyes (refer to Chapter 2.1 for explanation of "glare point").

In a recent study where Avipel® Shield was applied to potato shoots and vines by spraying, the compound was found to have leached potato tubers, leaving a bitter taste that is detectable by humans. As a result of this finding, research was halted. If this compound is to be considered as a future bird deterrent, the effects of this repellent on fruit and rice should be further evaluated.

Ultimately, the cost of Avipel® Shield may be a deciding factor for whether this repellent is used. In the 2006, it cost USD $6-8 to cover one acre with treated seeds compared to USD $10-12 per acre in 2010 (Lacy, 2016).

Comments & Summary

Chemical deterrents investigated during this study tour, methyl anthranilate (Avian Control®) and 9,10-anthraquinone (Avipel® Shield), are not registered with the Australian Pesticide and Veterinary Medicines Authority (APVMA), the national body that registers new chemicals for use in Australia. Both naturally derived chemicals are effective and have been used in the US agriculture sector for the last 50 years. Bird pests learn to avoid crops and locations treated with Avian Control® (a chemical that triggers a pain reaction) or Avipel® Shield (a chemical that confers digestive discomfort).

It was also reported that, in their search for food, some young birds resist the discomfort due to contact with Avian Control® so it remains to be determined if magpie geese would behave similarly. As for Avipel® Shield, some studies have shown that there may be chemical residuals in fruits and crops grown from treated seeds. This observation, taken in combination with the fact that limited emergency licenses were issued to certain US states by the Environmental Protection Agency (US), would raise questions about this chemicals safety. Both concerns would need to be assessed at, or prior to, product registration.

Chapter 5: Natural Predators

Two primary types of natural predator were examined for this study, firstly “man’s best friend”, being trained wildlife management canines, and secondly, birds of prey - specifically, the reintroduction and attracting of wild birds of prey onto farmlands.

Piper the Cherry Capital Airport K-9

Interview subject: Brian Edward and Piper (Cherry Capital Airport, Michigan); 20/05/2016

Piper is no ordinary eight-year-old Border Collie. What is so special about Piper is that he works at Cherry Capital Airport, Traverse City (Michigan, US) as the wildlife controller. His job with Brian Edward, his handler, is to keep birds and animals off the airfield. Bird strike can cause untold damage to planes and the passengers it carries. The January 2009 US Airways Airbus A320 safe crash landing into the Hudson River is an example of the hazards a flock of birds in a plane’s flightpath can cause. It was due to the skilled piloting of Captain Chesley Sullenberger that the lives of all 155 passengers and crew on board were saved from an accident that could have had catastrophic outcomes (Ross, 2012).

Piper's day-to-day role is to chase birds and other animals as well as collect foreign objects (FOB) from runways and taxi-ways. His focussed duties can vary depending on seasons - for example, during winter he is tasked with removing snow owls, while in summer he hunts and digs out underground mammal such as moles. Both wildlife are considered striking hazards to planes at take-off.

Figure 16: Piper at Cherry Capital Airport (Photo: Han Shiong Siah)

An interesting observation shared by Brian, Piper's handler, during our meeting was that after a year the birds Piper is tasked with "managing", learnt to recognise the K9-Airport Car which carries Piper, and prepare to fly away when they see the car. Brian haves since perfected technique to open the rear door to allow piper quicker access for Piper to ground to chase off those birds.

Even though Piper is part of Cherry Airport's wildlife management strategy, in truth, Piper is a volunteer dog who was trained by his handler and owner Brian. Pipers owner is responsible for covering most of his costs and training, including food, insurance, veterinary and protective gear. Piper and Brian rely on donations, most prominently through social media campaigns - Piper has huge following on Facebook[12]. Through these donations, most of Pipers protective gear and food is covered for the next couple of years. Piper is now eight years old and has reached his prime. Wildlife management is Piper's job is full time, he works a four days on and four days off roster. On his off days, he enjoys life as part of Brian's family.

Using K-9 for wildlife control or management is not new or unique. Many wildlife dogs are being used in many airports and their sole task is to chase birds or other wildlife from runways and taxiways. Other examples include:

- Southwest Florida International Airport in Florida has 'Aero', the fourth dog to work there (Ruane, 2014)

[12]https://www.facebook.com/airportk9/

- In Australia, Brisbane and Gold Coast airports have trained wildlife dogs as part of their bird control programs (Curtis, 2013 & Harvey, 2013)

Using dog control can be very effective, but it is not without its disadvantage. These include:

- Training costs - Brian, Piper's handler estimates that it costs up to US$10,000 to train a dog to same level as Piper.
- On-going maintenance, veterinary and training costs - while an on-farm wildlife management dog may not require the protective equipment Piper uses, these costs cannot be discounted.
- Overall welfare of the dog including injury prevention. The Northern Australian climate can be harsh (hot and high humidity), so keeping the dogs in top condition and minimising the risk of heatstroke and injury is paramount. Injury and illness can result in long layoffs and this happened to Piper in early 2016. He broke his front leg while on duty and was out of action for a long two-month recovery period, leaving Brian without his invaluable partner for the duration.

In discussions with Brian he suggested a dog-like radio controlled drone called the Goosinator. The Goosinator is a land-based bright orange drone designed and built with skis rather than wheels. The drone has the ability to move on difference surfaces, from turf, sand, snow to even water (http://www.goosinator.com/).

Figure 17: Goosinator (Photo: Goosinator website)

The designers/manufacturer suggest that the Goosinator would be a good addition to an integrated wildlife management strategy. Key advantages of the Goosinator are:

- The ability to work on different surfaces and climates, thus enabling the wildlife management dog to rest during extreme weather conditions and avoid health hazard risks such as heatstroke.
- In an airfield/airport environment, it reduces injury risks to the dogs.

Falconry Box, Traverse City

Interview subjects: Megan Shave & Dr Catherine Landell (Michigan State University, USA); 23/05/16

Birds of prey have long been used in managing wildlife population in airports and airfields to ensure runways, taxiways and flightpaths around the infrastructure are clear. Similar to the aviation sector, flocking birds present a major challenge to the horticulture sector, but through crop damage. As in aviation, the horticulture industry outside of Australia has also used of birds of prey, such as bald eagles, falcons and peregrines to deter flocking birds (Walker, 2013). This approach, however, can be expensive due to the cost associated to raising and training the birds of prey. As an estimate, a birds of prey pay-for-use service, which includes the service of the bird and its handler, can vary from £60-£80 per half hour to one hour through to £150 per visit for up to three hours. (Pigeon Control Resource Centre, 2009)

In the US, an innovative idea was proposed and successfully trialled in 2014-16 where wild birds of prey were used to manage flying pest problems in Traverse City, Michigan (US). Traverse City holds a "National Cherry Festival" every summer to celebrate the region's claim as the "cherry capital of the world"[13]. Just as cherries are beginning to ripen and change colour, birds such as American robins, seed wax-wings and starlings will start attacking the crop. Traditionally, farmers in this region have used a number of control strategies such as trained kites and inflatable air dancers to scare away these birds (Shave, 2016).

In early 2014, PhD student Megan Shave, under the supervision of Dr Catherine Landell from the Michigan State University, decided to test the hypothesis that re-introducing native American Kestrels into cherry farms during summer months will help reduce bird pests on the farm. During the summer months, American Kestrel (*Falco sparverius)* migrate to the region from the southern states to nest and rear their hatchlings. With the co-operation of local farmers, Shave placed ten falcon nesting boxes across cherry farms in the region. The boxes were mounted at a height of 4m and each were fitted with a camera to record the inhabitants'

[13] For more information about the festival, see http://www.cherryfestival.org/

activities within the nest. The adult birds were caught, fitted with radio-transmitters to track their movements and then released during the duration of the research. In Summer 2014, all ten falconry boxes were installed and occupied. An additional ten were installed in April 2015 and these boxes were also filled by the end of Summer 2015. In January 2016, a further five boxes were introduced and as of May 2016, three now house American Kestrels. (Shave, 2016)

Figure 18: Falconry Boxes (Photo: Han Shiong Siah, 2016)

Results from the first year of the study showed a significant reduction in population of problem birds and noticeable reduced damage to fruit crops. As the kestrels successfully hatched, GPS tracking data showed that the parents would actively hunt around the cherry farm and return with a starling for their young hatchlings.

In the second and third year of the study, it was noticed that as the kestrals migrate back to Traverse City for the summer months, the falcon boxes fill up more quickly. Thus, Shave's research has not only confirmed her PhD hypothesis, but have also shown that there could be a symbiotic relationship between birds of prey and the farm. The positive outcomes from this research have encouraged a number of farmers to install similar falconry boxes on their farms.

Due to the success of this research, Dr Catherine Landell is attempting to replicate the successful study in a nearby blueberry farm by introducing five falcon boxes. At the time of the study tour visit, there has been a slower uptake of occupancy of the boxes by the kestrels.

Being that this is only the first year that falconry boxes were installed in this farm, there is still hope that in subsequent years, more American Kestrals will nest in these boxes

Summary and Comments

Natural predators are widely known as an effective strategy for the management of pests and wildlife, and in the case of dogs for wildlife conservation in Australia. On studying dogs and birds of prey the following observations are made:

Dogs

Introducing and training dogs to undertake magpie geese (and general bird/wildlife) management is certainly an option, but this strategy should be part of an integrated approach to mitigate some of the health and welfare concerns particularly associated with Northern Australia's harsh climate (high temperature and humidity). A feasibility or trial study could be considered by the horticulture (or mango industry) for a project involving the engagement of a dog-trainer with wildlife management experience. The project could focus on:

- Training existing farm dogs and their owners (as many farmers are owners of dogs which are of working breeds)
- Assisting farmers in choosing and training the right dog for the job, *i.e.* looking for trainability and breed suitability for the harsher Northern Australian climate

While specialised dog training can be a costly option, this is potentially one of the most rewarding options, due in part to the companionship and loyalty of the dogs. Costs could perhaps be reduced by adopting shelter dogs and equipping farmers with self-sufficient skills and knowledge to perform ongoing training and maintenance once the dogs are trained. The next step could be to seek out the view and advice of an appropriately experienced dog trainer/behavioural expert with wildlife management experience, such as renowned Australian dog trainer Steve Austin.

Birds of Prey

From personal observations during the mango season, magpie geese are often hesitant to land if predators are circling. In a pest risk assessment report of the magpie geese, its natural flying predators were reported to be whistling kites (*Haliastur sphenurus*) and White Bellied sea

eagles (*Haliaeetus leucogaster*) (Resource management and Conservation Division, Department of Primary Industries, Parks, Water and Environment, 2011).

In the NT, there is no known research simulating the falconry box and cherry farm model but the positive outcomes of Shave and Landell's work suggests that this deterrent strategy may work. Further analysis would be required in assessing how best to simulate this model using the whistling kite, the most common predator (or an alternate species) around and near farms. However, the evolving intelligence of these magpie geese has to be taken into account in any study or eventual strategy put forward. It may also be prudent to use any eventual strategies alongside some of the others studied here.

Chapter 6: Environment Modification

In 2007, the Bureau of Rural Science released a comprehensive guide to manage crop damage due to birds. In addition to the different categories of deterrents discussed in this report, the guide published recommendations on how to modify the environment to reduce pest birds flocking or nesting in the property (Tracey et al 2007). Two novel approaches capable of reducing bird pest invasion were assessed and discussed below.

Salt Lake City Airport(SLC): Turf Replacement

Interview subject: Gib Rokich (Salt Lake City Airport Wildlife Manager, USA); 26/06/2016)

Salt Lake City Airport in Utah like most, if not all, airports have strategies in place to manage bird populations around its airfield to prevent bird strikes. One of their main problem bird populations are raptors flying into the grass ways to hunt rodent and other smaller mammals on airport grounds. As a result, the airport took a multi-prong approach to minimising opportunities for bird strike.

One solution that the airport and its wildlife management team used was to resurface grassy areas with asphalt. This minimised the presence of rodents, small mammals and limited the available food source for the raptors to hunt around airport grounds. The first phase of the project saw over one million square feet of airport grounds resurfaced leading up to 2013 (Jensen, 2013). Following the resurfacing of the airfields, there were no sightings of birds on the target areas. Owing to this success, as at May 2016, additional areas around the airport terminal and main runways were also resurfaced (Rokich, 2016). This particular strategy of replacing surface area with asphalt could be deemed as unsuitable and impractical for the horticulture sector.

Figure 19: Asphalt Modification at Salt Lake City (Photo: Han Shiong Siah)

Concurrent to resurfacing of grass ways with recycled asphalts, Salt Lake City airport also grew Russian ryegrass– a salt tolerant perennial plant - on the outer perimeter (boundary) of the airport to test the effectiveness of ryegrass as a food source. This strategy redirects wildlife to these areas thus keeping "active zone" airport grounds free of wildlife including raptors. Results of the trial indicated that grass ways needs to be cut low so that it does not seed and attract small birds.

To further limit the bird population management around the airport, Salt Lake City also commissioned the construction of a permanent wetland away from the airport. Water fowls are attracted to the permanent wetland, to reside and take refuge during waterfowl hunting season. Today, this wetland is an active ecosystem with an abundance of wildlife and plants for the birdlife to thrive (Rokich, 2016).

Figure 20: Artificial Wetland at Salt Lake City (Photo: Han Shiong Siah)

PGG Wrightson Turf – Avanex

Interview subject: Matthew Carter (Pennington Seed, USA); 10/08/2016

PGG Wrightson Turf is a New Zealand company specialising in grass/turf seed production. They sell a particular perennial ryegrass, Avanex®, which has a built-in natural defence against birds. It has been trialled and tested at Christchurch airport (Pennell, 2013). Originally bred by AgResearch in Christchurch, New Zealand, Avanex® ryegrass is bred with a naturally occurring endophyte fungus (*Neotyphodium spp*.) in the plant (Pennell, 2013). The fungus has a symbiotic relationship with the grass that it is bred into, where the fungus releases a chemical that causes digestive tract discomfort when ingested. Due to this discomfort suffered, birds

and other animal species (rabbits and other mammals) ingesting this grass learn to avoid this grass and move onto another area.

Summary and Comments

The Salt Lake City airport have shown some innovative ways in managing problem bird/wildlife populations but the strategies employed, particularly the replacing of grass surfaces with asphalt, may not be practical for managing bird numbers on horticulture land. While it is possible to remove a food source (*i.e.* grasslands) to deter bird landings on airports and its environs, the same is not true on farmland as primary food production is the core business in the horticulture industry. However, what is learned from the Salt Lake City airport experience is that in altering environment, it could assist with managing bird population.

Even though Avanex® ryegrass is effective in deterring birds at airports, how it could be used in the horticulture sector, or even in the agriculture sector, is unknown. Some questions that have emerged include:

- How effectively would the grass deter birds if another available food source is available, for example crops on fruit trees?
- Bird damage in primary production is not only limited to horticulture crops; a number of pastoral properties have reported increasing magpie geese population and grass damage in the Douglas-Daly Region of Northern Territory. Can this type of grass/ bird repellent be safely used as livestock feed, and has there been any trials investigating this?
- Could this grass be used as a companion plant for broadacre farming, for example in rice, or even vegetable farming?

Conclusion

In the past, lethal means to eradicate pest birds were the only viable option but in recent times following the development of innovative research and products, many non-lethal and humane bird deterrent techniques have become available to help farmers mitigate fruit damage due to flying pests.

As a grower of mangoes and other tropical fruits, the main problem bird species encountered, particularly during mango harvest season, are magpie geese, although other bird species including sulphur-crested cockatoos and rainbow lorikeets are also encountered. Over the years, there has been increased larger flock landings, but also seen the magpie geese's ability to evolve and adapt to environmental changes. For example, in recent years, the magpie geese are increasingly perching high up on trees in the evenings on bushlands and not returning to their natural habitat - the wetland. The “easy” access to produce as food source has consequently had a huge impact on the resources invested to deter, disperse and manage bird landings on farms in the region.

This Nuffield project emerged from a need to find effective strategies to manage magpie geese (and other bird) populations and mitigate crop damage on orchards, the farms of neighbours and colleagues in Northern Australia. On the authors mango farm, a number of techniques have been assessed and are still used, with variable outcomes. These include physical means (chasing using ATVs), sound (gas cannon and horns) and light deterrents (AgriLaser®). Due to the magpie geese's evolving intelligence and ability to habituate under stressful situations and conditions, no single technique has been successful at deterring them from the orchard completely.

A study tour ensued which involved travel to the Netherlands, USA and NZ to investigate best practice bird deterrent strategies and technology. This report describes the study tour, including visits to companies, research institutions and airports that have designed, produced and/or trialled innovative technologies to manage problematic bird population. The purpose is to recommend suitable technique and strategies identified that could be adopted or trialled for the management of magpie geese population in support of Northern Australian horticulture producers. The bird deterrent techniques/strategies investigated were visual

deterrents, drones, auditory deterrents, chemical deterrents, natural predators and environment modification. They included:

Deterrent Type	**Company or Products**
Light Deterrent	• Agrilaser® • Lite Enterprise
Drone	• Clear Flight Solution.
Auditory Deterrent	• Sonic Net® • Bird Gard® • Scarecrow® • HyperSpike® • Pyrotechnics by Rocket Man
Chemical Deterrent	• Avian Control® • Avipel® Shield -
Natural predator	• Dog – Piper K9 Airport Dog • Introduction of falconry boxes

Environment modification	• Salt Lake City Airport
	  ○ asphalt modification
	  ○ wetland relocation
	• Avanex®

This report has outlined a number of novel technologies and strategies to safe-guarding crops from magpie geese and other flying pests. However, it can be concluded, no one pest management technology or strategy is fool-proof. In isolation, many of the strategies studied will have some level of success but the author's experience with magpie geese is that they will eventually habituate. So, while various strategies may be initially effective, over time they may lose effectiveness. Thus, in the process of preparing this report, it has become abundantly clear that any approach in managing magpie geese (and bird pest) dispersion must be a multi-pronged approach.

The suitability of the technologies assessed during this Nuffield Scholarship study tour and recommendations to get these techniques to be farm-ready for the Northern Australian horticulture industry are set out below..

Recommendations

1. **Visual deterrents** are one strategy to disperse pest birds such as magpie geese. Laser technology to scare birds is highly effective in the right conditions, although research is needed to optimised the strength of laser beams to better suit the Northern Australia environment and wildlife. An alternative visual deterrent works with the UV light spectrum, and whilst the product has successfully passed the proof-of-concept stage, more research and testing is required to determine the UV frequencies needed to confer maximum discomfort on the eyes of bird pest (including magpie geese), and if indeed the concept is applicable across all bird types.

2. **A number of sound deterrents are available**. Some are designed to play the calls of distressed birds or birds of prey, some may be used to play noises of bird harassments, and others work on a combination of sound and visual deterrents (pyrotechnics). To get the best of one or more of these deterrents, selection of the correct parameters must be considered. This may include (a) selection of the correct calls of birds in distress, or calls of birds of prey, and (b) the correct speakers types to transmit these signals (volume, frequency). If pyrotechnics is the most suitable approach, then selection of the most situation-appropriate cartridges and launching mechanism should be considered.

3. **Methyl anthranilate and 9,10-anthraquinone** have been shown to be successful in the reducing crop damage due to bird pests. Rigorous testing and careful considerations, which may be based on existing case studies and literature searches, are needed before the chemicals are registered by the AMPVA as safe for use as bird deterrents.

4. **Natural predators** are one of the most effective ways to manage bird pests but this requires knowledge of the bird pest's natural predators – for example, kites and eagles are the magpie geese's natural predators. Installation of falconry boxes in orchards can result in a symbiotic relationship between the farm and the bird of prey. Alternatively, dogs may be trained to chase away pest birds such as magpie geese, although this may require significant investment of time, effort and money.

5. **Drones such as Robird may be considered,** if a natural predator is not an option. If Robirds can emulate the common birds of prey of the Northern Australia, this system may show promise in chasing away magpie geese and other bird pests. An alternative to this is the

Goosinator, a land-based drone. Both drones could benefit from in-field trials to determine if they will be suitable against magpie geese.

6. **A multi-pronged approach to managing bird pest invasion is advised.** Many of the technologies assessed in this report are worthy of consideration.

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Plain English Compendium Summary

Project Title:	Alternate and cost-effective methods to control flying feral vermin

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Objectives	To explore and evaluate the following flying vermin deterrent products for suitability for horticulture: • Sight and visual deterrent • Drone/robotic bird technology • Auditory deterrents • Chemical deterrents (non-lethal) • Natural predators • Environment modification
Background	Magpie geese, a native bird to Australia, are fast becoming a pest on farmlands as a consequence of changing environments and hunting, causing these birds to evacuate from their natural wetland habitats to farmlands of Northern Australia. With the introduction of firearms bans on small farms, farmers are now reliant on a limited number of non-lethal scaring techniques. Some of these techniques are very expensive and birds have adapted quickly, meaning new cost-effective products are needed to scare birds away.
Research	Visits to companies, universities, airport, conferences, research labs and farms in The Netherlands, United States and New Zealand during the study tour has yielded a number of new and novel technologies that have not been used by Australia farmers previously. A review of research associated with these technologies was also used to confirm the effectiveness of some of these products.
Outcomes	The majority of the technologies and strategies reviewed in this report are suitable for use in the horticultural and other primary production sectors but the end-user might like to use a number of these techniques and strategies together for maximum effectiveness.
Implications	Many of these technologies and techniques are not yet available in Australia. Introduction of these products in the near future may require registration with appropriate governmental bodies.
Publications	• July 2016 - ABARES Regional Conference – Darwin • September 2016 - Nuffield National Conference – Adelaide