Bee hotels to boost bees after bushfires Report BRCG000116 Australian Native Bee Association Inc Bushfire Recovery for Wildlife & Habitat Community Grants Program

Dr Kit Prendergast and Dr Rachele Wilson, on behalf of the Australian Native Bee Association

Wildlife and Habitat Bushfire Recovery Program Application
Project Title: Bee hotels to boost bees after bushfires
Applicant: Australian Native Bee Association (ANBA)

The project **Bee hotels to boost bees after bushfires** supported the recovery of native bee populations by installing artificial nesting substrates (bee hotels) in areas of high biodiversity value that were impacted by the 2019/20 bushfires. This was achieved through an Australia-wide citizen science effort, as well as through intensive monitoring of 100 bee hotels (50 bamboo and 50 wooden) and visual surveys at five burnt sites and three control sites by a native bee ecologist.

We recruited and provided information resources to 63 community groups and citizens to support native bee recovery in fire-affected regions across the country. An iNaturalist project facilitated citizen science data collection and allowed us to evaluate the impact of installed bee hotels and their uptake by bees: https://www.inaturalist.org/projects/bee-hotels-to-boost-australian-bees-after-the-bushfires. 195 observations were uploaded to this project by citizen scientists.

Importantly, at least 900 nests were created by bees in the bee hotels installed for this project and significantly more bees were observed in sites with bee hotels compared to control sites (nearby burnt sites without bee hotels). All milestones were met within the anticipated timeline (Table 1) and budget, even with setbacks for some participants due to the pandemic. The project also attracted many participants and nation-wide interest, thus increasing awareness of native cavity-nesting bees.

Table 1. Milestones and evidence

Milestone title	Milestone description	Governance & roles	Evidence / comments
Publicise the project	Publicise project on social media and contact landcare and community groups, indigenous community groups, schools, environmental organisations (potential citizen science pool) Create article on the project in the ANBA monthly newsletter	ANBA, Kit Prendergast, Rachele Wilson	Facebook posts: Bees in the burbs 1. 1.9K reached, 23 engaged 2. 5.1K reached, 68 engaged 3. 17.1K reached, 235 engaged Creating a Haven for Native Bees Facebook page: 1,493 people reached; 18 reactions; 1 share @beescapes_au: Instagram: 2,267 people reached (63 interactions) Facebook: 3,264 people reached (450 interactions) + 1,063 people reached (27 interactions) + 988 people reached (33 interactions) Twitter: 1,482 people reached (59 interactions) Bee Hotels - to boost bees after fire with Dr Kit Prendergast, Bee Babette! Atlas of Life South Coast National Science Week Program 2021 https://atlasoflife.org.au/2020-national-science-week-1 Recording available: https://www.youtube.com/watch?v=6noyiAac0Nc All the Dirt podcast "Episode 148: Native Bees and Pollinators with Kit Prendergast": https://www.allthedirt.com.au/podcast/2021/7/19/episode-148-native-bees-and-pollinators-with-kit-prendergast?fbclid=IwAR2DNI_tnH4nA8KKLNHK1V-LoRkvlrP8kKR7SmCy64mP4dIzKFFWeoAEJzc TripleM interview aired on regional WA networks on the 'Bee Hotels to Boost Bees After Bushfires' project, July 2021 Cross Pollinator Article:

			Prendergast, Kit. 2021. "Bee hotels to boost bees after bushfires", *The Cross Pollinator,* April 2021, issue 21, p. 8. ISSN 2652-8010 [published by the Australian Native Bee Association]. Reached 617 members. (see attachment for article) 63 respondents, with some respondents being leaders of community groups
Design bee hotel prototype template	Design an effective easy-to-make bee hotel as a template for citizen scientists and communities to replicate	Kit Prendergast	See below
Create how-to media (video and online document) for bee hotels & submitting citizen science observations	Create how-to media (video and online document) on how to make bee hotels, and how to install and monitor them and submit observations to the citizen science iNaturalist project.	Kit Prendergast	Links to files and videos emailed out to all participants and shared on the Facebook group Bee Babette's 'How to make a bamboo bee hotel': as of 16th Sept 2021, 257 views on Youtube https://youtu.be/z_irhSwRCN8 Bee Babette's 'How to make a wooden bee hotel': as of 16th Sept 2021, 131 views on Youtube https://youtu.be/iCYnbDbZoLY
Bee hotel workshops	Hold workshops in 3 x towns near fire-affected regions in the state on importance of	Kit Prendergast & Rachele Wilson	Dr Kit Prendergast bee hotel workshops: Araluen July School Holidays Bee Hotel Workshops 9th & 11th July 2021 Wooroloo native bee hotel workshop 6th July 2021 Native bee presentation for City of Busselton 13th July 2021 City of Joondalup Bee Hotel Workshop 3rd June 2021

	native bees and pollination, & show the bee hotel prototype, describing how to make bee hotels and monitor them, and contribute to the citizen science project		Dr Rachele Wilson bee hotel workshops: Citizen Antennae: Powering invertebrate research through citizen science" council event in Maleny. Coolum Community Native Nursery and Noosa District Landcare groups (presented in Oct due to COVID19)
Email out 'Creating a Haven for Native Bees' ebook and bee hotel design prototype	Email out 'Creating a Haven for Native Bees' ebook and bee hotel design prototype to communities and citizens who have expressed they will be involved in the community monitoring component of bee hotels	Kit Prendergast	Completed.
Create Facebook group	Create Facebook group 'Bee hotels to boost Australian bees after the bushfires' managed by Kit Prendergast and	Kit Prendergast	Facebook group 'Bee hotels to boost bees after bushfires': https://www.facebook.com/groups/bushfirebeehotels As of 21st Sept 2021, 48 members

	ANBA to promote the project, solicit interest from the community to participate, share information and resources, and provide the community with updates and a forum to ask questions and discuss results.		
Create iNaturalist project	Create iNaturalist project 'Bee hotels to boost Australian bees after the bushfires' for communities to submit observations of bee hotel use in fire affected areas.	Kit Prendergast	Completed: https://www.inaturalist.org/projects/bee-hotels-to-boost-australian-bees-after-the-bushfires
Make bee hotels	With the assistance of Men's Sheds make bee hotels for the fieldwork bee hotel installation and	Kit Prendergast, Men's Sheds, individuals and communities involved in	100 bee hotels made of the wooden block and bamboo PVC pipe designs

	monitoring by Kit Prendergast in southwest Western Australia.	the citizen science project	
Set up bee hotels at sites	Install 10 bee hotel sets (1 wooden + 1 bamboo per set) at five fire-affected sites in the southwest Western Australian biodiversity hotspot	Kit Prendergast	Bee hotels installed at all sites
Monitoring Sept - March	Visit the 5 sites to photograph bee hotels. Spend 2hr surveying native bees foraging at the sites. Visit 3 sites without bee hotels to survey native bees for 2 hrs as controls.	Kit Prendergast	Surveys completed.
Citizen science observations via iNaturalist	Throughout the bee activity season Sept – March citizens and community members who	Communities in fire-affected areas across Australia	As of March, 195 observations from 19 iNaturalist Project members.

	have set up bee hotels in fire-affected regions will photograph their bee hotels and upload photos to iNaturalist.	Checked by Kit Prendergast and Rachele Wilson	

Results and Discussion

Intensive bee surveys in the southwest Western Australian biodiversity hotspot.

Bamboo and wooden bee hotels (Fig. 1) were installed just before spring (in August) and were occupied by bees from October 2021. By the end of the study period (March 2022), the recovery action was a major success, with the majority of bee hotels occupied at every site (Fig. 2A, B). Total number of nests occupied was high, with up to 283 total nests occupied at just one site. Across all bee hotels across all five sites, a total of 900 nests were occupied (Fig. 2C, D). If we assume an average of three cells per nest (Prendergast, 2018), this means that 1,200 native bees would emerge in the next generation.

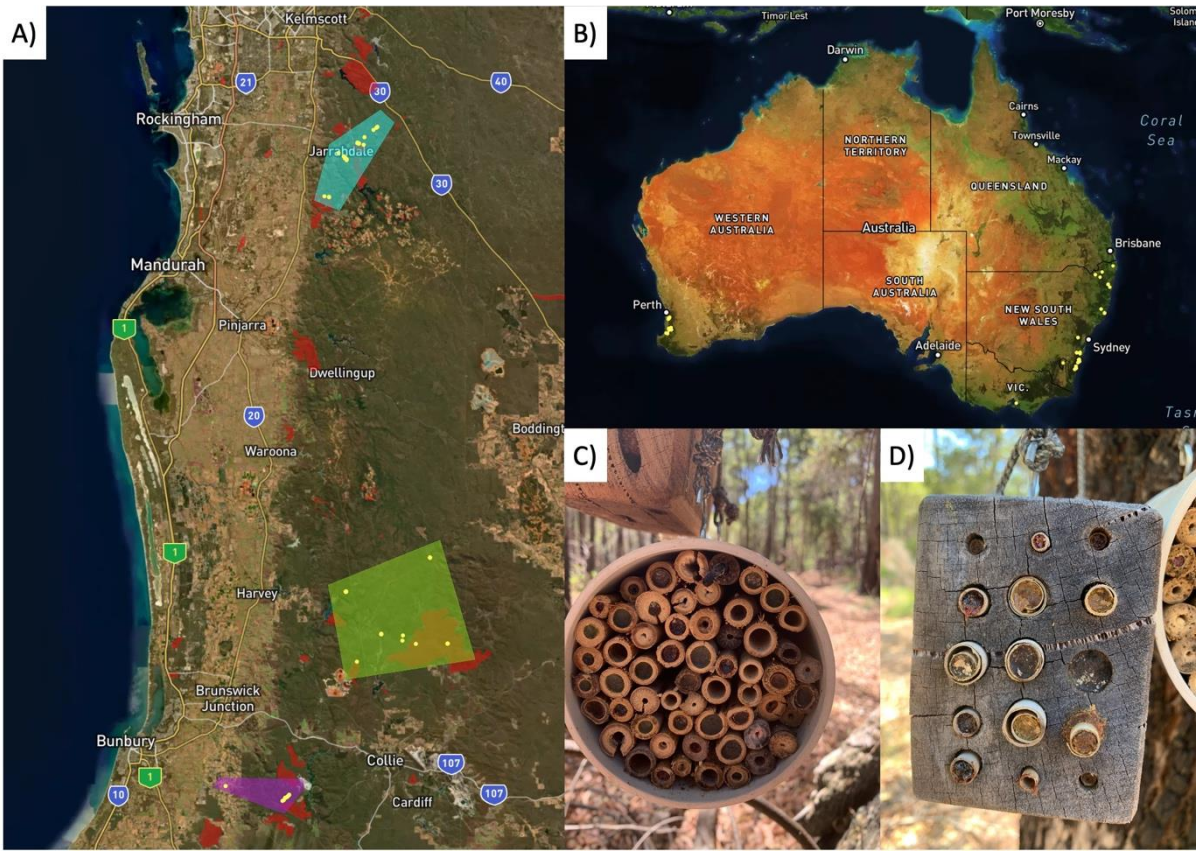

Fig. 1. Locations of bee hotels (yellow points) installed by Dr Prendergast in Western Australia (A) at Jarrahdale (blue), Harris River (green) and Wellington State Forest (purple) and by citizen scientists along the east coast of Australia (B). Occupation of bamboo (C) and wooden (D) bee hotels is indicated by "capped" nests.

There was some variation in bee hotel uptake between the sites. The Jarrahdale locations had very high occupancy (maximum occupancy by December at one site and March at both sites; Fig. 2). Even the site with the slowest uptake, Wellington State Forest, had 70% to 90% of wooden and bamboo bee hotels occupied, respectively, by March. (Fig. 2). Slow uptake at some sites may have been due to few flowering resources during the time when the cavity-nesting bees were active (pers obs.).

Comparative bee surveys found there was significantly more bees observed in the sites with bee hotels (mean = 41.3 ± 28.5 per day per month) compared to sites without bee hotels (mean = 1.62 ± 0.75; delta AICc = 10.4, $p<0.01$). Surveys at control sites (nearby burnt sites with no bee hotels installed) had relatively few bees, especially during the latter part of the season, suggesting that sites with bee hotels were attracting bees to the area as the season progressed (Appendix 2). In addition,

most bees were observed in these latter months at the bee hotels. However, it is possible that some bees foraging high in the canopy were missed in surveys, as the only flowering resource at this time of the year was *Corymbia calophylla*.

No bees were observed using bee hotels until October (Fig. 2). This is consistent with previous research in southwest WA where the main period of activity for cavity-nesting bees in this region is not until Nov – Feb (see Prendergast, 2020a; Prendergast, 2020b). Ground-nesting bees were observed during the earlier months, and as the season progressed this was replaced by cavity-nesting bees dominating the observed bees. The major increase in occupancy occurred in January and March at Jarrahdale, and March for Harris River, especially at one of the sites (Fig. 2).

By the end of the project, the proportion of bamboo and wooden hotels was fairly equal. A greater number of holes were occupied in the bamboo bee hotels, however this relates to how there were a greater number of potential holes to be occupied (up to about thirty), as opposed to the fixed number of potential nests in the wooden ones (fifteen). Occupation by bee hotel hole diameter was assessed to determine any preferences to aid future designs. The most frequently occupied design were holes with a diameter of 7mm (136 nests), followed by 4mm (113 nests) then 10mm (78 nests) (Appendix 3).

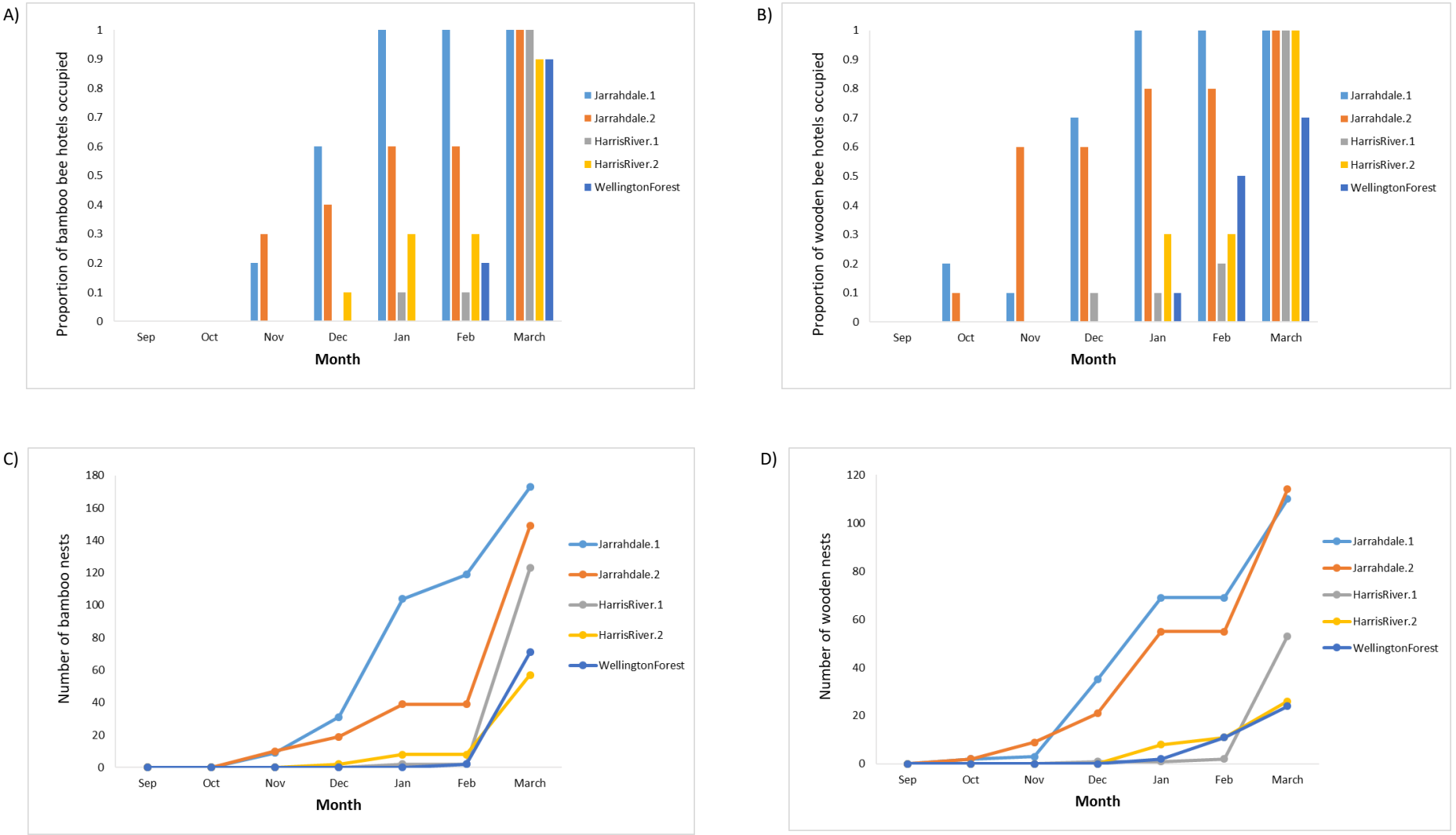

Fig. 2. Bee hotel occupancy across the five sites over the survey period (September - March 2021/22). Proportion of bee hotels occupied for A) bamboo and B) wooden bee hotels, and number of nests completed for C) bamboo and D) wooden nests.

Taxonomic composition of bee hotel communities

The majority of bee occupants were *Megachile* species, as evidenced by the resin, resin and sand, or chewed plant material nest caps (Appendix 1). No megachilids in the *Eutricharaea* subgenus ("leaf-cutters") used the bee hotels. Hylaeinae, which cap their nests with a polyester-like secretion, were the next most common (Appendix 1). This species composition is similar to that from urban bee hotel studies in the same greater region of southwest Western Australia (Prendergast et al., 2020). Unlike in the previous study (Prendergast et al., 2020), *Exoneura* bees used the 4mm wooden nests as well as a few observations in bamboo stems.

Although many native bee species cannot be identified based on field observation alone (as diagnostic characteristics are microscopic), the megachilids observed in the field during bee hotel monitoring were species Dr Prendergast is very familiar with, and the following megachilid species could be identified confidently: *Megachile erythropyga, Megachile aurifrons, Megachile oblonga,* and *Megachile monstrosa.*

Other occupants

A variety of non-target organisms were found using bee hotels installed by researchers (Appendix 1) and citizens (Appendix 5), especially during the earlier months. These were mainly spiders and ants, but also wasps and even a raspy cricket.

Foraging resources

Regenerating flower resources used by bees were identified in field surveys (Appendix 4). No exotic flowers were visited by native bees, whereas some exotic "weeds" were visited by honeybees. This is consistent with the preference of native Australian bees for Australian flora, compared with the more generalist flower preferences of the exotic honeybee (Prendergast, 2021a, b; Prendergast & Ollerton, 2021; Prendergast et al. 2022). It should be noted that, during some surveys, almost no flowers were observed. This was also noted in some of the citizen scientist notes on iNaturalist.

Earlier in the season (spring) native peas (Fabaceae: *Bossiaea*) were important foraging resources, and later in the season (summer) *Corymbia calophylla* (Myrtaceae) trees were an important resource. Whilst the *Bossiaea* is considered a "leguminous fire-weed" (Bell & Koch, 1980), the *Corymbia calophylla* was able to flower because the trees had survived and the canopy was flowering. However, with a devastating fire, mature trees may not survive and regrowth could take at least half a decade to reach maturity (Wajon, 2020).

Honeybee competition

Honeybees have the potential to compete with native bees for flowering resources (nectar and pollen), especially if resources are limiting (Prendergast et al. 2022b) such as post-fire. We found less native bees were observed and less bee hotel cavities were occupied if honeybee numbers in the area increased. Generalised linear mixed effect models were used to test the association between honeybees observed with bee hotel occupancy and native bees observed foraging. There was a significant, negative association between bee hotel occupancy and number of honeybees observed (estimate -0.451, se 0.022, delta AIC 1122, $p<0.01$) (Fig. 3). There was also a significant, but weak, negative association between honeybees observed and native bees observed (estimate -0.157, se 0.011, delta AIC 344, $p<0.01$).

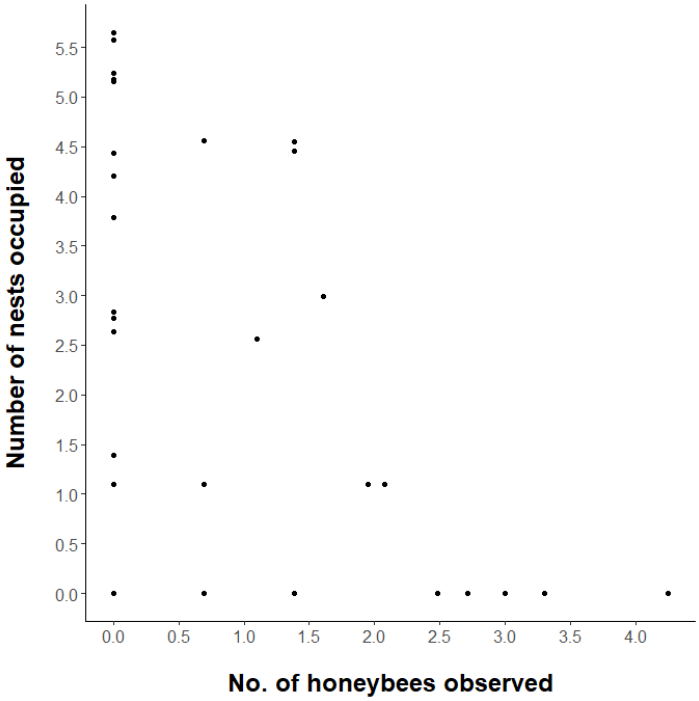

Fig. 3. Relationship between number of nests occupied and number of honeybees. Data are log+1 transformed for visualisation purposes.

Citizen Science Results

Citizen scientists contributed 195 bee hotel observations to the project (Fig. 1). A total of 66 bee hotels were installed by the citizen scientists. Of these, by the end of the reporting period, only ten had been occupied by bees (Appendix 5). Most were either unoccupied or had been occupied by non-target taxa (spiders, wasps, ants) (Appendix 5).

There were 63 respondents to the call-out for participation, 52 of which joined the Facebook group and 27 joined the iNaturalist project. Of those who joined the iNaturalist Project, there were 19 active participants (excluding researchers). One community group, Wallabi Coast Care, uploaded the greatest number of observations. The majority of participants were from burnt regions in NSW, with one participant each from Vic and ACT. The final month of data collection was hindered due to extreme flooding on the east coast.

The discrepancy in colonisation between the bee hotels installed by Dr Prendergast compared to citizen scientists may be due to differences in biogeography or designs. For example, there may have been more extreme fires in citizen scientist sites on the east coast compared to researcher sites in WA and bee fauna may be better adapted to fires in southwest Western Australia. Further, despite a book, instructional videos, and step-by-step detailed instructional guides being sent to all participants, many did not adhere to the optimal design, and still featured bamboo stems that were too wide, or had bamboo internodes close to the hole entrances.

Conclusion

Our on-the-ground intensive bee hotel installations and monitoring demonstrate that providing bee hotels for cavity-nesting bees allows native bees to recolonise post-fire habitats. Comparing native cavity-nesting bee populations, and bee hotel occupancy, at unburnt sites in the same region could further indicate the impact of fires on this guide of native bees, and the use of bee hotels in burned

areas. A comparison of pre- and post-fire cavity-nesting bee populations in the same sites would be ideal to determine the impact of fire and recovery actions. Such baseline data is unavailable, however, surveys of foraging bees in sites with and without bee hotels found there was significantly more bees observed in the sites with bee hotels. Furthermore, a previous study of bee hotel communities in urban sites in the same region in 2016/17 (Prendergast et al. 2020) found a lower occupancy among bee hotels compared to the present study (162 vs. 283 nests). This suggests that suitable nesting cavities are limited in burnt habitats and that installing bee hotels can aid recolonization by native cavity-nesting bees.

Appendices

Appendix 1. Raw data of bee hotel use at the five sites in southwest Western Australia monitored by Dr Kit Prendergast

Appendix 2. Bees observed at all sites (five treatment, three control) in southwest Western Australia monitored by Dr Kit Prendergast

Appendix 3. Holes diameters of wooden bee hotels occupied in southwest Western Australia monitored by Dr Kit Prendergast

Appendix 4. Flowering resources bees were observed foraging on in southwest Western Australia at sites monitored by Dr Kit Prendergast

Appendix 5. Citizen science data

References

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