Avon Regional Organisation of Councils

AROC Governance Group Meeting

14 March 2022

Minutes

To: AROC Members

Here within are the Meeting Minutes of the AROC meeting, held on the abovementioned date via zoom.

Suzie Haslehurst
CHIEF EXECUTIVE OFFICER
AROC Secretariat

Preface

These Minutes will remain "Unconfirmed" until the next AROC Meeting, where the Minutes will be tabled and confirmed subject to any amendments.

The "Confirmed" Minutes are then signed off by the Chairperson.

Attachments that formed part of the Agenda, in addition to those tabled at the Meeting are incorporated into a separate attachment to these Minutes

Distribution

These minutes were approved for distribution on 14 March 2022.

Suzie Haslehurst
CHIEF EXECUTIVE OFFICER

Confirmation

These minutes of meeting were confirmed at a meeting held on ....

Signed: ....

Note: The Presiding Member at the meeting at which the minutes were confirmed is the person who signs above.

CONTENTS

ATTACHMENTS *with separate index follows Item 5.*

1. DECLARATION OF OPENING

The AROC meeting commenced at 9.35am.

1.1. Announcement of Visitors

Mr Karl O'Callaghan, the CEO from the NRM was present at the meeting, without a camera, to give an update on the Corella Management issue that was discussed throughout 2021.

1.2. Record of Attendance and Apologies

Cr R Madacsi	Shire President / Chair
Cr B Ruthven	Deputy Shire President, Shire of Toodyay
Ms S Haslehurst	CEO, Shire of Toodyay
Cr C Antonio	Shire President, Shire of Northam
Mr J Whiteaker	CEO, Shire of Northam
Cr P Bantock	Shire President, Shire of Victoria Plains
Cr D Smythe	Shire President, Shire of York
Cr J Chester	Deputy Shire President, Shire of Goomalling

Apologies

Cr B Haywood	Shire President, Shire of Goomalling
Mr C Linnell	CEO, Shire of York

2. MINUTES AND ADDITIONAL INFORMATION

2.1 Confirmation of Minutes

RECOMMENDATION/AROC RES. NO. 01/03/22

MOVED Cr Antonio **SECONDED** Cr Smythe

That the Unconfirmed Minutes of the Avon Regional Organisation of Councils meeting held on 8 November 2021 be accepted as a true and correct record.

MOTION CARRIED

2.2 Review of Status Report

Review of actions and progress arising from previous meetings and decisions.

Points raised as follows:

- CEO from Shire of Northam advised that they are still sorting out the planning they are doing at the moment for recycled water facilities and it is taking them longer than anticipated.
- President from Shire of Victoria Plains asked whether in relation to the water sustainability regional initiatives whether the group of AROC was prepared enough for lobbying at the Federal Election? Response was that the group was not prepared enough.
- President from Shire of Toodyay advised that Gingin had pulled out of the Rural Water Group (RWG) due to feeling they were not included in the group's advocacy position as it was broadly scoped and was more on the central wheatbelt area and their water issues are not fitting in. A zoom meeting with RWG is scheduled for the 18th of March. Interested to hear what AROCS opinion was before that meeting. Thinking if not ready for federal election we should be looking at where we do have influence and the RWG has influence that travels up federally.
- President Shire of Vic Plains: I am unable to attend the zoom meeting on the 18th however this is a bigger discussion and not just a point on the status report. If AROC is not ready for Federal Election lobbying then perhaps it is best if we all continue to work on own individual parts as a group and bring a report to the next meeting as an item for discussion.

2.3 Inward / Outward Correspondence

2.3.1 Financial Report (to date)

RECOMMENDATION/AROC RES. NO. 02/03/22

MOVED Cr Bantock **SECONDED** Cr Smythe

That the financial report, as attached, be received, subject to the date at the bottom being corrected.

MOTION CARRIED

2.3.2 Attendance by Hon Melissa Price

Please note that Minister Price was unable to attend the meeting in person. An opportunity to attend via teams or zoom was extended to her office however, due to cabinet commitments she is unable to accept.

2.3.2 Advocacy Strategy – Role of Executive Officer

CEO, Shire of Toodyay proposed that an advocacy strategy be written by the AROC Executive Officer as part of their role as it would be useful for AROC to look at who particularly we need to target in relation to key issues. It would also comprise of the approach that would be taken to getting Ministers to talk with AROC.

Advocacy Strategy to include which State and Federal Ministers would be targeted for issues pertaining to AROC.

3. OTHER BUSINESS / NEW BUSINESS OF AN URGENT NATURE

3.1 Submissions, presentations or representations from third parties

Nil.

3.2 Matters referred by the Officer's Group for consideration or decision

Nil.

3.3 Matters raised by individual member local governments for consideration;

3.3.1 Employment of an AROC Executive Officer (S. Haslehurst)

The Executive Officer position description has been discussed by all CEO's and it has been agreed upon.

Have to concur that staff availability and pressures affected anyone. Hoping the position will be advertised later this week and we will ideally have someone chosen, who can attend the next governance group meeting.

3.3.2 The water sustainability regional initiative

Consideration given to whether AROC was moving forward with our lobby effort, given the federal election is around the corner. At this point we've been unable to meet with our Federal MP. We are yet to discuss any detailed proposal, and the timeline is becoming unachievable.

Shire President, Shire of Toodyay intends to request the RWG approve the establishment of a sub-group to be able to champion the issues that Gingin and AROC are interested in, to cover for the gap in what the RWG does not cover.

Relevant Ministers responsible for Water will be liaised with by the AROC Executive Officer as part of their role.

3.3.3 Update on Corella Management

Karl O'Callaghan spoke at 9.57am about the yet to be provided 60-page long report on corella populations and management, that provides a myriad of solutions the AROC can consider by way of development of a strategy and coordinated effort.

Points raised as follows:

- Lack of coordination and strategies required to address that and the different responses required for a townsite or a rural area.
- How to coordinate and develop the strategy.
- Wheatbelt wide coordinated response required to have broad impact across the region.
- Karl has liaised with other people managing other local governments who are interested in focusing on the corella program.
- The report will be sent out to all AROC Members through the secretariat and the strategy will be provided, proposing that AROC has one coordinator on the ground be responsible for trialling some of the methods suggested.
- Any method chosen would require endorsement and permission from regulatory government departments.

Clarification was sought as to whether CBH had been approached.

Response:

I have had conversations and will continue to have further conversations with them.

I have asked Edith Cowan to do this as well as they have suggested that CBH needs to amend their grain management strategies which encourage corella populations management so in order to solve some of the problem CBH needs to change their strategies.

- CBH had done a corella management presentation last year at the Avon Midland Country Zone Meeting where CBH reported that they had made a concerted effort to shoot them and in Albany they were poisoning them.

Further response:

On private land they can use an anaesthetising agent. CBH cannot spread the agent if it is not managed well nor cleaned up afterward to prevent contamination to other wildlife and/or grain.

CBH need to build silo infrastructure rather than continue using soft covers for their grain; or invest in hard covers for the grain. This is a long-term expense and engagement with CBH is required.

Where we choose to poison corellas some animals man inadvertently consume the poison and it may affect them which is the reason why AROC needs a coordinated response.

- CEO, Shire of Toodyay requested the strategy be sent back to the AROC group within one month rather than two months in order for it to be an item on the next Governance Group Meeting and have time to consider it before we come together.

Once AROC is happy with their strategy I will engage with the eastern zone who would become a part of the discussion and strategy.

- CEO, Shire of Toodyay: AROC can be the leading light in this area. Eastern Zone and WALGA zone meetings can be where the issue and strategy is championed.

4. CONFIRMATION OF NEXT MEETING

The 2022 schedule provided below.

Confirmation face to face and zoom if required.

2022	Officer's Group (CEO) Meetings	Governance Group (President's) Meetings
	9.30am	9.30am
	Zoom Meetings	Council Chambers
APR	11/04/2022	
MAY		9/05/2022
JUNE	13/06/2022	
JULY		11/07/2022
AUG	8/08/2022	

2022	Officer's Group (CEO) Meetings	Governance Group (President's) Meetings
	9.30am	**9.30am**
	Zoom Meetings	**Council Chambers**
SEPT		12/09/2022
OCT	10/10/2022	
NOV		14/11/2022

5. CLOSURE OF MEETING

Cr Madacsi closed the meeting at 10.08am.

AROC Governance Group Meeting

Attachments to Minutes – Monday 14 March 2022

Minutes and Additional Information

2.2 Status Report

2.3. Inward/Outward Correspondence

Other Business / New Business of an urgent nature

Report from Karl O'Callaghan - Corella Management

AROC STATUS REPORT

Avon Regional Organisation of Councils

Secretariat

CEO - Shire of Toodyay

Meeting Date	Purpose	Resolution	Target date for completion	Actioned by	Completion Date	Meeting Commentary
8/11/2021	2.1 Confirmation of Minutes	That the Unconfirmed Minutes of the Avon Regional Organisation of Councils meeting held on 13 September 2021 be accepted as a true and correct record.	18/11/21	EA	18/11/2021	Not applicable
8/11/2021	3.3.1 Executive Officer for AROC	That AROC agrees to appoint an Executive Officer to support the activities and progress of the AROC noting that: 1. The costs of the Executive Officer will be covered by the annual contributions paid by member local governments; 2. The Shire of Toodyay will continue to host the AROC on an in-kind basis. 3. The Shire of Northam will continue to administer the finances of AROC on an in-kind basis.	Mid-January 2022	CEO	t.b.a.	
12/07/2021	Climate Change Initiative & Water Sustainability	AROC CEOs to work together to identify a project we could apply for funding on a regional level.	ASAP	ALL		13.09.21: No action taken place. CEOs have not had a chance to talk about it at this stage.

AROC STATUS REPORT

Avon Regional Organisation of Councils

Secretariat

CEO - Shire of Toodyay

Meeting Date	Purpose	Resolution	Target date for completion	Actioned by	Completion Date	Meeting Commentary
10/05/2021	Corella Management	That AROC authorise the CEO Officer Group to expend up to $30,000 from AROC Funds to have Wheatbelt NRM undertake field work on behalf of the member shires to develop strategies for Corella management.	ASAP	J Whiteaker, CEO, Northam Shire	Completed.	13.09.21: Wheatbelt NRM engaged. It will be next year by the time we get the report.
10/05/2021	Water Sustainability (Actions to take)	Northam CEO to arrange a meeting with Water Corporation (Toodyay and York to be included) (Mike) to discuss the concept for the future and they may have advice to offer to Vic Plains' subject. Vic Plains to get some advice regarding their already written business case for lobbying of (Melissa) election candidate. Goomalling to also contact Melissa's office.	ASAP	Refer to Resolution column.	t.b.a.	13.09.21: Hon Melissa Price invited to AROC meeting in future – she has been invited but still awaiting when she will be free. Water Corporation being invited – SON CEO advised that once the SON has dealt with agreements with the WC they'll follow up with inviting that representative Issues with landholder side of it. Another meeting to be held as the business case written from Vic Plains but agreement needed on the content.

AVON REGIONAL ORGANISATION OF COUNCILS

Statement of Comprehensive Income

Administered by Shire of Northam

	01.07.2021 28.02.2022	2021	2020	2019	2018	2017	2016	2015
	$	$	$	$	$	$	$	$
Brought Forward	161,314	189822	165,490	139,323	118,752	95,655	101,543	134,108
Revenue								
Member Contributions	25,000	25,000	30,000	30,000	49,625	30,000	30,000	30,000
Fees & Charges							5,391	2,459
Interest Earnings	121	630	1,832	3,667	-	-	1,914	2,299
Other Revenue					7,900		-	-
Total Revenue	25,121	25,630	31,832	33,667	57,525	30,000	37,305	34,759
Expenses								
Insurance							846	1,158
Recreation Plan					5,000			
Equipment Expenditure							5,897	3,081
Shire of Toodyay Administration			7,500	7,500	7,500	7,500	7,500	7,500
Corella Population Management	3,000							
WB Infrastructure Conway Highbury								12,000
WB Infrastructure refund to WDC								17,273
Localise Aged Friendly Audit								26,312
Strategic Waste Management Plan							28,950	
Training					7,900			
Capacity and capability assessment	5,500	22,500						
Other Expenditure Exit Dowerin		31,637			16,554			
Total Expenditure	8,500	54,137	7,500	7,500	36,954	7,500	43,193	67,324
Net Result	16,621	(28,507)	24,332	26,167	20,571	22,500	(5,888)	(32,565)
Accumulated Funds on hand 28.02.2022	177,936	161,314	189,822	165,490	139,323	118,752	95,655	101,543
Represented by Bankwest Muni Account	177,936							

Research and Management Priorities for Corellas (*Cacatua* spp.) in the Shires of Goomalling, Northam, Toodyay, Victoria Plains and York

Pic: Western Corella, Gerald Allen/Macaulay Library

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Executive Summary

Populations of both Western (*Cacatua pastinator*) and Little (*C. sanguinea*) Corellas are increasing in the shires of Goomalling, Northam, Toodyay, Victoria Plains and York. This has led to these shires receiving an increasing number of complaints from residents about issues caused by corellas. As a first step to addressing these issues, Wheatbelt NRM on behalf of the affected parties, requested a review of the existing literature and site inspections. Specifically, we aimed to: (1) review the ecology of the two corella species in the relevant shires including breeding and feeding ecology and seasonal movements; (2) review past and current management methods for addressing corella issues and evaluate their potential efficacy in mitigating corellas issues; (3) propose an integrated management plan that should help reduce or eliminate corella issues; and (4) identify research gaps that are important for informing any management plan. Any management strategy needs to be embedded in the understanding that humans have modified the landscape to create ideal habitat for corellas and that reductions in corella populations are unlikely without management inputs that are economically and logistically realistic. The plan must also acknowledge that managing corellas is complex and reducing corella impacts will involve long-term solutions shared across all stakeholders. Lastly, the proposed plan should focus on reducing corella damage, not on reducing corella numbers *per se*, and should sit within an adaptive management framework. Given the scale, both spatial and temporal, and complexity of corella management, managing corellas will be most effectively achieved within a governance framework that coordinates all stakeholder groups to support long-term solutions to corella impacts at the regional, sub-regional and local level. This framework will be required to achieve long-term reductions in corella damage that are feasible to implement, as shires lack the resources to achieve more than reactive, short-term solutions. However, given that shires do have immediate issues that need to be addressed in the short-term, we propose that these issues may be reduced by an integrated management plan that includes the following management actions: (1) Scaring by gas guns, Bird Frite® cartridges, clapboards, strobe, laser, spot lights, model airplanes and/or drones; (2) Shooting and, potentially, trapping and gassing; (3) Preventing perching using spikes, piping or electric shock strips; (4) Exclusion; (5) Environmental site management including visual screening; and (6) Decoy models and decoy feeding to attract corellas to sacrificial sites. Reducing corella issues is likely to be most effective if a range of short, medium and long-term methods are integrated at specific sites and across all sites (Table 1). For example, scaring and environmental site management will both be most effective if combined with sacrificial sites to reduce on-going management inputs. The management actions implemented at each site will vary depending on the specific site type and the specific issues but should focus on long-term solutions to minimise on-going management costs. The management plan also needs to include *a priori* performance criteria that are measurable and time-related, as well as monitoring against these performance criteria, so that the effectiveness of management actions can be evaluated. This monitoring needs to sit within an

adaptive management framework so that management actions can be adjusted to maximise the effectiveness of the plan.

Table 1. Summary of the primary site types experiencing corella problems within the relevant LGAs along with suggested management actions and challenges with managing corellas at each site type.

Site type	Suggested management actions	Issues
Tennis courts, hockey fields	Scaring combined with sacrificial sites. Visual screening and preventing perching to reduce site attractiveness. Possibly exclusion if does not interfere with site uses.	Exclusion may be incompatible with human uses. Screening needs to be complete.
Sports ovals	Scaring combined with sacrificial sites. Explore options for different turf grasses that provide a less attractive food source. Possibly visual screening.	Turf grasses that provide little food for corellas may not be hard wearing enough for sporting ovals. Visual screening may not be effective when irrigated lawns cover a large area or may need to be erected when ovals not used and removed when it is, so time-consuming.
Golf courses	Scaring combined with sacrificial sites. Visual screening around greens and along fairways if required. Manage water sources to prevent access by corellas.	May be difficult to implement effective screening without affecting golf holes. Water sources potentially from much wider area than golf course.
Racecourses	Scaring combined with sacrificial sites. Explore options for different turf grasses that provide a less attractive food source. Visual screening on central turf areas	Unclear whether visual screening would interfere with uses of racecourse. May be difficult to find appropriate turf grass that is robust to horses' hooves.
Buildings	Scaring combined with sacrificial sites. Spikes or electrical shock strips to prevent perching. Exclusion to prevent access to roofs.	Spikes or electrical shock strips need to cover all available perching surfaces. Exclusion has high up-front costs.
Light fittings	Reconfigure light fittings to render wiring inaccessible. Find sealants unattractive to corellas or prevent access to seals.	Reconfiguration and reducing access to seals may be expensive. Unsure whether unattractive sealants exist.
Grain terminals	Scaring combined with sacrificial sites. Improved grain hygiene to reduce or eliminate food resources. Replace grain tarpaulins with grain silos. Manage water sources to prevent access by corellas.	Installing grain silos has high up-front cost. Water sources may need to be managed over a large area.
Roosting sites	Scaring combined with sacrificial sites. Manage water and food sources surrounding roost site.	Scaring may need to be maintained over a relatively long period. Water and food sources may need to be managed over a large area.

Knowledge that would improve our ability to manage corellas includes the attitudes of stakeholders towards corellas and potential methods for their control, corella impacts on native species and human health, the characteristics of problem sites, the spatial scale over which flocks move and where they roost, loaf, feed and drink on a daily basis and corella population sizes, demographics and movements both within and outside the relevant shires. Managing corellas is complex and there is no quick-fix solution but we believe the proposed management plan can help reduce corella issues in the short and long-term. However, effective management of corellas to reduce damage is likely to require management by a much broader group of stakeholders than shires alone and we would encourage shires to participate in developing such a governance structure long-term alongside managing corellas in the short-term.

1. Introduction

Over the past 100 years, humans have extensively modified the West Australian wheatbelt (Saunders 1994). The original vegetation, consisting of heaths and woodlands of Wandoo (*Eucalyptus wandoo*), Salmon Gum (*E. salmonophloia*), York Gum (*E. loxophleba*) and Jam (*Acacia acuminata*), were progressively cleared and replaced with paddocks for cropping and grazing livestock. In many districts up to 90% of the original vegetation was cleared and the little native vegetation that remained occurred primarily in small remnants (Hobbs and Saunders 1994). These changes to the landscape have had a profound effect on the native fauna with many species dependent on native vegetation declining significantly and some species becoming locally extinct. Conversely, some native species that preferred more open habitats expanded their range from areas north of the wheatbelt and continue to spread across the wheatbelt (Saunders 1989, Saunders and Curry 1990, Saunders and Ingram 1995). These species have successfully adapted to the highly modified landscapes in the wheatbelt and will almost certainly continue to expand their range and increase in abundance.

One group of native species that have greatly increased in range and abundance in the wheatbelt over the last 100 years are two species of corellas (*Cacatua* spp.). Western Corellas (*Cacatua pastinator*) were originally native to the north-western wheatbelt from Moora north to Geraldton and westwards to the coast and have expanded their range south and east since the 1920s (Saunders et al. 1986). Little Corellas (*Cacatua sanguinea*) were originally native to the Murchison River valley well north of the wheatbelt and expanded their range south since the 1920s or 1930s (Saunders et al. 1986). Both species have greatly benefitted from the clearing of the original vegetation that has created the open grasslands that mimic the low grassy valley bottoms and riparian plains that these species originally inhabited (Higgins 1999). Populations of both species in the wheatbelt have increased significantly and large numbers are now present in the central and northern wheatbelt year-round but numbers of both species increase in summer and autumn when they also form large flocks, as juveniles join with adults, and are more conspicuous.

Over the past decade, four shires in the Avon sub-region (Goomalling, Northam, Toodyay and York) and the Shire of Victoria Plains in the Central Midlands subregion, have received an increasing number of complaints from shire residents that relate to corellas. These complaints primarily relate to damage to grain and grain tarpaulins around grain terminals, damage to playing surfaces, roofs, television aerials and light fittings in urban areas, damage to roost trees causing long-term declines in tree health and noise from roosting flocks disturbing residents' sleep patterns. These increases in complaints, combined with the increasing abundance of corellas (indicating that problems will likely only increase in the future), have lead shires to search for solutions. However, previous and current management methods, including netting and sacrificial sites have had only limited success and the issues persist. Given the wide-ranging nature of corella issues, the challenges of managing these issues and the broad nature of affected stakeholders, the Wheatbelt NRM engaged researchers at Edith Cowan University (ECU) to prepare a scoping document. The purpose of this document is to review potential corella management methods and identify management options and relevant research gaps that would contribute towards a successful management plan that would reduce or eliminate corella issues in the five local government areas (hereafter referred to as the "relevant LGAs")

2. Aims and Methods

Aims

The aims of this report are broadly to:

(1) review the ecology of the two corella species in the relevant LGAs including breeding and feeding ecology and seasonal movements;

(2) review past and current management methods for addressing corella issues and evaluate their potential efficacy in mitigating corellas issues;

(3) propose an integrated management plan that should help reduce or eliminate corella issues; and

(4) identify research gaps that are important for informing any management plan.

More specifically, the report summarises the literature on the ecology of the Western and Little Corellas, covering distributional expansion, breeding, feeding and drinking ecology, demographics, movements and habitat. It then provides a summary of the ecological data that are most relevant to control methods and outlines methods of assessing the damage that corellas cause. A review is provided of past and current control methods and then justification is provided for a selection of a subset of these methods to be included in the proposed management plan. An integrated management plan is then outlined followed by more specific suggestions for site types where corellas create problems in the relevant LGAs. Finally, the report identifies knowledge gaps that, when answered, would help improve corella management and provides a summary of future potential work.

Methods

The review of corella ecology was achieved by searching databases, such as Scopus and Web of Science, for any journal articles or book chapters that investigated corella ecology. A similar method was used to review and summarise potential control methods although this also required an extensive search of the grey literature to find management plans and strategies prepared for local and state governments and government agencies. In order to better understand the nature of the issues in the relevant LGAs, site visits were conducted to shires to meet with relevant shire staff in order to quantify the key corella issues, characterise the sites where corella issues occur and discuss the efficacy of current management actions. Sites visits were conducted to the Shire or York and the Shire of Northam on 25th November 2021, the Shire of Toodyay on 26th November 2021 and the Shire of Goomalling on 23rd December 2021. Unfortunately, we were unable to conduct a site visit to the Shire of Victoria Plains. Records of birds were taken from Birdlife Australia's Bird Data database and the global birding database eBird.

3. Ecology of corellas in the wheatbelt

3.1. Distribution and historical changes

There are three species of corella that occur in southern Western Australia: Long-billed Corella (*Cacatua tenuirostris*), Western Corella and Little Corella. Of these three, the Long-billed Corella is not native to Western Australia, but feral populations are well established in the Perth Metropolitan area from Joondalup south to Mandurah and east to the base of the Darling Scarp. There are scattered records from outside this area, but they have not been recorded in the relevant LGAs and this species is not considered further.

The Western Corella is endemic to south-western Western Australia and occurs as two subspecies: the southern *Cacatua pastinator pastinator* and the northern *Cacatua pastinator derbyi*. The southern *pastinator* subspecies originally occurred within the relevant LGAs in the Avon valley to the west of Northam but had disappeared by 1900 (Masters and Milhinch 1974), presumably due to excessive persecution by farmers whose crops it predated. It is now confined to a small part of sub-humid south-western interior from Boyup Brook and Qualeup south to the lower Perup River, Lake Muir and Camballup and no longer occurs within the relevant LGAs (Storr 1991). The northern subspecies *derbyi* originally occurred from the Geraldton and Yandanooka south through the Irwin River valley, inland from Dongara, and the Hill River valley inland from Jurien Bay to Moora (Milligan 1905, Saunders et al. 1986, Storr 1991). In the 1920s, the species started to expand its range to the east and south-east arriving in Dalwallinu in the early 1930s and in Wubin by the 1940s (Saunders et al. 1986) and this range expansion continues to the present day. Its current distribution extends south to Dryandra Woodland, Narrogin, Yealering and Narambeen and east to Westonia, Elachbutting and Karroun Hill Nature Reserve (Figure 1). The western boundary of this subspecies' distribution in unclear due to the presence of feral populations in the Perth Metropolitan Region but is most likely to be from the coast south to Guilderton and then through Gingin, Toodyay and Northam to the eastern edge of the Jarrah (*Eucalyptus marginata*)/Marri (*Corymbia calophylla*) forest (eBird & Birdata). The subspecies is most common in the north and west of the range and becomes scarce in the southern and eastern parts of the range along the expansion front. To summarise, the southern *pastinator* originally occurred in the extreme west of the Shire of Northam but no longer does, whereas the northern *derbyi* did not originally occur within the relevant LGAs but is now found throughout them.

The Little Corella is widespread in northern Western Australia and originally occurred south to north of Geraldton and the Murchison River Valley, Wooleen, Meekatharra and Wiluna, far to the north of the relevant LGAs (North 1912, Serventy 1977, Saunders et al. 1986, Higgins 1999). Exactly when the species started to expand southwards is unclear but it likely started around the same time as the Western Corella in the 1920s. It was recorded in the Irwin River valley east of Dongara in 1927 and was breeding north of Burakin and at Three Springs by the 1970s, likely earlier (Saunders and Smith 1981, Saunders et al. 1982, Saunders et al. 1986). This expansion has continued to the present day and it current distribution extends south to Beverley, Corrigin and Merredin and east to Mukinbudin and Karroun Hill Nature Reserve (Figure 2: eBird & Birdata). Like the Western Corella, the western distribution of the species is unclear due to feral populations in the Perth Metropolitan Region but appears to mirror that of the Western Corella being from Guilderton inland to Gingin, Toodyay and Northam then south along the eastern edge of the Jarrah/Marri forest. The species is most common in the north and west of its range and becomes less common to the south and east along the expansion front. This species did not originally occur in the relevant LGAs but is now widespread throughout them.

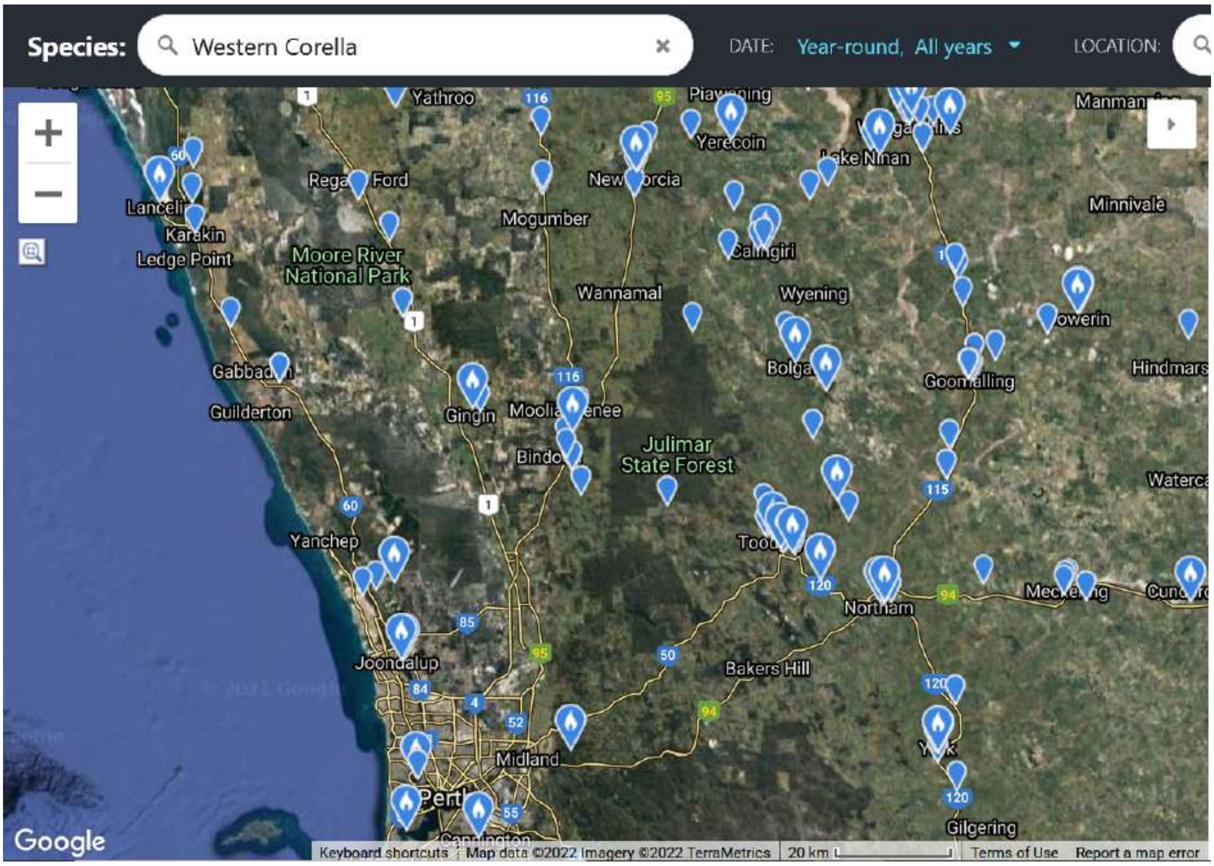

Figure 1. The citizen science eBird map showing the distribution of Western Corellas in the relevant LGAs. Western Corellas are currently present in all LGAs and will continue to expand southwards (from https://ebird.org/map).

The expansion of the Western and Little Corellas was facilitated by the provision of extra food resources through cereal crops and extra drinking resources through farm dams. They now overlap extensively in range but there is no evidence of interbreeding and none of the specimens collected show any signs of hybridization (Saunders et al. 1986). Neither Little Corellas nor the *derbyi* subspecies of Western Corella occurred naturally within the relevant LGAs before the 20th century and they self-introduced within those LGAs due to human modification of the landscape. Hence, it is equivocal whether they ae considered native or introduced in the relevant LGAs. What is certain is that native species have not evolve to compete with them and they cause some negative ecological impacts, such as competing with native species for tree hollows (Saunders and Doley 2019).

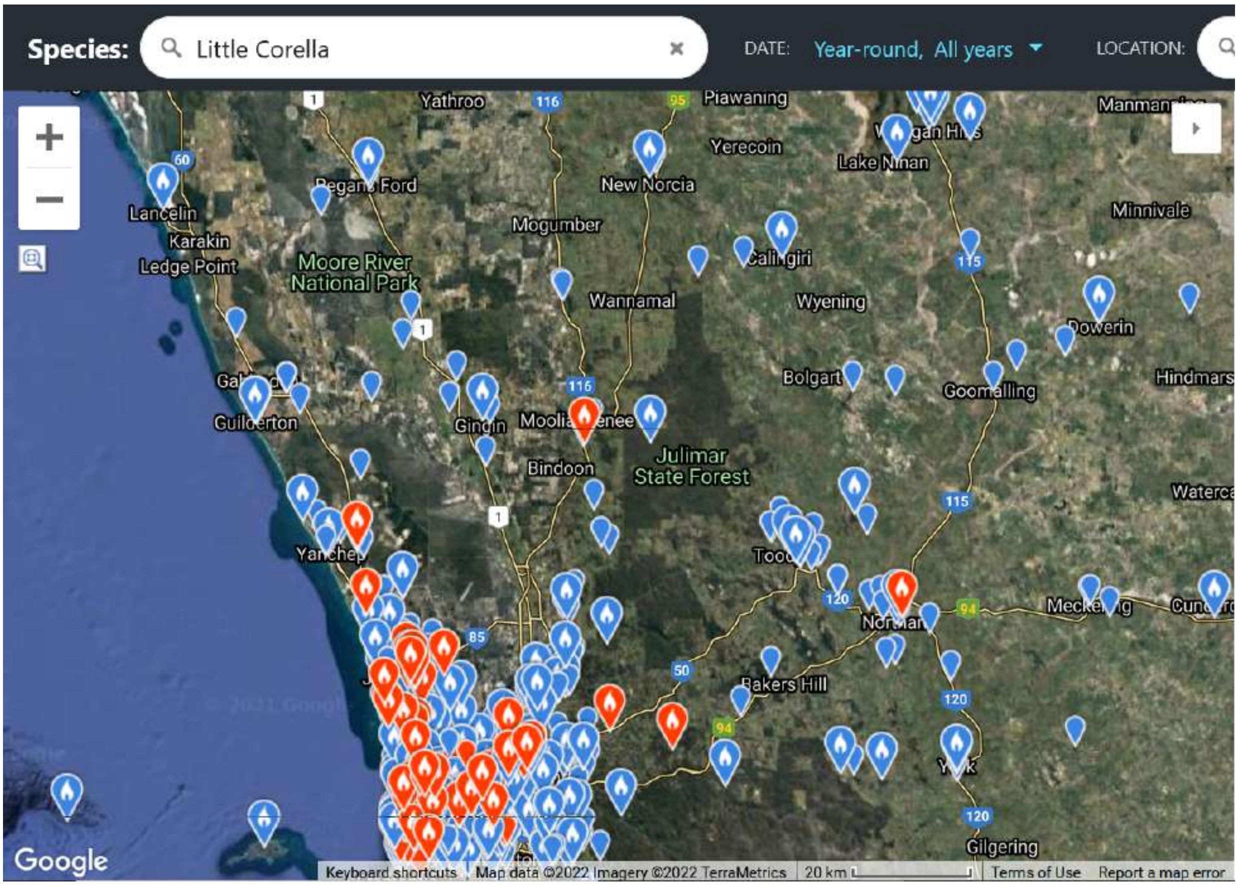

Figure 2. The citizen science eBird map showing the distribution of Little Corellas in the relevant LGAs. Little Corellas are currently present in all LGAs and will continue to expand southwards (from https://ebird.org/map).

3.2. Breeding ecology

Western Corellas are obligate tree hollow nesters whose breeding ecology has been the subject of detailed studies at Coomallo Creek (Saunders 1977), Three Springs (Saunders and Smith 1981, Saunders et al. 1982, Saunders et al. 1986) and Burakin (Saunders and Smith 1981, Saunders et al. 1982, Smith 1991). The breeding season, in terms of the period when eggs are laid, extended from August to October at Coomallo Creek, Burakin and Three Springs (Serventy 1977, Saunders et al.

1986, Smith 1991). At Burakin and Three Springs this resulted in young fledging (i.e. starting to leave the nest hollow) between late October and mid-December (Smith and Saunders 1986).

In terms of tree species, Western Corellas nest primarily in tree hollows in Wandoo and Salmon Gum because these two tree species provide a greater number of hollows suitable for Western Corellas than other tree species such as York Gum and Red Morrell (*E. longicornis*). At Coomallo Creek, all 15 nests studied were in Wandoo (Saunders 1977), at Three Springs all 14 nests were in Salmon Gums (Saunders et al. 1982) while at Burakin all 62 nests were located in Salmon Gum while in another study area 35km to the south, one nest was located in Wandoo and 14 nests in Marri (Smith 1991). At Three Springs, trees containing nest hollows averaged 0.57 m diameter at breast height (DBH) (range: 0.32 – 0.80 m) and 19.1 m in height (range: 12 – 26 m) (Saunders et al. 1982) whereas trees supporting nest hollows at Burkin were slightly larger averaging 0.65 m DBH (range: 0.35 – 1.21 m) and 21.3 m in height (range: 8 – 34 m) (Smith 1991). Western Corella did not choose nest trees based on their health, nesting in healthy, senescent and dead trees in proportion to their availability at both Three Springs (Saunders et al. 1982) and Burakin (Smith 1991).

In terms of hollow characteristics, Western Corellas nested in hollows that had horizontal and vertical entrance diameters that averaged 180 x 170 mm at Coomallo Creek (Saunders 1977), 185.2 x 197.9 mm (range: 78 – 400 mm x 105 – 420 mm) at Three Springs (Saunders et al. 1982) and 162.6 x 193.3 mm (range: 70 – 285 mm x 75 – 490 mm) at Burakin (Smith 1991). Nest hollow depth ranged from 0.53 – 1.02 m at Comallo Creek (Saunders 1977) and averaged 1.46 m at Three Springs (range: 0.45 – 4.53 m) (Saunders et al. 1982) and 1.60 m at Burakin (range: 0.48 – 4.20 m) (Smith 1991). Nest hollow entrances ranged from 3.4 – 9.8 m above the ground at Coomallo Creek (Saunders 1977) and averaged 9.6 m (range: 6.2 – 14.3 m) above the ground at Three Springs (Saunders et al. 1982) and 8.5 m (range: 5.0 – 13.8 m) at Burakin (Smith 1991).

Western Corellas lay between 1 and 4 eggs with the average clutch size being 2.3 (range: 1 – 4) at Coomallo Creek (Saunders 1977), 2.3 (range: 1 – 3) at Three Springs and 2.9 (range 2 – 4) at Burakin (Smith and Saunders 1986). Eggs are similar in size across their range, averaging 43.6 x 31.1 mm at Jurien Bay (Serventy and Whittell 1962), 45.3 x 30.2 mm at Coomallo Creek (Saunders 1977), 42.7 x 31.3 mm at Three Springs and 42.1 x 30.5 mm at Burakin (Saunders and Smith 1981). Eggs weighed 23.1 g at Three Springs and 21.8 g at Burakin (Saunders and Smith 1981). Both sexes incubate and incubation typically commences when the second egg is laid and lasted between 24 and 29 days at Coomallo Creek (Saunders 1977) and between 22 and 26 days at Burakin (Smith 1991). In most clutches, the eggs hatch in the order they are laid (Smith 1991). Chicks fledge sometime between 57 and 63 days after hatching at Comallo Creek (Saunders 1977) and this was similar at Burakin, averaging 60.2 days (range: 52 – 68 days) with no difference in the period between one, two or three egg clutches or between years (Smith 1991). The weight of fledglings averaged 476 g at Burakin with no difference between years but chicks from three chick broods averaged significantly heavier (502.2 g) than chicks from two (470.4 g) and one chick (470.1 g) broods (Smith 1991). However, weight at fledging did not influence whether chicks survived their first summer (Smith 1991). Fledglings were fed and watched over by their parents for 2-4 weeks after they fledged and left the nest, after which time they moved away from their breeding area (Smith 1991). The fledglings became independent three months after they left the nest at the end of their first summer (Smith and Rowley 1995).

Western Corellas prefer to nest communally but this may vary between localities and dispersion of nests varies widely from closely spaced colonies to single isolated nests (Smith 1991). At Coomallo Creek, nest hollows were scattered throughout the study area and the closest any two nests were together was 700 metres and there were unoccupied hollows between nest hollows (Saunders 1977). Conversely, at Burakin there was a wide range of nest dispersions with the distance between nests varying from a few metres in one case, where two pairs nested in the same tree, to 13 km. The mean nearest neighbour distance for the 105 active nests was 1650 m but there was a wide range with the nearest neighbour distance for 15 nests being >5 km, between 2 and 5 km for seven nests and between 1 and 2 km for six nests (Smith 1991). The remaining nests were in groups of two to six in the same patch of woodland or stretch of road verge, and were grouped into those nests within 100 m of each other and those within the same patch. Thirty-five nests in groups of two (n = 11), three (n = 3) and four (n = 1) had an average nearest neighbour distance of 27.6 m. Breeding success did not appear to be related to nest dispersion with nests in close proximity being no more successfully than isolated nests (Smith and Rowley 1995). These data indicate that corellas can nest successfully regardless of the proximity of other breeding pairs, but they appeared to prefer nesting close to other pairs (Smith 1991).

Female Western Corellas first breed when they are between 3 and 5 years of age and males first breed when they are 5 years of age (Smith 1991). Western Corellas are monogamous and pair bonds are generally long-term although birds re-mate if their mate dies. Overall, the divorce rates between pairs was 15.4% at Burakin but this rate was higher (25%) for pairs that had only been together for one year then for pairs that had been together for multiple years. Both sexes prepare the nest, incubate and feed the young. Based on a single pair, males and females shared incubation and brooding duties almost equally (female 54%) during the day. However, it appeared that the female did most of the incubating or brooding at night. The parents spent between 94 and 98% of the day either incubating or brooding the chicks until the chicks were about 1 week old. After that age, the time spent brooding declined rapidly and ceased when the chicks were about 25 days old, about the age when they were fully feathered (Smith 1991). The hatching success at Burakin was 67.2% and was unrelated to rainfall or clutch size but did vary between years, ranging from 62.2% in 1977 to 90.7% in 1980 (Smith 1991). The mean brood size post-hatching was 1.9 and did not vary between years. Nestling mortality at Burakin was 18% leading to an average of 1.6 young fledging per nest and nestling survival was slightly higher in one and two egg clutches (89 and 90% respectively) than in three and four egg clutches (74 and 75% respectively) (Smith 1991).

In comparison to the Western Corella, the breeding ecology of the Little Corella has been poorly studied, particularly in the wheatbelt. The summary here relies primarily on studies from the wheatbelt but supplements the information with data from other region where required. Like the Western Corella, the Little Corella is an obligate tree hollow nester. There are, however, old unconfirmed records of them nesting in crevices in cliffs at Yardie Creek and in the tops of termite mounds east of Point Cloates, both in north-western Australia, when no trees were available (North 1912), indicating they may breed outside tree hollows if none are available. The breeding ecology of the Little Corella has been the subject of detailed studies at Three Springs (Saunders and Smith 1981, Saunders et al. 1982, Saunders et al. 1986, Smith and Saunders 1986). The breeding season, in terms of the period when eggs are laid, extended from August to September at Three Springs (Smith and Saunders 1986), which resulted in young fledging (i.e. starting to leave the nest hollow) between late October and early December (Smith and Saunders 1986). Unfortunately, data for Western and Little Corellas was combined in Saunders et al. (1982) so it is unclear what types of hollows Little Corellas use for nesting but it is stated that their hollow requirements are the same as for Western Corellas (Saunders et al. 1986) and the two species are considered competitors for the same nest hollows (Saunders et al. 1986). They are known to nest in eucalypt hollows (Saunders and Ingram 1995) so it is likely that Wandoo and Salmon Gum are the main nest tree species. Elsewhere, the species nests in hollows with an average entrance height of 4.5 m (range: 1.6 – 11.0 m) and an average depth of 1.1 m (range: 0.5 – 2.0 m) (Higgins 1999) so it is likely that, in the wheatbelt, the species nests in trees and hollows like those of Western Corellas.

Little Corellas lay between 2 and 4 eggs with average clutch sizes being 2.6 at Three Springs (Saunders and Smith 1981, Smith and Saunders 1986). Eggs measured 41.3 x 29.7 mm and weighed 20.3 g at Three Springs (Saunders and Smith 1981). Both sexes incubate with the male doing the majority of incubation during the day and the female the majority at night (Higgins 1999) and the incubation period is 24 – 26 days (Rowley and Boesman 2020). Chicks fledged an average of 62 days after hatching (range: 59 – 64 days) at Three Springs and weighed, on average, 420.0 g (range: 355 – 530 g) (Smith and Saunders 1986). It is not known how long chicks are fed and watched over by their parents or when they become independent, but it known that they are fed by their parents for some time after fledging (North 1912, Sindel and Lynn 1992) so the period likely does not differ from the Western Corella. The breeding dispersion in not well known although at least 7 pairs bred within a 15 ha area at Three Springs (Saunders et al. 1982) and it is known that several pairs can nest in the same tree (North 1912). Whether breeding success relates to nest dispersion is unknown but, like the Western Corella, it probably does not.

The age at which Little Corellas first breed is unknown although it is likely similar to the Western Corella. Little Corellas form monogamous pair bonds and, like Western Corellas, these pair bonds are long-term (Higgins 1999). Both sexes prepare the nest, incubate and feed the young (Higgins 1999). Hatching success in Little Corellas was 76.9%, resulting in an average brood size of 2.0 (range: 0 – 4) from an average clutch size of 2.6. Nesting mortality was 40% resulting in nests fledging an average of 1.2 (range: 0 – 3) young per nest (Saunders et al. 1986, Smith and Saunders 1986). It is unknown how nesting success relates to rainfall or clutch size but it is likely similar to the Western Corella.

3.3. Feeding ecology

The feeding ecology of the *pastinator* subspecies of Western Corella has been studied at Unicup in southern south-western Australia, of the *derbyi* subspecies of Western Corella in the northern wheatbelt between Geraldton and Wongan Hills and of the Little Corella in the northern wheatbelt, Murchison, Pilbara and Kimberley regions (Smith and Moore 1991). This summary focuses on the feeding ecology of the *derbyi* subspecies of Western Corella and Little Corella in the northern wheatbelt but includes information from other regions where relevant.

Western Corellas feed on the ground and often in large flocks (Higgins 1999). In the northern wheatbelt, their diet, as determined from crop contents of 17 males and 23 females, consisted of 18 food items (Smith and Moore 1991). The most common food items consumed were Common Wheat (*Triticum aestivum*) (87.5% of individuals), Doublegee (*Emex australis*) (65.0%), Common Oat (*Avena sativa*) (52.5%) and Barley (*Hordeum vulgare*) (50.0%), which ae all introduced and three of the four species are the main crops grown in the relevant LGAs. Less frequent plant food items were Capeweed (*Arctotheca calendula*) (12.5%), the tiny native daisy *Siloxerus pygmaeus* (5.0%), Guildford Grass (*Romulea rosea*) (2.5%), native parakeelya (*Calandrinia* sp.) (10.0%), cudweed (*Pseudognaphalium* sp.) (2.5%), clover (*Trifolium* sp.) (2.5%), native mulla-mulla (*Ptilotus* sp.) (2.5%), native saltbush (*Sclerolaena* sp. (7.5%), native goosefoot (*Chenopodium* sp.) (2.5%), storks-bill (*Erodium* sp.) (2.5%), native lovegrass (*Eragrostis* sp.) (2.5%), an unknown daisy (Asteraceae) (10.0%) and an unknown grass (Poaceae) (2.5%). The native daisy *Helipterum hyalospermum* was also observed being fed on, although not observed in crops, while insect larvae were also commonly consumed (12.5% of specimens) and their contribution to the diet was likely underestimated (Smith and Moore 1991). There were no differences in the diets of males and females. Common Wheat was eaten throughout the year, although more commonly consumed in summer and autumn, in a number of different ways. After the wheat had germinated, the plant was dug up and the grain eaten. When the seed heads had set, birds would reach up and pluck the grain. If the head was too high, they would pull the plant down and hold it on the ground while they plucked off the grain (Smith and Moore 1991). Doublegee was also eaten more often in summer and autumn. Most food items were seeds but Western Corellas were also observed to eat the growing tips and leaf bases of Doublegee, Capeweed and storks-bill and the flower heads of Capeweed. Seeds were generally collected directly from the plant or from the ground. In areas where Cattle (*Bos taurus*) were fed grain, the seeds were sometimes collected from the cattle dung, and they are also known to dig in the ground for seeds and insect larvae (Smith and Moore 1991, Higgins 1999). Food fed to 12 nestlings in the northern wheatbelt was a subset of the adult food. The most common food items were Doublegee (91.6% of individuals), Common Wheat (75.0%), storks-bill (50.0%), Common Oat (41.5%), Capeweed (33.3%), parakeelya (33.3%), Barley (8.3%) and *Siloxerus pygmaeus* (8.3%). Young were also fed some unidentified plant stems and leaves (33.3%) and they were fed a lot more insect larvae (50.0%) then adults consumed. The food that was fed to young varied though their development with younger nestlings fed mainly on storksbill and Capeweed, which have small seeds, and the larger seeded Doublegee and Common Wheat increasing in the proportion of the diet as the nestling aged (Smith and Moore 1991).

Little Corellas also feed primarily on the ground and often in large flocks (Higgins 1999). Their diet in the northern wheatbelt, determined from crop contents of 14 males and 16 females, was similar to the Western Corella except they fed a lot more on Curcubitaceae (Smith and Moore 1991). In the northern wheatbelt, they consumed 13 food items of which the most common were Doublegee (69.3% of individuals), Common Wheat (63.3%) and Common Oat (40.0%), with the native bluebush (*Meireana villosa*) (25.8%), native Bush Onion (*Cyperus bulbosus*) (13.3%), native mulla-mulla (*Ptilotus* sp.) (25.3%), native Purslane (*Portulaca oleracea*) (13.3%), native fig (*Ficus* sp.) (13.3%), Paddy Melon (*Cucumis myriocarpus*) (13.3%) and Watermelon (*Citrullus lanatus*) (3.3%) consumed less frequently. Like Western Corellas, insect larvae were commonly consumed (13.0%). There was no difference in the diets of males and females and it is unknown whether the diet changes seasonally, although it seems likely it does (Smith and Moore 1991). The diet of nestlings is unknown.

3.4. Drinking ecology

The drinking ecology of both Western and Little Corellas is poorly known although they both need to drink daily, especially in hot weather

Little Corellas are known to roost near water and are said to drink in the morning after feeding for “an hour or two” (North 1912). They return to their roost sites in the evening and, although it is not stated whether they drink in the evening, it is likely they do. The types of sites that Little Corellas drink from has not been described, but the provision of artificial waterpoints has been considered to be a significant factor in their spread southwards and eastwards into the wheatbelt (Saunders et al. 1986). Hence, in addition to natural drink sites, such as river pools and freshwater wetlands, it is likely they also drink from farm dams, troughs and any other anthropogenic sources of water such as puddles left over from watering gardens and ovals. The drinking ecology of the Western Corella is essentially unknown, although its expansion into the wheatbelt is considered partly due to “the expansion of farm dams" (Storr 1991), and so likely does not differ from that of the Little Corella. Much remains to be learnt about the drinking ecology of these two corella species.

3.5. Life history and survivorship

The survivorship of nestling and adult Western Corellas was studied at Burakin by individually marking 164 nestlings and 34 adults (Smith and Rowley 1995). Adult survivorship from one year to the next averaged 0.94 for males and 0.93 for females. Annual survival varied from 0.85 to 1.00 between years but survivorship was not related to rainfall or food resources (with wheat harvest taken as the proxy), indicated that food is not a limiting resource for Western Corellas. Average life expectancy was 16.8 years for males and 14.2 years for females (Smith and Rowley 1995). The survivorship of immature Western Corellas was much lower. Survival after fledging was 77.4% to three months and 50.8% to one year. It is unknown whether immature survivorship differs between males and females but, as it was very similar for adults, it can be assumed it does not. Based on this assumption, survivorship of females to first breeding was 23.3% f they first bred at three years, 13.6% if they first bred at four years and 9.0% if they first bred at five years. Males start breeding at five years (Smith 1991), at which age only 9.0% of the original cohort had survived (Smith and Rowley 1995). The number of years that Western Corellas need to breed to replace themselves if they started breeding at three, four or five years were 5.4, 9.2 and 13.9 years, respectively, with the assumption that the mean number of young fledged was 1.6 (Smith 1991). That the replacement age is less than the average lifespan, indicates that populations are increasing.

The survivorship of the Little Corella is unknown but it can be assumed, in the wheatbelt at least, that it is very similar to the Western Corella as populations are also increasing and expanding. In summary, the life history profile of both corellas is *k*-selected, which means that they have high adult survivorship, long adult lifespans and relatively low juvenile recruitment into the population.

3.6. Movements

The movements of Western Corellas have been studied in the northern wheatbelt, primarily at Burakin and Three Springs, but smaller number were also tracked at Booralaming, Popes, Calle and Goodlands (Smith and Moore 1992). This annual movement depended on the life stage of the bird, being different for juveniles still dependent on their parents, immature birds that were independent but not yet breeding and adult breeding birds. Birds at Burakin started to arrive at that location in mid-January and by March all breeding adults had returned. Whilst at Burakin, the nest hollow remained the focus of movements with daily movements to foraging, drinking and roosting sites. In winter, these movements averaged 2.4 km from the nest and most foraging movements were to the nearest foraging sites and there were few long foraging trips (Smith and Moore 1992). In September and October, when adults were incubating or feeding young, the movements were shorter and averaged

1.6 km. In November and December, the mean foraging distance increased to 2.1 km as the adults moved with their fledglings to suitable feeding and roosting sites where they joined other family groups and immature birds. Two to three weeks after fledging their young, breeding adults at Burakin left with their dependent young to fly to Dalwallinu 55 km NW, the first 30 km appeared to be flown non-stop. In the Dalwallinu area, birds from various breeding districts joined up to form a flock of up to 700 birds. During the summer, this flock moved around the district spending days or weeks at any one location. Frequently, the flock broke up into smaller groups that foraged in different areas. Juvenile Western Corellas at Burakin remained with their parents immediately after leaving the nest. During the seven to ten days after leaving the nest, the parents and their young gradually moved to areas where other family groups and the immature flock were congregating. After this period, the juveniles left with their parents for Dalwallinu. Once at Dalwallinu, immatures started to gradually become more independent of their parents and started to form flocks composed solely of immatures. At Dalwallinu, this immature flock moved over a core area of 80km^2 and usually stayed in the vicinity of one to five frequently used areas for one to two weeks at a time, although on occasion they moved over most of the core area in one day. They certainly used the whole area at some time during the course of a year. There were no seasonal patterns to the locations of the immature flock. Most of these immature birds then returned to Burakin at the same time as their parents but some dispersed to other breeding areas. However, there was some variation in movements between breeding districts. A flock of 500-700 birds at Wubin appeared to be more sedentary, but occasionally it moved south to join the Dalwallinu flock. Interchange between the two flocks was infrequent; only one immature bird from Burakin was seen at Wubin and only three immature birds from the northern breeding districts were ever seen at Dalwallinu (Smith and Moore 1992). Birds at Coomallo Creek also appeared to be relatively sedentary with most birds not moving to a separate non-breeding area but moving locally around the breeding area. However, some individuals moved post-breeding to around Badgingarra, up to 35 km SSW (Saunders 1977). Birds tagged near Three Springs moved in summer to non-breeding areas from Dongara north to Geraldton (Smith 1991, Smith and Moore 1992). There are few data on the movements of Western Corellas between different breeding districts. Three birds, tagged as nestlings in Burakin in 1975, were seen there regularly until 1978 when they appeared at Booralaming late in the breeding season. Two disappeared during 1980 while the third bird bred at Booralaming from 1980 to 1982. The only other Burakin bird recorded from another breeding district was found 70 km to the east, six years after it had fledged. On the other hand, Booralaming birds were regularly seen at Burakin. No birds from Burakin were ever seen in flocks that moved between Goomalling, Wongan Hills and Yerecoin (Smith and Moore 1992).

The daily movements of Western Corellas are less well studied but they are known to roost in large trees with dense, green canopies (Smith 1991, Smith and Moore 1992). Daily movements are primarily to a small numbers of areas, characterised by having good feeding areas (judged by their frequent use throughout the year) adjacent to a farm dam and areas of trees with dense canopies in which the birds could loaf during the day with these three resources never more than 100-200 metres apart. There were only four such areas at Burakin and five such areas at Dalwallinu. Subsidiary areas and those only used occasionally were characterised by being further away (> 500 m) from water and having trees that provided less dense shade. Consequently, a large portion of the completely cleared wheatland was unsuitable and was unused by Western Corellas (Smith and Moore 1992).

Both annual and daily movements of Little Corellas are poorly studied. Annual movements in the northern wheatbelt showed that birds from Three Springs, like Western Corellas, moved in summer to non-breeding areas from Dongara north to Geraldton (Smith and Moore 1992). Movements in other parts of their range are variable with birds being considered resident (Boekel 1980, Howard 1986) and partly nomadic (Higgins 1999). In the Murchison district, the birds regularly move 100 to 200 km during the year but there was no evidence movements were seasonal (Higgins 1999). In terms of daily movements, Little Corellas roost in large trees (Higgins 1999). Originally this would have been near water where these trees grow (North 1912) but now they likely also roost in towns and where large trees have been planted away from water. In northern Australia, they flew from their roost sites at first light to the foraging areas where they fed for 1 to 2 hours before returning to water, presumably to drink. Then they loafed in the middle of the day in trees before returning to feed in the afternoon and then flying back to their roost sites at dusk (Forshaw 1989). Given this daily patterns it seems likely that they require similar resources to Western Corellas, namely abundant food, water and large trees in close proximity and, hence, the two species likely use similar areas in the landscape. It has been noted in northern Australia that, in the dry season, it assembles in large flocks that remain in the neighbourhood of tanks and waterholes (North 1912), which shows its reliance on water for drinking.

3.7. Habitat

Western Corellas occur primarily in eucalypt woodlands dominated by Wandoo, Salmon Gum, Marri and Jarrah. With clearing for agriculture, most of these woodlands are now remnant patches, in or adjacent to farmland or along roadsides, paddock boundaries or watercourses although these species also sometimes occur as isolated trees in otherwise cleared paddocks. Western Corellas often occur in farmland, especially crops and, sometimes, pasture where there are ample watering points and some nearby large trees for roosting or breeding (Higgins 1999). Optimal foraging habitat is near water sources and suitable roosting trees. They usually feed on the ground in open areas and are attracted to artificial grain sources, such as silos, pigpens and grain-fed cattle and sheep and their dung. They roost or loaf in trees with dense canopies, often in remnant woodlands in agricultural woodlands or in urban areas (Higgins 1999).

The Little Corella has similar habitat requirements to the Western Corella although it occurs in a wider variety of habitats due to its wider distribution. Little Corellas occur on open plains, grasslands and savannas, usually near watercourses or lakes bordered by eucalypts, but always near permanent sources of water. In northern Australia, it often occurs in open woodlands and sometimes occurs in mangroves. Throughout its range, it regularly occurs around homesteads and in towns (Higgins 1999). Little Corellas forage on the ground and, in natural habitat, feed on open riverine plains with low native grasslands or on the shores of wetlands, sometimes being attracted to recently burnt areas. In agricultural areas, Little Corellas mainly feed in open paddocks with cereal crops and in short pasture and they are attracted to spilt grain around silos or stockyards and along roadsides. They sometimes feed on golf courses (Higgins 1999). They roost in the upper canopy of tall trees including *Eucalyptus* and *Melaleuca* next to a watercourse or wetland and usually close to their feeding and drinking sites. They often loaf in towns, in tall trees, gardens, roofs, power lines, television aerials and posts (Higgins 1999). The habitat preferences of Little Corellas in the relevant LGAs is poorly known but is likely very similar to those of the Western Corella, requiring suitable roosting/loafing, foraging and drinking sites in relatively close proximity.

At the local scale, habitat suitability models for Little Corellas in South Australia showed that corella distribution was positively related to the number of patches of residential, agricultural and recreational land uses in the surrounding area (Scanlon et al. 2017). Residential and agricultural land use provided water and food resources the corella required, while recreational land uses, such as ovals, golf course and caravan parks provided food resources. It was also found that Little Corella favoured highly fragmented patches of native vegetation, such as along roads and watercourses and around ovals, and avoided areas of bushland (Scanlon et al. 2017).

At the patch scale, habitat suitability models for Little Corellas in the Mount Lofty Ranges in South Australia showed that nearly 60% of the distribution of Little Corellas was explained by a positive relationship with irrigated green space. Distance to a major creekline or watercourse was the next most important factor, explaining about 25% of the distribution, as creeklines provide the tall trees that corellas require for roosting and loafing. These were the only two variables found to significantly influence the distribution of Little Corellas in the Mount Lofty Ranges (Scanlon et al. 2017).

In South Australia, the site-specific characteristics of Little Corella problem sites were the presence of irrigated lawn and a low number of native plant species (100% of sites), an absence of shrub cover and a low number of native shrub species and a low cover (<5%) of short (<10m) trees and a moderate cover (5-25%) of tall (>10m) trees. Furthermore, an obvious water source was present at 50% of sites and a permanent water source at 39% of sites and <5% of sites had a barrier (vegetative or dam lining) to accessing the water source (Scanlon et al. 2017).

3.8. Ecological information relevant for control

To summarise the ecological information that is most relevant for control, both Western and Little Corellas are arguably self-introduced into the relevant LGAs. Little Corellas and the *derbyi* subspecies of Western Corellas are clearly self-introduced and Western Corellas as a species are arguably self-introduced because the *pastinator* subspecies was originally present in the Avon Valley in the west of the Shire of Northam before becoming locally extinct, likely due to persecution. The reasons behind this distributional expansion of Little Corellas and *derbyi* Western Corellas is the provision of abundant food resources, namely Common Wheat, Common Oat and Barley and the provision of numerous drink sites, such as farm dams. Large trees are also now commonly planted in towns and as windbreaks in agricultural areas and this has also likely facilitated their expansion.

Both species nest exclusively in tree hollows and they are classic *k*-selected species (MacArthur and Wilson 1967) with long lifespans and high annual adult survival and low productivity and juvenile recruitment. This means that factors that reduce juvenile survivorship would have little effect on population trends whereas factors that reduce annual adult survival would be likely to reduce population sizes. Western Corellas, and likely Little Corellas, move over large areas and so populations almost certainly move between shires in the relevant LGAs implying that reducing population sizes is likely to require pan-LGA coordination to be effective. Critically, flocks in the non-breeding seasons can consist of individuals from multiple breeding areas and so potentially contain a substantial proportion of the population from an area of up to 6000 km^2 (Saunders et al. 1986).

Furthermore, the habitat requirements for corellas are tall trees for roosting and loafing, suitable food and foraging sites and suitable drinking sites. European modification of the relevant LGAs has created abundant suitable habitat for the species and so any management of corellas need to acknowledge this and include management actions that reduce habitat suitability for corellas.

3. Strategic approach to managing corellas

Managing corellas in the relevant LGAs requires a strategic approach that involves four basic activities: (1) Define the problem; (2) Develop a management strategy and plan; (3) Implement the strategy and plan; and (4) Monitor and evaluate the results (Tracey et al. 2007). In this section, we outline the problem in terms of the damage caused by corellas, outline the current management practices for corellas and discuss them in relation to the principles of vertebrate pest management, suggest a strategy within which the plan would sit and then suggest potential ways to evaluate the efficacy of the proposed management program.

4.1. Defining the problem: Damage by corellas

Critical to any corella management plan is gaining a full understanding of the damage caused by corellas as the aim of the management plan is to reduce or avoid this damage. Consequently, the success criteria of the management plan will need to be based on reduction in this damage. Understanding the damage caused by corellas obviously helps to identify suitable management actions but also helps identify who is being affected by corellas and, hence, who can be potentially involved in managing them. Broadly, defining the problems caused by corellas involves identifying what is being damaged and who is suffering as a result of that damage.

The following is a recommended list of questions (from Tracey et al. 2007) that can help define the problems caused by corellas:

1) Who has the problem? This is likely to include government agencies (e.g. shires, DBCA), private companies (e.g. CBH) and individuals (e.g. town residents, farmers)
2) Who else could help control corellas? List all the stakeholders even if they are not directly affected by corellas as they could be involved in their management (e.g. sporting shooters)
3) Is the problem caused by corellas or other species? There is the possibility that damage is caused by species that occur with corellas (e.g. Galahs [*Eolophus roseicapilla*] or Australian Ringnecks [*Barnadius zonarius*]) and, hence, controlling corellas will not reduce the damage
4) Where is the problem and over what area is it occurring? Defining the area over which damage occurs can help identify whether dealing with a flock will reduce damage at one or multiple sites.
5) When is the problem? Does it occur all year round and all day or only at certain times of the year or during certain times of the day?
6) How severe is the damage? Is the damage permanent or is the damage temporary (e.g. does snipping of branches kill trees or reduce foliage for a period after which the tree recovers)?
7) For how long will the damage occur? Will the damage reduce over time, increase over time or stay the same?

Once these questions have been answered, more specifics about corella damage can be quantified in four main categories (Tracey et al. 2007), namely: 1) economic; 2) environmental; 3) social; and 4) health. Economic factors are typically the most obvious damage that corella cause. The economic damage they cause can vary widely, such as broken television aerials or damage to turf that needs to be dug up and re-laid, through to damaged grain tarpaulins that need to be replaced and crop losses. Environmental damage can include the fouling of water sources or buildings with corella faeces or the loss of threatened species, such as Carnaby's Black-Cockatoos (*Zanda latirostris*), due to competition for nest hollows or the direct destruction of eggs by corellas (Saunders and Doley 2019). Social damage can include the loss of amenity values caused by the noise of corellas, which results in people not utilising facilities, such as urban parks, because the presence of corellas reduces their enjoyment of those areas. Alternatively, people may move outside the region to avoid corella issues, leading to population losses and associated issues. Health damage would include diseases transmitted by corellas either through their faeces or by fouling water sources so that diseases are indirectly spread through other species or the loss of sleep due to excessive noise from roosting corellas.

Apart from identifying potential suitable management actions and potential stakeholders in corella management, quantifying the damage caused by corellas helps to determine the direct and indirect financial costs of corella damage which, in turn, helps to identify the cost-benefits of corella management. Finding that the annual costs of rectifying or managing corella damage can help justify the costs of a long-term corella management program as well as helping identify the management actions that deliver the greatest financial benefits in the short, medium and long-term.

4.2. Develop a management strategy, identify and evaluate the management options and develop the management plan

The management of corella impacts is challenging from both social and practical perspectives. Community opinion about corellas, and how best to manage their impacts, are often polarised and current management actions undertaken to address corella impacts in the past decade have had little success in reducing corella issues. The attractiveness of cities, towns and agricultural landscapes to corellas has not been reduced by existing management actions and so corellas are still attracted to the sites where they continue to cause issues. Existing and proposed management tools require documentation of their effectiveness, and novel management tools require investigation. Better information needs to be available to the community about the complexity of the issue and assistance provided to build community resilience and capacity to manage impacts. There is no quick fix to the issue and a long-term reduction in corella impacts will not be attainable if we rely on uncoordinated, short-term management actions. Instead, coordinated multifaceted management approaches, undertaken by a number of stakeholders, are required to manage the impacts of corellas (Scanlon et al. 2017). Current management methods vary but there is a general trend away from former methods of controlling numbers of the pest towards a more holistic approach based on the principles of vertebrate pest management (Braysher et al. 2012). These principles are that: (1) A pest is a human construct; (2) All key stakeholders need to be actively engaged and consulted; (3) Rarely can pest be eradicated; (4) Most pest management needs to focus on the outcomes, reduction in damage, not just killing pests; (5) A whole-system approach is required for managing pest damage; (6) Most pest management occurs in ecosystems in which our knowledge is imperfect: and (7) An effective monitoring and evaluation strategy is essential for all management interventions. On this basis we believe that the management strategy that will guide the development of the management plan needs to be embedded in the following 5 principles (based on Anon 2019):

1) Acknowledge that human have modified the landscapes to create perfect habitat for corellas, with abundant food and water, trees for roosts and expansive areas of short grass to provide good visibility of predators. Hence, changes to landscapes, including native revegetation, town planning and agricultural practices, as well as community education, will be required to achieve long-term reductions in human-corella conflict.
2) Long-term solutions to reduce the impacts of corellas requires effective long-term partnerships between stakeholders. This entails identifying, communicating, collaborating and sharing responsibilities across all stakeholder groups, such as local and state government agencies, industry, land managers, landowners and community groups in a regional working group model with coordination across multiple shires.
3) As far as practicable, the responsibility, both financial and logistical, of proactive actions to support long-term solutions to reduce corella impacts will shared across all stakeholders. Actions need to be focused on solutions that benefit all stakeholders and, while acknowledging that some short-term actions to control issues currently occurring may be borne by individual landholders, responsibility for long-term solutions needs to be shared.
4) Effective management of corellas will involve using best practices methods that have been develop elsewhere based on evidence. However, we need to acknowledge that methods developed elsewhere will not necessarily be effective in the wheatbelt and so any management plan needs to operate within an adaptive management framework that is continuously updated to maximise efficacy.
5) Managing corellas needs to focus on reducing or eliminating the damage caused by corellas rather than on the reduction of corellas themselves. While acknowledging that reducing corellas in the short-term will likely be required in localized cases, the primary land use in the shires, agriculture, creates a landscape that benefits corellas to the extent that broadly reducing corella populations will require continuous intensive management that is both economically and logistically unrealistic.

4.2.1. Identify and evaluate the management options

The first critical step in developing a corella management plan is to identify the myriad of potential options and evaluate their likely efficacy. In this section we review past management strategies of both Western and Little Corellas and then review current management options for corellas. Nearly all of the current management options have been developed for Little Corellas in South Australia (e.g. QED Pty Ltd 2003, Temby 2010, Hodgens 2015, Scanlon et al. 2017, Anon 2019, 2020), although some recent efforts have been made in Western Australia (Strang et al. 2014, City of Greater Geraldton 2019). However, we provide a summary of current management options for both corella species combined because we assume that their similar ecologies mean they will respond in a similar way to control methods. However, we wish to highlight several issues to remember when reviewing the current management options. Firstly, the past management options are provided as a review of previous methods. However, these methods were implemented at a time when very little land clearing had taken places and so corella populations were likely small and restricted in distribution, unlike their present-day abundance and distribution. Hence, past control methods are unlikely to be effective today. Secondly, apart from shooting to protect Carnaby's Cockatoos at Koobabbie, essentially no control methods have been performed on Western Corellas and so the efficacy of current control methods on this species are unknown. It is possible, though unlikely, that different control methods will have different efficacies on each corella species and so the methods employed may need to be varied between shires under an adaptive management framework, depending on the abundance of species present in each shire. Lastly, as most of the methods outlined were developed in South Australia, they may not as effectively in the Wheatbelt. This emphasises the importance of continuously evaluating control methods under an adaptive management framework so that successful methods can be rapidly incorporated into management plans.

4.2.1.1. Former management methods

4.2.1.1.1. Western Corella

The Western Corella has been considered an agricultural pest since soon after European invasion due to its habit of feeding extensively on crops. The earliest record of it being considered a pest was from June 23, 1835 when George Fletcher Moore, the Advocate-General, wrote in his diary that at Guildford the "white cockatoos are becoming very troublesome upon the wheat as well as the crows". The very simple control method was to frighten them off the wheat such that "one is obliged to keep a boy to drive them away, or to make some contrivance to frighten them" (Serventy and Whittell 1962).

Other early accounts usually highlight the pest nature of the species and include some mention of methods used to control them. Along the south coast, Carter (1912) commented that "Mr. F. Muir, who manages his father's station told me that many years previously the Cockatoos had been abundant and were very destructive to his corn crops. He begged me to shoot as many as possible, and upon walking round the crop, some of which was still uncut, his anger increased finding that a strip about two hundred yards in length, arid thirty in width, was completely ruined by having been pulled down and trampled flat on the ground by his unwelcome visitors". Describing control measures, he wrote that they "caused such destruction to the corn-crops (mostly wheat) that boys were employed to shoot and frighten the birds away, and that it was customary to lay poisoned wheat wholesale in order to reduce their numbers" (Carter 1912).

Around Broomehill, the issues and control methods were similar with the control methods appearing to be very effective. Carter (1924) wrote how "some of the original settlers around Broomehill told me how, when boys, they has been sent out by their fathers to frighten the flocks away from the corn crops, to which these bids were most destructive. They dug up the newly-sown grain with their long, pointed mandibles, pulled up the young plants to obtain seed grain and later on in the season settled in flocks on the full-grown stalks and flattening down the crop. They also ate the ripened grain as it stood in sheaves after being cut. In consequence of these depredations, the farmers strewed poisoned corn in such wholesale manner that most of these cockatoos were destroyed and for many years now only an occasional pair, or a small party, could be seen in the extreme south-west" (Carter 1924).

Western Corellas also take over hollows from Carnaby's Black-Cockatoo (*Zanda latirostris*), often destroying eggs to do so. At Koobabbie property, north-east of Marchagee in the northern wheatbelt, shooting has been employed in the last 25 years by using local members of the Western Australian Sporting Shooters Association to protect Carnaby's Black-Cockatoos. Between 1997 and 2017 inclusive, nearly 6000 Western Corellas were shot. This was very successful at increasing reproductive output of Carnaby's Black-Cockatoo but required ongoing shooting for one weekend every month throughout the year, so was quite intensive (Saunders and Doley 2019).

4.3.1.1.2. Little Corella

Little Corellas are also regarded as a pest although most issues historically have not been due to them eating crops. In northern Australia, their roosts often seriously polluted the water beneath their roost trees so, in early 1910, a man was employed to trap or otherwise get rid of the birds (North 1912). In the Carnarvon Shire, it is regarded as a pest in the town-site as it destroys leaves of the river gums and the shire undertook to have a number destroyed in November 1977, although the method used is unknown (Howard 1983). Around Wittenoom, Little Corellas cause damage to the trees surrounding the pools in the gorges by stripping them of every green leaf and shoot, and in due course the trees die. Pastoralists made attempts to cull these flocks, although again the method is unknown, but with little success (Howard 1986).

Little Corella, like Western Corellas, also displace other cockatoos from nest hollows and kill nestlings that are already in the hollows. They are self-introduced on Kangaroo Island and are controlled as they are known to kill nestlings of the threatened Kangaroo Island Glossy Black-Cockatoo (*Calyptorhynchus lathami halmaturinus*). Between 1998 and 2005 inclusive, 486 Little Corellas were shot, which resulted in no cockatoo nestlings being lost in that time, despite the corella population increasing. However, attempts by the Kangaroo Island Pest Bird Management Task Group to reduce numbers through trapping have had only limited success to date (Masters 2002, Mooney and Pedler 2005).

4.3.1.2. Current management methods

In this section, we provide a review of all recent corella management practices and then discuss them in relation to their efficacy and likely benefit within the relevant LGAs to arrive at recommendations for potential future corella management practices.

4.3.1.2.1. Environmental and site management

This involves modifying problem sites for corellas to make them less attractive, or preferably unattractive, to corellas. This can either be achieved by removing, or reducing, resources that corellas require, such as water, food or roost trees. At sporting grounds, corellas often feed on Guildford Grass (*Romulea rosea*) and so removing this weed with herbicide can make the sites less attractive (Department of Environment Land Water and Planning 2018). Reducing access to food and water reduced the size of roosts in River Redgums (*Eucalyptus camaldulensis*) and reduced damage to the trees in South Australia (St John 1994). Alternatively, site management can involve modifying the habitat to make it less attractive to corellas, for example by adding features such as understorey shrubs and bushes, which renders the site less attractive to corellas, which prefer open spaces. In addition, troughs can be modified by adding wires and polyethylene pipes that rolls to render them inaccessible to corellas (St John 1994) but this ideally needs to be added to all troughs within a few kilometres of the affected sites to be effective. Troughs can be left unmodified at decoy sites. Habitat modification is a long-term option that might take several years to be effective but has very low on-going management costs (St John 1994) and so is an excellent option in combination with other, shorter-term approaches. One particularly long-term option would be to consider options to attract birds of prey to nest or roost at corella sites, by providing perches and nesting platforms, as this would likely reduce the attractiveness of these sites to corellas.

4.3.1.2.2. Scaring methods

Scaring involves a variety of methods to encourage or frighten birds to go elsewhere, usually by evoking a neophobic response. The effectiveness of scaring strategies depends upon several factors, including the persistence of the scaring method, variety of scaring methods to reduce habituation, and the timing of the scaring strategy. Scaring methods can generally be subdivided into noise makers and scaring sounds or visual deterrents. One method that potentially combines the two is scaring by aircraft or by drones. While we are unaware of either being used to manage corellas, the former has been mentioned as a method to control crop damage by bird pests. Drone technology is relatively recent and this is likely the reason it has not previously been trialled on corellas. However, birds generally are frightened of drones and it could potentially be successful in frightening corellas, although there remains the risk of drones being attacked by birds of prey (Lyons et al. 2018). In addition, the method is very intensive, requiring a person to be present so can only be used for a minority of the time while the birds are present.

4.3.1.2.2.1. Noise makers and scaring sounds

Noise making deterrents typically make a loud and sudden noise that is above the pain threshold for birds (>130 dB) or frightens the birds so that they leave a site. These noise making deterrents include bioacoustics sounds, such as alarm or distress calls of corellas or related species, gas guns that make a noise like a shot gun and Bird Frite® cartridges that are explosive projectiles that are fired from a 12 gauge shotgun and designed to explode ~80 m from the shotgun. All of these methods are most effective if they are utilised in a random fashion or at the time when birds are present on the site and can be set to go off remotely at pre-specified times, which reduces their cost. These types of stimuli are effective in scaring birds away from sites in the short-term and are most effective if used in combination. The technique has even been successful at preventing birds from roosting at a single site but the method requires constant vigilance and to be repeated every year the corellas return and on an as needs basis while they are present and so can be very labour intensive (Hodgens 2015). In addition, there are risks of fire ignition from the use of Bird Frite® cartridges so they should only be used outside the fire danger season, reducing their utility (Hodgens 2015). Another technique that has proven effective in South Australia is clapping two large sticks together, or using a corella clapboard (https://www.alexandrina.sa.gov.au/live/animal-management/corellas) and this has been effective in moving corellas away from specific sites (Hodgens 2015). One main disadvantage of noise scarers is that they are, by definition, very noisy and so add to noise created by the corellas, which is often one of the main issues with corellas. Overall, the best results with scaring sounds are achieved when: (a) the sound is presented at random intervals; (b) a range of different sounds is used; (c) the sound source is moved frequently; (d) the sound is supported by other control methods; and (e) sounds are reinforced by real danger, such as shooting (Environment and Natural Resources Committee 1995). Although corellas become habituated to scaring sounds relatively quickly, they are effective in the short-term and could form part of a holistic corella management plan.

4.3.1.2.2.2. Visual deterrents

Visual deterrents, such as scarecrows, are possibly the oldest bird scaring technique. While the efficacy of visual deterrents can be enhanced by making them move, they tend to be fairly ineffective as corellas quickly become habituated to them. This is especially the case in urban areas where corellas are already exposed to many novel visual stimuli and so this method would only be of limited value. However, balloons with large eyes painted on and kites with an image of a bird of prey on them do seem to have some effect in frightening corellas (Department of Environment Land Water and Planning 2018). Another visual deterrent could be the use of trained birds of prey to scare corellas from sites. This is often more effective than other visual deterrents but has the disadvantage that it is expensive (being more expensive than two people shooting; Dolbeer 2003), requires a long time to train suitable birds of prey, assuming any are available to use, and can only be used for short periods of time because a trainer needs to be present. Given all these disadvantages, combined with the fact that the method if often not particularly effective, this would not be recommended for corella management, even in the unlikely event, that trained birds of prey were available. Strobe lights and lasers can be used at roost sites and have proven effective at moving birds on in the Flinders Ranges in South Australia (Hodgens 2015, Anon 2020). The use of bright, flashing lights placed in trees could also potentially discourage corellas from roosting, although the method has not been previously used on corellas. Placing plastic snakes on extensive grassy areas has also been shown to be effective in Hawker in South Australia (Hodgens 2015). However, there may be issues with this method if the roost site occurs in a town as it may cause disturbance to humans. Overall, visual deterrents are not likely to be effective and corella are likely to habituate to them quickly so their use would be unlikely to form a wide part of any corella management plan, but their use could be considered for specific site for a short time period.

Considering both types of scaring method, one issue is that it only scares birds away from a site and those birds will go somewhere else so there is the risk that the problem is simply relocated. Hence, scaring tends to be most effective when combined with decoy sites so that the birds have somewhere to go to (Jarman 1990, Crossfield 2000). Another issue is that corellas will quickly become habituated to the scaring stimuli and its efficacy will reduce over time. The length of efficacy can be extended if the scaring is accompanied by actual mortality through shooting but shooting need to be continually used to be effective, so is a more expensive option, plus is not a feasible option in towns. Overall, scaring is a short-term strategy that can be a useful part of a holistic management approach but is of limited value on its own.

4.3.1.2.2.3. Physical deterrents

Corellas can be discouraged from perching on buildings and infrastructure by providing a physical deterrent. This can take the form of sharp objects, such a metal wires and prongs, that physically prevent the birds from roosts. For example, commercially available “spike clusters” can be applied to perches to prevent corellas from perching on them. Perches that corellas damage can also be covered in 5cm lengths of polypipe, or longer lengths of PVC pipe, that roll when the birds attempt to perch on them, and these can be useful when applied locally to reduce damage. Alternatively, electrical matting, such as Bird Jolt, can be laid on problem perches that provide a non-lethal electric shock to birds and discourages them from perching at the site. These are potentially effective methods and may be useful components of a corella management plan as they are low cost but potentially work in the long-term, although their efficacy on corellas remains to be determined.

4.3.1.2.3. Chemical controls

4.3.1.2.3.1. Bird deterrent chemicals

Most bird deterrent chemicals rely on the chemical being applied to a food that is ingested. The deterrent causes primary repellency because they have an unpleasant taste or smell or because they cause pain or irritation. Secondary repellency results from the chemical making the birds feel sick or nauseous. In a series or trials, wooden frames treated with hot English mustard, hospital strength disinfectant or methyl anthranilate were destroyed just as quickly as frames treated with water as a control. It was concluded that this was because cockatoos were just biting pieces off the timber rather than ingested them. This indicates that this method would not work if the aim was to prevent corellas from pruning and stripping roost trees. Oats coated in methyl anthranilate were not found to be repellent to Long-billed Corellas in the field although methyl anthranilate coated on seeds was found to be repellent to Little corellas in cage trials (Sinclair and Campbell 1995, Kentish et al. 2003), suggesting it may have some repellent effect on corellas where coated on seeds. Anthraquinone, commercially known as Flight Control®, is a polycyclic aromatic hydrocarbon that occurs naturally in insects, plants and fungi. It has been used as a grazing repellent to deter birds (particularly Canada Geese) from golf courses, airports, urban and industrial areas and landfills, and could potentially be used on ovals to repel corellas although whether it would be effective is unknown (Tracey 2012). Methyl anthranilate can also be applied as an aerosol from a fogging machine or pressure pack and causes irritation to the mucous membranes of the eyes and nose. However, this requires calm conditions so the aerosol can be directed where required, which rarely happens in the wheatbelt, and it also irritates mucous membranes in humans so is not appropriate for use in towns. Furthermore, it is not registered for commercial use in Australia. Overall, bird deterrent chemicals show very limited use for controlling corellas and would be unlikely to form a major component of a corella management plan.

4.3.1.2.3.2. Ingested poisons

Various chemicals are used as avicides globally, including DRC 1339, Avitrol and alpha-chlorolase. DRC 1339 was developed in the USA specifically for starling control. It is not registered for use on corellas in Australia and is not considered appropriate for the purpose. Avitrol is registered in Australia for use on Silver Gulls and some exotic species. It causes distress behavior and erratic flight in affected birds, which scares off the rest of the flock. Affected birds usually die. It is not regarded as humane and is not registered for use on corellas and so is not an appropriate management method. Furthermore, for these two chemicals, there is likely to be considerable mortality of non-target species and a high risk of secondary poisoning from other animals feeding on carcasses. 4-aminopyridine is a potassium channel blocker that acts as a central nervous stimulant. It is registered for use in Western Australia but has never been trialed on corellas. One disadvantage of this chemical is that it kills non-target species as well as corellas and so would not be recommended for use except where corellas form monospecific flocks, or at most mixed flocks of corellas. Alpha-chloralose is a narcotic agent that is used for the capture of birds but can be used to kill birds by providing an overdose. One advantage of this chemical is that it anaesthetizes birds and so there is the opportunity for non-target species to be revived. It takes between 12 and 60 minutes in Little Corellas for the onset of narcosis and sufficient immobilization for capture when mixed with grain bait at a concentration of 2% (Nelson 1994). Hence, there is a risk that corella may disperse from the site of administration before they can be captured. The chemical is approved for the control of Silver Gulls (*Larus novaehollandiae*) and Little Ravens (*Corvus mellori*) in Victoria. In Western Australia, only licensed pest management technicians with a licence endorsement of 'Feral Pigeons' and alpha-chloralose printed on their plastic licence may access this chemical and it is not currently approved for use on corellas. However, there is some evidence that cockatoos may be reluctant to eat seeds coated with alpha-chloralose and it may be difficult to ensure that a sufficient dose to immobilize birds can be administered through treated grain. One alternative is to administer alpha-chloralose to corellas in water when they drink and this has been shown to be an effective technique, cause a short-term reduction in corellas numbers and pruning damage to trees in South Australia. However, corellas quickly become habituated to grain or water treated with alpha-chloralose and avoid them, so the technique had only short-term benefits of less than 6 weeks (St John 1994, Hodgens 2015). Overall, alpha-chloralose shows some promise as control agent for corellas, potentially either coated on food or placed in drinking water. As with many other methods, however, birds are likely to start avoiding grain after a period of time and so the method primarily provides a short-term solution to corella issues. In addition, poisoning or narcotizing corellas is illegal under the *Biodiversity Conservation Act 2016* and so obtaining permission to use alpha-chlorolase would be difficult. Given the short-term benefit and difficulties of obtaining permits to use it, we do not recommend its use.

4.3.1.2.3.3. Toxic perches

Toxic perches are another method occasionally used for bird control. This typically involves coating potential perches with a grease contained the active ingredient Fention which is absorbed through the birds' feet and skin. While this method is approved for use in eastern Australia on sparrows, starlings and Feral Pigeons (*Columba livia*) there are serious secondary poisoning hazards for anything that eat the carcasses of birds poisoned this way (Temby 2010). Furthermore, this method will also kill any non-target birds that utilise the treated perches so this method cannot be recommended as method of control for corellas,

4.3.1.2.3.4. Surfactants

Another chemical approach to controlling birds is to spray roosting birds with a surfactant that reduces the ability of the birds to thermoregulate. Hence, in cold or wet weather, the birds subsequently die of hypothermia. This method has not been trialed on corellas but is of potential use in winter on roosts that are located outside towns. One major disadvantage would be the animal welfare concerns because the birds die of hypothermia (Temby 2010), which would mean the method would be unlikely to be approved even in the unlikely event it had community support.

4.3.1.2.4. Tactile deterrents

Non-sticky polybutene gels can be applied to perches as it is a soft material that birds do not like to perch on and it discourages them from using those perches. However, use of these gels is problematic as small birds can become stuck to the gels, creating animal welfare issues (Temby 2010). It has not been trialed on corellas and it is not registered for use, or practical, on roost trees and so cannot be recommended as a method for corella control.

4.3.1.2.5. Decoy models

Decoy models can be used to both repel or attract birds to a site. Long-billed Corellas (*Cacatua tenuirostris*) can be attracted by the sight of other corellas feeding and will change course to join them (Emison et al. 1994). Research on Little Corellas in South Australia has shown that dead Little Corellas were useful as decoys to attract other corellas to a water trough (Environment and Natural Resources Committee 1995) and that corellas in feeding posture may be effective in attracting other corellas to join them at decoy feeding or trapping sites, although this remains untested. Conversely, corellas feeding on the ground assume an alert posture, in which the stand erect just before taking off, and model corellas set in this posture may be effective in deterring other corellas from landing in the vicinity, although its effectiveness would likely be short-lived. Overall, model or dead corellas show some promise in attracting, and potentially deterring, corellas to particular area. These areas may be sites where we want to trap or shoot them, or they may be sacrificial areas that we want to encourage birds to use. The method has no value in deterring corellas from roosting in towns but could be a useful part of a holistic corella management plan.

4.3.1.2.6. Lethal control to reduce populations

Killing pest birds directly seems like an obvious solution to the damage they cause. In reality, killing birds is time intensive and relatively ineffective as a long-term strategy and also runs the risk of focusing management on the number of birds killed rather than the degree of damage reduced.

4.3.1.2.6.1. Shooting

Shooting of birds is a commonly used method both in its own right and as part of a scaring program, by reinforcing the scaring stimuli of non-lethal methods by creating direct mortality. Shooting can be a useful control method for small numbers of corellas in specific locations and to achieve specific outcomes. As described above, Saunders and Doley (2019) have used shooting as a method to improve fledging success of Carnaby's Black-Cockatoos at Koobabbie and it has proven effective in achieving this goal. However, generally it is ineffective and expensive as a long-term strategy because it requires people to be present and corellas move so widely that they can easily avoid areas where shooting occurs for the time when the shooter is present. Even at Koobabbie, the number of Western Corellas shot between 1997 and 2017 did not decrease over the years demonstrating that shooting was not effective in reducing the population on that one site, only in reducing the number of Western Corellas that evicted Carnaby's Black-Cockatoo from their nest hollows. Shooting of birds at their roosts at night can also be effective in causing birds to relocate roosts (Environment and Natural Resources Committee 1995), showing it can have some value at specific locations. One disadvantage of shooting is that it cannot be conducted safely near towns and it is also ineffective against large flocks of corellas as most individuals escape before many can be shot. Overall, shooting can be a useful component of a holistic management plan when targeted to specific sites for specific short periods of time, or to reinforce scaring methods, but has limited value as a control method on its own.

4.3.1.2.6.2. Trapping and gassing

Trapping and euthanasia of corellas can be effective in reducing numbers of birds locally. However, it is time-consuming and there are also issues of animal welfare and public perception to be overcome, particularly if the trapping is to be conducted in a town. Trapping and gassing has been a commonly used method by local governments in southern Western Australia, such as the Cities of Rockingham and Bunbury (Strang et al. 2014, Puglisi and Leslie 2018) and is subject to Standard Operating Procedures published by the Department of Biodiversity, Conservation and Attractions (Blythman 2017). However, the efficacy of the method in reducing corella damage, particularly where populations are large, is questionable and it may be less effective than it appears if it is mostly naïve, immature birds that are trapped. Given the life history of corellas, the method may result in trapping killing primarily birds that were going to die anyway and so may have less of an impact on the population than the number killed may indicate. A control program in Victoria that used trapping and gassing to reduce Long-billed Corella and Sulphur-crested Cockatoo (*Cacatua galerita*) damage to fruit crops killed over 100 000 birds and cost over $1 million (Temby 2010). However, the program could not demonstrate any real reduction in fruit damage, which was the reason for the program, suggesting that trapping and gassing alone is unlikely to be an effective control method. Furthermore, the Flinders Council trialed trapping and gassing in 2012 and found the technique to be ineffective, time-consuming and expensive (Anon 2020). There is also little evidence that trapping programs in the Cities of Rockingham and Bunbury are having any long-term effects on reducing corella damage, although there is some evidence it leads to a short-term reduction in numbers. Hence, if conducted at sites where the damage is actually occurring, trapping and gassing can potentially be an effective short-term strategy and could be used as part of an overall control program.

4.3.1.2.7. Fertility control

Fertility control is regarded as a highly desirable technique of population control since it does not require animals to be killed. A range of potential chemicals could be used, such as Mestranol, BDH10131, Ornitrol, triethylenemelamine, thioTEPA and nicarbizin (Tracey 2012). However, the technology does not currently exist to implement this method on corellas and it is not currently practical to use on free-ranging wild birds so cannot be recommended as a control method. Furthermore, in long-lived species, such as corellas, it may take decades before population start to be significantly reduced and so is likely too long-term a solution for the corella issues in the relevant LGAs.

4.3.1.2.8. Destruction of eggs

Destruction of eggs could potentially reduce corella population if sufficient eggs could be destroyed. However, corellas breed over a large area in many sites and can re-breed if their eggs are destroyed early in the breeding season. Hence, to destroy enough eggs to reduce the population would require significant effort and be expensive. Furthermore, given the long lifespan on corellas and their life history that has low juvenile recruitment, it would likely be decades before this method started to reduce populations significantly. Hence, we do not recommend this method as part of a corella management plan.

4.3.1.2.9. Decoy food sources and sacrificial sites

There are many examples of the successful use of decoy crops and bait stations or feeding stations to reduce, or avoid, damage by birds at specific sites (Cummings et al. 1987, Knittle and Porter 1988). This typically involves the sacrifice of some quantity of crop to protect a larger quantity of crop from being damaged or consumed. In South Australia, up to 4000 Long-billed Corellas were fed 20 tons of Oats over a 10-week period while the main seeding and germination phase of winter crops was completed. Accounting for the value of the grain, there was estimated to be a 10 to 15-fold benefit from the use of this decoy crop (Alexander 1990). This method can be a useful way of diverting corellas from sites where we want damage to be reduced to sites where the damage is unimportant, although it should be done at a time of the year when food is not limiting to reduce the risk of increasing population sizes (Environment and Natural Resources Committee 1995). In southern Australia, autumn and winter are times of food abundance for corellas and decoy feeding at this time would not influence population sizes. In Victoria, a grain farmer had some success with supplying corellas with alternative feed to distract them during sowing. They ploughed up four hectares of onion grass 800m away from the paddock they were sowing. The ploughing was effective in distracting the birds away from the crop but did not work when he repeated the activity the next year. Still, the method shows potential as a method of controlling corella damage. Overall, using decoy sites is likely to be an important part of any corella management plan although it relies on suitable decoy sites being available. Decoy sites are more effective when they are close to the corella's flight path and close to trees that can be used as perches or roost sites. If decoy sites contain all the resources that corellas require, such as water, food and roost trees, it can also be useful in preventing corellas from roosting where they are not wanted.

4.3.1.2.10. Visual screening

Corellas prefer to forage and drink in open areas where they have good visibility of the surrounding landscape to search for predators and other hazards. Hence, placing visual screens around foraging and drinking sites can discourage their use by corellas. Corellas are known to avoid drinking troughs that have nearby tall vegetation and visual screening would be a useful strategy as part of the environmental management of a site. Planting tall sorghum around the edges of crops to provide a visual barrier to foraging corellas has been shown to significantly reduce crop damage and was 300% more cost effective than conventional methods (De la Motte 1990). Placing visual screens made of shade cloth or hessian that are between 2 and 2.5m tall has been recommended as a method of reducing corella damage to small areas, such as bowling greens. In the short and long-term, placing visual screens around drinking and foraging sites should reduce their use by corellas although the material used to make the screen may need to be resistant to damage by corellas (e.g. corrugated iron). Visual screening of resources used by corellas is likely to be an effective and inexpensive short and long-term method of corella control and would likely form part of a corella management plan.

4.3.1.2.11. Exclusion

Exclusion refers to the use of a physical barrier to prevent access to an area by corellas. Examples would be the use of netting to prevent access to specific food sources or drink sites, covering timber with metal sheeting or covering outdoor furniture or timber frames with chicken wire (Department of Environment Land Water and Planning 2018). It may even be possible to cover trees used for roosting with netting to prevent corellas from accessing them if they roost in a small, isolated grove. However, there is the potential for other birds to become trapped in netting so there are potentially some animal welfare issues with this method. Another option would be to place powerlines underground or to replace lights at sporting arenas with light that have no external electrical wiring. These methods are intensive and have a large up-front cost but are effective in the long-term and may result in significant long-term savings. Hence, these methods have potential value to a holistic corella management plan.

4.3.2. Defining management objectives and performance indicators

The objectives of pest bird control are to: (1) prevent damage caused by pest birds or reduce bird damage to an acceptable level; (2) produce economic benefits; and (3) use the most effective, least objectionable and safest methods that are acceptable to the stakeholders (Tracey et al. 2007). As far as practicable, these objectives should also be assessable and time-limited with measurable performance indicators.

This enables an assessment of whether the objectives of the control are being achieved and, if not, adjustments made to the management programs to better achieve those objectives. Objectives should not be defined in terms of the effort made to control birds but should relate to reductions in damage. Hence, appropriate objectives are those that are measurable and related directly to the problem such as "reduce the number of evenings when corella noise is problematic to fewer than 10 days annually within 24 months measured over the last 12 months of that period". Inappropriate objectives are those that solely measure control effort such as "spend more than 500 hours annually shooting corellas" or "kill more than 5000 corellas annually" because these objectives may have no relationship with a reduction in damage (Tracey et al. 2007).

Defining satisfactory objectives needs to be a collaborative process with input from all stakeholders, including individual landholders, such that the objectives of the plan are acceptable and supported by all affected stakeholders. We would recommend that objectives include a mix of short-term, medium term and long-term objectives with the short-term objectives addressing immediate issues and medium-term objectives relating to the long-term objectives, which are arguably the most important. The objectives need to include performance criteria that are measurable and time-related so that the effectiveness of the control measures can be evaluated. Examples of potential objectives could include reducing the area of damaged grass to below 5% of the football oval within 3 years, the number of damaged television aerials to fewer than 5 annually within 2 years or reducing the number of trees along a given street that have visible damage from corellas to fewer than 3 within 12 months. As can be seen from these examples, it is critical that the objectives are measurable and time-related so that the objectives can be evaluated as required and, either methods can be implemented more widely if successful, or improvements to control methods implemented, if unsuccessful.

4.4. Choosing management options

The effective management of wildlife requires the necessary consideration of social, environmental and regulatory factors (Kellert and Clark 1991). This means that interactions between stakeholders and the values held by stakeholders should influence decision-makers, the biological and ecological requirements of the wildlife should guide the entire process and the legal (or policy) system in which managers are operating should also guide the process. Hence, identifying the appropriate management option, or combination of options, to control pest species relies on assessing each method in relation to 8 criteria or questions. The criteria are: (1) is it legally acceptable?; (2) is it socially acceptable?; (3) is it environmentally acceptable?; (4) is it technically possible?; (5) will it work?; (6) is it economically feasible?; (7) is the scale of the control program feasible to achieve the desired outcomes?; and (8) is expertise available to use the preferred control techniques?

When choosing management options, it is also important to recognise that there is no "silver-bullet" or "solution" to management issues associated with corellas, which means that a combination of management options are likely to be required and that the options chosen may change through time as the efficacy or cost of certain options either changes or becomes known. It also means that management will be a continuous and on-going activity and so the aim of the management programs should be to reduce the economic and logistical costs of the program as much as practicable so that on-going costs are minimised.

In terms of legal considerations, the *Biodiversity Conservation Act 2016* states that prohibited methods of taking or disturbing fauna include using, laying or spreading any explosive, poisonous, noxious or narcotising substance. Hence, any ingested poisons (Section 4.3.1.2.3.2) or toxic perches (Section 4.3.1.2.3.2) would be illegal to use on corellas. The Biodiversity Conservation Act 2016 lists both Western Corella (*Cacatua pastinator derbyi*) and Little Corella (*Cacatua sanguinea*) as Managed Fauna. This means that within specified LGAs, including Goomalling, Northam, Toodyay, Victoria Plains and York, corellas can be taken or disturbed if they are causing, or are reasonably expected to cause, economic damage and the taking or disturbance is by means of a firearm or the disturbance is by means of a noise or light generating device. This means that shooting (Section 4.3.1.2.6.1), noise-makers and scaring sounds (Section 4.3.1.2.2.1) and strobe and laser lights (part of Section 4.3.1.2.2.2) can be used by landowners within the relevant LGAs on their own land without the need for a licence. Environmental and site management (Section 4.3.1.2.1), visual screening (4.3.1.2.10) and exclusion (Section 4.3.1.2.11) do not involve the taking or disturbing of birds and so, likely, do not require licences to implement. All other methods outlined in Current management methods (Section 4.3.1.2) require a licence to be used. It is also important to note that a Regulation 15 licence used to be required to cull corellas and that a condition of this licence was that no culling of corellas took place between 1 May and 31 October inclusive. This was to prevent any nesting birds being killed and leaving dependent young in the nest and so we would discourage the use of lethal control techniques during this period. Finally, legislation can change, there are local government area regulations that may be relevant to some control methods and we may be unaware of some legal issues so we recommend that all stakeholders contact the Department of Biodiversity, Conservation and Attractions and the relevant shire before commencing any corella management activities.

In terms of which methods are socially acceptable, it is strongly recommended that any corella management plan conduct online surveys of stakeholder attitudes towards corellas, with paper copies provided if required, combined with community workshops early in the process to guide the direction of the management plan. Engaging with stakeholders not only identifies which management actions will have widespread community support, and are therefore viable long-term, but can also help identify stakeholders and locations that could potentially be involved in subsequent stages of the plan. We would recommend that this part of the plan is conducted by professional consultants with experience in the social aspects of human-wildlife conflicts. Their experience should ensure that the questions asked best assess stakeholders' attitudes and they can promote the activities through traditional and social media.

Once legal and social constraints are placed on the management options, the next part of the process should assess the remaining options in terms of what is environmentally acceptable, what is technically possible and what is likely to work. What methods are environmentally acceptable will be largely driven by the stakeholder engagement process, but we consider is unlikely that surfactants (Section 4.3.1.2.3.4), tactile deterrents (Section 4.3.1.2.4) or methyl anthranilate would be acceptable (and their efficacy is questionable as well) and some noise-scaring devices would be unlikely to be acceptable close to human habitation. What is technically possible likely removes the use of fertility control (Section 4.3.1.2.7) and birds of prey as visual deterrents, notwithstanding the cost and questionable efficacy of this latter option. What is likely to work is harder to determine given the lack of research conducted on corella management techniques in Western Australia. Destruction of eggs is unlikely to be an effective method because it kills solely corellas that would grow to be juveniles and these are unlikely to recruit into the population. Hence, this method would likely have negligible effects on population sizes, even locally, and negligible effects on reducing corella damage. Furthermore, bird deterrent chemicals have been shown to be inefficient methods of controlling corellas elsewhere and we consider it unlikely they would be efficient in Western Australia. The remaining control methods are all legally acceptable, although their social and environmental acceptability may vary.

We would consider the range of methods that would potentially form part of a corella control plan would be:

(1) Environmental and site management

(2) Scaring by model airplanes or drones

(3) Scaring by gas guns, Bird Frite® cartridges or clapboards

(4) Scaring using strobe, laser or spotlights

(5) Shooting

(6) Trapping and gassing

(7) Preventing perching using physical methods

(8) Decoy models

(9) Decoy feeding and sacrificial sites

(10) Visual screening

(11) Exclusion

Given the complexity of corella management, it is likely that any management plan will contain several, if not all, of these methods. These methods will vary greatly in their spatial and temporal efficacy and acceptability and so it is likely that certain methods will be useful in some locations, but not others. For example, shooting could be a useful strategy around small patches of high-quality crops but would not be acceptable in urban parks. The temporal efficiency of methods will also vary greatly with scaring methods likely to be effective only in the short-term, trapping and gassing, and potentially decoy models useful over medium timeframes and environmental and site management and decoy feeding and sacrificial sites being effective over the long-term. We would recommend that any corella management plan contains a mixture of short-term actions, to address immediate locations where corella problems are acute, combined with medium-term and, critically, long-term strategies to manage corellas problems more broadly across the shires. Efficacy is also critical for selecting appropriate control methods, but it should be noted that the efficacy of many of these methods for controlling corellas within the relevant LGAs remains to be determined. Hence, any management plan needs to remain flexible and adaptive so that methods can be added or terminated as their efficacy is quantified. It is also needs to be recognised that the efficacy of methods may vary temporally, being more effective in some years than others, and so methods excluded in some years may be included in others. This emphasises the importance of understanding the mechanisms behind the efficacy of methods so any temporal variations in efficacy can be better predicted.

Another criterion in the process of choosing appropriate management methods is the likely economic costs of the various management options. Critically, this needs to estimate not only the short-term costs of each management action but also the on-going costs of each action, as corella management will be a continuous and never-ending activity and, hence, there will be permanent annual costs in perpetuity. We believe that the most desirable management plan will include the methods that combine efficacy with low on-going costs. Calculating the economic cost of current corella damage and the cost of current management actions will further help to guide the selection of appropriate management methods. This process needs to acknowledge that corellas problems are likely to get worse in the future and so the economic costs of damage are likely to increase through time without effective management. We have provided a framework for calculating the costs of corella damage to communities as a starting point. However, given the complexities of working out the full economic costs of corella damage, plus quantifying the non-economic damage caused by corellas (e.g. lack of sleep), this process may require external expertise and this is something the relevant LGAs could consider.

Table 2. Framework for assessing the impacts of Little Corellas (adapted from QED Pty Ltd 2003).

Type of Impact	Nature of Impact	Data Required	Method of Assessment
Social	Disturbance to daily activities	Proportion of community affected and degree to which affected What level of impact is acceptable?	Community survey Community consultation
Economic	Cost to Council of control program	Annual expenditure on control	Interviews with shire staff
	Cost to Council of maintenance of parks and infrastructure	Annual expenditure on maintenance of Council property	Interviews with shire staff
	Cost to individual residents due to damage to property	Average annual individual expenditure on repairs to property	Community survey/interviews with residents
	Decline in revenue to local businesses	Estimate of annual income lost to town	Community survey/interviews with business owners
	Cost to agricultural/horticultural industry	Annual expenditure on control; estimate of lost production	Survey of agricultural/horticultural companies/Interviews with business owners
Environmental	Disturbance due to noise	Average and maximum noise levels of birds in affected areas	Monitoring by acoustic engineer
	Decline in tree health	Extent of damage to individual trees over time Predicted survivorship of individual trees	Monitoring of individual trees by shire staff using photopoints in conjunction with arborist's assessment
	Competition with native bird species	Changes in abundance of native bird species over time; proportion of available nesting hollows used	Bird atlassing; seasonal survey of hollow use
	Other environmental effects (e.g. erosion, increased nutrient input into waterways)	Extent of sediment increase and nutrient input into waterways	Monitoring of water quality at affected sites
Health	Illness due to direct corella fouling or indirect fouling of water sources	Lost work time or hospitalisation from illness	Interviews with business Data from Health Department

4.5. Implementation of a corella management strategy and plan

Choosing the range of management options that will be implemented is only part of the challenge of effectively managing corellas. Before management options are selected and a plan implemented, it is important that this plan sits within a governance framework that maximizes the chances of success. Interviews with the shires in the relevant LGAs revealed that corella management so far has been hampered by a lack of collaboration between shires and, more importantly, an unclear idea of who is ultimately responsible for corella management. This has led to confusion as to which agencies are responsible for specific aspects of corella management and has resulted in corella management which has been piecemeal, reactive and poorly coordinated, with limited success in addressing corella problems. Furthermore, the impacts of corella is so broad that is comes under the aegis of several organisations. For example, corellas have negative impacts on other native wildlife species, such as Carnaby's Black-Cockatoos (Saunders and Doley 2019), and hence control of corellas to protect other native species would normally be the responsibility of the Department of Biodiversity, Conservation and Attractions. Furthermore, corellas are an agricultural pest in many areas and control of agricultural pests is normally the responsibility of the Department of Primary Industries and Regional Development. While the extent to which each of these organisations have contributed to corella control was not investigated, the overlap in responsibilities for corella control between several organisations mean that effective corella management is likely to be best achieved by a broad strategy that can coordinate a holistic plan and assign responsibilities across the relevant organisations and stakeholders. The issue of managing corellas is too big to be effectively implemented by shires alone, due their limited personnel and finances, and so we believe a different governance framework is required. What form this would take would need to be developed by an organization, or individual, with experience in vertebrate pest management, based on input from all the stakeholders involved in corella management. Furthermore, experiences from South Australia suggest that a collaborative wheatbelt-wide management approach, that coordinates efforts and takes into account the long-term nature of the issues, is required for the effective management and control of corellas. Hence, dedicated position(s) for the control of corellas that sit across multiple stakeholders is likely required for more informed, effective corella controls. These positions can also identify and implement long-term actions that work towards long-term reductions in corella issues as well as develop and help implement regional, sub-regional and local management plans that clarify roles and responsibilities to reduce little corella impacts in each region and across the wheatbelt. They would also establish and maintain community and regional stakeholders commitment to undertaking appropriate long, medium and short-term actions that reduce corella impacts. We believe that the establishment of an appropriate governance framework is required for the implementation of an effective corella management plan. However, we acknowledge that the implementation of an appropriate governance framework will be difficult to achieve and, even if it can be done, will likely take several years to develop.

In the meantime, shires have corella issues that they need to be addressed and so we propose the following management plan that shires can use until such a time as more holistic and cohesive management of corellas eventuates.

Based on prior research, we believe that the most effective management plan for corellas is an integrated management plan that involves a combination of short, medium and long-term management actions that ideally are implemented concurrently. Which of these management actions are implemented at any specific site will vary depending on the nature of the problem at that site but, regardless, corella issues will be reduced most effectively in the long-term at each site by implementing a combination of short, medium and long-term actions. Short-term actions include: (1) scaring by model airplanes or drones; (2) scaring by gas guns, Bird Frite® cartridges or clapboards; and (3) scaring using strobe or laser lights. These methods are all short-term because corellas will rapidly habituate to the scaring strategy and so their effectiveness will likely last only months. Their effectiveness can be increased by adding a lethal deterrent by shooting during the initial, or first few, scaring sessions and we recommend this option where possible (i.e. outside urban areas). Ensuring that the person(s) conducting the scaring always uses the same car and always wears the same headgear further increases the effectiveness of scaring with the birds often departing upon arrival of the vehicle or the person exiting the vehicle (Hodgens 2015). One major issue with scaring is that is typically needs to be conducted with a person present, which makes it an expensive option, particularly given the short-term benefits of the strategy. For scaring with gas guns or Bird Frite® cartridges, this expense can be reduced by automating the firing and ensuring that firing occurs at random times from random locations at the problem sites, as well as changing locations frequently, all reduce habituation. One issue with scaring with gas guns, Bird Frite® cartridges and clapboards in urban areas is that they create a noise and are unlikely to be tolerated by residents so, in these areas, scaring using strobe or laser lights is likely to be a more practical option. Using strobe, laser and spotlights has been shown to be effective in scaring corellas from roost sites, at least in the short-term. This method is most effective if corellas are scared as soon as they arrive as roost sites and that this scaring continues as long into the evening as required until no more corellas arrive. It is an intensive method but can be effectively if utilized in locations where people live. Scaring with drones or model airplanes has not been previously used for managing corellas and it effectiveness is unknown. However, it could potentially have advantages over the other scaring methods in that corellas could be followed by the drone or model airplane and encouraged in the direction of sacrificial sites, where the corellas could roost without being disturbed. This leads on to the final point about scaring which is that it is a very intensive and impractical long-term strategy unless it is conducted alongside the creation of sacrificial sites (see below). The ideal management strategy is to scare birds to these sacrificial sites, which should reduce the intensity of scaring required over time so that only on-going scaring of scout birds is required on an annual basis. It is important that birds displaced by scaring are monitored so that we know where the birds have moved to. It is critical that they move to sacrificial sites (which they may not do immediately) as, otherwise, scaring will simply transfer the problem to new problem sites and there will be no long-term reduction in corella issues. Furthermore, scaring without sacrificial sites is likely to be a very intensive and long-term strategy. For example, moving corellas from Quorn Caravan Park in South Australia involved the two owners spending around 30 person hours a week over 12 years to finally move the corellas to roost at another site (Hodgens 2015). Identification of a nearby sacrificial roosting site and encouraging corellas to move to this site would likely reduce both the effort and length of time required to achieve this.

Medium-term actions include shooting and trapping and gassing. Shooting can be effective if there is a small flock that is causing issues at a specific site and shooting in a single session can remove most of the flock. However, corellas typically occur in large flocks, so shooting is unlikely to form a major part of a control program. Furthermore, shooting cannot be conducted in urban areas and can exacerbate corella issues by moving flocks into new areas where they cause the same problems. Shooting will not reduce the numbers of corellas to any practical extent in the relevant LGAs, the number of birds shot will simply be replaced rapidly through increased juvenile recruitment and increased immigration from surrounding areas. Therefore, shooting will only be useful in a limited number of scenarios. One is to scare birds away from a site, either alone or in combination with other scaring techniques, and prior studies have shown this can be an effective method to discourage corellas from certain locations (Hodgens 2015). It is particularly effective if targeted at the first scout birds that return to problem sites each year. As with other scaring strategies though, this method is most effective when combined with the provision of sacrificial sites where corellas remain undisturbed. Another scenario where shooting can be effective is in improving breeding success of native hollow-nesting species. Shooting of corellas has been shown to be effective in increasing the nesting success of both Carnaby's Black-Cockatoos (Saunders and Doley 2019) and Kangaroo Island Glossy Black-Cockatoos (*Calyptorhynchus lathami halamturinus*) (Mooney and Pedler 2005) and would likely have similar benefits in the relevant LGAs. The disadvantage of this method is that it is required in perpetuity. Hence, we would recommend shooting to reduce hollow competition by corellas be conducted in conjunction with long-term strategies such as environmental site management to reduce site attractiveness to corellas. Overall, shooting can a useful strategy when used as part of a scaring strategy or in combination with environmental management to reduce nest competition. One major disadvantage of shooting is that it requires skilled personnel and so is expensive. For example, one shire within the relevant LGAs paid $10K for a shooter to kill 60 corellas, which would have negligible impact on corella issues. While this cost can be reduced by involving sporting shooters clubs in corella management, paying shooters is one of the more expensive management options compounded by the need to maintain the management, and cost, in perpetuity. Consequently, we see shooting as only forming a small part of any management plan.

Gassing and trapping is a strategy that has been quite widely used previously in Western Australia. However, it has been previously used in shires that have much smaller populations of corellas and, even in these shires, the benefits have been short-term. However, the method could potentially be effective in removing a small flock at a specific location if that flock is particularly problematic. Again, however, this method will be most effective if it is combined with long-term strategies to reduce the suitability of sites for corellas. Otherwise, the flock that is removed will quickly be replaced by another flock eager to utilise the resources at that site. Another issue with trapping and gassing is that it is expensive because it requires birds to be pre-fed at a site over several weeks (Blythman 2017). Furthermore, the method requires highly skilled people and this adds to the expense. The method is also only recommended for flocks of fewer than 100 birds as ethical issues arise when more corellas than that are trapped. For these reasons, given the large numbers of corellas and flocks within the relevant LGAs, we would consider trapping and gassing to be the least useful method considered. It is unlikely to form part of a corella management plan but we retain it as there may be some cases where it could be useful for removing a corella flock in some urban setting.

Lastly, we would strongly encourage any corella management plan to focus on long-term methods for reducing corella problems as these will ultimately be the most effective at reducing problems and also have the lowest on-going management costs. Implementation of these methods acknowledges that humans have modified the landscape in the relevant LGAs for agricultural production and this provides perfect habitat for corellas. Given the importance of agriculture in the relevant LGAs, widespread revegetation of the landscape to reduce corella numbers is neither feasible nor desirable. Hence, a reduction in corella numbers is unlikely to be achieved without impractical levels of controls that would be required in perpetuity and so a better strategy is to learn to live with corellas and share the landscape with them. This sharing involves encouraging corellas to avoid sites where they create issues for humans and encouraging them to use sites where they do not create issues.

Table 3. A summary of the recommended control methods indicating the timeframes of their use, their likely effectiveness and whether they should be including in any management plan.

Management action	Timeframe	Effectiveness	Include in plan?
Scaring using strobe, laser or spotlights	Short-term	Effective for several months	Yes, if combined with sacrificial sites
Scaring by gas guns, Bird Frite® cartridges or clapboards	Short-term	Effective for several months	Yes, if combined with sacrificial sites
Scaring by model airplanes or drones	Short-term	Unknown, possibly effective for longer than other scaring methods	Yes, if effective. Needs to be combined with sacrificial sites
Shooting	Medium-term	Effective at commencement of scaring programs. Reduced effectiveness	Yes, as part of scaring programs. Needs to be combined with

		over time as birds flee on arrival of shooter	sacrificial sites to maintain effectiveness
Trapping and gassing	Medium-term	Effective but very time consuming and only achieves short-term reduction in numbers	Possibly where problems are acute but time-consuming and expensive so other options likely better
Preventing perching using physical methods	Long-term	Effective if perches are narrow	Yes, where problems occur on buildings and, possibly, trees
Environmental and site management	Long-term	Highly effective in the long-term but will take time to reduce problems	Yes, most effective when combined with sacrificial sites
Visual screening	Long-term	Highly effective in appropriate sites and if screening is complete	Yes, more effective when combined with sacrificial sites
Exclusion	Long-term	Highly effective but high up-front costs	Yes, more effective when combined with sacrificial sites
Decoy models	Medium-term	Unknown	Yes, if trials show it to be a successful method
Decoy feeding and sacrificial sites	Long-term	Highly effective	Yes, a critical part of any management plan

These long-term methods include environmental and site management, visual screening, exclusion, preventing perching using physical methods and decoy models, decoy feeding and sacrificial sites. Preventing perching using physical methods is a technique that has already been widely use to prevent perching of birds in undesirable locations, although it effectiveness on corellas has not been tested. We consider this method is likely be most effective when used on buildings or other built infrastructure and in placed where shallow-sloping roofs are absent. In these areas, sharp objects such as metal wires and prongs could be placed to prevent corellas perching. Electrical matting could also potentially be used in similar locations. On fences, 5cm lengths of polyethylene or PVC pipe, that roll when birds attempt to perch on them, could be placed on wires or other small perches to prevent corellas perching. While the effectiveness of any of these methods is unknown, they are likely to be effective in some circumstances and their inclusion in a corella management plan should be trialed within an adaptive management framework.

Another long-term management method is environmental site management, with which we also include visual screening and exclusion as these latter two methods are essentially specific subsets of environmental site management. Environmental site management essentially is reducing the long-term suitability of a site for corellas so that numbers are either reduced or eliminated from that site, thereby reducing or eliminating the issues they cause. Reducing long-term suitability involves reducing or, preferably, eliminating access to the three main resources that corellas require and reducing the suitability of the habitat structure at sites. The three main resources that corellas require at a site are roosting and loafing trees, food and water, which we discuss in increased feasibility of reduction or elimination. Corellas loaf in tall trees during the day and roost in tall trees (not necessarily the same trees used for loafing) at night. Therefore, removing tall trees from sites would prevent corellas from roosting there and encourage them to roost at alternative sites. However, tall trees provide many services valued by humans, such as shade and visual attractiveness, as well as providing habitat for many native species valued by humans. Hence, the community does not generally support removal of tall trees to reduce site attractiveness to corellas (Scanlon et al. 2017) but it could be done at sites where it is acceptable (e.g. around grain terminals and silos). Reducing food availability at sites is another method of reducing site suitability for corellas. Corellas often feed on agricultural crops and so often congregate at grain terminals where grain crops are collected and stored. Improving grain hygiene is an important part of reducing corella issues at these types of sites. Improving grain hygiene can involve ensuring all grain is stored in enclosed storage units (i.e. not covered with tarpaulins) and ensuring spilt grain in loading areas is immediately collected and placed in enclosed storage units before it is discovered by corellas. While these options may seem expensive, it is likely that once the costs of corella damage at grain terminals is calculated, these options will pay for themselves within a relatively short-time frame. Corellas also often visit town ovals and urban parks to feed on grass rhizomes and cause extensive damage to playing surfaces that incur significant costs to fix. One option is to trial different types of grass as playing surfaces for town ovals, focusing on those that provide a less attractive food source for corellas. There are a range of native grass species that could potentially be used in place of introduced grasses (e.g. https://nativeseeds.com.au/lawns/?v=6cc98ba2045f, https://www.sgaonline.org.au/native-lawns/) to reduce food resources for corellas. However, these species are unlikely to be hardwearing enough for a sport surfaces. We would recommend that shires experiment with a range of suitable grass species to identify which is least attractive to corellas and then resurface playing surfaces if an appropriate species can be identified. Native grasses also require less water than introduced species further reducing site attractiveness for corellas (which have a strong preference for extensive irrigated lawns) and costs. For urban parks, it is likely that suitable ground cover can be more easily identified, with the same cost benefits, although there are other methods that can be implemented to further reduce the attractiveness of urban parks to corellas. Arguably the easiest and most effective method of reducing site attractiveness to corellas is to reduce access to water resources. Corellas need to drink daily, particularly in hot weather, and while they are prepared to travel several kilometres to drink, eliminating drink sites at problem sites is likely to be a highly effective method of reducing corella issues. Potential drink sources are primarily artificial dams and ponds or troughs and a range of methods are available to reduce corella access to these water sources. For artificial dams or ponds, the three best methods to reduce access to corellas are: (1) increase bank height to at least 45cm; (2) vegetate shorelines to eliminate open banks; and (3) place screening around water sources. For problem sites with built banks around water sources, the banks can be raised to a height of a minimum of 45cm above the water level to prevent access to the water by corellas (Scanlon et al. 2017). If banks are not present around water sources, they could be installed although the following option might be easier in that scenario. A potentially easier option for ponds is to vegetate the entire shoreline (Figure 4) with tall rushes or reeds, species in the Typhaceae, Juncacae and Cyperaceae would include a good range of suitable native species at problem sites. Corellas need an open shoreline, with little or no vegetation, to access water sources for drinking and so vegetation effectively eliminates the water source as a drink site. An important consideration with this method is to ensure that the vegetation is dense and complete as even small gaps along the shoreline can be effectively exploited by corellas. Visual screening around water sources is also likely to be effective in eliminating their suitability as drink sites. Corellas like to have a clear view of a wide area to identify approaching predators (see below) and they avoid drinking from areas that lack suitability visibility. One important factor with this approach is to ensure that the screening is absolute as even small failures in the screening can reduce its effectiveness. Screening can be achieved with hessian and shade cloth or more robust screening with corrugated iron could be considered. Due to aesthetics, we would not recommend screening as a long-term solution in urban areas but it could be a useful short-term strategy while waiting for shoreline vegetation to grow or banks to be re-contoured. For dams, vegetating the shoreline is one potential method of eliminating corella access to water sources if the dams is used for irrigation rather than as a stock watering point. If the dam is used for irrigation, then lining the dam with a polyethylene liner can prevent use by corellas if the liner extends 45cm about the water line to prevent access by corellas. Screening could also be an effective method

Figure 3. An example of an open, unvegetated dam shoreline that provides easy access for corellas and was a heavily used drink site.

if dams are used either for irrigation or as a stock watering point. If used for irrigation, the screen could potentially be complete with a gate for access. If used as a stock watering point, the screen would need to provide access for livestock. As stated before, screening needs to be absolute to be effective and hence, around farms dams, we would encourage the installation of robust screens out of corrugated metals as, ultimately, these will be easier and cheaper to maintain in the long run as well as being more resistant to damage by corellas and more complete. For drinking troughs, the two best methods to reduce access to corellas are: (1) modify troughs to preclude access by corellas; and (2) place screening around troughs. Modifying troughs to preclude access by corellas involves placing six fence droppers cut in half in the corners of the trough and halfway along the long sides. A pair of wires is then strung at 80 and 145mm above the trough lip and along the entire lip of the trough and through the fence droppers. 50mm lengths of polypipe are then threaded onto the upper wire to prevent corellas from perching on it (Figure 5). Wires can be kept taut by means of turnbuckles that connect the wire to the droppers. See St John (1994) for more details. Screening of troughs to reduce

Figure 4. An example of a vegetated dam shoreline that precludes access for corellas and was used rarely as a drink site.

access for corellas would be the same as described previously for farm dams and, again, we would recommend more robust structures of corrugated metals to increase effectiveness and reduce long-term maintenance and costs. Rivers can be problematic if used as drink sites because it is more difficult to reduce corella access along entire rivers and corellas often congregate in riparian areas. However, several methods could potentially reduce access to rivers for drinking by corellas. The first is to prune any logs or snags to below water level if corellas are using them to drink from. They provide important habitat for aquatic life and so should not be removed, just pruned. Another option is to vegetate the shoreline to prevent corellas drinking there using the same method as described previously for artificial ponds and dams. The last method would be to plant screening shrubs along the banks of rivers to reduce visibility although this method may not be as effective as the other methods as sentinel corellas may perch in tall trees along the rivers to search for predators while other members of the flock are drinking.

Another method of environmental site management that can reduce the attractiveness of sites for corellas is the use of visual screening, which can involve screening to opaque material or vegetation. Corellas naturally feed on open plains and increasing the density of vegetation decreases the openness

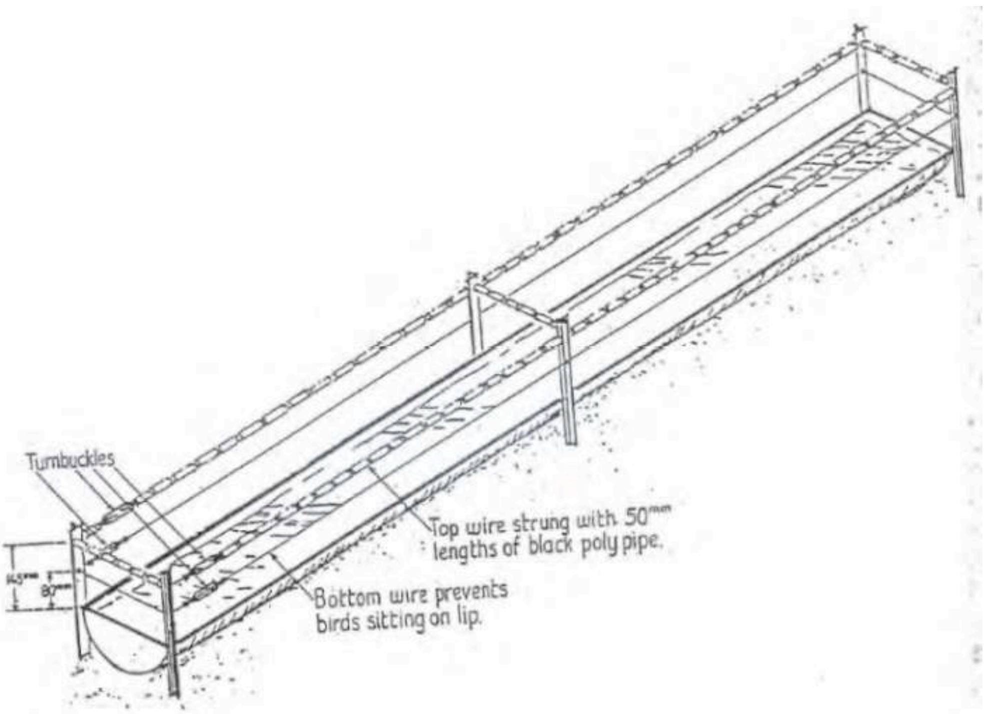

Figure 5. Diagram showing how to modify drinking troughs to render them inaccessible to corellas while still enabling livestock to drink from the trough (from St John 1994).

of the habitat and reduces corella's perceptions of safety by removing a clear view of the surrounding areas and reducing their ability to detect predators. Several methods can be used to decrease habitat openness, and all could potentially be used in urban parks. The first is to increase the density of trees by planting trees in between established trees. These new trees do not need to be tall but should ideally reach at least the bottom of the canopy of existing trees. Trees that also have a dense canopy should be selected over those that have a more open canopy to increase their screening effect. Another effective method is to reduce visibility at ground level by planting short shrubs in linear or round garden beds. These shrubs do not need to be tall, no less than 60cm and not more than 1m is ideal but can be placed to maximise their screening effect. Again, shrubs with a dense canopy should be chosen over species with a more open canopy, A wide range of native species are potentially suitable and should be prioritized over introduced species as corellas have a strong affiliation with introduced species and avoid areas with a high degree of nativeness (Scanlon et al. 2017). This method can work very effectively in urban parks, where screening is compatible with human uses and may even augment them. Effective screening in small sporting areas, such as tennis courts, bowling greens and hockey fields can be best achieved by attaching screening, such as hessian or shadecloth to any fences that surround them or erect fences for the purpose if none exist. These fences should be between 2 and 2.5m tall and it is important that the screening effect is absolute and it may be important to prevent corellas from perching on any fences by using, for example, polypipe or PVC tubing. If summer heat is an issue for people using the playing surfaces, it would be prudent to add screening that can be removed when the playing surface it being used. Town football ovals are more problematic because there are no obvious easy solutions. One possible screening solution is to plant trees and shrubs around the periphery of the oval to act as a visual screen. However, whether this would be successful in preventing corellas from using the site is unclear, but it would provide shade for spectators in the long-term and so may be worth attempting. Erecting seating around the periphery that attains a height of several metres is another strategy worth considering. It would like be expensive, and it is uncertain whether it would work, but it might work out cheaper than replacing the playing surface on a regular basis. Another thought to try and create some visual screening would be to place some temporary fencing with attached hessian or shadecloth screening across the ovals during the week when they are not in use and then remove the temporary fencing on weekends when games were played. Again, this would not be cheap as people would need to be employed to put out and pull in the fencing on a regular basis but it may work out cheaper than replacing the playing surface.

One long-term method of addressing corella issues is exclusion, which involves the installation of barriers to exclude corellas from specific areas at problem sites. For small areas, such as hockey fields where height is not such an issue, it may work out cheaper to cover the areas with netting in the long-term. Netting roost trees has also been suggested as a management strategy at problem sites and netting could potentially be installed with cherry pickers and that might work out to be a cheap long-term strategy. Corellas have also damaged wiring on lights at several sporting venues in the relevant LGAs and redesigning the lighting units so that wiring is no longer accessible to corellas could be a good long-term strategy. Preventing corellas from perching on flat or shallowly sloping roofs is a more difficult issue to address but covering those roofs in netting that prevents corellas from perching is an expensive solution but one those will likely rapidly pay for itself. As mentioned previously, ensuring good food hygiene at grain terminals by placing grain in enclosed storage units is a form of exclusion. All methods of exclusion are likely to have large up-front costs but when the economic benefits of avoiding ongoing costs of managing corellas are calculated, it is likely that the costs will be quickly recouped in some, if not all, scenarios. Corellas have also created issues by chewing electrical wiring in some shires within the relevant LGAs. Exclusion by placing electricity infrastructure underground would be a highly effective way of excluding corellas. The up-front costs would be very high, although this could be potentially partly offset by grants, but given the costs of replacing damaged wiring, the economics might work out cheaper over decades.

The last long-term methods that are likely to be part of any corella management program are decoy models and decoy or sacrificial sites. Sacrificial sites emphasise the importance of the integrated nature of any management plan because they are not a satisfactory method of addressing corella issues on their own but greatly increase the efficiency of other method within the plan. Sacrificial sites are identified suitable areas that are deliberately set aside for corellas where no deterrence or control activities occur. Sacrificial sites provide suitable feeding, watering and roosting resources and corellas are encouraged to move into these sites, and away from problem sites. The aim is that corellas eventually become accustomed to these sites and habitually return to these sites, avoiding sites where they previously caused problems. Note that the term "sacrificial" in this context does not imply that the site is of no value, but that the area is set aside for this purpose, to offset damage to, and concern about, specific sites elsewhere (Scanlon et al. 2017). The primary criterion for a sacrificial site is that it is in a location where surrounding landholders will tolerate the presence of corellas so that they are not disturbed. It is important that corellas are not harassed or disturbed either at the sacrificial site or while commuting to and from the site. Ideally, the site would already have the roosting, food and water resources, as well as the open habitat with good visibility, required by corellas. However, it is likely that sacrificial sites will need to be managed in the long-term to maintain suitability for corellas, for example by slashing long grass and/or providing drinking troughs or grain for corellas. It is important that the need for these long-term actions, and their long-term costs, are recognised in selecting sacrificial sites. The use of sacrificial sites has already been attempted with the relevant LGAs and was shown to be a successful method for reducing corella damage at a nearby hockey field and playing oval, despite the sacrificial site being only 300m away. Given that this sacrificial site is below the recommended minimum of 500m from problem sites, yet was successful, this indicates the potential utility of this method on the relevant LGAs.

For all of these management methods, it is important to first identify, and then engage with, all stakeholders at problem sites, which could include private landholders as well as government agencies and private companies. Supporting these stakeholders to implement appropriate methods on their properties will ensure management is integrated across stakeholders and will improve the effectiveness of reducing corella damage at these sites. This could include, for example, reducing access to water resources and reducing the area of irrigated lawn across both private yards and urban parks and playing fields. It is also important to communicate with stakeholders about management actions conducted at problem sites to maintain community support and avoid management actions being sabotaged. This communication could include the dissemination of information, either online, by post or at community fora, on the management actions being proposed and the reasons for choosing those management actions before management commences and erecting signs about management activities at problem sites. This will help retain community support for control measures and integrate management actions across all stakeholders.

We believe that a long-term integrated management plan that includes the control methods outlined above would be the most effective at managing corella issues in the long-term in the relevant LGAs. This plan needs to acknowledge that there is no quick or easy fix to resolving corella issues and that management is likely to require significant time and incur significant costs before reductions in damage are seen. The plan also needs to acknowledge that corella problems occur at a variety of sites and that management actions at problem sites need to be tailored to the specific problems at those sites but that actions should ideally always contain multifaceted short, medium and long-term management approaches to achieve long-term solutions. Critically, the plan needs to acknowledge that effective corella control needs widespread support from all stakeholders affected by corellas and that the selection of management actions needs to be co-developed with the input of stakeholders. We believe that enacting the proposed management actions suggested should help reduce corella problems. However, we also consider the issue of corella damage to be too large to be effectively addressed by local shires alone, who lack the required personnel and finances. Given the magnitude of the issues, corella management will be most effectively implemented with a regional wheatbelt-wide governance framework that coordinates efforts to reduce the negative impacts of corellas in the long-term and guides and supports all stakeholders involved in corella management. The framework should: (1) define clear responsibilities for corella management across the wheatbelt; (2) develop and implement regional, sub-regional and local management plans, that clarify roles and responsibilities, to reduce corella impacts in the region; (3) establish and maintain community and regional stakeholder commitment to undertaking appropriate short, medium, and long-term actions that reduce corella impacts; (4) undertake practical alterations to infrastructure, agricultural practices, town planning and native landscape revegetation to reduce impacts of corellas; and (5) establish sacrificial sites and areas for corellas. While shires alone will be able to achieve some local improvements in corella damage, only involvement of a broad range of stakeholders in the development and implementation of a corella management plan is likely to achieve effective long-term and region-wide reductions in corella damage.

4.5.1. Suggested strategies for specific site types

Discussions with the shires of York, Northam, Toodyay, and Goomalling indicated that corella problems primarily occurred in several types of sites. Common site types where corella issues occur are playing ovals, tennis courts and hockey fields, where corellas damage the turf by digging up the rhizomes of grasses. This is a very common site types for problems as the corellas are strongly attracted to extensive grassy areas and irrigated lawns. However, there has even been damage to some synthetic surfaces, possibly due to beak maintenance by corellas, so there are likely multiple reasons for corellas to be attracted to these sites. For smaller, grassed areas, visual screening, with hessian or shadecloth placed along fences is one potential management strategy as well as methods to physically prevent corellas from perching on fences (e.g. poly or PVC piping or spikes). In the case of hockey fields, physically enclosing the playing surface by placing netting above the field is another option. Large football and cricket fields are arguably the most challenging sites to manage because management solutions are not obvious. Visual screening is likely to be the most effective method and could be achieved through a range of options such as temporary stands and/or dense shrubs around the borders to a height of 3m. Temporary screening could also be placed across ovals when they were not being used for sport and then removed when the ovals were required for a game. However, given the uncertainty around identifying a likely successful method for these large grassy areas, it is likely that a range of options will need to be tested before successful methods are identified.

Table 4. Summary of the primary site types experiencing corella problems within the relevant LGAs along with suggested management actions and challenges with managing corellas at each site type.

Site type	Suggested management actions	Issues
Tennis courts, hockey fields	Scaring combined with sacrificial sites. Visual screening and preventing perching to reduce site attractiveness. Possibly exclusion if does not interfere with site uses.	Exclusion may be incompatible with human uses. Screening needs to be complete.
Playing ovals	Scaring combined with sacrificial sites. Explore options for different turf grasses that provide a less attractive food source. Possibly visual screening.	Turf grasses that provide little food for corellas may not be hard wearing enough for sporting ovals. Visual screening may not be effective when irrigated lawns cover a large area or may need to be erected when ovals not used and removed when it is, so time-consuming.
Golf courses	Scaring combined with sacrificial sites. Visual screening around greens and along fairways if required. Manage water sources to prevent access by corellas.	May be difficult to implement effective screening without affecting golf holes. Water sources potentially from much wider area than golf course.
Racecourses	Scaring combined with sacrificial sites. Explore options for different turf grasses that provide a less attractive food source. Visual screening on central turf areas	Unclear whether visual screening would interfere with uses of racecourse. May be difficult to find

		appropriate turf grass that is robust to horses' hooves.
Buildings	Scaring combined with sacrificial sites. Spikes or electrical shock strips to prevent perching. Exclusion to prevent access to roofs.	Spikes or electrical shock strips need to cover all available perching surfaces. Exclusion has high up-front costs.
Light fittings	Reconfigure light fittings to render wiring inaccessible. Find sealants unattractive to corellas or prevent access to seals.	Reconfiguration and reducing access to seals may be expensive. Unsure whether unattractive sealants exist.
Grain terminals	Scaring combined with sacrificial sites. Improved grain hygiene to reduce or eliminate food resources. Replace grain tarpaulins with grain silos. Manage water sources to prevent access by corellas.	Installing grain silos has high up-front cost. Water sources may need to be managed over a large area.
Roosting sites	Scaring combined with sacrificial sites. Manage water and food sources surrounding roost site.	Scaring may need to be maintained over a relatively long period. Water and food sources may need to be managed over a large area.

Golf courses and racecourses were other areas that were identified as often having corella issues. Again, visual screening along the interior fencing of racecourses combined with discrete beds of dense shrubs in the interior grassy areas, if possible, would be one way of visually disrupting visibility for corellas. For golf greens or fairways, it may be possible to plant dense shrubs on the sides of fairways and the sides and back of greens to provide visual screening. Urban parks are another area where corella problems can arise and there are several potential management solutions in these types of sites including replacement of introduced grasses with native grasses or ground cover that do not provide food for corellas, increasing the density of trees or visual screening by planting strips or beds of low dense shrubs. Managing water sources around all these sites types would also be a useful management strategy even though sites where corellas drink may be quite distant from the sites where problems occur.

Buildings, including flat and sloping roofs and light fittings along streets and around sporting fields are other sites that often have corella issues. Issues on buildings could potentially be addressed by physically preventing birds from perching using spikes or electric shock strips and flat roofs could be covered with netting the was durable to corellas and prevented them from perching. Issues with corellas around light fittings appear to be related to chewing wiring and resins around the light seals. Solutions to these issues could include hiding wiring inside fittings to make it inaccessible to corellas and experimenting with sealing light fitting with resins or sealants that are unattractive to corellas. While these options would have significant up-front costs, if they are successful at eliminating corellas issues then they would likely pay for themselves relatively quickly.

Grain terminals are another common area where corellas often cause issues. Improved grain hygiene is likely to be critical at these sites and placing grains inside silos where they are inaccessible to corellas would be an effective long-term strategy, as well as managing water sources around the terminals. Again, these options are expensive but given the continual damage to expensive grain tarpaulins, it is likely that costs would be recouped fairly quickly.

Roosting sites, often along rivers but essentially anywhere near suitable resources, causing disturbance to people's sleep and damage to television aerials, was another common issue. In these sites, the management solution needs to be focus on reducing accessibility to resources. This could potentially involve netting roost trees, reducing accessibility to food resources or reducing accessibility to water resources, likely in decreasing order of difficulty. Reducing accessibility would likely involve a combination of exclusion, vegetation screening and visual screening methods. Reducing access to food and, particularly, water resources is also likely to be an important management strategy for this and all other the other site types outlined above and should be a focus at all sites. Lastly, discussions with shires obviously focused on issues in urban areas but all relevant LGAs have issues with corellas eating and/or damaging crops and this imposes significant costs on farmers. Again, long-term solutions to depredation of crops could include screening vegetation around the edges of fields to reduce visibility, reduction of access to food through improved grain hygiene or, perhaps most significantly, reduced access to water resources through screening or exclusion.

This section has focused on long-term solutions to corellas issues but, as we have acknowledged before, there are a variety of scaring methods that can be used to address short-tern issues at each of these site types. However, we reiterate the point that these short-term methods are likely to be labour-intensive, costly and relatively inefficient unless combined with long-term solutions that focus on environmental site management combined with decoy or sacrificial site that corellas are encouraged to move to once scared away from the problem sites.

4.5.2. Why not just cull corellas?

This review is not intended to be a prescriptive and shires are free to implement corella management actions as they see fit. Discussions with shires indicated that there was a strong desire to reduce corella numbers within the relevant LGAs and so the obvious question from this review is why do we not recommend reducing corella numbers by lethal means? While there is nothing to prevent shires from enacting such a strategy, we believe that it is not an effective way of reducing corella issues for a variety of reasons. The first is that it focuses on reducing the number of birds not on reducing the damage caused by corella. There is no guarantee that reducing the number of corellas will reduce the damage, at least in the long-term. It is also unclear what number of corellas would need to be culled in order to achieve even a short-term reduction in damage, and the number is likely to be at least hundreds, if not thousands. Another issue with lethal control, particularly shooting, is that it often causes corella flocks to leave problem sites and move to other sites before most of the corella flock have been culled. Therefore, there is a reasonable likelihood that shooting will not reduce corella issues but merely move them to different sites. Another major issue with shooting corellas is that it is expensive. One shire in the relevant LGAs recently paid $10K to a contractor to shoot 60 corellas. While this cost can be reduced with the involvement of local shooting clubs, the fact that thousands of corellas are likely to need to be culled to achieve even short-term reductions in corella damage means the management bill is likely to be hundreds of thousands of dollars, which is likely economically unviable for shires. Furthermore, because culling merely removes birds that are rapidly replaced through immigration and juvenile recruitment, the management costs remain fixed or increase in perpetuity, locking shires into costs that are unviable in both the short and long-term. Culling corellas likely derives more from a sense of a need to do something and seems an obvious way to reduce corella damage. However, because the numbers of corella in the relevant LGAs results from anthropogenic landscape modifications in the shires, which will not change significantly in the long-term, we believe that the most effective and viable long-term management plan is one that accepts we need to learn to live with corellas rather than continuously attempting to achieve short-term reductions in numbers through culling.

4.6 Monitoring

Monitoring is a critical component of any effective management plan because it enables constant improvements to be made to the effectiveness of the plan. Monitoring achieves this by enabling past management actions to be evaluated based on *a priori* performance criteria at problem sites so that highly effective methods can be retained, moderately effective methods can be modified to improve them and unsuccessful methods can be stopped. To align with the overall aim of the management plan to reduce corella damage, rather than reduce corella numbers, the monitoring needs to evaluate criteria related to corella damage rather than the birds themselves. Hence, monitoring might include, for example, assessing the areal extent of damage to turf on town ovals or assessments of the health of roost trees based on tree dieback or branch loss. The temporal frequency of monitoring needs to align with the timeframes stated in the performance criteria so that performance criteria requiring a reduction in damage within 12 months would require monitoring to be conducted within a minimum of 12 months. However, for all performance criteria, but particularly for long-term criteria, we would recommend a minimum of annual monitoring because this frequency of monitoring will likely enable to effectiveness of control methods to be evaluated annually so that long-term methods that do not result in gradual reductions in damage can be replaced with methods more likely to achieve the desired damage reduction.

The type of monitoring described above is called performance monitoring, because it monitors how well the plan satisfies the objectives of the management plan. However, monitoring should also include operational monitoring, which includes monitoring the cost of management actions as well as their cost effectiveness. Continual improvements to methods, or changes in the cost of materials, can change the cost of a specific management action and monitoring also needs to evaluate these changes and use them to evaluate the cost-benefit analysis of specific methods.

5. Information gap analysis

The process of managing corellas is very complex, as discussed above, and requires a considerable amount of information to be effective, information we are currently lacking. So what additional information do we require to effectively manage corellas?

Before we decide on methods to include as part of a corella management plan, we first need to understand the attitudes of stakeholders and community members towards corellas and potential methods for their control. This can be achieved through a combination of online and postal surveys and community workshops that should, ideally, be run across all shires contemporaneously. Control methods can then be selected that align with community attitudes, or community members can be educated about the reasons for certain control methods being selected if concerns or reservations are expressed about these methods.

Improving our understanding of the actual impact of corellas would help prioritise management actions to address more significant corella issues. Two major areas where we do not currently understand corella impacts are impacts on native species and impacts to human health. We know that corellas negatively impact populations of native species, particularly tree hollow-nesters, and corellas are known to reduce breeding success in Carnaby's Black-Cockatoos (Saunders and Doley 2019). However, whether corellas negatively impact other native species through, for example, competing for nest hollows or water resources or by spreading pathogens that reduce survivorship or breeding success is unknown. The impact of corellas on human health is also poorly understood, yet is potentially an issue at some sites within the relevant LGAs (e.g. schools). The prevelance of psittacosis or other *Chlamydia* species in corellas in the relevant LGAs is unknown as is the risk or rate of human infection with these pathogens. Better understanding the actual impacts of corellas on native species and human health would improve prioritisation of management actions to reduce the most significant impacts of corellas. Better understanding the true cost of corellas would also help identify the level of management that would be appropriate from a financial viewpoint.

Understanding the characteristics of problem sites would also enable these sites to be modified to reduce their attractiveness to corellas. Research in South Australia has shown that sites where corellas are problematic are characterised by extensive areas of exotic turf grasses, access to water, low tree densities and very few shrubs (Scanlon et al. 2017). Identifying whether problems sites in the relevant LGAs display similar characteristics will help guide long-term site management to reduce or eliminate the characteristics of these sites that make them attractive to corellas, which should also reduce problems at those site.

It is also critical that any management actions are implemented at the right spatial scale if they are to be effective. Reducing access to water resources within 2km of problem sites will not be effective in reducing corella issues if birds move 5km to drink sites. On this basis, having information on the spatial scale over which flocks move and where they roost, loaf, feed and drink on a daily basis is critical to effectively managing corellas. Also, identifying these sites could potentially help identify sacrificial sites. If flocks currently access certain resources at sites where they do not cause problems, providing the additional resources they require at those sites may encourage them to remain at those sites instead of accessing resources at sites where they cause problems.

Improving our understanding or a range of parameters about corella populations in the region would also potentially help improve corella management. Understanding how many corellas are present across the region, their demographics and movement patterns, both within and outside the relevant LGAs, would potentially help identify where and when control could be most effectively implemented. It could also potentially help identify which control methods are likely to be most effective by, for example, identifying when and where populations are most concentrated.

What governance framework is required to ensure any corella management plan is effectively implemented to maximise the chances of success is also unknown. As mentioned previously, any governance framework would need to sit across all stakeholders and would likely need a hierarchical structure at regional, sub-regional and local levels so that management actions are cohesive and can be successfully integrated across the region. The South Australian government has already established a state-wide management plan for corellas and the governance structure within this plan would provide a template for any wheatbelt-wide management plan.

Finally, the most obvious gap in our knowledge is which methods are most effective in reducing corella problems. Identification of potentially suitable control methods currently relies on research from South Australia and it is unclear whether the same methods will be similarly successful in Western Australia. It is also unclear whether the success of methods varies in effectiveness across the regions or are equally successful in all locations. Answering these questions will be a critical part of any corella management plan and an adaptive management framework should enable information on the effectiveness of specific methods to be incorporated into future management actions. Identifying and trialling new control methods that are effective in reducing corella impacts is also an important research priority as it is likely that new methods will be required in the future as corellas adapt to current management methods, reducing their effectiveness.

6. Proposal for future work

The Information Gap Analysis has identified areas of potential future work. Given the differing areas of expertise required to address these information gaps, any potential future work would likely involve a range of different personnel from different organizations. To address all the knowledge gaps would require expertise in human health, citizen science, science communication, vertebrate pest management, conservation biology and vertebrate ecology. Personnel at ECU have expertise in vertebrate ecology and conservation biology and could address knowledge gaps related to corella impacts on native species and quantifying the characteristics of sites where corella problems occur to inform environmental site management at these sites to reduce corella problems. Personnel at ECU could also identify feeding, roosting and drinking sites utilized by corellas as well as the spatial extent of flock movements to inform corella management. Lastly, personnel at ECU could attempt to address the question of how many corellas occur within the relevant LGAs, as well as their demographics and movement patterns. Detailed proposals on any, or all, of the potential projects that fall within the fields of expertise of personnel at ECU can be provided if it is decided to proceed with these projects.

7. Further reading

Most, if not all, these reports are available on the internet.

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