A framework to dynamically price almond pollination contracts through hive strength

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Introduction - Measuring Pollination

1. How do you measure how many honeybees are required for a given pollination event?
    a. No universal metric
        i. Required # pollinators … Per flower? Per crop? Fruit tree?

2. How do you measure how many flowers one hive can pollinate?
    a. ⅓ of the hives population are foragers. Population constantly in flux
    b. Often there is an upper limit with not enough flowers for the number of foragers

Introduction - Pollination Contracts

- Hive strength: key metric of pollination contract
  - Defined by “frame count”

- Frame count definition in almonds
  - Two sides of standard frame of comb or equivalent comb area at least 75% covered by bees at a density of 4 bees/in2 or more.
    - Area of frames with less than 75% coverage should be combined and counted toward the standard of an active frame of bees

Sidenote: how can total forager population be approximated from frame count?

The New York Times Magazine

FEATURE

The Super Bowl of Beekeeping

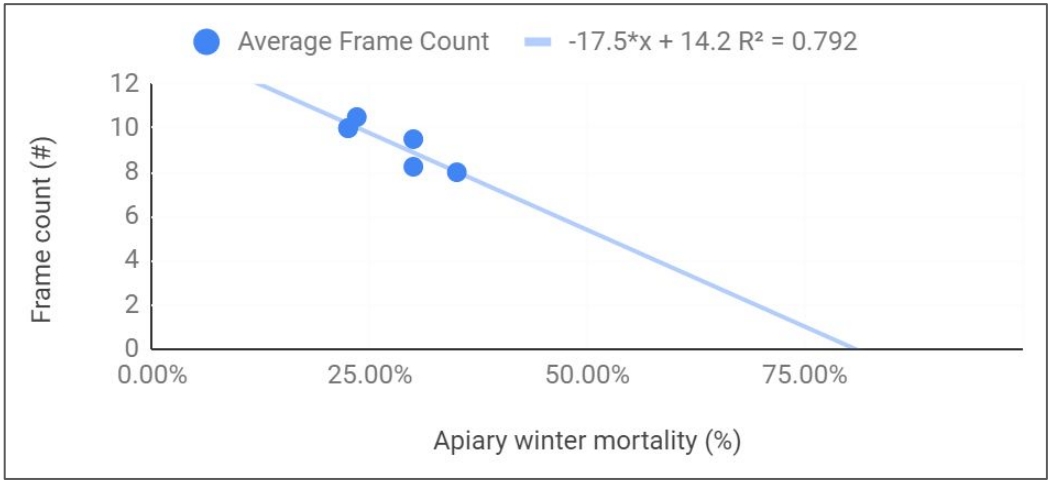
Almond growing in California is a $7.6 billion industry that wouldn't be possible without the 30 billion bees (and hundreds of human beekeepers) who keep the trees pollinated — and whose very existence is in peril.

Modelling Methodology

Assumption 1:

Winter mortality correlates with following year's frame count.

	Winter mortality rate	Average Frame Count
2014	23.50%	10.5
2012	22.50%	10
2015	22.50%	10
2011	30.00%	9.5
2013	30.00%	8.25
2010	35.00%	8



Sources:

Goodrich, B., and R. Goodhue. "Honey bee colony strength in the California Almond Pollination Market." *Agricultural and Resource Economics Update: University of California Giannini Foundation for Agricultural Economics* 19.4 (2016): 4

Modelling Methodology

Assumption 2:

Hives with higher populations pollinate more flowers[1].

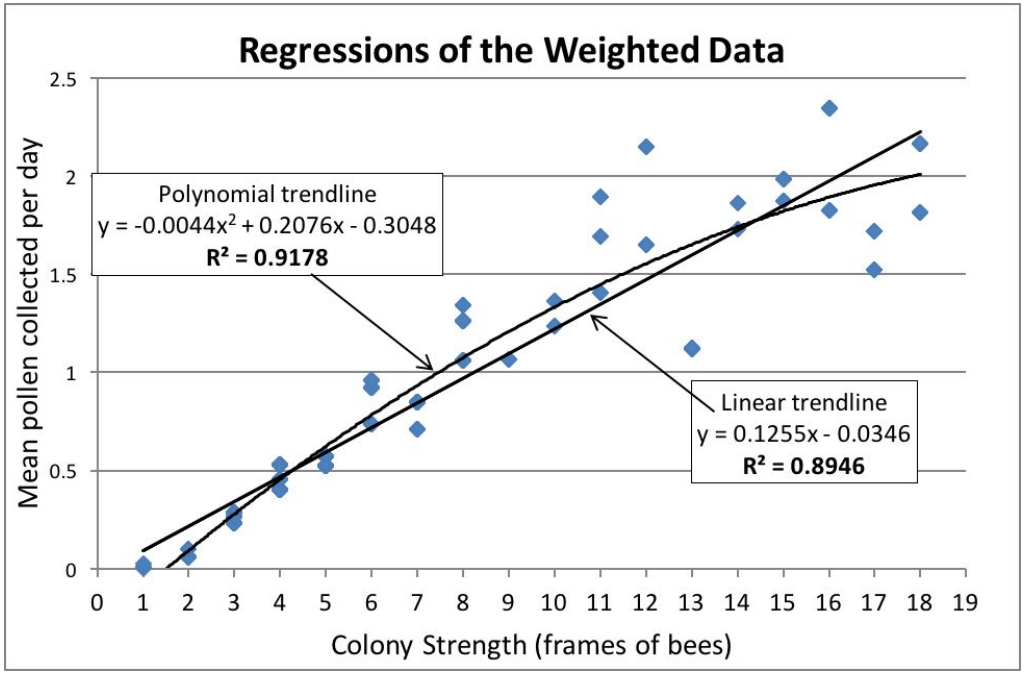


Figure 2. Plot of Sheesley and Poduska raw data. Figure courtesy of Oliver 2018[2].

Sources:

1.Sheesley, B & B Poduska (1970) Strong honeybee colonies prove value in almond pollination. California Agriculture 24(8): 5-6. http://calag.ucanr.edu/archive/?type=pdf&article=ca.v024n08p5

2. Oliver, R. (2018) Determining the Relative Value of Hives for Almond Pollination First Published in ABJ

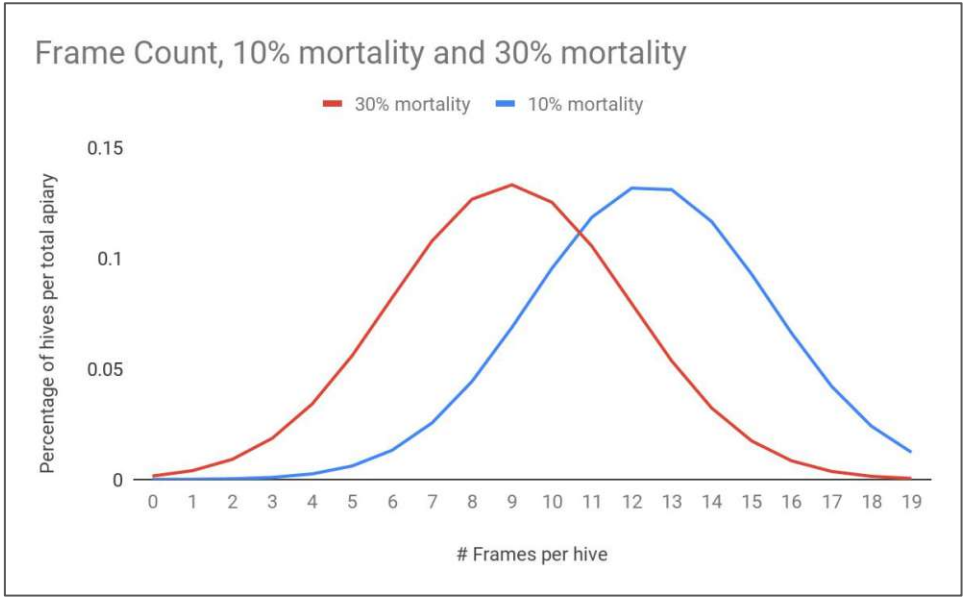
Modelling Methodology

Assumption 3:

Following assumption 1's mortality ~ frame count relationship:

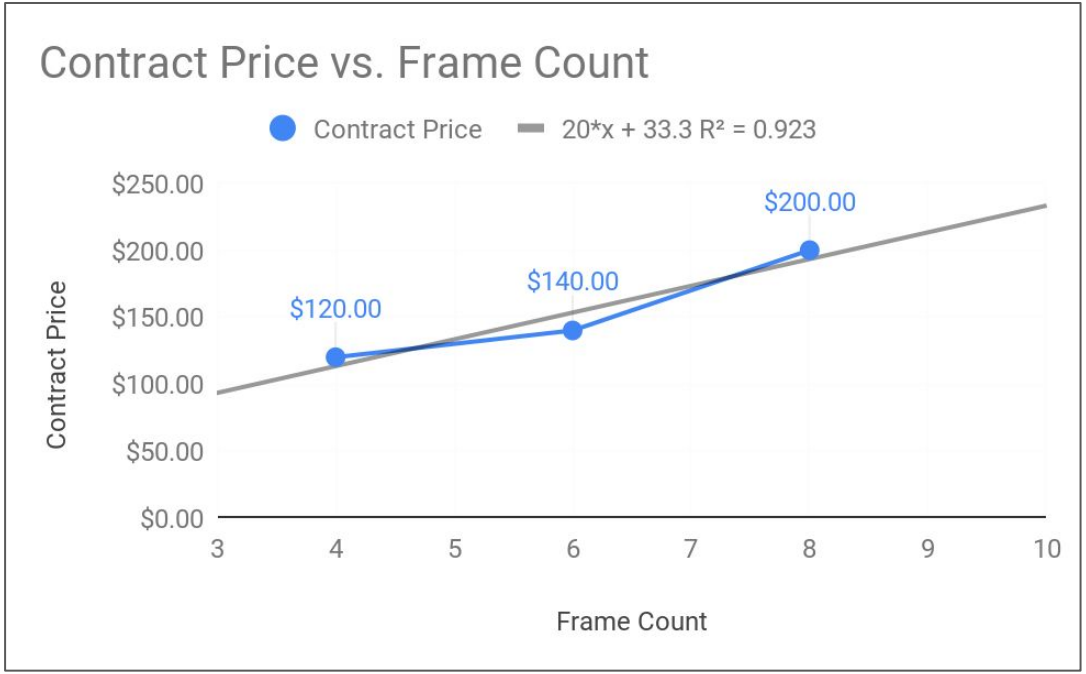
Given a mortality rate, the surviving hives follow a normal distribution around the average frame count

St dev = 2.5



Modelling Methodology

Assumption 4: Almond contract prices increase with frame count[3].



Sources:

3. Mussen E. (2010) *UC Apiaries, Jan-Feb. 2010.* https://beesource.com/point-of-view/joe-traynor/the-game-of-almond-pollination/

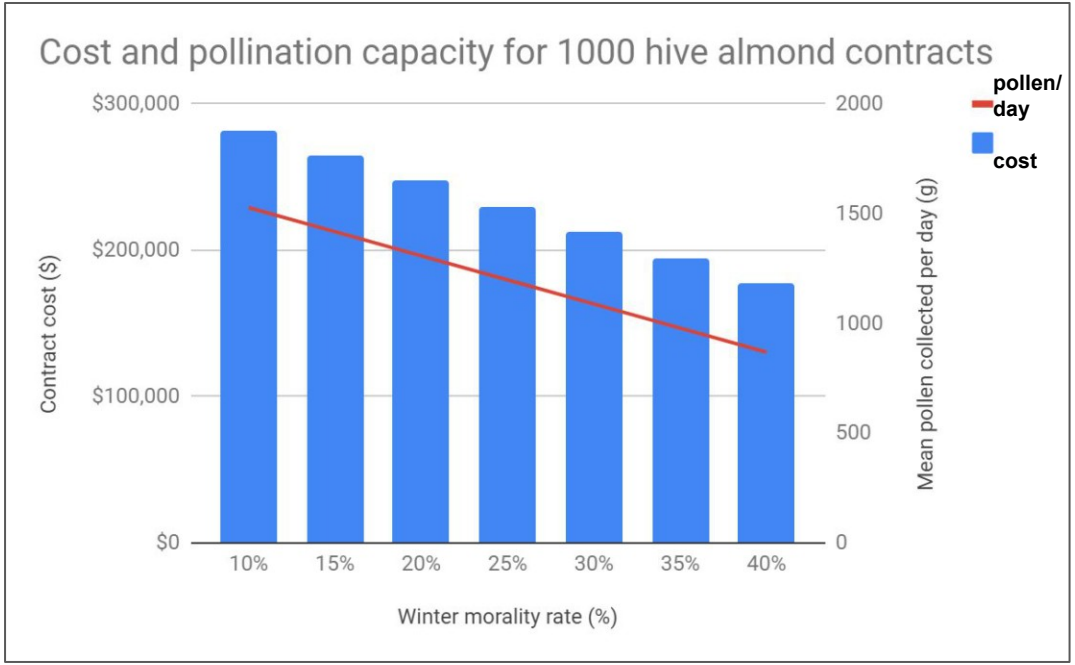
Results: mortality ~ pollination calculator

Lower mortality -> higher rate of daily pollen collection

For 1000 hives:

10% mortality = 12.4 FoB = 1527.8 g/day

40% mortality = 7.2 FoB = 869.11 g/day

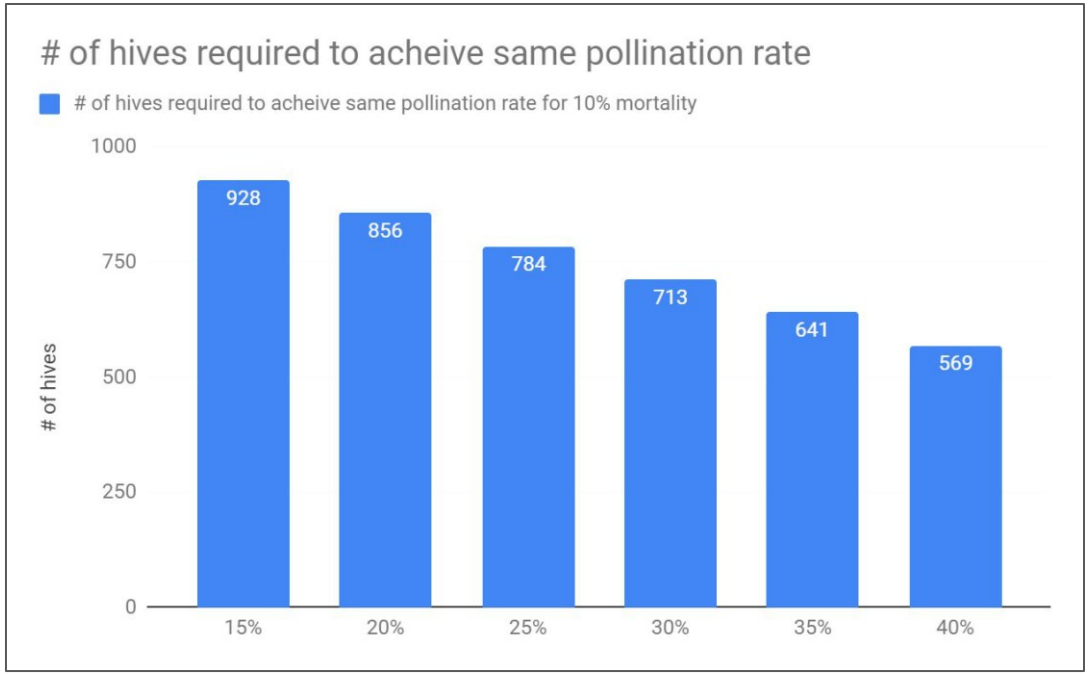


Results: Scenario 1

Large differences in hives required to achieve same pollination rates:

- 1000 hives @ 7.2 FoB (40% mortality) = 569 hives @ 12.4 FoB (10% mortality)

- **43.1% reduction in hives**

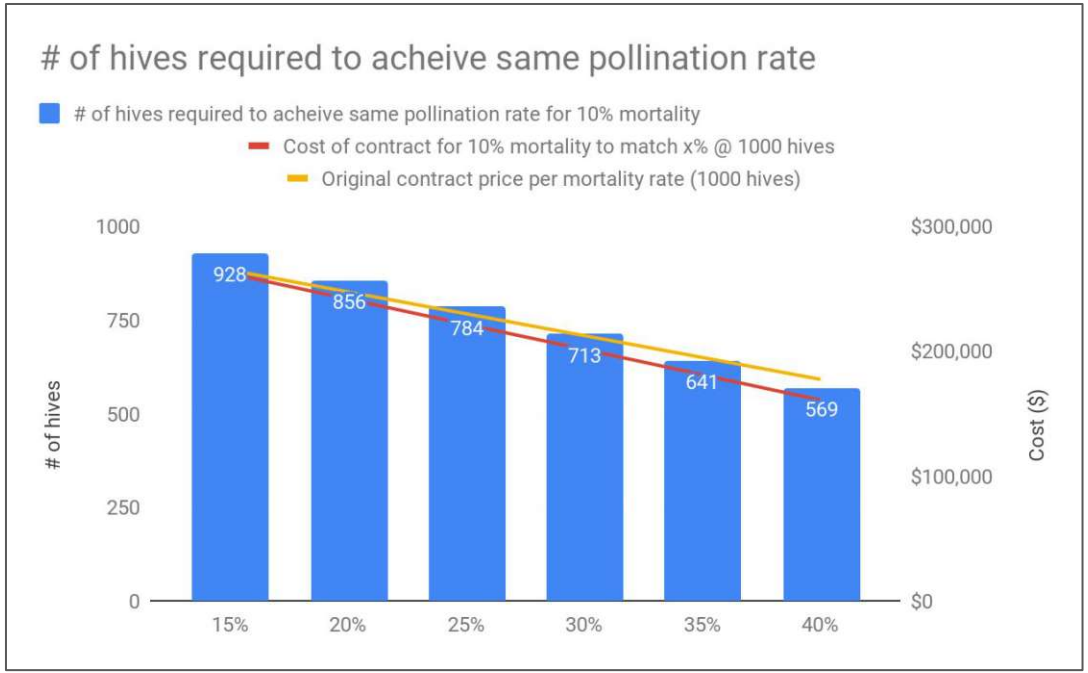


Results: Scenario 1

Yet small differences in prices:

- Contract 1000 hives @ 7.2 FoB (40%) = **$177,303**
- Contract 569 @ 12.4 FoB (10%) = **$160,629**

- Difference of **$16,674**
  - **9.40%** savings

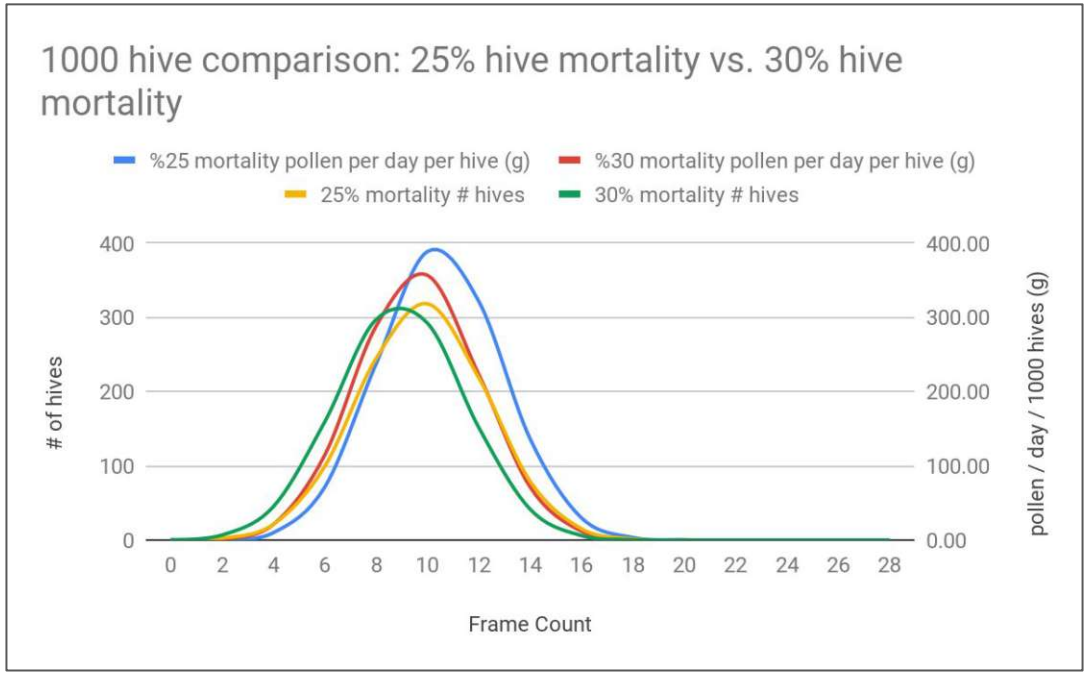


Results: Scenario 25% vs. 30% mortality

25% mortality rate = 9.8 FoB

30% mortality rate = 8.9 FoB

- 924 hives @ 9.8 FoB (25% mortality) required
- 7% reduction in hives
- $30 difference between
  - 1000 hives : 8.9 FoB (30% mortality)
  - 924 hives : 9.8 (25% mortality)



Discussion - model limits

“All models are wrong, but some are useful”

- Limited data
  - Mortality determines spring frame count
  - How much does frame count vary per a given hive mortality?
  - Pollen collection during almond blooms - 1970s data
  - Simplistic almond contract pollination pricing scale

Discussion

Model takeaway:

- *Less, stronger hives can achieve similar pollination in almond industry*
  - Optimizing to stronger hives presents:
    - Large opportunity to reduce hives involved in almond pollination
    - Small opportunity for cost savings between lots of weaker hives or less stronger hives is relatively small

- Improved quantification of pollination services = more efficient economy

Conclusions

- Need for better, tangible metrics regarding pollination services

- Future of pollination services - data driven and powered by Nectar ™ … ?
  - Add transparency - 3rd party brokers
  - Possibility for real time insights on foragers and pollination

- Future work: collect data!
  - Mortality ~ springtime hive strength
  - Hive strength ~ pollination capacity