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Impact of wildlife provisioning on species diversity, relative frequency, and richness in New South Wales

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Impact of wildlife provisioning on species diversity, relative frequency, and richness in New South Wales

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Abstract:

Wildlife provisioning and camera trapping are two recently evolving methods of conservation and wildlife management, aimed at protecting animals in the face of ever worsening climate change. Habitats are being destroyed by climate disruption, decreasing species diversity and abundance worldwide. It is imperative that methods of protecting species are developed to slow or reverse this era of extinction. By providing supplementary food and water to ecological communities, the hope is that species will have improved survivorship and reproduction, making them more resilient and resistant to population decline. Camera trapping is product of modern technology, allowing researchers to monitor species without invading their habitats and causing them harm. The cameras are triggered by movement, capturing images of animals as they move through their environment.

Using an array of cameras set up in four locations near Sydney, NSW, Chantelle de Kock and I monitored the populations over two periods of 6-8 weeks. Between the periods, Chantelle set out food and water provisions at two of the sites – leaving the other two as controls – creating a before and after treatment study design. This project aims to assess the impact of wildlife provisioning on the species within the study area and if it is a worthwhile conservation tool.

I found little to no difference in species diversity, relative frequency, or richness at the Golden Jubilee site before and after provisioning. These findings suggest that provisional feeding does not improve species measurements and was not an effective conservation tool within the study area.

Keywords: wildlife provisioning, camera trapping, species diversity, relative frequency, species richness

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Acknowledgements:

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Helen Penrose, my advisor, provided guidance and support from the early stages of brainstorming through to the culmination of my ISP.

Dr. Lynn Christenson is my employer at Vassar College who I have worked with for the past two years as a biology research assistant. She has taught me skills in data analysis, statistics, and wildlife camera trapping that gave me the means to complete this project.

I must also thank Julie Schatz and Thomas Meyer, good family friends that generously hosted me during my time in Sydney, giving me comfortable accommodations to do my work from and companionship that kept me entertained through long days of data analysis.

My family back home also provided help during this time, forging the connection that provided me with a homestay and also encouraging me throughout this process.

Finally, I would like to thank my Academic Director Peter Brennan and the rest of the SIT Australia: Sustainability and Environmental Action staff for guiding me through workshops, class lectures, field trips and more in order to prepare me for this final month of my study abroad experiences.

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INTRODUCTION

History of wildlife conservation and management in Australia

More than two hundred and fifty years ago, Europeans arrive en masse to Australia and forever changed the natural environment (Bradshaw, 2020, para. 1). British settlers brought with them fully formed ideas of development and progress built on centuries of land use back in the United Kingdom (Bradshaw, 2020, para. 1). The settlers enforced their ideals of “conquering wilderness” and “transforming it into the bucolic landscape typical of the English countryside” that they were so used to (Bradshaw, 2020, para. 1). The Australian bush land was seen as ugly and monotonous, full of features that needed to be overcome by human occupation and cultivation (Bradshaw, 2020, para. 2). In 1861, the Australian government passed the Crown Lands Alienation Act that planned to “open up” the colony to settlement and penalized landholders for not clearing land (Bradshaw, 2020, para. 3). This act created a wave of deforestation across the continent, devastating Australia’s biodiversity (Bradshaw, 2020, para. 3).

In light of the demise of the environment, Aboriginal people stood up as the first defenders of the land and its various flora and fauna, representing the first inklings of environmentalism in the country (Bradshaw, 2020, para. 4). By 1879, the first national park was established in Australia: Royal National Park (Bradshaw, para. 8). The Wild Life Preservation Society of Australia was formed in 1909, acting as a precursor to the modern-day Australian Wildlife Society that protects biodiversity across the nation (Australian Wildlife Society, n.d., para. 1). Over the next century, more and more national parks were created, and as the years progressed, so did the inclusion of conservationist principles in the foundation of these parks (Bradshaw, 2020, para. 9-10). By 1967, the National Parks and Wildlife Act was passed, including protection for fauna, wildflowers, and native plants (Australian Wildlife Society, n.d., para. 1). Out of the 1960s came a large-scale expansion in wildlife management involving examinations of societal values as well as knowledge and behaviors associated with wildlife and wildlife management (Miller, 2009, p. 1).

Wildlife provisioning as a conservation technique

Wildlife provisioning is defined as "intentional provision of resources for wildlife," often interpreted as urban greening and wildlife gardening (Cox & Gaston, 2018, p. 2). It can be motivated by different incentives, such as tourism, game management, or conservation (Shutt & Lees, 2021, p. 2). In some westernized countries, the scale of provisioning has become extremely high, leading to both positive and negative effects on ecosystems (Cox & Gaston, 2018, p. 1). Bird provisioning is by far the most common, with approximately 12.6 million households in the UK providing food for birds and 54.3 million in the US (Cox & Gaston, 2018, p. 2).

Wildlife provisioning can target specific species, such as those that are endangered, but generalized provisioning occurs more commonly (Shutt & Lees, 2021, p. 1). However, vast inputs of resources can have ecosystem-wide consequences that forgo the goal of aiding wildlife (Shutt & Lees, 2021, p. 1). Issues such as increased risk of pathogen transmission, feeder-related diseases, decrease in abundance on non-target species, and increased competition can occur (Cox & Gaston, 2018, p. 3). Despite these drawbacks, there is also evidence that provisioning results in a wider community of invertebrate species, increases adult overwintering survival, earlier lay dates, and increased egg sizes in birds (Cox & Gaston, 2018, p. 3). Due to the uncertainty in the positives versus negatives of wildlife provisioning, it is worthwhile investigating these practices further to see if it is a reliable tool for conservation.

Usage of camera trapping

Camera trapping is a growing global phenomenon full of quickly advancing technology and a plethora of new discoveries (Fleming et al., 2014, p. x). This approach to wildlife management has been used to discover new species, rediscover old ones, and extend the known range of more (Fleming et al., 2014, p. x). Camera trapping was introduced as a survey tool in Australia in the 1950s in an attempt to rediscover the thylacine, more widely known as the Tasmanian tiger (Meek et al., 2015, p. 1). While their efforts proved to be fruitless, as the species had already gone extinct, the technology was not abandoned and began appearing in research papers in 1989-1991 (Meek et al., 2015, p. 1). By 2008, usage was widespread with improvements in the rigor of reporting key methods (Meek et al., 2015, p. 1). Application of camera trapping has shifted from purely theoretical and experimental to approaches focused on population ecology, behavioral ecology, conservation biology, and wildlife management (Meek et al., 2015, p. 1). There is now potential for camera trapping to be a tool for assessing global changes in biodiversity of animals (Fleming et al., 2014, p. 4).

Currently, camera traps refer to infrared camera units that are triggered by movement of an animal within the detection area (Fleming et al., 2014, p. 4). They are often shoebox sized or smaller, shoot both still or video images, and are passively triggered by infrared light sources (Fleming et al., 2014, p. 4). The use of these cameras can provide basic knowledge of population distribution, is relatively inexpensive, and relatively non-invasive and safe for the subjects studied (Fleming et al., 2014, p. 4). Improvements in camera technology have allowed for the studying of smaller animals via camera traps to be possible, as they can now pick up on smaller heat signatures, removing the need for live trapping of these animals (Fleming et al., 2014, p. 5). Camera traps also act as a workaround for other wildlife monitoring issues such as animals being rare, nocturnal, or avoiding humans (Fleming et al., 2014, p. 7). These cameras can be set to constantly record data, day and night, and in a variety of locations to account for those barriers. Over the past few decades, camera traps have been used for a multitude of research purposes, such as comparing the impact of different forestry practices on mammal communities, assessing effects of human populations on large carnivore populations, and assessing effects of predator control on prey species populations (Fleming et al., 2014, p. 6). Reliable assessment methods for animal populations have plagued wildlife ecologists and managers for decades and finally there is a tool that simplifies this process (Burton et al., 2015, p. 676).

Species diversity, abundance, and richness

Within an ecological community, measurements such as diversity, abundance, and richness are equated with stability and health (Travlos, 2018, p. 2). A community is defined as a group of populations of species interacting within a space (Stroud et al., 2015, p. 4758). Communities imply that there are multiple different species occurring within the defined space, but the number of each species and the number of individuals within those species are important measurements in ecological research (Babu, 2016, para. 1). Species diversity incorporates the number of species in an area, the abundance of those species, and their distribution, measuring the variety of species in an ecosystem (Babu, 2016, para. 4). There are a variety of diversity indices used to calculate species diversity, such as Simpson's Diversity Index (Species abundance represents the number of individuals of each species in an area, which is represented as a quantitative value (Babu, 2016, para. 3). Finally, species richness is simply the number of different species observed in an area, another quantitative measurement (Babu, 2016, para. 2). Along with species richness, you can also calculate species evenness, which is the abundance within each species (Travlos et al., 2018, p. 2).

Simpson's indices

Simpson's indices are tools for quantifying biodiversity within communities (Simpson's Diversity Index Calculator, n.d., para. 1). These measurements consider how many different species are present in a community and how evenly distributed the populations are (Barcelona Field Studies Centre, n.d., para. 2). Simpson's index, defined as *D*, was introduced in 1949 by British statistician Edward H. Simpson (Simpson's Diversity Index Calculator, n.d., para. 2). *D* represents the "probability that any two individuals randomly selected from an infinitely large community will belong to the same species" (Simpson's Diversity Index Calculator, n.d., para. 2). Within the Simpson Index, higher values of *D* reflect lower diversity, so an amended index was made, the Gini-Simpson Index, which expresses the value as $1-D$ (Simpson's Diversity Index Calculator, n.d., para. 9). The value of $1-D$ can range between 0 and 1, with values closer to 1 reflecting higher diversity (Barcelona Field Studies Centre, n.d., para. 4).

Site Locations

Golden Jubilee

The Golden Jubilee Field is located in Wahroonga, NSW – about 23 kilometers north of Sydney - and is part of Ku-ring-gai Council land (Golden Jubilee Field, n.d., para. 2). The park is publicly available, featuring walking trails, a mountain bike park, and sports fields. (Golden Jubilee Field, n.d., para. 2). The terrain is variable and hilly, crisscrossed by small streams.

Figure 1. Golden Jubilee site (Photographed by Alanah Cohen-Tigör)

Turner Fire Trail

The Turner Fire Trail is located in Berowra Heights, NSW – about 49 kilometers north of Sydney – and passes near Berowra Valley National Park (Turner Fire Trail Loop, n.d., para. 1-2). The trail runs in a circular loop and is open to the public year-round (Turner Fire Trail Loop, n.d., para. 1). The trail is steep and rocky, sloping down into the valley and then back out.

Figure 2. Turner Fire Trail site (Photographed by Alanah Cohen-Tigör)

McCallum's Road

The McCallum's Road trail is located in Berilee, NSW – about 45 kilometers north of Sydney – and is also a fire trail for the region (LOCAL BUSHWALKS, 2020, para. 4). The land is mostly flat, and the soil is quite sandy.

Figure 3. McCallum's Road site (Photographed by Alanah Cohen-Tigör)

Ku-ring-gai Wildflower Garden

The Ku-ring-gai Wildflower Garden is located in St. Ives, NSW – about 19 kilometers north of Sydney – and is part of Ku-ring-gai Council land (Ku-Ring-Gai Wildflower Garden, n.d., para. 1). The land is open to the public and is comprised of 123 hectares of untouched bushland (Ku-Ring-Gai Wildflower Garden, n.d., para. 1).

Figure 4. Ku-ring-gai Wildflower Garden site (Photographed by Alanah Cohen-Tigör)

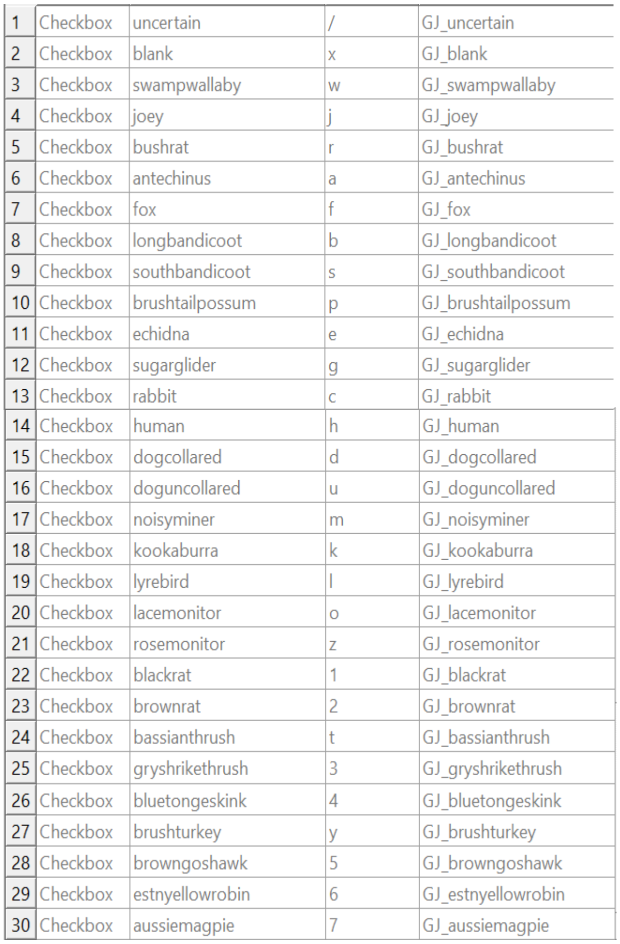
Species studied

I was provided with a preliminary list of species common to the region that I would be likely to view on the camera trap images. This list includes terrestrial and arboreal mammals, as well as birds and reptiles. From this list, some species were never observed while additional species needed to be added.

Table 1. Preliminary list of species – 20 species (not including dogs, humans, and options for uncertain or blank)

	Value Type	Name	Shortcut	XMP Name
1	Checkbox	uncertain	/	GJ_uncertain
2	Checkbox	blank	x	GJ_blank
3	Checkbox	swampwallaby	w	GJ_swampwallaby
4	Checkbox	joey	j	GJ_joey
5	Checkbox	rockwallaby	t	GJ_rockwallaby
6	Checkbox	bushrat	r	GJ_bushrat
7	Checkbox	antechinus	a	GJ_antechinus
8	Checkbox	fox	f	GJ_fox
9	Checkbox	longbandicoot	b	GJ_longbandicoot
10	Checkbox	southbandicoot	s	GJ_southbandicoot
11	Checkbox	brushtailpossum	p	GJ_brushtailpossum
12	Checkbox	echidna	e	GJ_echidna
13	Checkbox	sugarglider	g	GJ_sugarglider
14	Checkbox	rabbit	c	GJ_rabbit
15	Checkbox	human	h	GJ_human
16	Checkbox	dogcollared	d	GJ_dogcollared
17	Checkbox	doguncollared	u	GJ_doguncollared
18	Checkbox	noisyminer	m	GJ_noisyminer
19	Checkbox	brushturkey	y	GJ_brushturkey
20	Checkbox	magpie	i	GJ_magpie
21	Checkbox	kookaburra	k	GJ_kookaburra
22	Checkbox	lyrebird	l	GJ_lyrebird
23	Checkbox	lacemonitor	o	GJ_lacemonitor
24	Checkbox	rosemonitor	z	GJ_rosemonitor

Table 2. Updated list of species – 25 species (not including dogs, humans, and options for uncertain or blank)



1	Checkbox	uncertain	/	GJ_uncertain
2	Checkbox	blank	x	GJ_blank
3	Checkbox	swampwallaby	w	GJ_swampwallaby
4	Checkbox	joey	j	GJ_joey
5	Checkbox	bushrat	r	GJ_bushrat
6	Checkbox	antechinus	a	GJ_antechinus
7	Checkbox	fox	f	GJ_fox
8	Checkbox	longbandicoot	b	GJ_longbandicoot
9	Checkbox	southbandicoot	s	GJ_southbandicoot
10	Checkbox	brushtailpossum	p	GJ_brushtailpossum
11	Checkbox	echidna	e	GJ_echidna
12	Checkbox	sugarglider	g	GJ_sugarglider
13	Checkbox	rabbit	c	GJ_rabbit
14	Checkbox	human	h	GJ_human
15	Checkbox	dogcollared	d	GJ_dogcollared
16	Checkbox	doguncollared	u	GJ_doguncollared
17	Checkbox	noisyminer	m	GJ_noisyminer
18	Checkbox	kookaburra	k	GJ_kookaburra
19	Checkbox	lyrebird	l	GJ_lyrebird
20	Checkbox	lacemonitor	o	GJ_lacemonitor
21	Checkbox	rosemonitor	z	GJ_rosemonitor
22	Checkbox	blackrat	1	GJ_blackrat
23	Checkbox	brownrat	2	GJ_brownrat
24	Checkbox	bassianthrush	t	GJ_bassianthrush
25	Checkbox	gryshrikethrush	3	GJ_gryshrikethrush
26	Checkbox	bluetongeskink	4	GJ_bluetongeskink
27	Checkbox	brushturkey	y	GJ_brushturkey
28	Checkbox	browngoshawk	5	GJ_browngoshawk
29	Checkbox	estnyellowrobin	6	GJ_estnyellowrobin
30	Checkbox	aussiemagpie	7	GJ_aussiemagpie

I observed a few additional bird species when analyzing the image data from the four different sites and added them to the species tag list. Rock wallaby was omitted as they are not located in NSW. There are also options for dog collared, uncollared, and human, so that no images are untagged, even though those species were not of interest to this research.

Terrestrial mammals

Eleven of the species on the list are terrestrial mammals, including: swamp wallaby, fox, rabbit, joey, south bandicoot, long-nosed bandicoot, echidna, bush rat, brown rat, black rat, and antechinus.

* The rabbit and fox are non-native species to Australia

* Joeys were never observed

Arboreal mammals

Two of the species on the list are arboreal mammals, including: sugar glider and brushtail possum.

* The bush rat, brown rat, black rat, and antechinus are semi-arboreal species

Birds

Nine of the species on the list are birds, including: brush turkey, eastern yellow robin, magpie, kookaburra, brown goshawk, noisy miner, grey shrike thrush, bassian thrush, and lyre bird.

Reptiles

Three of the species on the list are reptiles, including: lace monitor, rose monitor, and blue-tongued skink.

* Rose monitors were never observed

Focus and Rationale

This project aims to identify the impacts that resource provisioning – providing supplementary food and water – has on various animal populations and add to the limited pool of knowledge on the efficacy of this conservation strategy (Fleming et al., 2014, p. 7). Evidence on the broader outcomes of resource provisioning is lacking, especially in regard to generalized provisioning and ecosystem-wide consequences (Shutt & Lees, 2021, p. 1).

Relation to sustainability

Sustainability can be broadly defined as the "ability to maintain or support a process continuously over time" (Mollenkamp, 2022, para. 1). My personal definition of sustainability is supporting and creating systems that allow humans to exist in harmony with nature without extracting more than can be put back in. In general, sustainability is broken up into three core concepts, including economic, environmental, and social (Mollenkamp, 2022, para. 2) while I personally associate sustainability with the environmental aspect most strongly. The project I am undertaking addresses the environmental section of sustainability most directly, aiming to isolate an effective conservation technique for wildlife, thus ensuring that populations can be sustained over time. Resource provisioning is a technique that humans have undertaken in order to restore animal populations that have been limited by human actions, hoping to reverse some of these adverse effects.

Research question

What are the impacts of wildlife provisioning on broader ecosystems, in terms of population diversity, relative species abundance, and richness?

Relation to study goals

By combining the management techniques of wildlife provisioning and camera trapping, this project aims to provide a comprehensive assessment of how additional resources affect population diversity, abundance, and behavior. The camera traps will act as a data gathering tool to monitor which species are interacting with resource provisions and if it impacts the number of individuals and species observed. This method allows for a non-invasive approach to wildlife monitoring while still gathering reliable information from the field.

METHODS & ETHICS

I received ethics approval from the Study Abroad Review Board (LRB) on 24 March 2023 to undertake this research project. No ethical issues arose during the study.

This project is looking at the outcomes of wildlife provisioning – providing supplementary food and water – at the site level. The main aim is to determine whether provisioning causes changes in species diversity, abundance, and richness at each site. There are four different sites that were previously set up by head researcher Chantelle Mari de Kock, two as controls (Ku-ring-gai Wildflower Garden and Turner Fire Trail) and two treatments (Golden Jubilee Field and Mccallums Road). The four sites were set up in pairs of two, a treatment (provisioned) and control (non-provisioned) at roughly the same habitat type for each pair. The experiment follows a before and after design as follows:

Before treatment

Chantelle set up camera trap arrays at each site – 17 cameras in total (Swift Enduro model SKU 7115). These cameras were left to collect data at the sites over approximately 4-6 weeks. When animals are in range of the cameras, their movement triggers the camera to capture an image.

After treatment

All sites had post-provisioning monitoring for 4-6 weeks. Provisions were no longer available at the treatment sites, and the cameras continued to capture data to see if provisioning impacted the communities.

Treatment description

Two of the four sites had provisions deployed to wildlife at the center of each treatment site for approximately 10 days, then removed. Chantelle provided food and water for terrestrial and arboreal mammals, plus bird seed. Terrestrial animals received macropod pellets, sweet potatoes, carrots, and water tubs. Arboreal animals received sweet potatoes, carrots, pumpkins, apples, pears, rock melons, bird seed block, and water drinkers. There were video camera traps to assess which species were using provisions and their behavior in addition to the standard camera array. Chantelle is writing a paper as a fourth-year honors project, using the behavioral data. Treatment sites were located at least 2km from the control sites, separated by both creeks and urban developments to avoid contamination. The paired treatment sites were located approximately 10km apart to ensure independence.

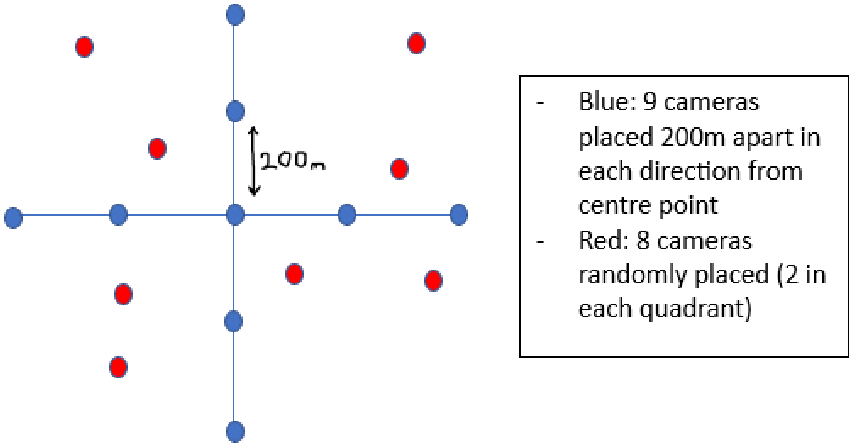


Figure 5. Example of desired positioning of the cameras at each site

Images of paired sites

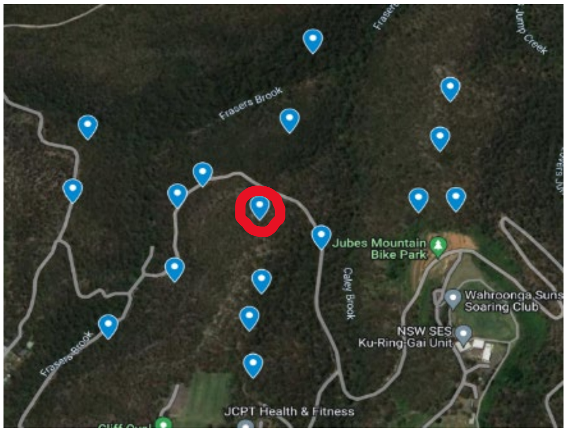


Figure 6a. Treatment (provisioning at center of site – red circle): Golden Jubilee Field

Figure 6b. Control (no provisioning): Ku-ring-gai Wildflower Garden

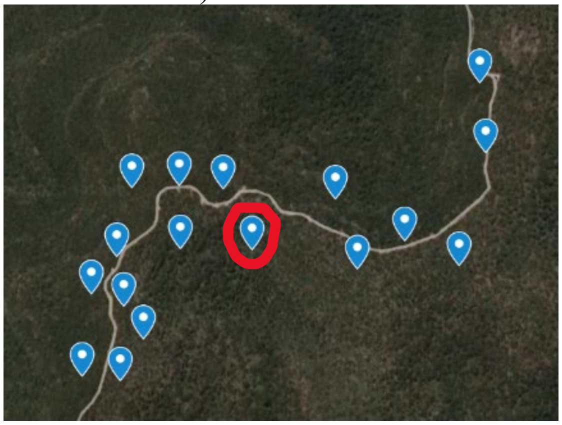


Figure 6c. Treatment (provisioning at center of site – red circle): McCallum's Road

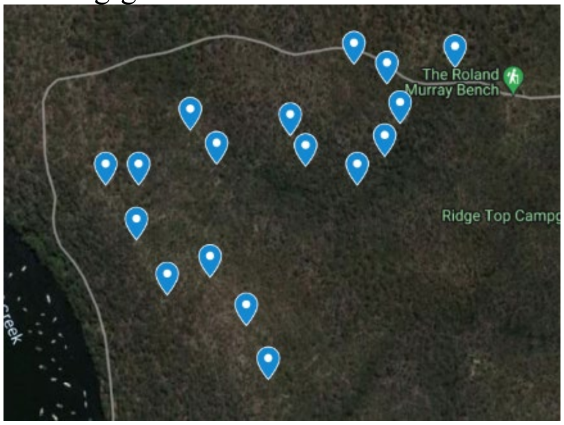


Figure 6d. Control (no provisioning): Turner Fire Trail

Camera collection

Following treatment, I assisted Chantelle in removing the cameras from the various sites. On April 12th, 14th, and 15th, 2023, we visited all four sites to gather data for analysis. We first went to Golden Jubilee and Ku-ring-gai Wildflower Garden, and only collected the SD from those cameras. Another student at the University of Sydney will continue to use the cameras at those two sites and requested that they be left up for further data collection. At McCallum's Road and Turner Fire Trail, we took down the entire camera trap arrays. The cameras are secured at the bases of tree trunks, connected by an adjustable strap and a lock that wraps around the tree.

Chantelle created a map with pins placed at the location of each camera in order to help us find them when we retrieved them. There was also colorful flagging tape set out to guide the way to each camera location.

* Link to camera map: https://www.google.com/maps/d/u/0/viewer?mid=1dJbKdoxrkfm4XzYkBf8EDAUqiR_SQHA&ll=0%2C0&z=14

Figure 7. Example of wildlife camera (Photographed by Alanah Cohen-Tigör)

Figure 8. Example of camera secured to tree (Photographed by Alanah Cohen-Tigör)

Figure 9. Chantelle de Kock collecting flagging tape from McCallum's Road site (Photographed by Alanah Cohen-Tigör)

Data analysis

After all of the cameras and SD cards were collected from the field, Chantelle uploaded the images to a Google Drive that both of us can access. I downloaded the image processing software Aardwolf onto my computer that I used to analyze the image data. I uploaded the images from the Google Drive into Aardwolf and sorted them by camera. From there, I went through each image individually and assigned a species tag. I used the preliminary species list that Chantelle provided me with and added additional species as needed. For images without any animal present, I labelled them blank, so that every image had a tag assigned to it. I then exported the data to a CVS file that I opened in Google Sheets to compile. I went through the data, filtering out unneeded information – images labelled blank, human, or dog – and combined successive photos into one sighting. Many animals were in front of the camera for extended periods of time, resulting in dozens of photos, but each photo does not count as a sighting. Any photos taken within a second of each other were combined as a singular sighting. Then I totaled up the number of species, number of sightings, and sightings per species for the Golden Jubilee site, before and after provisioning.

RESULTS

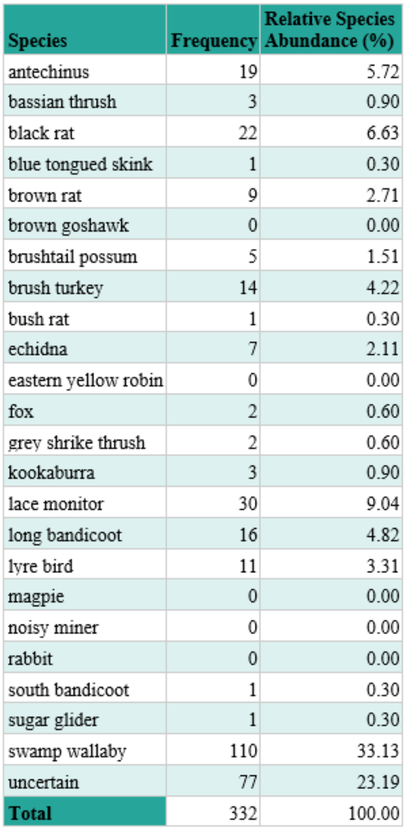
Species richness

After compiling all of the before and after provisioning data from the Golden Jubilee site, I tallied up the totals for all of the different species. From the before and after data, I found 18 different species, but there were some differences between the two. In the before images, I observed bassian thrushes, blue tongued skinks, sugar gliders, and brushtailed possums, which were not present after provisioning. In the after images, I observed eastern yellow robins, noisy miners, rabbits, and magpies, which were not present before provisioning. All of the other species observed were seen both before and after. There were more total observations of species after provisioning, while the individual species observations varied. I observed 332 individuals before provisioning and 379 afterwards.

Species abundance

Using the frequency data, I calculated relative species abundance for each species to see how they compared before and after. I used the relative frequency formula defined by Travlos et al., dividing the number of target species occurred by the number of all the species occurred, and multiplying it by 100 to reach a percentage (2018, p.2). Swamp wallabies were by far the most abundant, comprising 33.13% before provisioning and 34.30% after provisioning. Relative frequency describes the degree of dispersion of a target species in relation to the number of all the species that occurred within a sampling unit (Travlos et al., 2018, p.2).

Table 3. Species observation frequency and relative species abundance for Golden Jubilee before provisioning



Species	Frequency	Relative Species Abundance (%)
antechinus	19	5.72
bassian thrush	3	0.90
black rat	22	6.63
blue tongued skink	1	0.30
brown rat	9	2.71
brown goshawk	0	0.00
brushtail possum	5	1.51
brush turkey	14	4.22
bush rat	1	0.30
echidna	7	2.11
eastern yellow robin	0	0.00
fox	2	0.60
grey shrike thrush	2	0.60
kookaburra	3	0.90
lace monitor	30	9.04
long bandicoot	16	4.82
lyre bird	11	3.31
magpie	0	0.00
noisy miner	0	0.00
rabbit	0	0.00
south bandicoot	1	0.30
sugar glider	1	0.30
swamp wallaby	110	33.13
uncertain	77	23.19
Total	332	100.00

Table 4. Species observation frequency and relative species abundance for Golden Jubilee after provisioning

Species	Frequency	Relative Species Abundance (%)
antechinus	7	1.85
bassian thrush	0	0.00
black rat	26	6.86
blue tongued skink	0	0.00
brown rat	9	2.37
brown goshawk	1	0.26
brushtail possum	0	0.00
brush turkey	11	2.90
bush rat	0	0.00
echidna	3	0.79
eastern yellow robin	1	0.26
fox	1	0.26
grey shrike thrush	1	0.26
kookaburra	5	1.32
lace monitor	11	2.90
long bandicoot	11	2.90
lyre bird	24	6.33
magpie	3	0.79
noisy miner	1	0.26
rabbit	1	0.26
south bandicoot	5	1.32
sugar glider	0	0.00
swamp wallaby	130	34.30
uncertain	126	33.25
Total	379	100.00

$$\text{Relative frequency (\%)} = \frac{\text{number of target species occured}}{\text{number of all the species occured}} \times 100$$

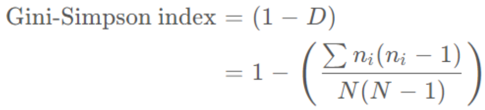
Figure 10. Relative frequency formula (Travlos et al., 2018, p.2)

Species diversity

I used the Gini-Simpson Index to calculate the species diversity before and after provisioning. Using the omni calculator website, I plugged in the frequency of each species, and it provided me with the Simpson's index, Gini-Simpson index, and Simpson's Reciprocal index for each. Before provisioning, the Gini-Simpson index was 0.79 and after it was 0.71. This suggests that there was greater species diversity before provisioning than there was after.

* Link to omni calculator:

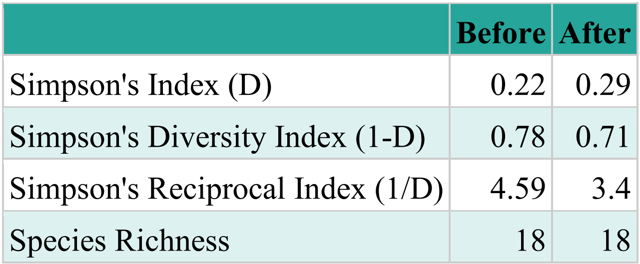
https://www.omnicalculator.com/statistics/simpsons-diversity-index



$$\text{Gini-Simpson index} = (1 - D) = 1 - \left(\frac{\sum n_i(n_i - 1)}{N(N - 1)} \right)$$

Figure 11. Gini-Simpson Index formula (Simpson’s Diversity Index Calculator, n.d., para. 10).

Table 5. Species indices and richness before and after provisioning



	Before	**After**
Simpson's Index (D)	0.22	0.29
Simpson's Diversity Index (1-D)	0.78	0.71
Simpson's Reciprocal Index (1/D)	4.59	3.4
Species Richness	18	18

DISCUSSION

Summary of findings

The data collected from the Golden Jubilee site before and after provisioning showed little to no difference in the species diversity, relative abundance, and richness. The same number of individual species were recorded both before and after provisioning, totaling 18 species each for species richness. Between the two, there were four species that were unique to before and four that were unique to after provisioning, while the rest overlapped. The relative species abundance varied for each species. Some frequencies, such as those for the swamp wallaby or lyre bird increased after provisioning, while others such as the brushtail possum and echidna decreased. In regard to species abundance, the Gini-Simpson index was higher after provisioning than before, 0.78 and 0.71 respectively. Values closer to one indicate higher species diversity, so the results suggest that there was greater species diversity before provisions were provided.

What does this mean?

Historically, there are a variety of reasons that wildlife provisioning would be provided (Shutt & Lees, 2021, p. 1). Motivations such as game management, tourism, or conservation act as drivers for wildlife provisioning (Shutt & Lees, 2021, p. 1). For the purposes of this research project, the provisioning was provided for conservation purposes and to assess if it is an affective wildlife management tool. The results from the Golden Jubilee provisioning site do not suggest that provisioning was effective at improving species diversity, relative abundance, or richness.

Implications:

While wildlife provisioning has been associated with increased survival and reproduction (Murray et al., 2016, p. 165), this study was not conducted over a long enough period of time to assess those factors. Unfortunately, supplementary feeding has also been linked to increased transmission of pathogens from humans to wildlife (Murray et al., 2016, p. 165). Due to the nature of this project, I was unable to interact directly with the wildlife to make transmission, survival, or reproductive assessments. However, the purpose of using a camera trapping methodology is to create a relatively non-invasive and safe approach to wildlife management (Fleming et al., 2014, p. 4). Through the use of camera traps, the measurements of species abundance, diversity, and richness are easily accessible via camera data. This method allows the researcher to assess what species are present, which species are interacting with provisions, and the overall diversity in the study area. It is also notable that provisioning is most effective when applied to nutritionally limited, drought prone, or energetically expensive environments (Shutt & Lees, 2021, p. 2). Even if wildlife provisioning is not suited for every environment, it has the potential to be beneficial in environments in crisis, which is more likely to be prevalent as climate change decimates our planets.

Limitations:

Due to the short time period allotted for this ISP, I was not able to analyze data from all four sites, limiting the conclusions I can draw from my research. I was only able to get through the data from the Golden Jubilee site, but not the other treatment site or the control sites. I had originally planned to complete both Golden Jubilee and its paired control site, Ku-ring-gai Wildflower Garden in order to do a statistical analysis to measure significance of my findings. Unfortunately, I did not have time to analyze the data from both sites, so I was limited to just the before and after provisioning on one site. Additionally, I was only able to assist in one piece of the larger project that Chantelle has been working on, so I could not contribute to the study design of this project.

Future research:

In the future, I would like to continue working with the data from the other three sites to conduct a comprehensive analysis of the entire study area. Chantelle has already given me permission to continue accessing the image data once I return to the United States. She has only had time to analyze the video data depicting animal behavior to include in her paper, so she is hopeful that other people will use the data. At my home school, Vassar College, I work on a different wildlife camera trapping project, and brought with me skills that helped while working on this project. My home school also requires that I complete a senior thesis for my final year, so there is potential that I could combine both of these avenues of research.

At the University of Sydney, there are other students working on research in this field, assessing the efficacy of wildlife provisioning post bush fires. This project aims to understand how ecosystems recover after environmental disasters, and if wildlife provisioning can assist animals' recovery. This type of research could be extrapolated to other ecosystems and environmental disturbances.

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Appendix

* Link to spreadsheet with raw data – too large to include in the paper

https://docs.google.com/spreadsheets/d/1bR8HvCd58CR34uDXcrSvZmb9RX2BzfuHFqqgFg7Vnns/edit#gid=0