The common myna: introduction, spread, impact and control

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Native Distribution

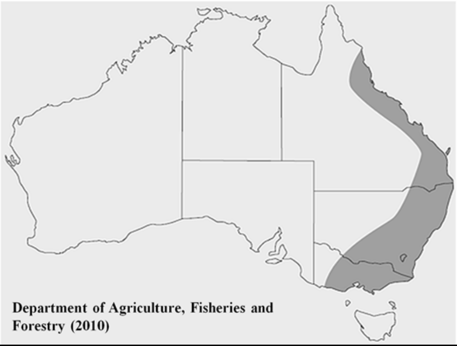
- Native to southern Asia (grey)
- Introduced over the world (black)
- Control insect pests

(Peacock *et. al*, 2007)

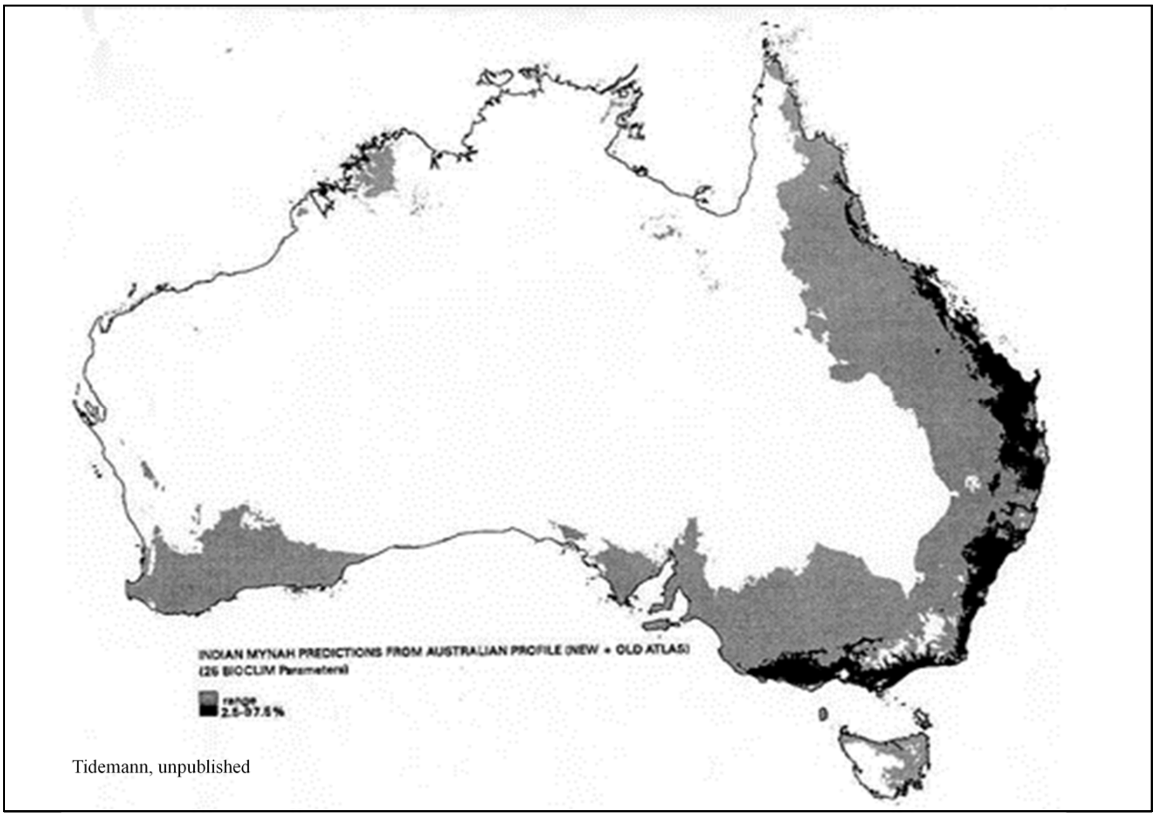
Fig. 1. Worldwide distribution of the common myna, *Acridotheres tristis*. Small populations, or populations thought to be extinct, are indicated with circles.

Australian introduction and distribution

- Melbourne, 1862 - Quickly established
- East Coast (Dominate in cities and towns)
- May invade new areas (Adelaide, Perth, Tasmania)



Department of Agriculture, Fisheries and Forestry (2010)



Black where currently
Grey where could live

Reputation

Useful species (eat insects)

More Recently:

- ‘100 of the World's Worst Invasive Species’
- ‘The Most Hated Pest in Australia’
- ‘Serious Pest Bird’
- ‘A Cane Toad on Wings’
- ‘Rats of the Sky’

The Science So Far…

- Concern that they displace native species through competitive domination of cavity-nest sites and territories
  - Dominate aggressive encounters with the Eastern and Crimson Rosella
  - Dominate nest sites and can build more than one nest
  - Evict native birds from nest hollows
  - native birds increased when the common myna was removed (NZ)
- Despite this - only very limited scientific evidence they impact the abundance on native species

Project Overview

1. Introduction and spread of the common myna in Canberra

1. Impact of the common myna on native birds?

   2.1 before and after myna establishment – long term impact

   2.2 drivers and passengers of change – impact in conjunction with habitat

   2.3 cavity nesting competition across different habitat

2. Control of the common myna

1. Introduction and spread of the common myna in Canberra

Under Review: *Journal of Environmental Management*

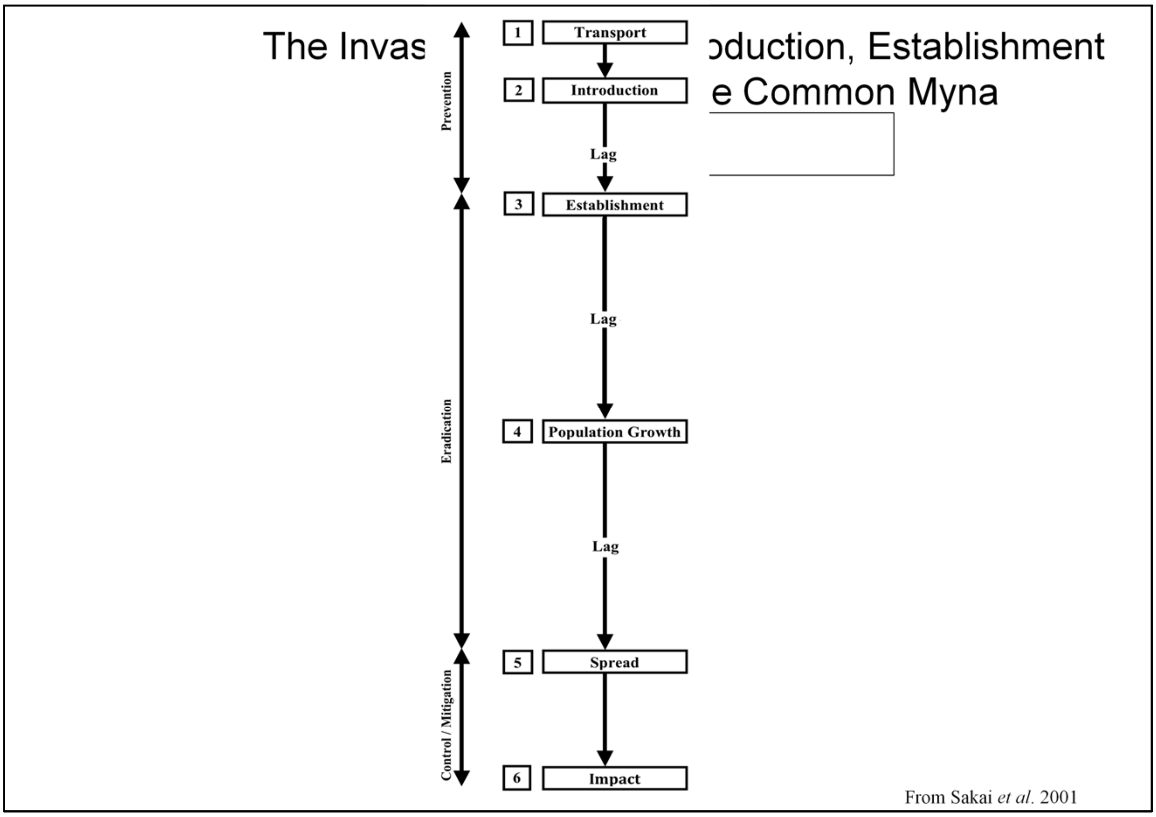
Using invasion process theory to enhance the understanding and management of introduced species. A case study reconstructing the invasion sequence of the common myna

Grarock K., Lindenmayer D.B., Wood, J.T, Tidemann C.R.

biological invasion research has grown exponentially over the past 50 years

research indicates that invasion is a multi-step process, where each stage is contingent on the stage that precedes it

There are numerous hypotheses addressing the factors that influence each stage of the invasion process, but how well does this theory match what actually occurs in the natural world?



A firm understanding of the invasion process, and factors influencing the success of each stage, is critical for decision makers who wish to prevent, eradicate or control introduced

To develop effective management plans, decision makers need to understand: (1) the stage an invasion is in, (2) the length of time before the next stage is reached, and (3) the most effective plan of management for a given stage. Early detection and action are also important factors for successful management, with the cost of control rapidly increasing as a species moves through the invasion process

In this paper, we investigate the congruence between invasion process theory and an observed species invasion sequence. At the outset of this study, we created a general conceptual model of the six stages of the invasion process, drawing on the extensive body of invasion research

We use a composite 41-year data set to reconstruct the invasion sequence for the common myna (*Acridotheres tristis*) in the Australian city of Canberra. We then compare how well this observed invasion corresponds with what invasion process theory would predict. XX

Data:

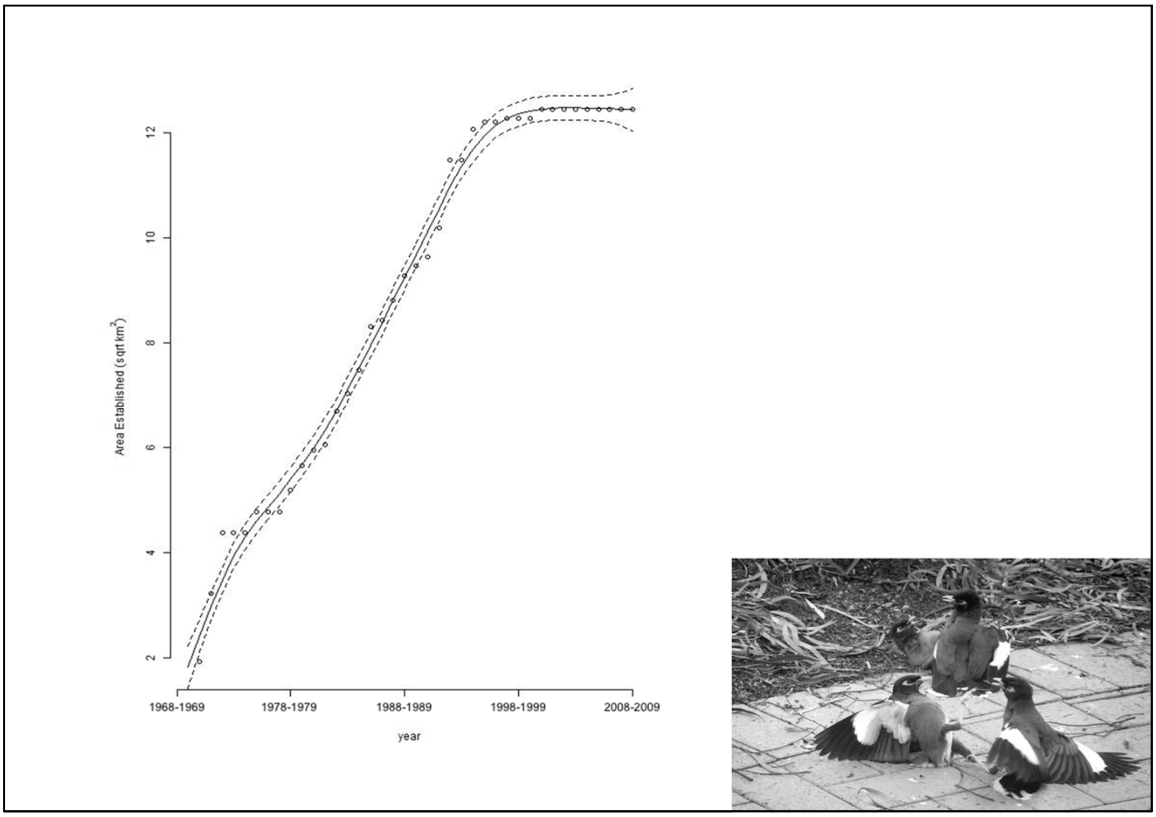
- Early sightings 1969-1984 (Gregory-Smith, 1985)
- Canberra Ornithologists Group, Garden Bird Survey 1981-2009

The introduction and subsequent spread of the common myna in Canberra is a rare case where the entire invasion process has been well documented. Detailed records of the location, date and number of birds released, in addition to long-term bird surveys, enabled us to track the introduction, establishment, population growth and spread of the species.

To reconstruct the ip of the cm we used…xx

From this data we were able to track the spread and establishment of the common myna in Canberra
COLOUR= red myna estab, green not est, pink/clear unknown

Discuss spread – from release site forrest 1969- SW xx



If we graph the square root of cumulative total area occupied by cm over time (years) get the following graph +-SE for the spread of the myna in Canberra. The square root transformation of area represented the average radial distance of invasion when range is expanding in approximately concentric circles

Initially, the spreading rate was relatively high. However, this period corresponds with the release of over 100 bird.

After human introductions of the common myna stopped the rate of spread slowed and almost plateaued (DOTS)

The rate of spread then began to increase.

The common myna exhibited a lag period in natural spreading of approximately six years

the rate of spread reached a maximum spreading rate of 0.43 km per year

The rate of spread then slowed as the common myna became established in the majority of suburbs

By 2000-2001, the common myna had become established in all suburbs surveyed, 31 years after introductionXX

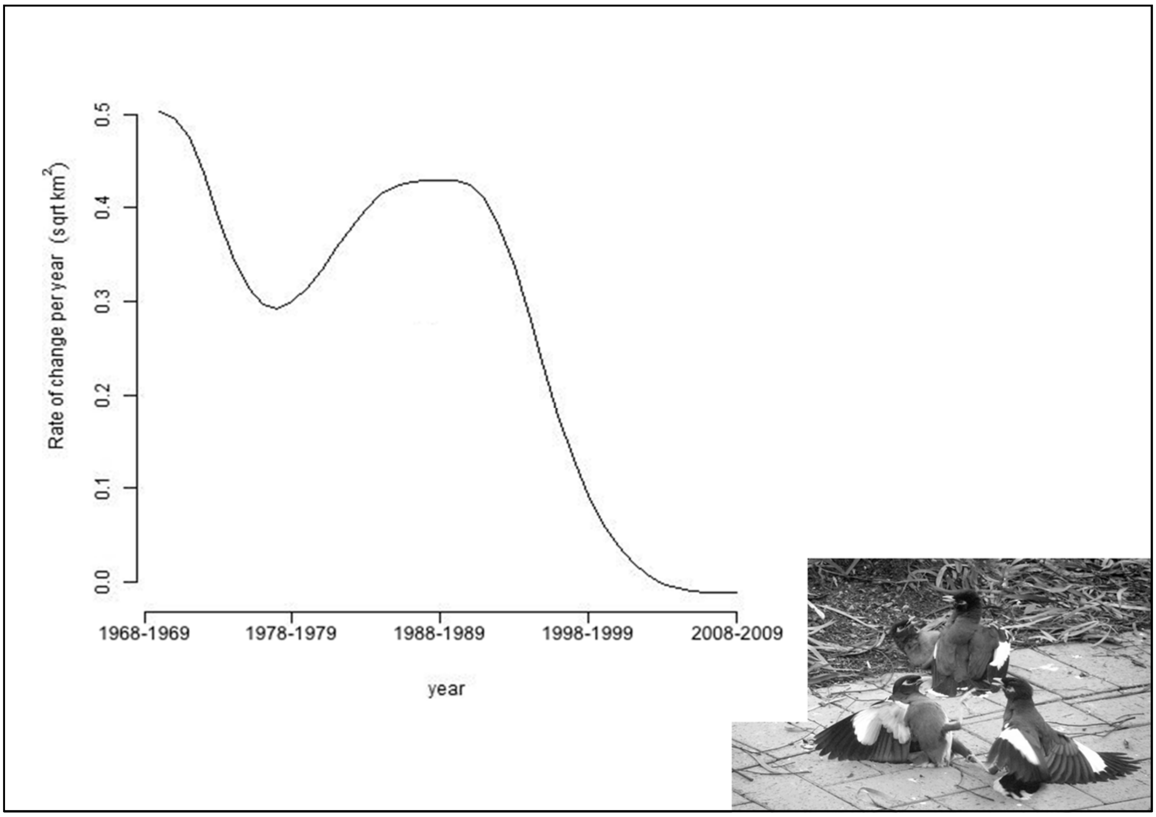
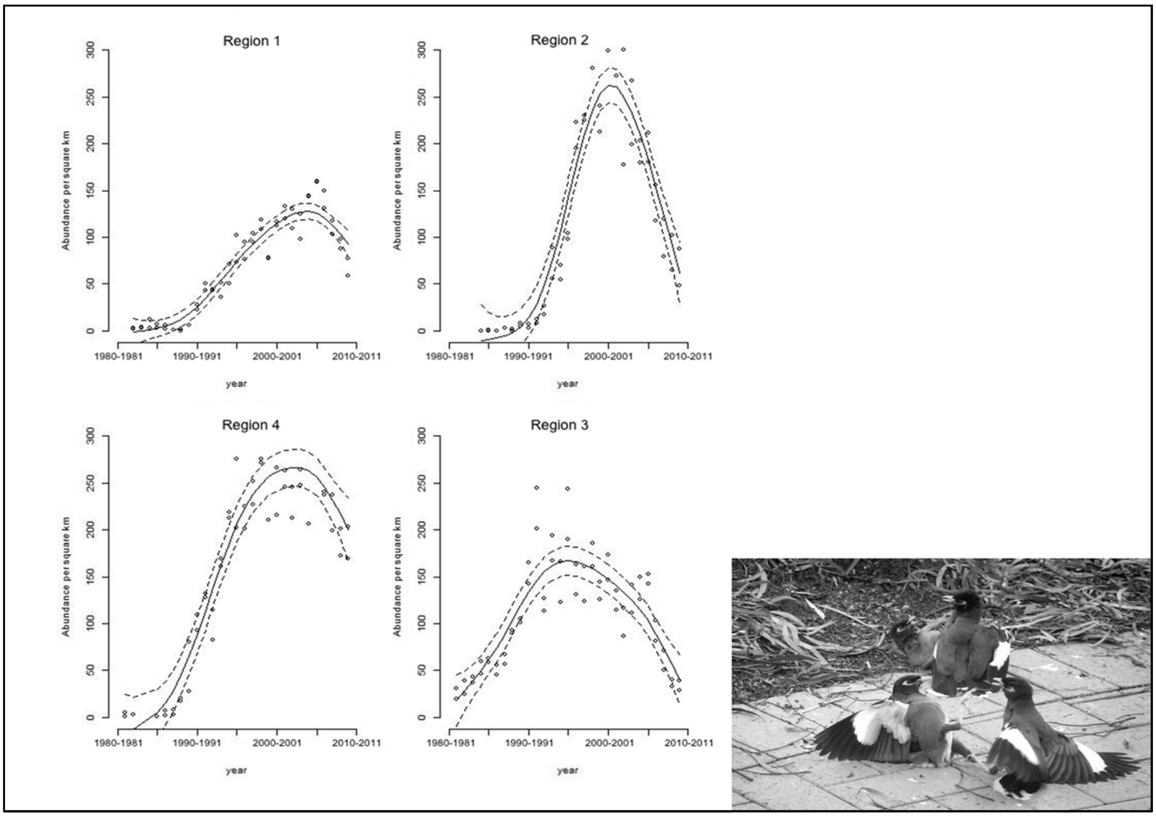


Fig. 5. Smoothing spline relating the change in the square root of the area established (km^2) over time (years) for the spread of the common myna (*Acridotheres tristis*) in Canberra, Australia.

The lag in spreading was deemed to occur from the end of human introductions (1971-1972) until the spreading rate in Fig. 5 started to increase. This process provided a simple estimate of the lag phase duration, excluding the period of repeated human introductions. We then calculated the maximum rate of spread across Canberra using the rate of change in Fig. 5. Once again, we excluded the spreading rate for the first four-years due to repeated human introductions of the common myna over this time.



Then using COG data across the 4 broad regions of canberra (tuggernanong, woden/weston, nth cbr, belconnen)

We calculated the abundance (birds per km^2) of the common over time (years) (± SE) in each region

Population growth of the common myna followed the same pattern in all four regions with numbers remaining low before steadily increasing. Common myna abundance reached a peak size before decreasing in each region

“Using GenStat 14® (VSN International, 2011), we fitted hierarchical generalized linear models (HGLMs) (Lee et al., 2006) to the individual counts using a quasi-Poisson model with a logarithmic link function. Region, year and all their interactions were treated as fixed effects, while sites were treated as a random effect with a gamma distribution and a logarithmic function. This process enabled us to estimate the annual mean numbers of the common myna per km^2 per region. We then fitted a smoothing spline (Green and Silverman, 1994) relating the annual mean number of common myna birds per km^2 by year (± SE) for each region (Fig. 6). “XX

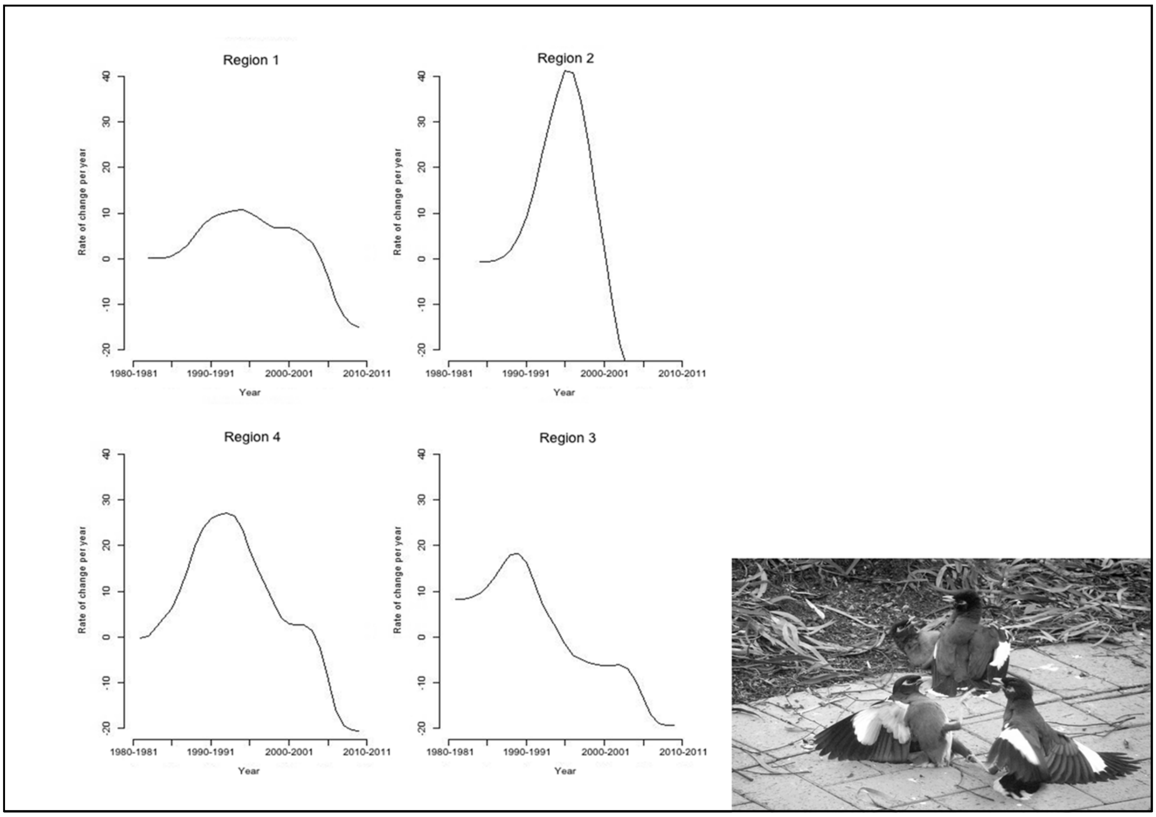


Fig. 7. Smoothing spline relating the change in abundance (birds per km^2) of the common myna (*Acridotheres tristis*) over time (years) in four regions in Canberra, Australia.

We also fitted a smoothing spline (Green and Silverman, 1994) relating rate of change in birds per km^2 to time (Fig. 7).

Using Fig. 7, we calculated the lag in population growth and maximum rate of population growth. The lag phase was defined as occurring from establishment until common myna populations increased by one or more birds per km^2 (Fig. 7). For a definition of establishment see section 2.6: *Reconstructing establishment and spread*. This process provided a simple method for distinguishing the lag phase from population growth. We avoided using more intricate methods as entire studies have been dedicated to statistically distinguishing the lag phase from population growth (see Aikio et al., 2010).

The maximum rate of population growth for the four regions was calculated from data on the rate of change in Fig. 7. We also calculated the maximum population size for each region from the peak of the spline curve in Fig. 6. Table 1 summarises data on the establishment year, lag time, maximum population growth rate and the maximum number of common myna birds per km^2 for each of the four regions of Canberra.

Table 1. Elements of the common myna (*Acridotheres tristis*) invasion sequence

Region	Year established	Year population growth started	Lag in population growth (years)	Maximum rate of population growth (birds per km^2)	Maximum population size (birds per km^2)
Region 1	1982-1983	1985-1986	3	10.7	128.0 (±4.2)
Region 2	1986-1987	1988-1989	2	40.4	262.3 (±9.4)
Region 3	1970-1971	No data	No data	18.3	167.2 (±7.7)
Region 4	1980-1981	1983-1984	3	27.1	266.2 (±10.0)
Mean (±SE)			2.7 (±0.3)	24.1 (±6.4)	205.9 (±34.6)

From these graphs we can determine the following information.

After establishment in a region, numbers of the common myna remained low for an average of 2.7 (±0.3) years

Lag period before population growth ranged from two to three years

After this lag, the rate of population growth increased, reaching an average maximum rate of population growth of 24.1 (±6.4) birds per km^2

The maximum rate of population growth varied between regions, ranging from an increase of 10.7 to 40.4 birds per year

average maximum population size for all regions was 205.9 (±34.6) birds per km^2. xx

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Time lag before population growth

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Rate of population increase

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Max population size

1. Introduction and spread of the common myna in Canberra

Key Findings

- **Invasion sequence similar to what invasion theory would predict**
- **Conceptual model + basic species, environment, event information -> useful tool to understand invasions**
- **Knowledge of invasion sequence = enhanced management**

Detailed studies on all introduced species are not possible due to limited resources and an increasing number of invasions. Therefore, anticipating the invasion process could identify potential high-risk species to target for management and further research. This potential predictability could also bring together the two key elements of successful management: knowledge of the invasion process and rapid response to invasion. An ability to quickly predict the general stages of the invasion process would enable more timely management responses, leading to more successful outcomes. xx

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2.1 Before and after establishment: long term impact

Published 2012: *PLoS ONE*: 7 (7): e40622

Is it benign or is it a pariah? Empirical evidence for the impact of the Common Myna on Australian Birds

Grarock K., Tidemann C.R., Wood, J.T., Lindenmayer D.B.

The magnitude of impacts of an introduced species can be variable. Some have a devastating impact while others are relatively benign.

Understanding the impact of an introduced species is essential for effective management

Due to limited resources, management prioritization should be given to introduced species that have the greatest undesirable impact

The traditional belief that all introduced species have a negative impact can lead to wasteful allocation of resources (see tamarisk shrub example above).

Empirical evidence of the impact of an introduced species can be very difficult to obtain for three key reasons:

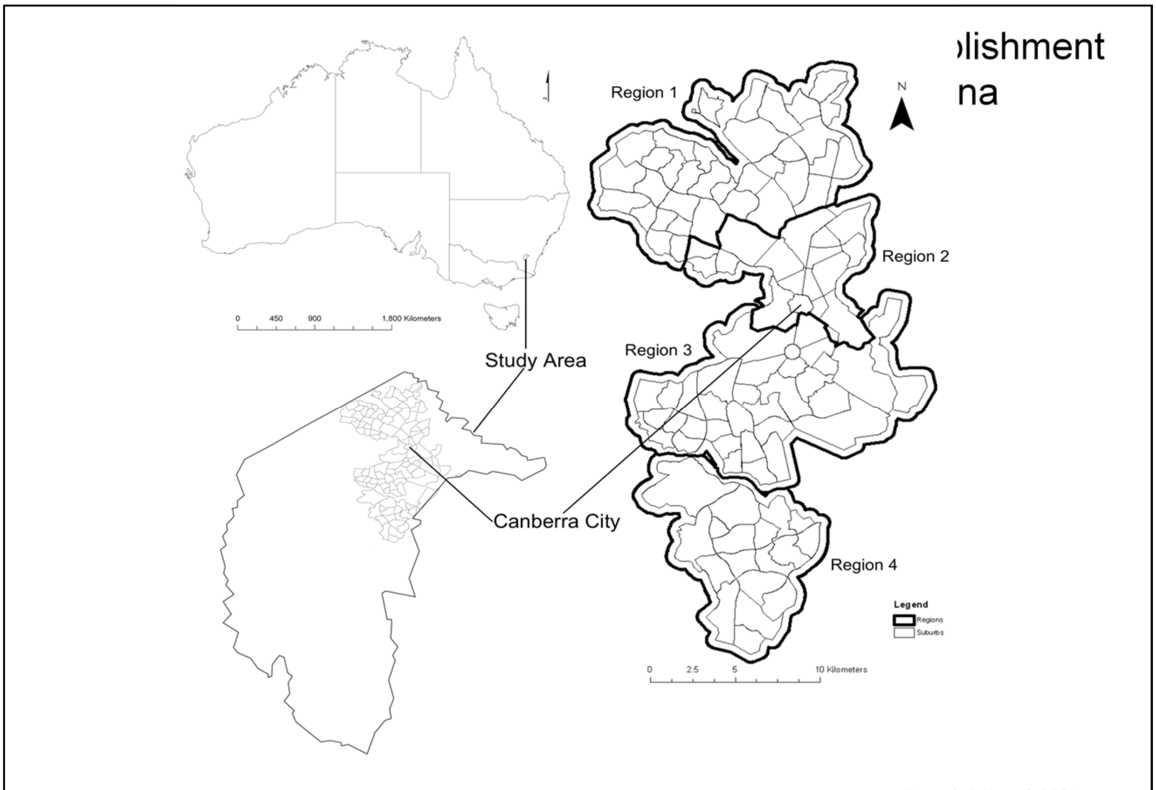
-A lack of long-term data prior to, and then after, invasion

-Environmental change occurring alongside species introductions, making it hard to distinguish species impacts from the impacts of environmental change (eg habitat clearing, climate change) and

-A poor understanding of the mechanisms of impact (eg competition vs. predation)

we were in unique position to have all three…

In this paper, we assess the impact of Common Myna establishment on long-term bird abundance. xx



From Sakai *et al.* 2001

We investigated the abundance of 20 bird species in 4 regions in Canberra. pre and post Common Myna establishment.

Due to earlier studies indicating the cm may impact cavity nesting and small bird species we selected

-7 cavity-nesting

-10 small – and as a control

-5 large (no expected impact).xx

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Variables:

- Season (breeding, non-breeding)
- Dwellings (per km^2)
- Population density (per km^2)
- Native grassland (%)
- Dry forest (%)
- Modified urban grassland (%)
- Woodland (%)
- Tree cover (%)
- Year
- Before common myna
- After common myna
- Weather

Basically we designed the analysis to examine what was going on with bird abundance before CM and then after the establishment of the CM. – also incorporated environmental variables into the analysis to account for the changing environment over the past 29 years.

“We fitted autoregressive models for each of our 20 target species using their bi-annual abundance as the response variable in the model. The candidate fixed variables included in the modeling were season, urban development (dwellings per km^2, population per km^2) and vegetation type (native grassland, dry forest, modified urban grassland, woodland, tree cover). We also included the fixed variables of year, and years after Common Myna establishment, in the model. The random model was set to region and time and we used autoregressive models of order one (AR1) and two (AR2), and Wald tests for dropping individual terms from the full fixed model. We sequentially removed the least significant explanatory variable from the model, continuing this process until only significant (<0.05) explanatory variables remained (with the exception of the variables year and years after Common Myna establishment, which were included in all models) (Table 1-3). We used a table of effects to predict the impact of each significant variable (±SE).“xx

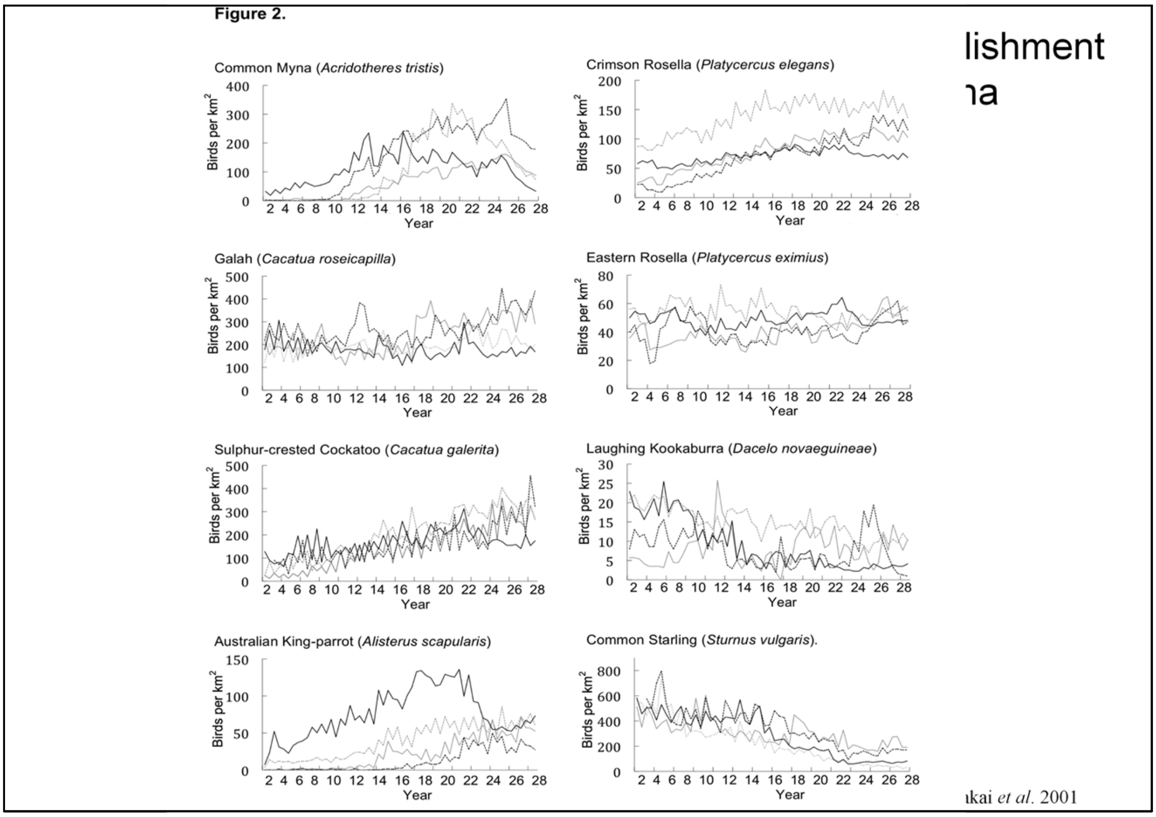


Figure 2.
lishment
ıa
Common Myna (Acridotheres tristis)
Crimson Rosella (Platycercus elegans)
Galah (Cacatua roseicapilla)
Eastern Rosella (Platycercus eximius)
Sulphur-crested Cockatoo (Cacatua galerita)
Laughing Kookaburra (Dacelo novaeguineae)
Australian King-parrot (Alisterus scapularis)
Common Starling (Sturnus vulgaris).
Birds per km²
Year
ıkai et al. 2001

Table 1. Cavity-nesting species autoregressive analysis

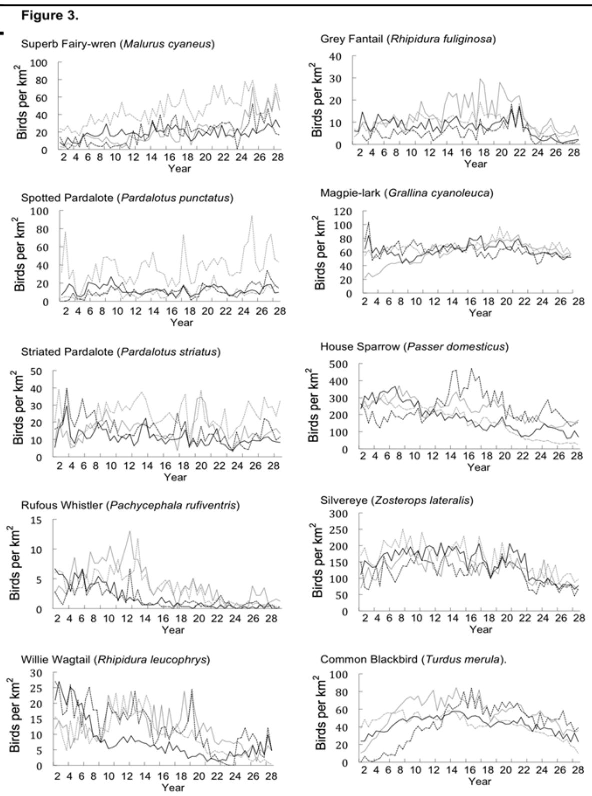
Species	AR1 phi_1 (estimate)	Season non-breeding	Dwellings per km	Population density per km	Native grassland	Dry forest	Modified urban grassland	Woodland	Tree cover	Year	Years after Common Myna establishment
Galah (*Cacatua roseicapilla*)	0.47 ±0.05					10.42 ±2.57 p<0.001	6.73 ±1.22 p<0.001			3.91 ±1.23 p=0.002	-1.41 ±1.30 p=0.284
Sulphur-crested Cockatoo (*Cacatua galerita*)	**0.20 ±0.05**	**-27.59 ±5.45 p<0.001**							**2.11 ±0.39 p<0.001**	**10.31 ±0.78 p<0.001**	**-1.97 ±0.75 p=0.010**
Australian King-parrot (*Alisterus scapularis*)	0.76 ±0.04	-5.73 ±0.94 p<0.001					2.42 ±0.83 p=0.006		2.74 ±0.51 p<0.001	0.79 ±0.63 p=0.224	2.33 ±0.62 p<0.001
Crimson Rosella (*Platycercus elegans*)	**0.59 ±0.05**	**-12.90 ±0.88 p<0.001**							**2.35 ±0.15 p<0.001**	**5.86 ±0.30 p<0.001**	**-3.45 ±0.30 p<0.001**
Eastern Rosella (*Platycercus eximius*)	0.55 ±0.05							9.03 ±1.80 p<0.001		-0.71 ±0.23 p=0.003	1.10 ±0.25 p<0.001
Laughing Kookaburra (*Dacelo novaeguineae*)	**0.69 ±0.05**						**-0.79 ±0.21 p<0.001**	**-5.07 ±2.25 p=0.030**		**0.02 ±0.15 p=0.884**	**-0.39 ±0.18 p=0.030**
Common Starling (*Sturnus vulgaris*)	0.30 ±0.05				-7.36 ±3.19 p=0.024				-3.55 ±0.80 p<0.001	-17.35 ±1.58 p<0.001	2.00 ±1.52 p=0.195

We found a significant negative relationship between the establishment of the Common Myna and the abundance of the **Sulphur-crested Cockatoo** ($F_{1,77}$=6.9, P=0.010), the **Crimson Rosella** ($F_{1,33}$=135, P<0.001) and the **Laughing Kookaburra** ($F_{1,52}$=5.0, P=0.030).

We found no significant negative relationships between Common Myna establishment and the others. xx

Establishment

n Myna



From Sakai *et al*. 2001

Table 2. Small bird species (<25 cm head to tail) autoregressive analysis

Species	AR1 phi_1 (estimate)	Season non-breeding	Dwellings per km	Population density per km	Native grassland	Dry forest	Modified urban grassland	Woodland	Tree cover	Year	Years after Common Myna establishment
Superb Fairy-wren (*Malurus cyaneus*)	**0.42 ±0.06**	**-6.56 ±0.82 p<0.001**				**-1.34 ±0.43 p=0.003**	**-1.81 ±0.20 p<0.001**			**1.77 ±0.21 p<0.001**	**-0.89 ±0.22 p<0.001**
Striated Pardalote (*Pardalotus striatus*)	**0.39 ±0.06**	**1.68 ±0.56 p=0.003**	**-0.06 ±0.01 p<0.001**							**0.51 ±0.12 p<0.001**	**-0.70 ±0.12 p<0.001**
Willie Wagtail (*Rhipidura leucophrys*)	**0.53 ±0.05**	**-1.62 ±0.37 p<0.001**		**-0.02 ±0.01 p=0.011**				**-4.21 ±1.78 p=0.022**	**-0.25 ±0.08 p=0.004**	**0.17 ±0.20 p=0.417**	**-0.77 ±0.21 p<0.001**
Grey Fantail (*Rhipidura fuliginosa*)	**0.29 ±0.06**	**-1.65 ±0.38 p<0.001**					**1.23 ±0.12 p<0.001**		**0.80 ±0.08 p<0.001**	**0.82 ±0.09 p<0.001**	**-0.91 ±0.09 p<0.001**
Magpie Lark (*Grallina cyanoleuca*)	**0.29 ±0.06**			**-0.09 ±0.02 p<0.001**			**3.43 ±0.55 p<0.001**		**1.05 ±0.20 p<0.001**	**2.67 ±0.35 p<0.001**	**-2.24 ±0.32 p<0.001**
House Sparrow (*Passer domesticus*)	0.73 ±0.05	11.71 ±3.22 p<0.001	0.90 ±0.18 p<0.001		-10.53 ±4.13 p=0.019					-6.62 ±1.70 p<0.001	-1.59 ±1.66 p=0.348
Silvereye (*Zosterops lateralis*)	**0.43 ±0.06**	**9.63 ±2.48 p<0.001**					**3.90 ±1.04 p<0.001**		**4.26 ±0.65 p<0.001**	**0.45 ±0.77 p=0.560**	**-2.65 ±0.75 p<0.001**
Common Blackbird (*Turdus merula*)	**0.91 ±0.03**						**3.25 ±0.89 p=0.003**		**1.89 ±0.50 p<0.001**	**2.83 ±0.48 p<0.001**	**-2.78 ±0.50 p<0.001**

Impacts on small bird species

We found a significant negative relationship between Common Myna establishment and the abundance of seven of the eight small bird species we examined

The abundance of the **Superb Fairy-wren, Striated Pardalote, Willie Wagtail, Grey Fantail, Magpie Lark, Silvereye and Common Blackbird** increased throughout the survey period

However, after Common Myna establishment, growth in abundance of these bird species declined significantly (Table 2). House Sparrow abundance declined throughout the survey period by an estimated 6.6 (± 1.7) birds per km^2 each year. After Common Myna establishment, abundance continued to decline by an estimated 1.6 (± 1.7) birds per km^2 each year, although this was not statistically significant ($F_{1,20}$=0.9, P=0.348)xx

Figure 4.

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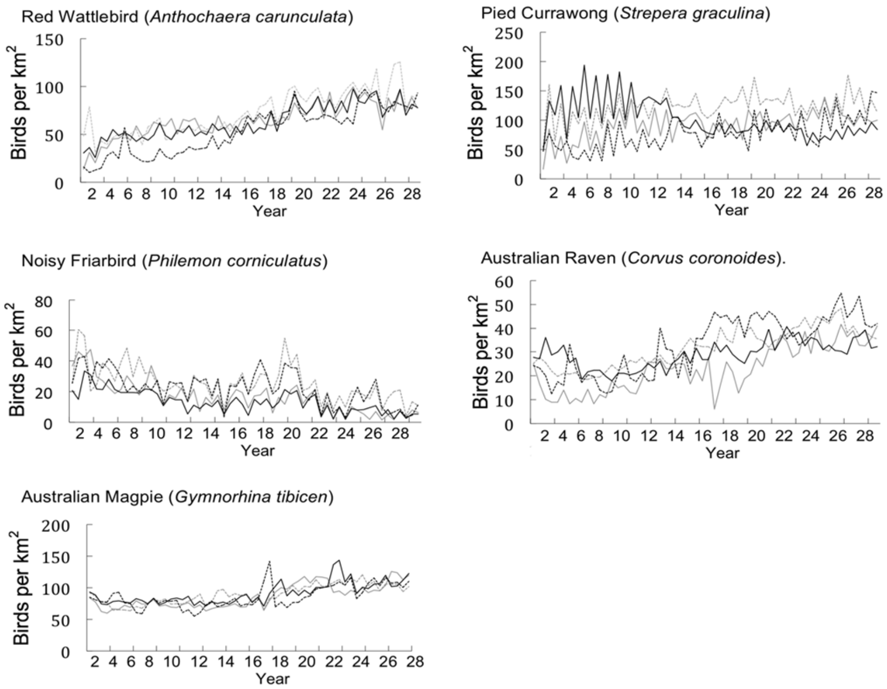

From Sakai *et al*. 2001

Table 3. Large bird species (>30 cm head to tail) autoregressive analysis

Species	AR1 phi_1 (estimate)	Season non-breeding	Dwellings per km	Population density per km	Native grassland	Dry forest	Modified urban grassland	Woodland	Tree cover	Year	Years after Common Myna establishment
Red Wattlebird (*Anthochaera carunculata*)	0.23 ±0.06			0.05 ±0.01 p<0.001		-3.48 ±1.19 p=0.005		25.27 ±7.91 p=0.002	0.76 ±0.19 p<0.001	1.27 ±0.40 p=0.002	0.95 ±0.44 p=0.033
Noisy Friarbird (*Philemon corniculatus*)	0.34 ±0.06	-2.61 ±0.74 p<0.001						6.49 ±1.29 p<0.001		-0.90 ±0.17 p<0.001	0.13 ±0.19 p=0.487
Australian Magpie (*Gymnorhina tibicen*)	0.55 ±0.06	4.24 ±0.89 p<0.001								1.15 ±0.27 p<0.001	0.34 ±0.27 p=0.217
Pied Currawong (*Strepera graculina*)	0.17 ±0.05	7.90 ±3.15 p=0.013	0.35 ±0.10 p<0.001				-4.71 ±0.84 p<0.001			-0.98 ±0.64 p=0.129	1.23 ±0.55 p=0.028
Australian Raven (*Corvus coronoides*)	0.58 ±0.05	0.86 ±0.42 p=0.041		0.02 ±0.01 p=0.014	-1.94 ±0.38 p<0.001				0.38 ±0.13 p=0.005	0.66 ±0.15 p<0.001	0.15 ±0.14 p=0.310

We found no negative relationships between Common Myna establishment and the abundance of all of the five large bird species we analysed xx

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2.1 Before and after establishment: long term impact

Key findings

- Negative relationship between the establishment of the common myna and the long-term abundance:
  - Cavity-nesting species (sulphur-crested cockatoo, crimson rosella, laughing kookaburra)
  - Small bird species (striated pardalote, rufous whistler, willie wagtail, grey fantail, magpie-lark, house sparrow, silvereye, common blackbird)
- Management prioritisation: contentious issue (impact severity)

Previous attempts to investigate Common Myna impact have relied on short-term data (from one to three years) with limited success. Our long-term data and integrated approach provided a unique opportunity to present the strongest evidence to date for the impact of the Common Myna on native bird species.

Our analysis suggests that the Common Myna had a negative impact on the long-term abundance of some cavity-nesting bird species and some small bird species.

None threatened

Our results highlighted the extent to which the Common Myna influences both cavity-nesting and small bird species. We conclude that the effect of the Common Myna on native bird species in the Canberra area is not benign. However, there are still questions regarding the seriousness of this impact and the type of management (if any) that is warranted xx

2.2 Drivers and passengers of change: impac in conjunction with habitat

Published 2013: *Austral Ecology*: doi:10.1111/aec.12049

Are invasive species drivers of native species decline or passengers of habitat modification? A case study of the impact of the common myna on Australian bird species

Garock K., Tidemann C.R., Wood, J.T., Lindenmayer D.B.

Both habitat modification and the introduction of invasive species pose major threats to biodiversity across the glob

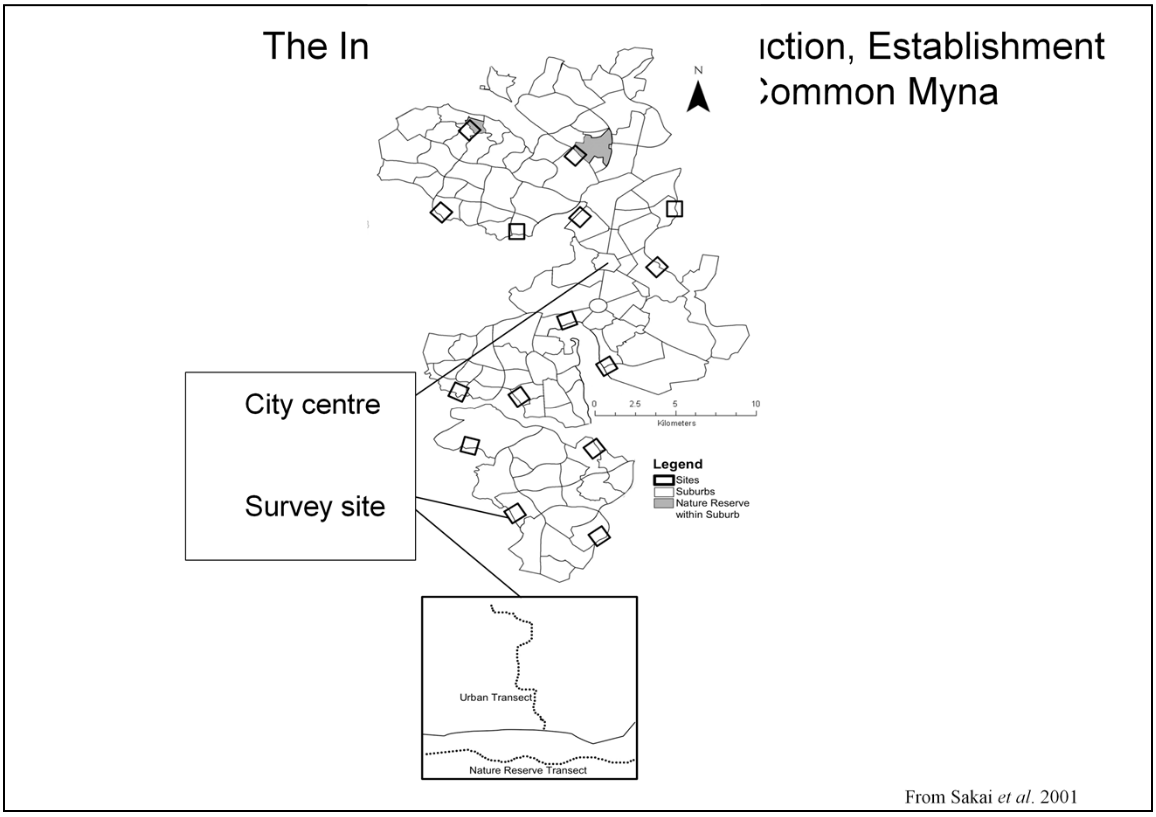
Research often investigates the impact of human-induced habitat modification *or* the effects of invasive species on native species abundance. Studies that rely on correlations between native and invasive species abundance allow only weak inferences of impact to be made. In fact, studies reliant on these correlations may mistakenly identify an invasive species as a driver of change. For example, in New England, USA, native plant species decline was primarily driven by the same habitat variable that promoted invasive species, however, correlation did not imply causation. In this scenario, the invasive species were 'passengers' of habitat modification, not 'drivers' of native species decline. Therefore, to successfully investigate native species decline, research must incorporate both habitat modification and invasive species impact.

CM as a case study to investigate the driver-passenger model. Specifically, we asked whether the common myna is a passenger of habitat modification or a driver of native species decline. We investigated changes in bird abundance, over two and a half years, in relation to different habitat types and common myna abundance. We hypot:

-the common myna would be more abundant in urban habitats than in nature reserves;

-common myna abundance would increase as tree density declined;

-common myna abundance would have a negative impact on the abundance of some cavity-nesting species and small bird species.XX



15 sites -2 1km transect surveys. Reserve/nature

every second month (January, March, May, July, September, November) for 3 nesting seasons September 2008 to March 2011

Experienced Observers walked transects for 20 minutes, within 3 hours of sunrise. good weather - little or no rain or wind. 1071 transect surveys

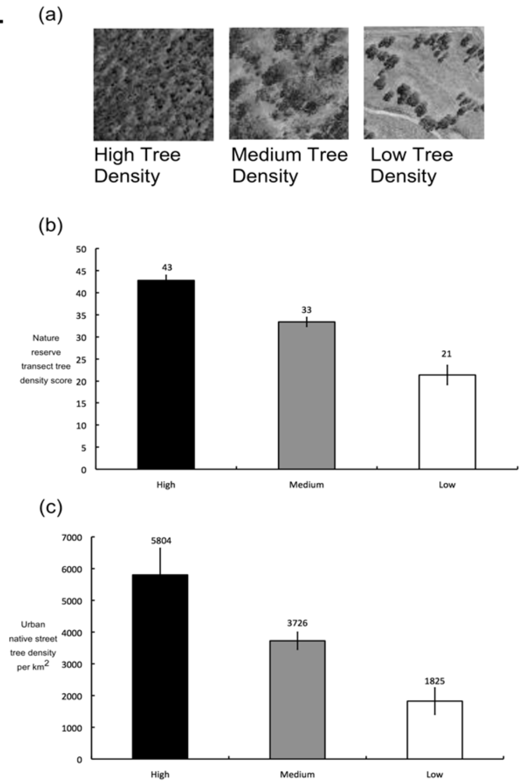
To conduct the analysis, we selected the 40 most abundant bird species within the following categories: ten cavity-nesting species (>3.03 g), 20 small bird species (≤4.53g) and ten large bird species

We also selected the following variables for analysis: total species abundance and richness, native cavity-nester bird abundance and richness, small native bird abundance and richness, and large native bird abundance and richness.

“We fitted mixed models in GenStat 14® using restricted maximum likelihood to investigate the factors that influenced: (1) common myna abundance (2) the abundance of the 40 target species, (3) the abundance and richness of particular species groupings. We included the following explanatory variables in the model: area (urban or nature reserve), tree density (high, medium and low), urban housing density per km^2, season (breeding: November to March and non-breeding: May to September) and year (1, 2 and 3). We also included common myna abundance as an explanatory variable for all analyses except for those exploring abundance of the common myna itself. We treated site as a random effect and used Wald tests for dropping individual terms from the full fixed model, until only significant (<0.05) explanatory variables remained.

We used the table of effects from the GenStat 14® (VSN International 2011) output, to observe the *influence* (either positive >0.00 or negative <0.00) each significant variable had on species abundance or species richness. We also used the table of predicted means, from the model output, to estimate (reverse log(x+1) transformed) species abundance across different areas.”xx

T n, Establishment
mon Myna



From Sakai *et al*. 2001

stablishment
Myna

Table 1. Significant explanatory variables for restricted maximum likelihood analysis of common myna (*Acridotheres tristis*) abundance and species groupings in Canberra, South East Australia.

Species/ Species Group	Area	Tree density				Human Housing Density (km^2)	Season	Year		common myna abundance
	nature to urban	nature		urban			breeding to non-breeding	year 1 to year 2	year 1 to year 3	
		high to med	high to low	high to med	high to low					
common myna (*Acridotheres tristis*)	0.91 ±0.10 p<0.001	0.74 ±0.24 p<0.001	1.11 ±0.24 p<0.001	0.29 ±0.24 p<0.001	0.20 ±0.24 p<0.001		-0.24 ±0.07 p=0.002	-0.15 ±0.08 p=0.013	-0.23 ±0.08 p=0.013	N/A
Total Species abundance		-0.05 ±0.06 p<0.001	-0.12 ±0.06 p<0.001	-0.06 ±0.06 p<0.001	-0.16 ±0.06 p<0.001		0.08 ±0.02 p<0.001	0.07 ±0.02 p<0.001	0.09 ±0.02 p<0.001	0.07 ±0.02 p=0.004
Total Species richness	0.01 ±0.02 p=0.003	0.06 ±0.03 p=0.018	-0.03 ±0.03 p=0.018	0.01 ±0.03 p=0.018	-0.07 ±0.03 p=0.018	-0.0003 ±0.0001 p=0.020	-0.02 ±0.01 p=0.002	0.03 ±0.01 p=0.003	0.03 ±0.01 p=0.003	
Native cavity-nester bird abundance	0.12 ±0.03 p<0.001						0.15 ±0.03 p<0.001			
Native cavity-nester bird richness	-0.04 ±0.02 p<0.001	-0.01 ±0.04 p=0.037	-0.13 ±0.04 p=0.037	-0.03 ±0.04 p=0.037	-0.13 ±0.04 p=0.037		0.03 ±0.01 p=0.007			
*Small native bird abundance		0.09 ±0.01 p=0.002	-0.08 ±0.01 p=0.002	-0.04 ±0.01 p=0.002	-0.23 ±0.01 p=0.002	-0.001 ±0.0004 p=0.029				-0.08 ±0.04 p=0.035
*Small natives richness	-0.04 ±0.02 p<0.001						-0.03 ±0.02 p=0.049	0.05 ±0.02 p=0.003	0.05 ±0.02 p=0.003	-0.06 ±0.02 p<0.001
Large native bird abundance	0.20 ±0.02 p<0.001						0.11 ±0.02 p<0.001	0.07 ±0.02 p<0.001	0.08 ±0.02 p<0.001	0.09 ±0.02 p<0.001
Large native bird richness	-0.05 ±0.01 p<0.001						-0.03 ±0.01 p=0.002	-0.01 ±0.01 p=0.028	-0.03 ±0.01 p=0.028	

From Sakai *et al.* 2001

Our results indicated that common myna abundance in nature reserves was 13.6 birds per km^2, while in urban areas it was almost three times higher at 41.1 birds per km^2. This finding supported our hypothesis that the common myna would be more abundant in urban habitats than in nature reserves.

We also identified a significant negative relationship between common myna abundance and tree density in nature reserves

common myna abundance in low tree density nature reserves was 44.2 birds per km^2, 18.5 birds per km^2 for medium tree density and 2.5 birds per km^2 for high tree density nature reserves. This finding supported our hypothesis that common myna abundance would increase as tree density declines.

Therefore, the common myna was strongly influenced by habitat and appeared to be a passenger of habitat change.

We found no significant relationship between common myna abundance and total species richness, native cavity-nesting species abundance or richness or large bird abudnace or richness

We found a negative relationship between the abundance of the common myna and the abundance of the gang-gang cockatoo and crimson rosella

significant negative relationships between common myna abundance and small native species abundance and small native bird species richness- 8 of 20 small birds white-throated treecreeper spotted pardalote, speckled warbler, brown thornbill, buff-rumped thornbill eastern spinebill grey fantail and grey butcher bird. supported our hypothesis that the common myna would negatively affect the abundance of some small bird species.

We observed a significant positive relationship between nature reserve areas and small native species richness ($F_{1,134}$=30.4, P<0.001). Urban areas with high tree density supported a greater abundance of small native species than urban areas with medium or low tree density.xx

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Key Findings

- The common myna is primarily a passenger of habitat change
- But it may drive the decline of
  - gang-gang cockatoo
  - crimson rosella
  - small native species abundance and richness
- Need to look at habitat modification and invasive species impact together (effective management)

Read slide-

Low tree density in nature reserves, or fragmentation of native vegetation, may enhance habitat quality for the common myna enabling the species to spread into new areas and compete for resources with native species. The results of our study suggest that the effects of habitat modification and invasive species are interrelated. Many species are strongly influenced by habitat, with greater abundance in high quality habitat than in low quality habitat. However, high quality habitat for one species may not constitute high quality habitat for another species

Given the influence of habitat on species abundance, we suggest that habitat restoration and tree planting may be useful tools to both control common myna abundance and aid native bird species recovery. Other Australian studies have suggested vegetation regeneration and dense planting of vegetation in reserves could be used as a method to control bird species such as the noisy miner and the bell miner. xx

2.3 Cavity nesting competition

Published 2013: *Environmental Management*: doi: 10.1007/s00267-013-0088-7

Does human-induced habitat modification influence the impact of introduced species? A case study on cavity-nesting by the introduced common common myna and two Australian native parrots.

Grarock K., Lindenmayer D.B., Wood, J.T., Tidemann C.R.

As defined in previous studies species distribution and abundance is predominantly determined by resources that are critical for their survival (Elton 1927). Therefore, habitat features can have a large impact on species abundance and distribution). For example, the availability of tree cavities can be a critical resource for some species

Human modification of landscapes (eg habitat clearing, tree removal for public safety) and fire can lead to reductions in cavity availability

Nest cavity availability can be further reduced by the introduction of new species that compete for these limited resources

Looked at tree density and nesting of :

- common myna
- crimson rosella
- eastern rosella

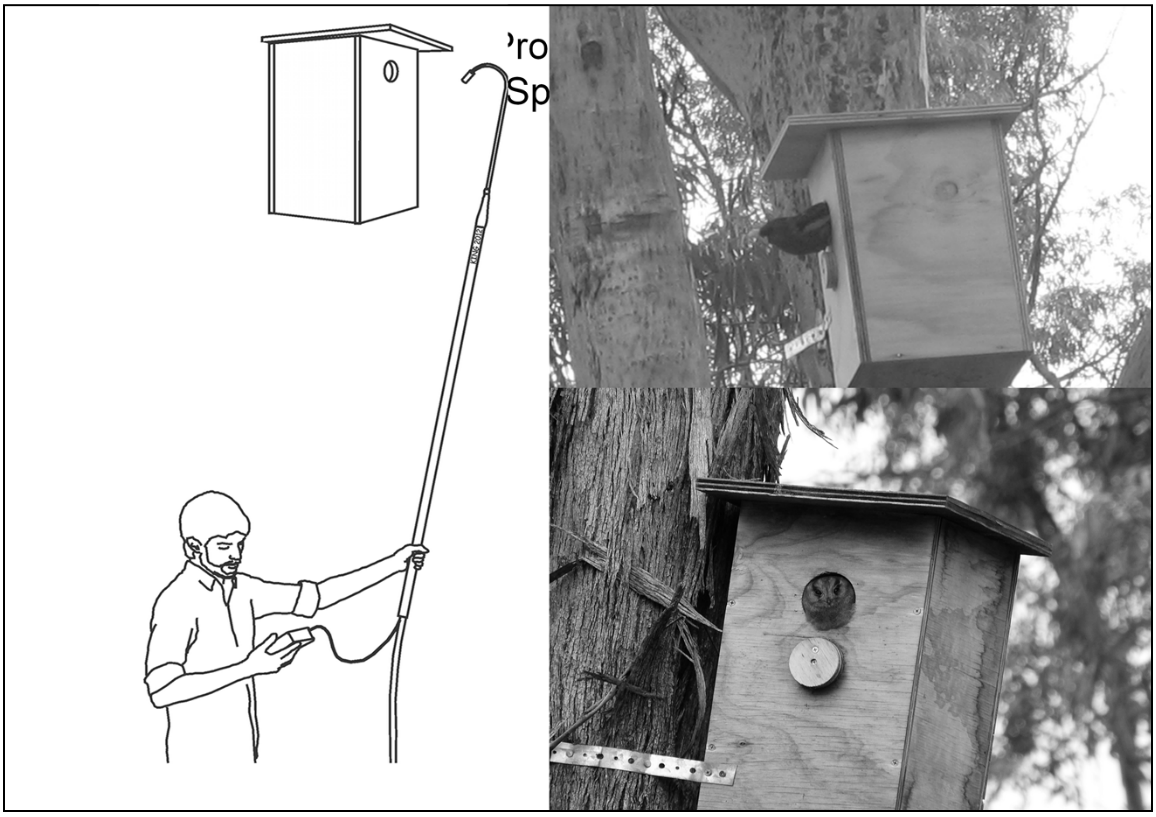
We investigate cavity nesting competition between CM crim and eastern rosell across differing tree densities

Building off previous studies - we hypothesized

-that tree density (high, medium and low) would influence the abundance, rate of cavity-nesting and nesting success of our three study species.

-common myna nest box occupancy would have a negative impact on the abundance of the crimson rosella and eastern rosella at low tree density sites (as more abundnat in these areas).

Used same 15 survey sites as previous studies and transect data in nature reserves. xx



We constructed 225 nesting boxes from 15 millimeter plywood. 65 millimeter diameter entrance hole in the front panel. established 15 nesting boxes in each of the 15 sites –randomly selected nest box placement - surveyed for 3 nesting seasons.

To check nest boxes we used a bullet-camera surrounded by five light-emitting diodes (32 millimeters in diameter), that allowed color viewing in total darkness. We mounted the camera on the end of a three-meter pole and connected it to a video camera via a five-meter coaxial cable. To check nest boxes, we placed the camera at the entrance hole of each box, viewing and recording the images on a video camera

The procedure was fast and effective, resulting in minimal disturbance to nest box occupants and enabled us to identify the species and the number of eggs in each nest box.

Nest boxes were checked every four weeks throughout the breeding season (

Used transect sureys from previous.xx

Table 2 Common myna abundance and nesting in nature reserves surrounding Canberra, Australia[a]

Tree density	Number of nest boxes added	Common myna abundance (birds per km^2)	Nest boxes used by the common myna (%)	Common myna egg success (%)	Average eggs per clutch	Common myna interrupt rosella species nesting (% of boxes)
High	75	9.7 ±3.6	9.3% ± 2.1	56.3% ±22.7	4.5 ± 0.3	1.3 ±1.3
Med	75	45.4 ±10.1	27.1% ±2.8	90.0% ±4.0	4.3 ±0.2	6.6 ±2.2
Low	75	101.9 ±22.4	43.1% ± 8.0	91.1% ±1.8	4.2 ±0.1	12.7 ±6.2
Significance		$F_{2,42}$=10.51, P<0.001*	$F_{2,42}$=11.29, P<0.001*	$F_{2,28}$=6.24, P=0.006*	$F_{2,28}$=0.24, P=0.787	$F_{2,42}$ =1.79, P=0.179

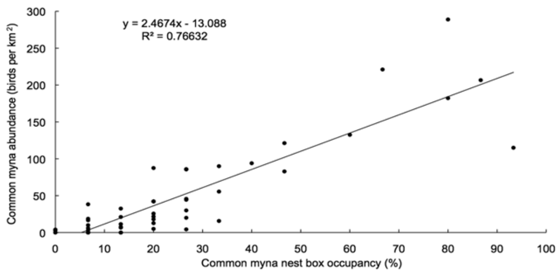
Table 3 Crimson rosella abundance and nesting in nature reserves surrounding Canberra, Australia[b]

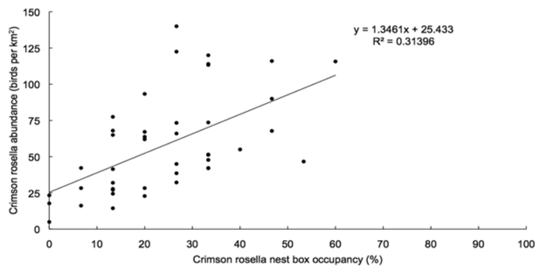
Tree density	Number of nest boxes added	Crimson rosella abundance (birds per km^2)	Nest boxes used by the crimson rosella (%)	Crimson rosella egg success (%)
High	75	83.9 ±9.3	28.9% ±3.0	65.7% ±4.0
Med	75	61.6 ±6.4	25.8% ±3.0	46.1% ±5.1
Low	75	31.4 ±3.9	18.2% ±4.3	44.6% ±8.5
Significance		$F_{2,42}$=14.65, P<0.001*	$F_{2,42}$=3.55, P=0.038*	$F_{2,38}$ = 4.04, p = 0.026*

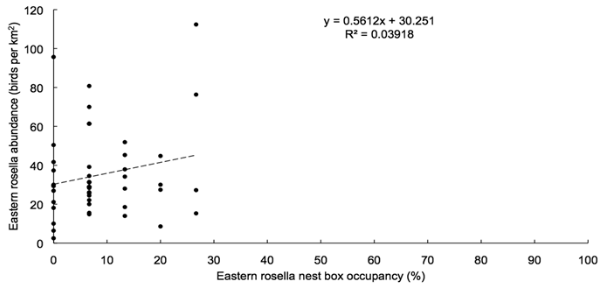
Table 4 Eastern rosella abundance and nesting in nature reserves surrounding Canberra, Australia[c]

Tree density	Number of nest boxes added	Eastern rosella abundance (birds per km^2)	Nest boxes used by the eastern rosella (%)	Eastern rosella egg success (%)
High	75	34.5 ±3.9	4.4% ±1.2	63.3% ±13.5
Med	75	48.6 ±8.0	11.1% ±2.1	46.8% ±10.1
Low	75	22.6 ±3.0	11.1% ± 2.4	46.3% ±7.5
Significance		$F_{2,42}$=5.79, P=0.006*	$F_{2,42}$=3.75, P=0.032*	$F_{2,29}$ = 0.72, P = 0.495

Talk about tables) xx





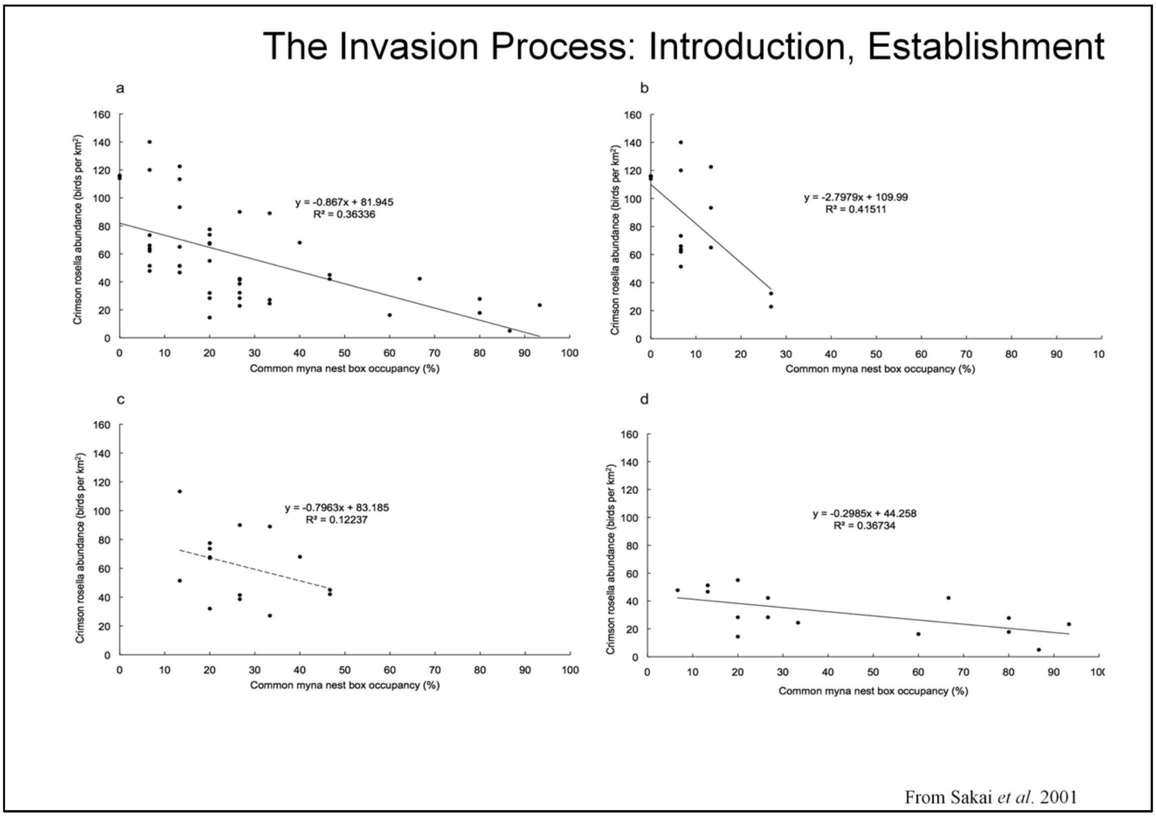


From Sakai *et al.* 2001

Fig. 3 Relationship between common myna abundance and the proportion of nest boxes occupied by the species ($F_{1,43}$=131.71, P<0.001)

Fig. 4 Relationship between crimson rosella abundance and the proportion of nest boxes occupied by the species ($F_{1,43}$=17.85, P<0.001)

Fig. 5 Relationship between eastern rosella abundance and the proportion of nest boxes occupied by the species ($F_{1,43}$=1.75, P=0.192)



Relationship between the proportion of nest boxes occupied by the common myna and the abundance of the crimson rosella.

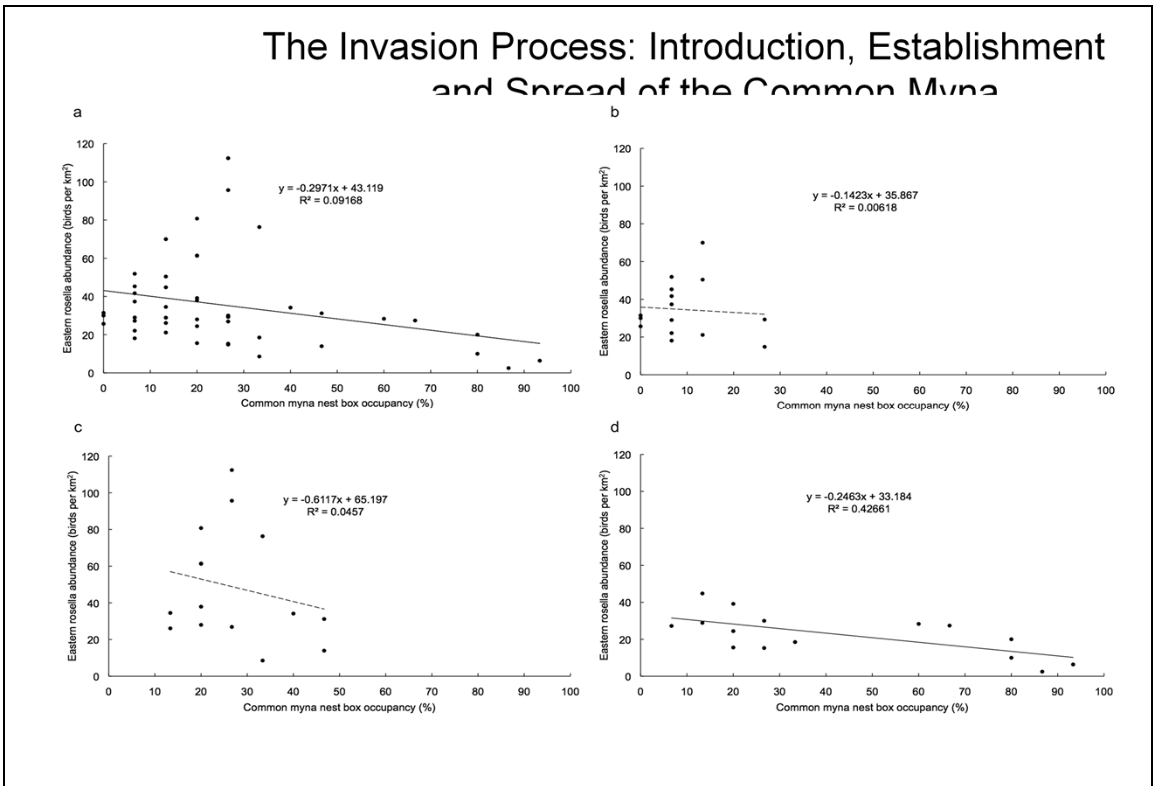
(a)all sites of differing tree density ($F_{1, 43}$ = 26.057, P <0.001), expect due to hab pref alone

(b)high tree density sites only ($F_{1, 13}$ = 9.226, P <0.001),

(c)medium tree density sites only ($F_{1, 13}$ = 3.256, P = 0.094)

(d)low tree density sites only ($F_{1, 13}$ = 7.548, P = 0.017)

At high tree density sites, an increase in the proportion of nest boxes occupied by the common myna, from ten to 25 %, was related to a sharp decrease in crimson rosella abundance (Fig. 6b). At low tree density sites the relationship between common myna nest box occupancy and reduced crimson rosella abundance appeared to be less dramatic xx



From Sakai *et al.* 2001

We also observed a significant negative relationship between common myna nest box occupancy and eastern rosella abundance ($F_{1, 43}$= 5.101, P = 0.029) (Fig. 7a). However, further investigation revealed this relationship was only significant at low tree density sites ($F_{1, 13}$ =9.672, P <0.001) (Fig. 7d).

Other species

The European honey bee occupied 9.9% (±1.8) of nest boxes throughout the survey period

Key Findings

- Tree density strongly influenced abundance and nesting of all species
- Low tree density:
  - Common myna domination – impact abundance crimson rosella and eastern rosella
  - Greater number - nest box interruptions (N/S)
- High tree density:
  - More severe negative relationship on crimson rosella

Read slide

In our study tree density significantly influenced the abundance, nest box occupancy and nesting success of the common myna and the crimson rosella in opposite ways.

The common myna appeared to prefer low tree density sites, occurring in greater abundance, occupying more nest boxes and having a greater egg success than in other areas (Table 2).

The crimson rosella appeared to prefer high tree density sites, occurring in greater abundance and nesting in more nest boxes than in other areas. Egg success were similar to the 50% success rate found in a study of the crimson rosella nesting in a high tree density reserve in Canberra, where the common myna was absent (Krebs 1998). This indicates that the common myna may not negatively impact native parrot egg success; rather the common myna may potentially 'impact' species through reducing the availability of cavities.

Impact of the common myna appeared to be more severe in high tree density sites. Therefore, management of the common myna may be required in these areas that represent 'high quality' habitat for native species, especially in areas where threatened species are nesting, such as the superb parrot (*Polytelis swainsonii*). xx

3. Control of the common myna

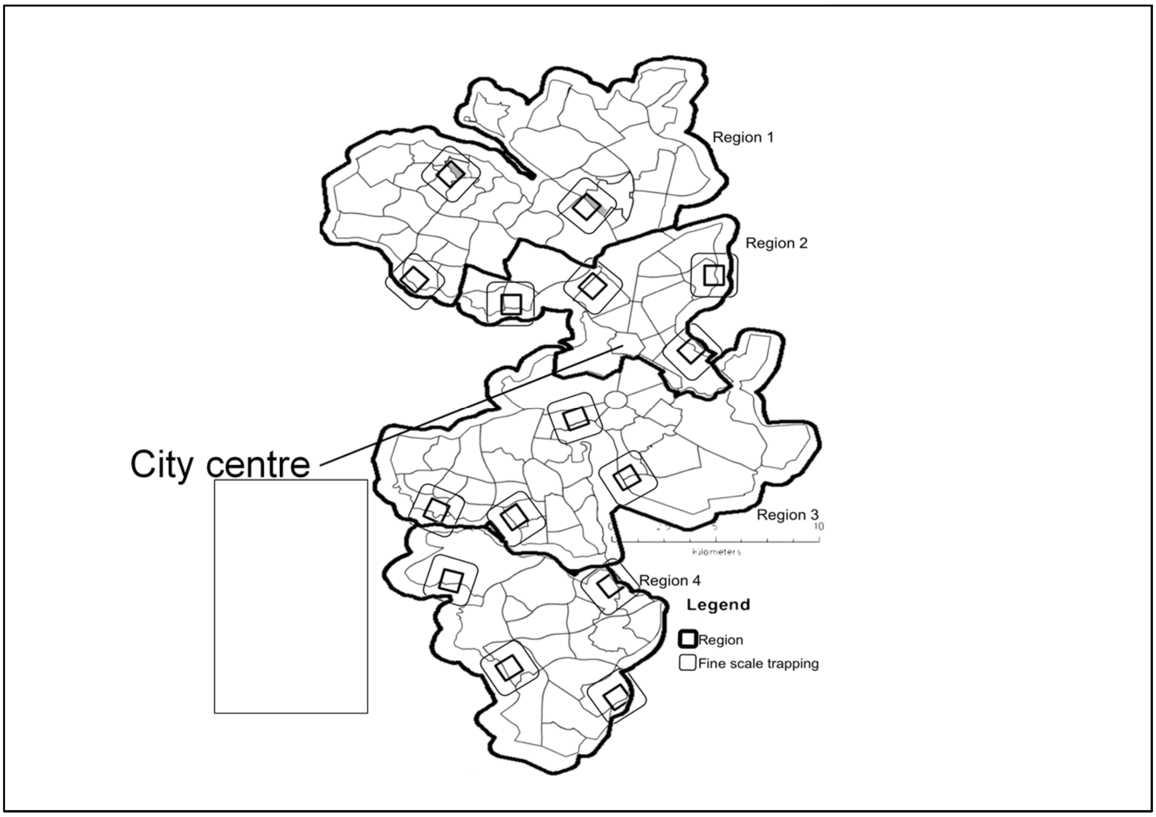
Under Review 2013: *Biological Invasions*

Understanding basic species population dynamics for effective culling: A case study on culling of the common myna by the community.
Grarock K., Tidemann C.R., Wood, J.T., Lindenmayer D.B.

Introduced species management has traditionally focused on eradication (Newton 1998). However, many widespread eradication or reduction measures have failed, leading to a waste of resources

A population can compensate for culling losses through density dependent changes in reproduction, survival or immigration). Therefore, some species can be culled heavily year after year without achieving long-term reductions in their abundance or the damage they cause.

In this paper, we used culling data and bird survey data to investigate whether community culling is reducing common myna abundance in canberra. We analyzed changes in common myna abundance over fine-scale (one square kilometer) and broad-scale regions (approximately 80 square kilometers), in relation to community culling. We hypothesized that community culling in Canberra is responsible for apparent reductions in common myna abundance. We then utilized a basic population model to enhance understanding of common myna population dynamics and the potential impact of various culling rates.xx



CIMAG DATA -Broad scale tapping – cog

Fine scale transect surveys urban

To assess the impact of culling, we performed linear regression analysis of the change in common myna abundance per square kilometer on birds culled per square kilometer.

We also modeled Common Myna population to try and get better understanding of impact of culling

$$N_{t+1} = N_t + r_{max}N_t(1 – N_t/K) - c_tN_t$$

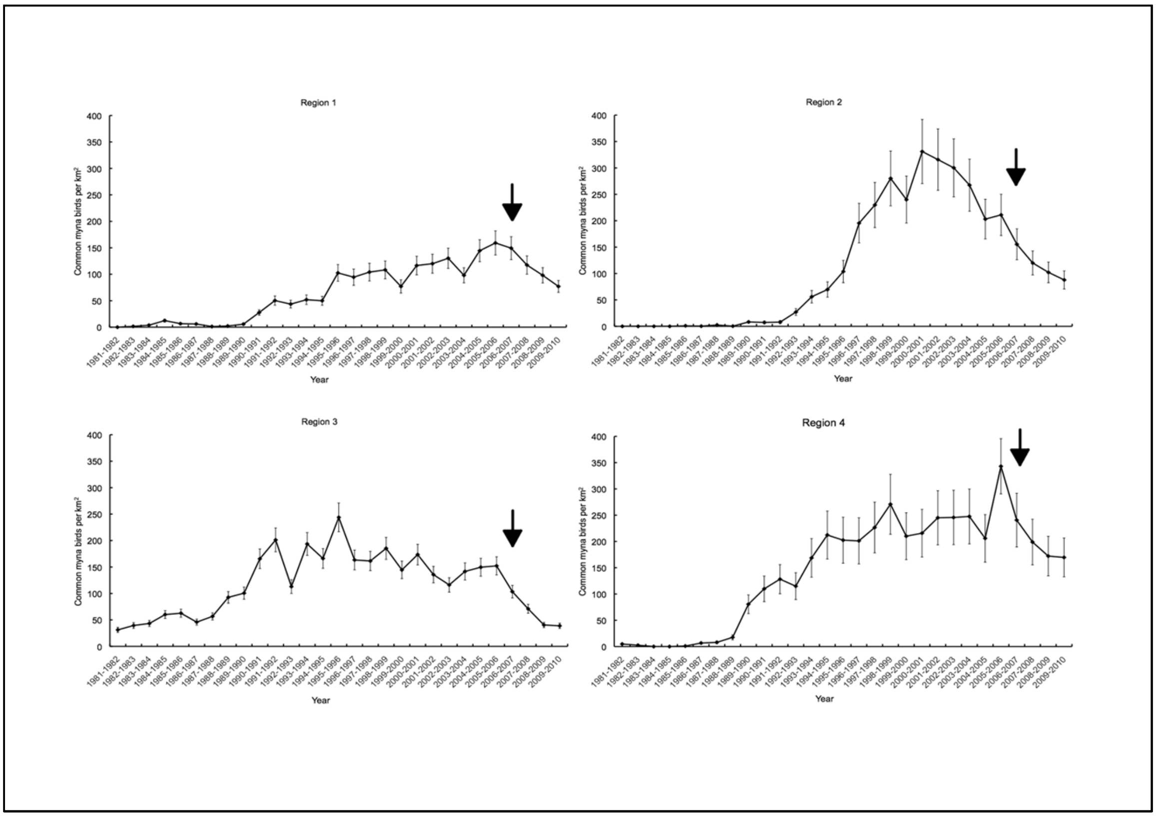
We use a logistic growth model to investigate how a common myna population would react to various levels of culling at different population densities. For simplicity, we utilized a model with no stochastic dynamics (environmental change). We use the generalized logistic model outlined by Sutherland et al. (2004) and derived from Caughley (1977). The change in population from one time period to the next was governed by the following equation (Sutherland et al. 2004):

$$N_{t+1} = N_t + r_{max}N_t(1 – N_t/K) - c_tN_t$$

Where N_t is population size at $time_t$, r_{max} is the maximum growth rate, K is the carrying capacity, and, c_t is the culling rate for the same time period.

We used the average estimates from first paper The average maximum rate of population growth was 24.1 (±6.4) birds per square kilometer per year and the average maximum population size was 205.9 (±34.6) birds per square kilometer.

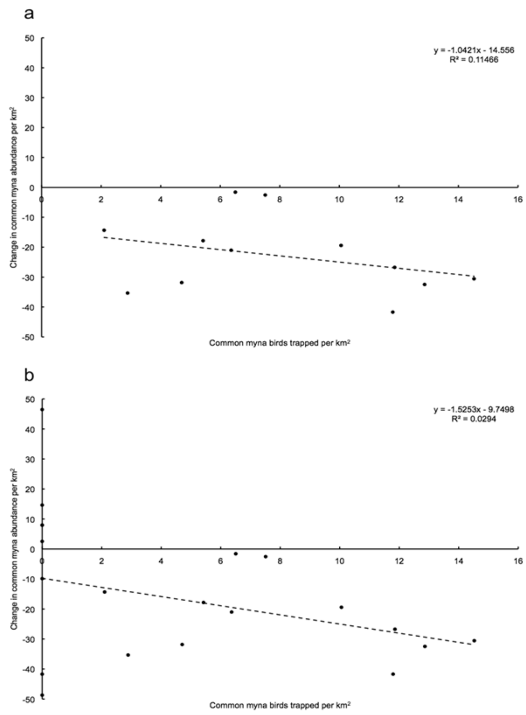
We estimated the level of cull required (per square kilometer per year) at various population sizes to produce a significant (>10%) reduction in common myna abundance. We used this model to establish an understanding of the number of individuals that need to be culled to reduce the population size. xx



Broad scale CM abundance

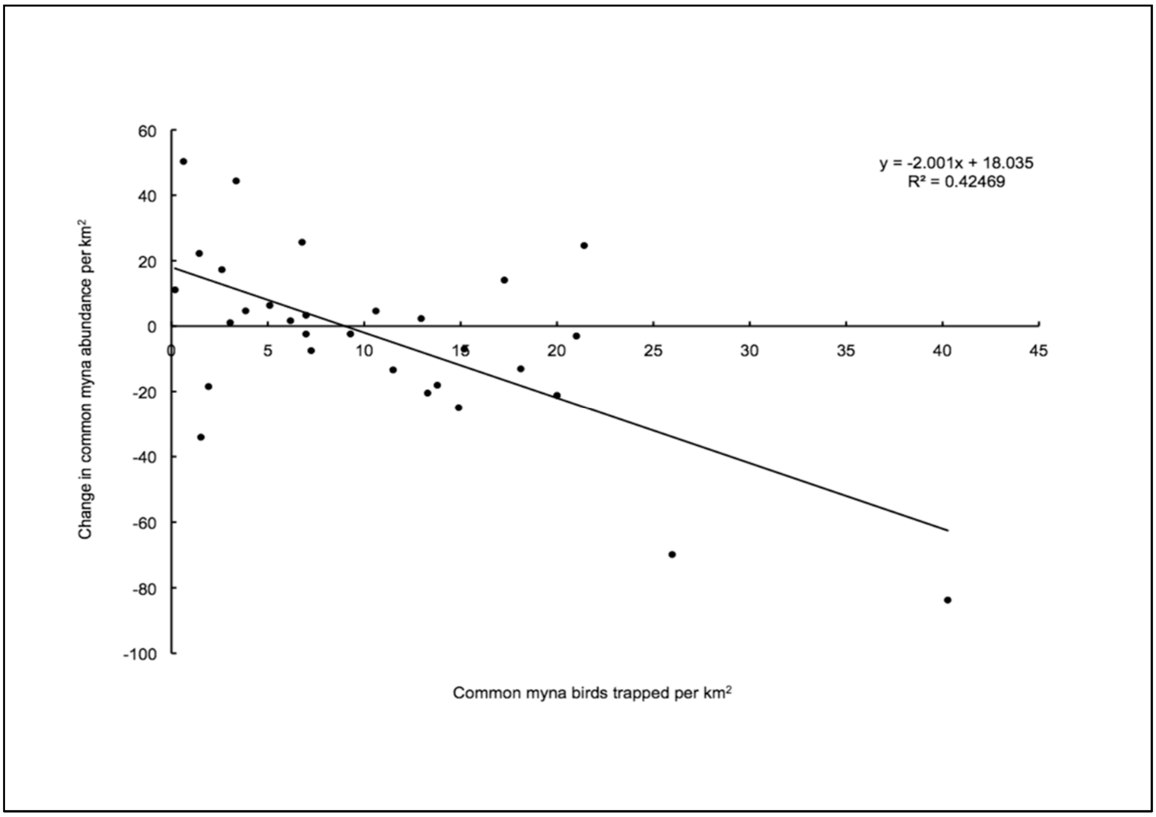
In all four regions in our study, common myna abundance peaked before declining (Figure 2). This decline in abundance appeared to occur in 2001 and 1996 in Regions 2 and 3, respectively. This was prior to the commencement of the community culling program in 2006. In Regions 1 and 4, common myna abundance reduced one year before culling commenced (Figure 2).

Some areas common myna abundance was in decline prior to April 2006, when culling commenced. We wanted to avoid mistakenly identifying culling as reducing common myna abundance when it could potentially be due to other influences (for example, natural population limitation). Therefore, we extended our analysis to include common myna abundance in the 3 years prior to common myna culling (when common myna culling was approximately equal to zero). We used linear regression, to investigate the relationship between change in common myna abundance per square kilometer and birds culled per square kilometer. xx



Broad scale

We found no significant relationship between the yearly change in common myna abundance per square kilometer and yearly culling per square kilometer ($F_{1,10}$=1.30, P=0.282) (Figure 3a). When we included the three years of data prior to common myna culling, the relationship further weakened ($F_{1,22}$=0.67, P=0.42) (Figure 3b). Two of the largest observed reductions in common myna abundance (41 and 49 birds per square kilometer) occurred prior to culling (Figure 3b). This finding indicates that community culling in Canberra is *not* responsible for reductions in *broad scale* common myna abundance.



Fine scale

highly sig

We found a significant negative relationship between yearly change in common myna abundance per square kilometer and yearly culling per square kilometer ($F_{1,28}$=20.67, P<0.001). We observed that culling more than ten birds per square kilometer often (but not always) resulted in reductions in fine scale common myna abundance (Figure 4). This finding indicates that community culling in Canberra *is* capable of reducing *fine scale* common myna abundance.

Table 1. Expected common myna (*Acridotheres tristis*) abundance after various culling regimes and initial population densities, using a basic logistic growth model. Grey shading indicates populations would be expected to reduce in size and an asterisk indicates populations that would be expected to reduce significantly (>10%).

Culling rate (birds per km^2 per year)	0	2	5	10	15	20	24	25	30	40
Initial population size (birds per km^2)										
10	14.5	12.5	9.5	4.5*	0.0	0.0	0.0	0.0	0.0	0.0
20	28.5	26.5	23.5	18.5	13.5*	8.5	4.5	3.5	0.0	0.0
30	42.0	40.0	37.0	32.0	27.0*	22.0	18.0	17.0	12.0	2.0
40	55.1	53.1	50.1	45.1	40.1	35.1*	31.1	30.1	25.1	15.1
50	67.7	65.7	62.7	57.7	52.7	47.7	43.7*	42.7*	37.7	27.7
60	79.9	77.9	74.9	69.9	64.9	59.9	55.9	54.9	49.9*	39.9
80	102.9	100.9	97.9	92.9	87.9	82.9	78.9	77.9	72.9	62.9*
100	124.1	122.1	119.1	114.1	109.1	104.1	100.1	99.1	94.1	84.1*
150	169.1	167.1	164.1	159.1	154.1	149.1	145.1	144.1	139.1	129.1*
200	202.7	200.7	197.7	192.7	187.7	182.7	178.7*	177.7*	172.7	162.7
250	224.9*	222.9	219.9	214.9	209.9	204.9	200.9	199.9	194.9	184.9

The level of cull required to create a significant reduction (>10%) in population size for each population size is highlighted with an asterisk (Table 1). Grey shading is used to highlight populations that have reduced in size.

Discuss more here less there…

Our model indicated that culling at a rate of 25 birds per square kilometer would result in reductions in the population size regardless of initial density (Table 1). Our model corresponds closely with what we observed for culling in Canberra. The culling rate in regions ranged from 0 to 15 birds per square kilometer (Figure 3) and is considerably lower than the model estimate of 25 birds per square kilometer. This helps to explain the lack of observed correlation between culling and common myna abundance across regions. However, at fine scale sites, we observed that culling at a rate greater than 25 birds per square kilometer corresponded with significant reductions in common myna abundance (Figure 4), as would be predicted by our model xx

Key Findings

- Trapping effect over fine scales
- No effect of trapping over broad scale (doomed surplus)
- Population model – cull target = 25 birds per square kilometre
- Population model = understand species = better management

Read slide: Our study is the first study to demonstrate that community culling is capable of reducing the *local* abundance of the common myna. This knowledge will enable culling targets to be set and guide planning into ways to achieve these targets.

Influence on success of culling

-life history strategy – compensate eg myne 7 eggs per clutch x3

-population density – rate of growth, hard to catch

-The timing of cull - critical – eg prior to the breeding, pop nat low –less likely to remove the 'doomed-excess' (individuals that may not have survived over winter) also before biggest impact.

-spp ecology – vulnerable traits eg roosts – nb

-Spatial dispersal - Attempts to control only a small proportion of the population may fail due to immigration from surrounding areas

Eg quella In Africa, millions of dollars were spent culling hundreds of millions of red billed quelea (*Quelea quelea*) for many years, yet the population size was not really affected by this culling. Quick repro compensate - quickly immigrated

This study indicated that intense localized culling appears to be effective The common myna appears to be somewhat sedentary and slow at spreading to new areas (Grarock et al. 2013b), potentially enhancing cull effectiveness in the medium term. Due to the species broad distribution across Australia and other continents, perhaps management actions should be undertaken in localized areas where the species is deemed to have the greatest impact. For example, management of the common myna near threatened species breeding areas, such as the superb parrot (*Polytelis swainsonii*), may be a good strategy. The highly intelligent and adaptable nature of the common myna indicate that complimentary methods for controlling the species (such as shooting and roost and nest box trapping), will likely be required to successfully reduce the abundance of this species. xx

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