How many bees do we need and how many do we have?

Ben Oldroyd, University of Sydney

AgriFutures™ Securing Pollination

Australian Government
Department of Agriculture and Water Resources

THE UNIVERSITY OF SYDNEY

AgriFutures Australia

What are the densities of feral honey bee colonies in natural and agricultural areas across Australia?

- Is pollination satisfactory?
- Biosecurity response
- Conservation concerns
- Access to forests

Recommended stocking rates for most crops

2-8 hives / ha

- FREE J. B. (1970). *Insect pollination of crops*. Academic Press
- MCGREGOR S. E. (1976). *Insect pollination of cultivated crop plants*. USDA Washington.
- DELAPLANE, K.S AND MAYER, D.E. (2000). Crop pollination by bees. CABI Publishing

Actual stocking rates in many Australian crops

She'll be right mate. Plenty of bees up in them hills

Surveys show that the density of feral bee colonies in Australia is 10-100 times lower than the recommended stocking rate.

- Wyperfeld National Park Victoria: 0.5-1.5 colonies per ha
- Grenfell NSW 0.005 colonies per ha
- Stratford NSW 0.0025 colonies/ha

OLDROYD B. P., THEXTON, E. G., LAWLER, S. H. & CROZIER, R. H. (1997). Population demography of Australian feral bees (*Apis mellifera*). *Oecologia* **111,** 381-387.
HINSON E. M., DUNCAN, M., LIM, J., ARUNDEL, J. & OLDROYD, B. P. (2015). The density of feral honey bee (*Apis mellifera*) colonies in South East Australia is greater in undisturbed than in disturbed habitats. *Apidologie* **46,** 403-413.

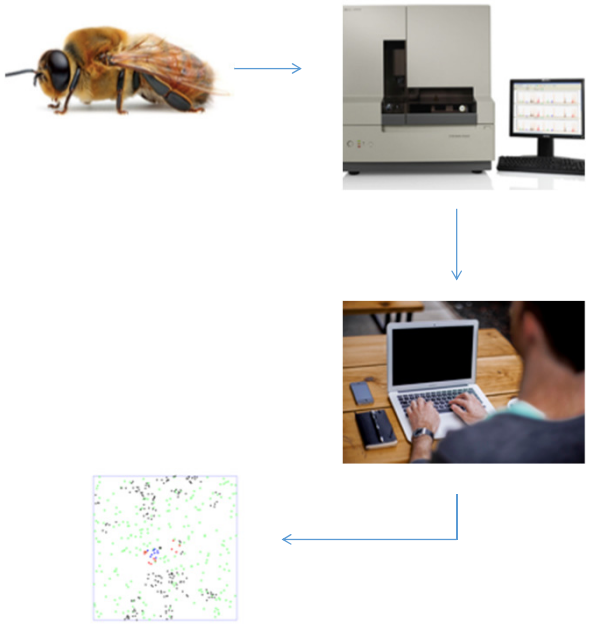
Are there enough pollinators in our agricultural landscapes?

Manual surveys are too slow

OLDROYD B. P., SMOLENSKI, A., LAWLER, S., ESTOUP, A. & CROZIER, R. (1995). Colony aggregations in *Apis mellifera*. *Apidologie* **26,** 119-130.

Much easier to have the bees come to you

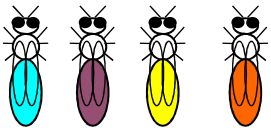
- Catch drones
- Genotype drones at microsatellite loci
- Use complicated maximum likelihood program
- **Number of feral colonies in flying range**



Queen in unknown colony

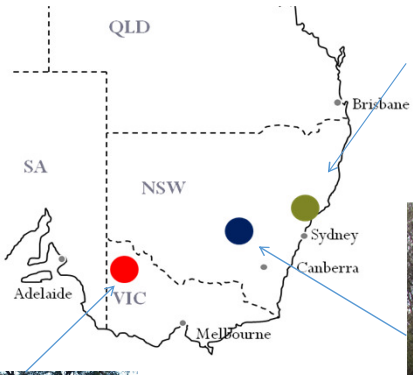
22 28
36 36
13 17
16 12
8 5
96 89

Sons



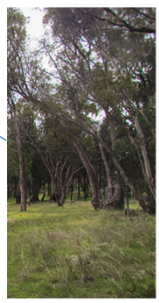
22	28	28	28
36	36	36	36
13	17	13	17
16	12	12	16
8	5	8	5
89	96	89	89

Maximum of 2 alleles per locus per mother. All her sons carry one of these alleles



Rainforest

Arid Malley



Eucalypt forest

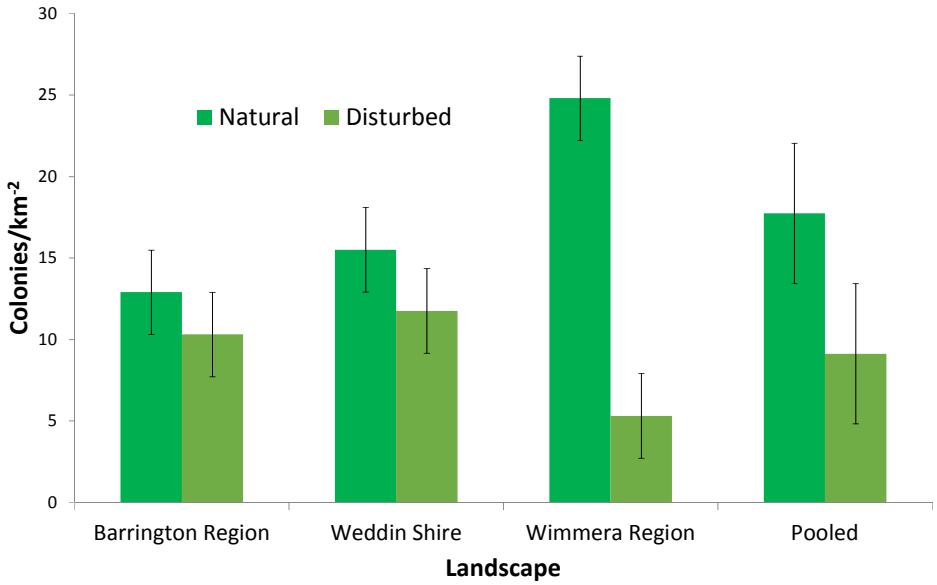
Disturbed and undisturbed sites

Grenfell agricultural area and Wedden Mountains National Park

NSW survey

Site	Disturbed/natural	Drones sampled	Estimated colonies/km^2
Gloster Tops	Undisturbed	79	10.4
Stratford Park	Disturbed	123	5.6
Allyn River	Undisturbed	72	15.4
Monkerai	Disturbed	70	13.8
Ben Hall's cave camp	Undisturbed	62	12.2
Grenfell	Disturbed	70	12.9
Holly camp	Undisturbed	278	18.9
Tyagong	Disturbed	74	10.6
Black flat	Undisturbed	222	27.7
Lake Albacutya	Disturbed	29	6.2
Lake Brambrook	Undisturbed	241	21.0
Yaapeet	Disturbed	13	4.4

Hinson, E.M., et al. 2015. The density of feral honey bee (*Apis mellifera*) colonies in South East Australia is greater in undisturbed than in disturbed habitats. *Apidologie* 46: 403-413.



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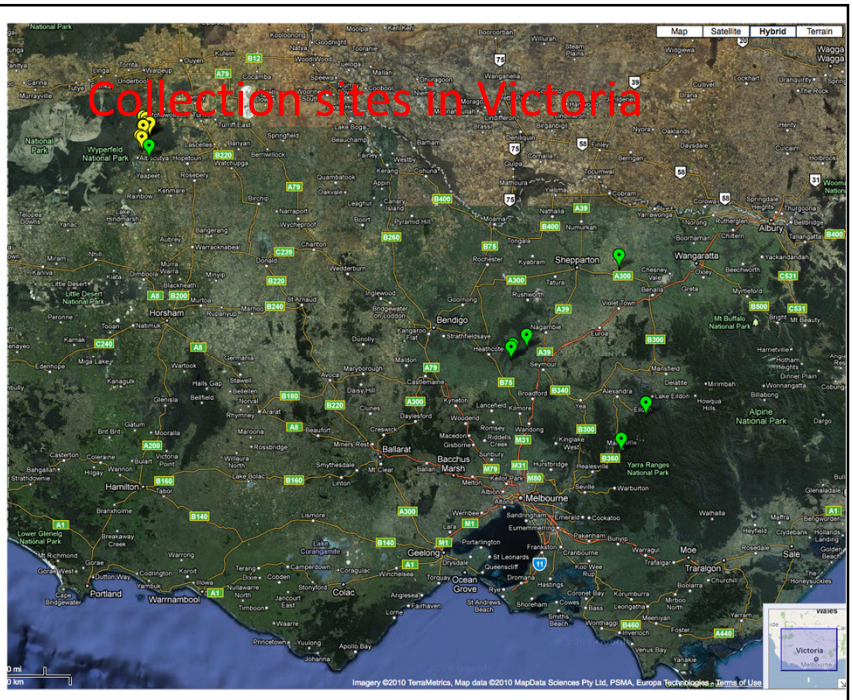
Victoria



Victorian survey

Site	Colonies / km² 2 km flight range	Colonies km² agent based models
Wyperfeld	6.4	0.9
Yaapeet	5.6	0.7
Dookie	3.1	0.4
Pukapunyal	2.7	0.3
Eildon	3.3	0.6
Marysville	2.9	0.4

Note that this is 10-100 times less than recommended (50 colonies / km ^{2})

Arundel, J., B.P. Oldroyd, S. Winter. 2012. Modelling honey bee queen mating as a measure of feral colony density. *Ecol Mod* 247: 48-57.
Arundel, J., et al. 2014. Remarkable uniformity in the densities of feral honey bee *Apis mellifera* Linnaeus, 1758 (Hymenoptera: Apidae) colonies in South Eastern Australia. *Aust Ent* 53: 328-336.

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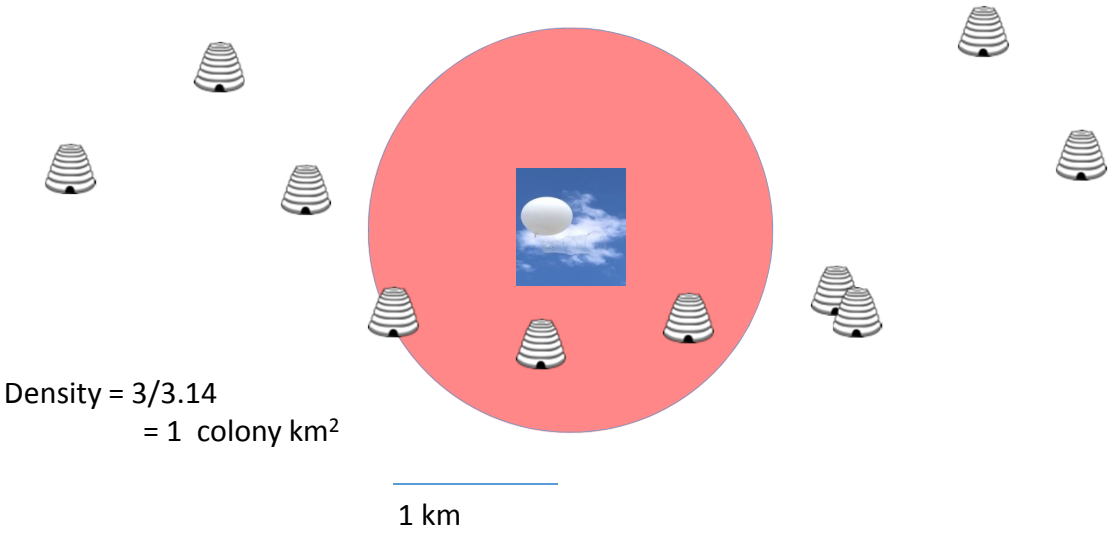
Marysville fires

How far do drones fly?

- Need to exactly know how far males fly

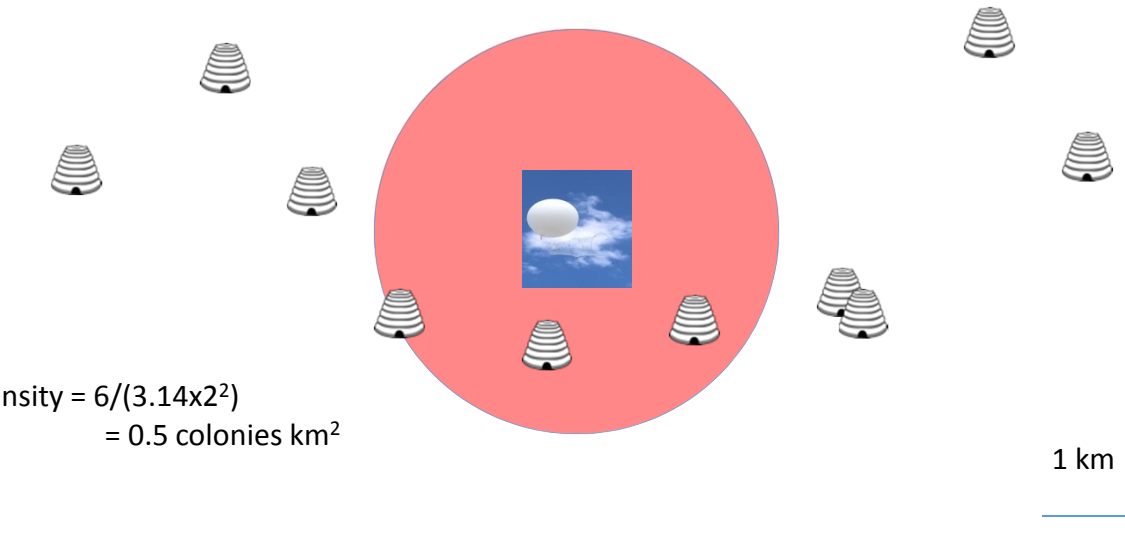
From how far can we attract males?



Density = 3/3.14
= 1 colony km^2

1 km

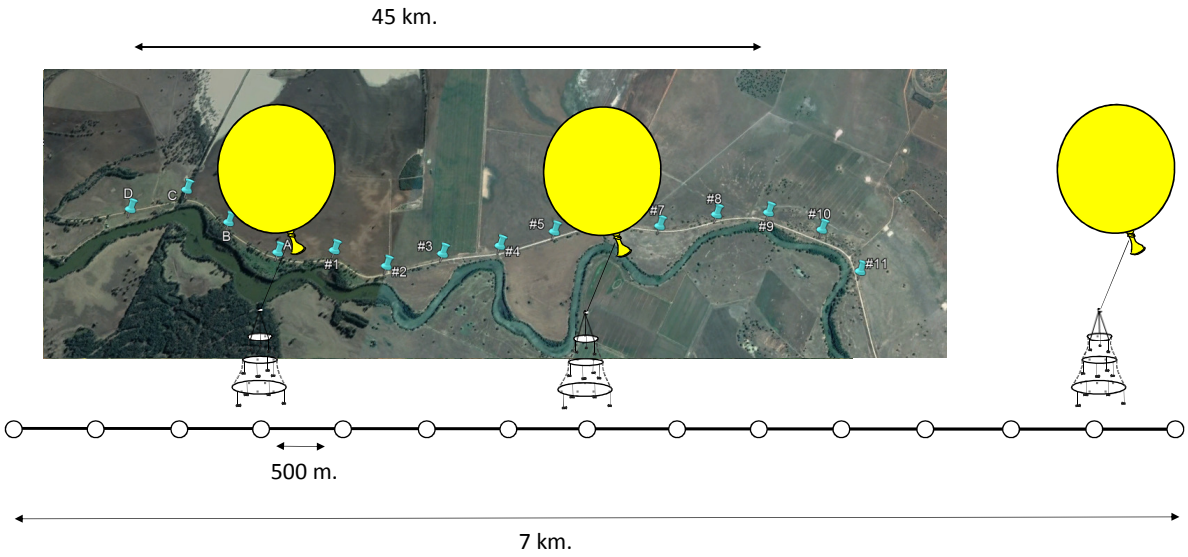
From how far can we attract males?

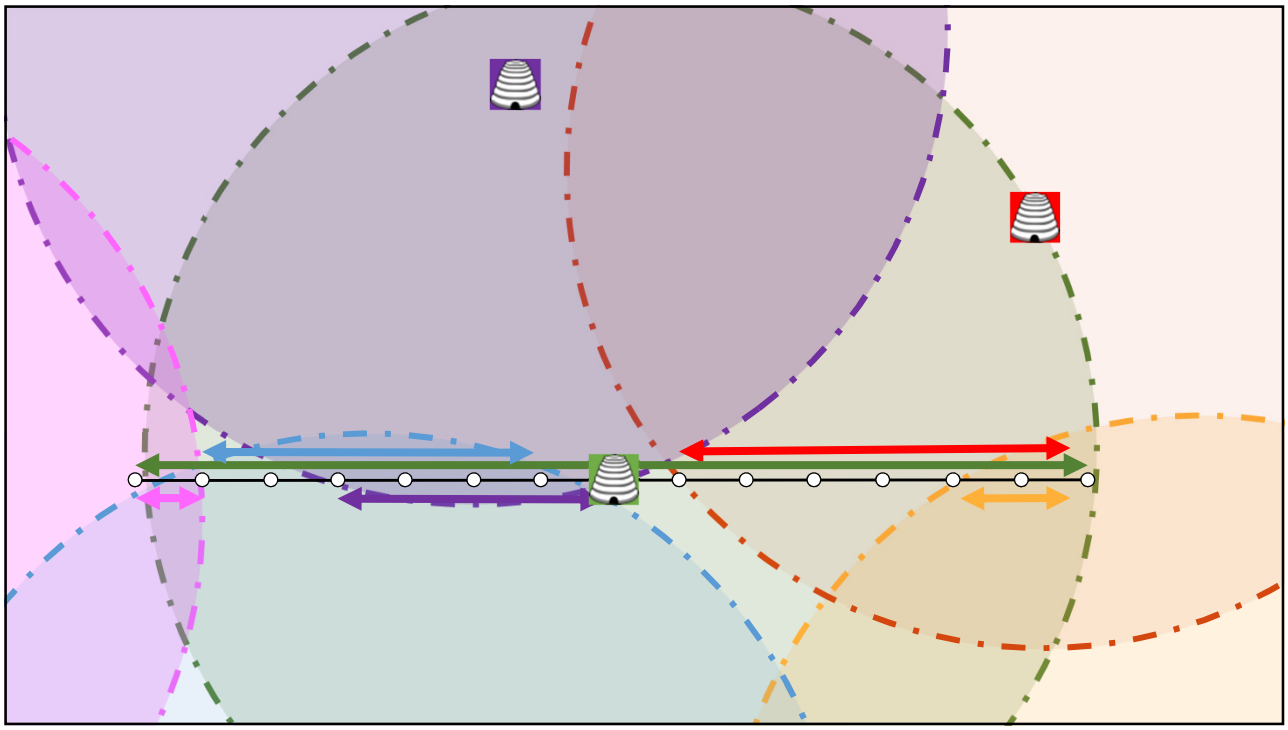


Density = 6/(3.14x2^2)
= 0.5 colonies km^2

1 km

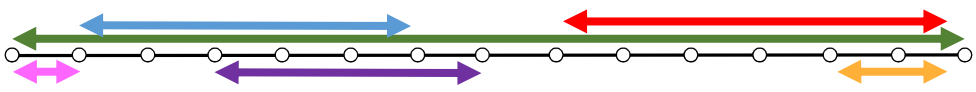
Murrumbidgee River, Wagga Wagga, NSW





AVE
SAM

Average Radius = 1.73 km
Average flight range = 3.46 km
Average area sampled = 9.40 km^2
n = 4343 drones sampled and genotyped
N_c > 230 colonies each



Transect experiment summaries

First transect

Average Radius = 1.82 km
Average flight range = 3.64km
Average area sampled = 10.41 km^2
n = 2288 drones sampled and genotyped
N_c = 236 colonies
Colony density* = 25.11 colonies/km^2

Second transect

Average Radius = 1.63 km
Average flight range = 3.26 km
Average area sampled = 8.34 km^2
n = 2055 drones sampled and genotyped
N_c = 263 colonies
Colony density* = 27.98 colonies/km^2

* Based on an average area sample from both experiment (9.4 km^2)

Conclusions

- Density of colonies in Wagga is 4.04 colonies per km^2
- A single balloon attracts drones from a 7.8 km^2 radius
- Average flight range: 3.16 km
- Maximum flight range: 7 km
- Probably better to sample from two spots 500 m apart.

A potential problem – worker-laid males

Queen-laid drone brood (big cells)

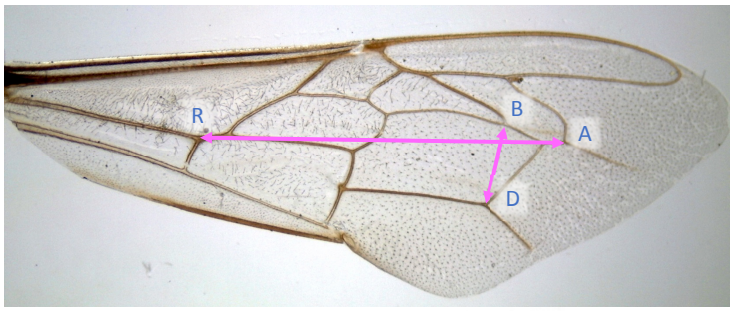
Worker-laid drone brood (little cells)

- We noticed that in early sprin
- If they are worker-laid, that v number
- Worker-laid males would be dec colonies.

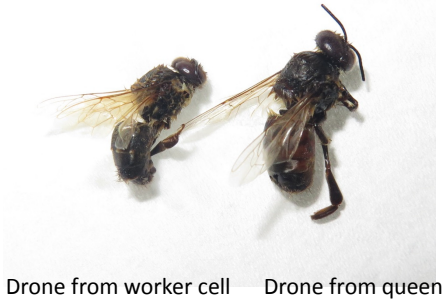
I'M NOT YOUR BROTHER; I'M YOUR NEPHEW!

Drone from worker cell (Queenless colony)

Drone from queen cell (Queenright colony)

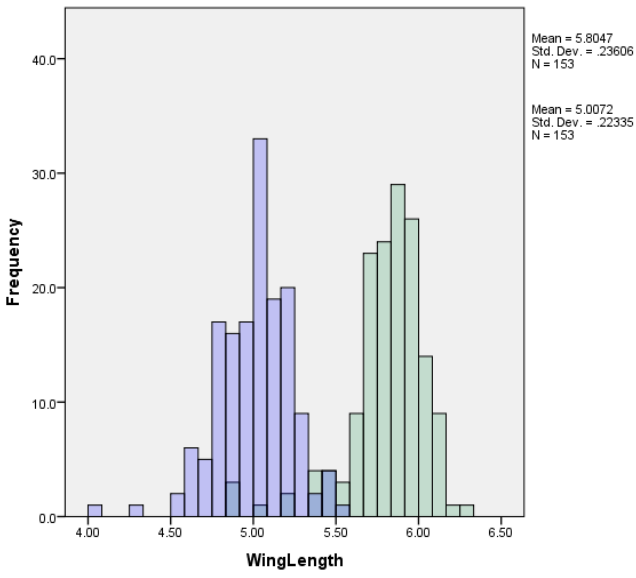


Wing size of worker-laid and queen-laid males



Drone from worker cell (Queenless colony)

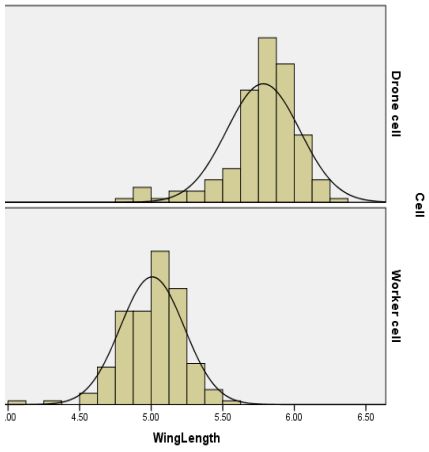
Drone from queen cell (Queenright colony)



Wilk's lambda = 0.277

P < 0.001

5.70% misclassified (18/316)

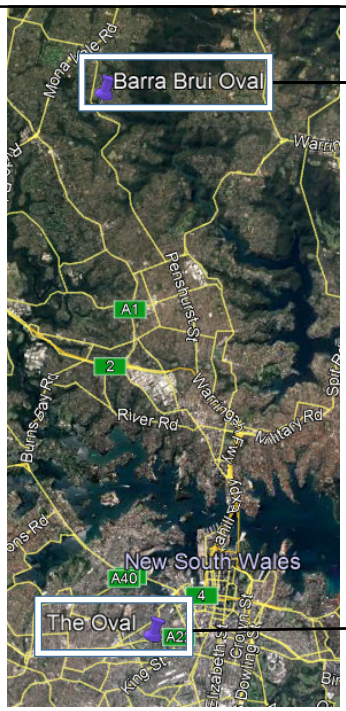


We reject small bees

- Any male with a wing width less than 5.5 mm will be discarded.

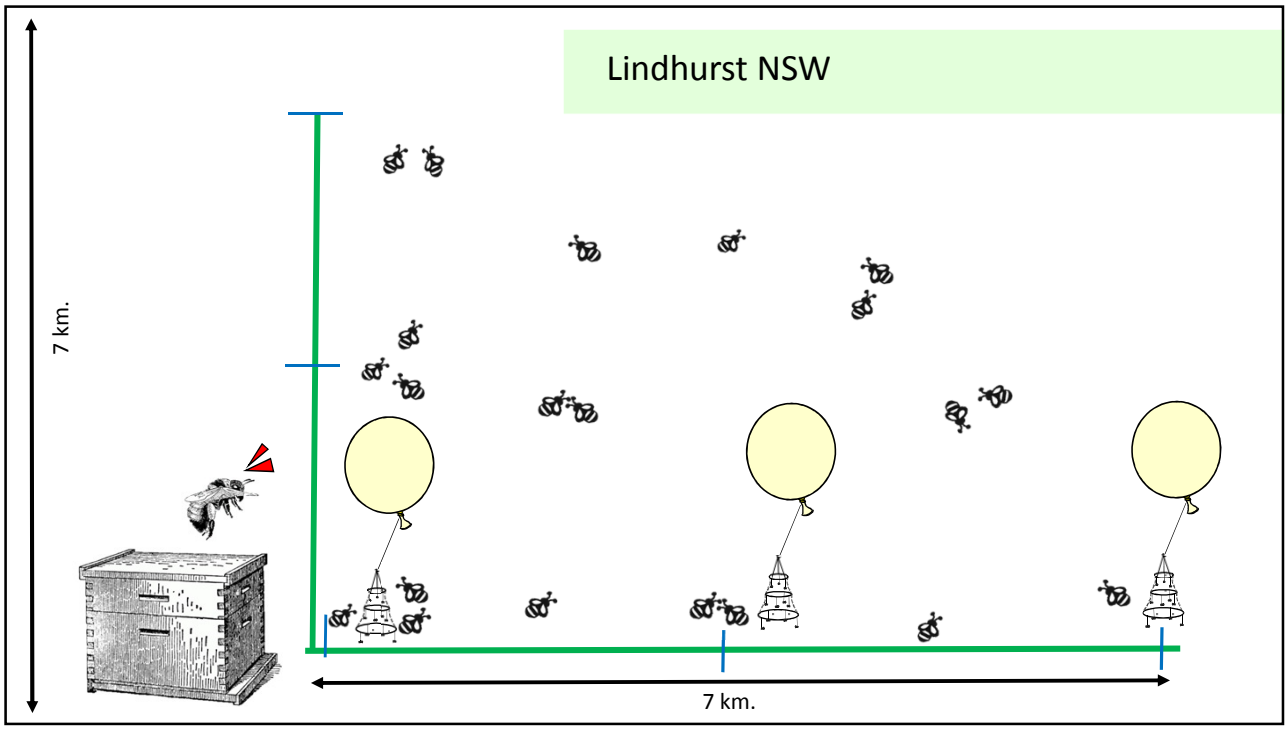
We are interested in how colony density and identity change across time.

- Sampling two ovals in Sydney once a month throughout the project.



Plans for spring

- Transect out from one colony in an isolated area.
  - How far will the drones fly?
- Drones to watch drones
  - Observe how drones behave around drone balloons



- Our dedicated team of professional drone catchers and gene jocks is eager to sample near your crop!

Michael Holmes
Wee Utaipanon

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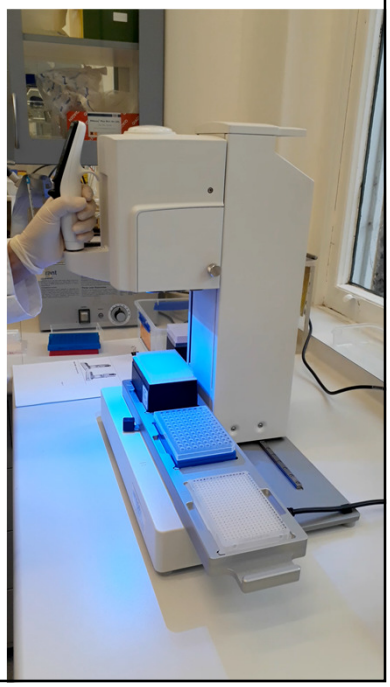
gy PhD students
robots!



Securing Pollination

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Thanks to: Bob McDonald, Jonathan Arundel, Eloise Hinson, Gabi Buchmann, Michael Duncan

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