Honey Bee Colony Density and Almond Nut Set

Project No.: **12-POLL11-Eischen**

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Objectives:

The objectives of this cooperative research project is to examine the effectiveness of differing colony densities on pollen transfer and almond nut set during the 2013 season. This is a continuation of 2011 and 2012 studies.

Interpretive Summary:

We examined the impact of honey bee colony density on almond pollination. This was carried out on the same four ranches that were used in 2012 (near Bakersfield, CA). Both early and late varieties were tested on each ranch. Blocks of almonds were paired for variety, age, tree density and management. One of the pair had a higher number of colonies per acre placed in or around it prior to bloom. Nominal colony density differed between pairs of orchards by 0.5 - 1.0 colony per acre. Colonies in surrounding orchards out to 1.5 miles were counted and mapped. Their contribution of foragers to test orchards were predicted based on prior work involving the modeling of almond pollen foraging data near Bakersfield, CA. Flower counts and video recordings of bee activity aided in interpreting pollination rates. A fifth, impromptu trial (Bidart Bros.), was initiated at the request of one of our cooperators. This involved an early variety orchard stocked with 0.5 colonies/acre. Pollination

was monitored over transect of diminishing colony density projections made by the model for this orchard.

<u>Early varieties:</u> With the exception of Sonora, all early varieties in orchards with higher colony densities had significantly higher pollination rates. Differences in percent pollination between low and high bee densities ranged from 1.5 to 18.4% (x = 9.6%, n = 13) for varieties Nonpareil, Fritz, Monterey, Sonora, and Aldrich. Significant increases in pollination occurred in 92% of the paired early variety blocks. We did not detect a significant increase for the early variety Sonora, but availability of compatible pollen may have been a limiting factor.

<u>Late varieties:</u> With the exception of South Valley Farms, all orchards stocked with the higher colony density had significantly higher levels of pollination. Differences in percent pollination between low and high bee densities ranged from 5.7 to 18.4% for varieties Butte, Padre, and Mission. On South Valley Farms, we found a significant decrease in pollination for the high density, late variety orchard. The colonies on this pair of orchards were of poor quality and many of the hives were empty. We suspect the poor level of pollination in these two orchards is due to this.

The harvestable nut count from the pollination trial will be done in early August and will be reported at the December 2013 meeting. Commercial nut harvest has yet to be done. Determining the impact that differing pollination rates may have had on harvest will be reported later.

Materials and Methods:

<u>Orchards</u>. Pairs of early and late blooming variety orchards were matched as closely as possible for variety, tree age, density (spacing) orchard management, proximity (close enough that climatic conditions are similar, but distant enough to preclude significant bee flight between them). Appendix A shows the size, varieties, and tree spacing for the 19 orchards. Most of the test orchards are the same as those used during the 2012 trial. Test orchards had many commonalties, however there were unique attributes. Some of these factors involved missing trees, replanted young trees in an older orchard, and almond plantings in the surrounding area. On the King/Gardiner ranch we overlaid a secondary trial on the Northeast late variety orchard. Colonies were placed only on the western side of the orchard. Pollination was monitored on the western side of the orchard and on its eastern side. One of our cooperators (Joe Traynor) was interested to know what levels of pollination would occur in an orchard where the nominal stocking rate was 0.5 colonies/acre (Bidart). We noticed that the eastern portion of this orchard had a lower density of colonies than did the western side. We selected Nonpareil trees on these two sides and flagged limbs on 20 trees on the two sides of the orchards.

<u>Bees</u>. Colony densities located around and in the orchards are shown in **Table 1**. Colony density for a particular orchard is not entirely defined by the number of colonies placed there. We plotted colony placement 1.5 miles distant from the

boundaries of test orchards. This information and our model of pollen foraging in almonds allow us to calculate effective colony densities. Effective colony densities were calculated as a function of foraging range observed in almond orchards near Bakersfield, CA during 2009 and 2010 (Eischen et al. submitted). The effective colony densities for test orchards are shown in **Table 1**. Colonies not rented by the grower, but within 1.5 miles of test orchards were plotted but not examined for strength. We made a simplifying assumption that, on average, they met a minimum strength of eight frames of bees. **Table 1** shows the number of additional colonies within 1.5 miles of test orchards.

A representative sample of colonies placed specifically for a test orchard were randomly selected and examined for adult bee strength (10-32/orchard). Strength was measured using the standard pollination criteria of frames 70% covered with bees and all stages of brood present. The colonies were given this examination mid-bloom (6 – 9 March 2013, Appendix B). On the King orchards, all colonies were owned by Mr. Ron Spears of Mountain Avenue Bees, Inc. On the Wegis ranch, all colonies were owned by Mr. Ray Marquette. On Premier/Westchester all colonies were owned either by Mr. Rhea Stroope or Mr. Ray Green. Four different beekeepers had colonies on the South Valley Farms test orchards (brokered by Mr. Steve Cantu, CDH Pollination, FL). We examined a random selection for each of them. The Wegis late variety high bee density orchard had only 36 colonies rented, i.e., 1.16 col/ac. With permission from Mr. Wegis, we applied bottom-style pollen traps. The removal of about 50% of the corbicular pollen loads by these traps causes colonies to double their pollen foraging, thus effectively doubling the number of colonies. Pollen traps were also placed on 48 colonies used to pollinate the NE high density late variety block on the King/Gardiner Ranch.

<u>New blossom counts</u>. Fifteen trees per variety in Wegis high density early-variety and low density late-variety orchards were monitored daily for new blossoms. These trees were immediately adjacent to and in the same row as our "pollination rate" tree. One or more branches at or above 10' were flagged with engineering tape. The flagged branch(s) typically had 100 – 200 large buds. When flowering started (ca. 1-2%), we began counting the number of open blossoms. After counting, these newly opened blossoms were removed.

<u>Petal fall</u>. This was conducted in the high density early-varieties and the low density late variety Wegis orchards. These two orchards were of the same size and adjacent allowing us to carry equipment between them. We sampled petal fall during 28 Feb. - 25 Mar. This covered the entire petal drop. Both orchards were divided into three equal segments of 36 rows (similar to the grouping shown in **Figure 1**). In the early-variety orchard, four rows of trees in each of the three segments were selected for sampling. These four rows were centered in each of the three segments and were composed of a row of Monterey, Fritz and two rows of Nonpareil, reflecting the composition of the orchard. Petal collection devices (5-gal. buckets lined with a plastic trash liner secured with a large rubber band) were placed in sets of 16 each at equal intervals throughout the length of the orchard (ca. every

20 trees). The 16 buckets set nearly perpendicular to the north-to-south tree rows. The orchard is planted in the diamond fashion, so the line of buckets was angled so the line of buckets followed the line of tree rows NE-to-SW. Each tree received one bucket about 6" south of its bole. Two additional buckets were placed 37" to the NW and SE of the tree line bucket. An additional bucket was placed center of the tree row isle. This arrangement was replicated, in a straight line, across the four rows. Each orchard segment received six of these sets for a total of 18 sets or 288 buckets. Petal fall was recorded daily. Petals were counted by 3-5 observers starting about 8.30am. Rain fell on two days making onsite counting difficult. On these days, the trash liners were collected and counted indoors.

The sampling methods described above for the early variety orchard was used in the late variety orchard with the exception that since only two varieties were present (Butte & Padre) and in equal tree numbers, we applied the buckets as described across two rows for a total of eight buckets per set and 18 sets total. This involved 144 buckets.

Because there were gaps between the buckets, some segments of the sampling transect were not represented by this method. To get a better understanding of the petal fall distribution in the aisles between tree rows, we conducted two additional samplings. 1) On five consecutive days (18-22 Mar.) we placed buckets rim-to-rim starting at the center of the tree row aisle and extending toward the tree row to within 35 inches of the tree canopy. Petal fall in these buckets was recorded daily. 2) Using two steel 20' carpenter's tape measures positioned 0.25' apart and extended 12' to the center of the tree row aisle, we counted the petals between the two tape measures. We conducted these counts directly opposite a tree and at a midpoint between two trees. The measurement was repeated on both the east and west side of the tree row. This was done for all varieties at five locations in the orchards on 14 Mar.

Bucket mouth surface area was 0.7526 $ft.^2$. Both the bucket and the tape measure transects found that petal distribution diminished gradually and evenly away from the tree. Regression analysis was applied to the data of each set of three buckets placed on each side of a given tree. Petal density for spaces not covered by the buckets could thereby be calculated. Each test tree was assigned an east of tree row area of 16' x 12' (mid-tree row length x mid-aisle width) and a west of tree row area of equal proportions. The number of petals falling to each square foot was calculated. With these data, we calculated the average number of petals falling for the trees of each variety. Numbers of petals were divided by five to give the number of flowers they represented. Knowing the number of dropped petals and the flowers that represents and indexing that number to the number of new blossoms allows a refinement of our calculations of the bee-to-bloom ratio on a daily basis. Because the findings of this study may be of interest, we present raw data and the associated calculations in Appendices C - I of this report.

Flower visitations and nut set. On 28 Feb, 2 and 4 March selected branches of Fritz and Nonpareil were exposed during the early afternoon and video recorded. Two days prior to exposure branches having about 20 large buds each were bagged with a pollinator-exclusion basket Appendix J). All open blossoms were removed. At the time of exposure exclusion devices were removed. Open blossoms facing the camera position were tagged and numbered; those facing away were removed. Video recording was made for 45 minutes and then exclusion devices were replaced. The time spent/blossom and the number of flowers individual bees visited on the branch were recorded. Eight days later, pollination exclusion device was removed. Nut set was determined on 29 Mar. We are still collecting the data from these videos and it will be presented prior to the December ABC meeting.

Flower visitation in high and low bee density orchards. We monitored bee foraging on Monterey and Padre blossoms. Pairs of early blooming high and low bee density orchards were located at King and Wegis ranches and monitored on 28 February, 1, 2, and 3 March. Late blooming high and low bee density orchards were located at King Ranch and were monitored on 5 March. Two days prior to exposure randomly chosen flowering branches about 36" long, 4-5' above ground and on the same tree flowering branches at 10 -15' were selected. Open flowers were removed and branches bagged with a pollinator-exclusion bag. We made 45-minute videos during late morning. On the day of monitoring each orchard had 10 cameras near the lower branches and five cameras by the 10 -15' branches. Pollinator-exclusion baskets were removed for the 45-minute exposure. We counted the number of bee foragers, number of flowers visited by each bee and the time spent at each flower. Colony density was at 2.0/ac at King Northeast blocks and 1.0 at King West blocks. Colony density was at 2.0 at the Wegis North block and 1.125 at the Wegis South block.

Orchard Pollination. Pollination was monitored by selecting 20-30 trees of each variety in each orchard. These were spaced at regular intervals. Each tree had two branches flagged. Both at about 10-14 feet high on opposite sides of the tree. Each flagged early-variety branch had 172.4 ± 75.0 well-developed buds. Late varieties had 182.5 ± 55.8 buds. Developing ovaries were examined for proof of fertilization during 28 March – 4 April 2013. Gentle pressure on its side was applied to the embryo. If it came off easily, it was considered unfertilized and vice versa.

Nut harvest. Mature nuts will be counted during 5 - 12 August 2013.

Results and Discussion:

Orchards. Tree age, density and spacing are shown in Appendix A. Four of the 19 orchards had some level of replanting. On South Valley Farms, the percentage of replants ranged from 0.84 – 1.13%. On Premier it was 0.82 – 3.35%. Replants were of varying ages. We have discounted the amount of bloom on trees up to three years old. Bloom for 4 & 5 year-old trees will be adjusted on a variety basis, and our final estimates of the bloom: bee ratio will reflect this (2012 count). Tree height was about 25’ for both early and late varieties on both the South Valley Farms orchards and the Premier orchards. Most of our flagged branches were at or above 12’. Nevertheless, the majority of the blossoms in these old orchards were above our test branches.

Colony density. Based on our model of foraging by colonies placed in/near the test orchards plus those up to 1.5 miles distant, we found that the effective colony densities (ECD) for the early variety Wegis orchards were similar to the nominal number set at/in the orchards with a separation of density values of 0.59 colonies/acre. The two late variety orchards had a lower separation of ECD values of only 0.15 colonies/acre. ECD values for the early (**Table 1**). ECD values for the King/Gardiner pairs of orchards were differed by 0.91 and 0.61 colonies/acre for the early and late variety orchards, respectively (**Table 1**). On the high-density late variety orchard, we calculated the ECD for the west and east end of the orchard. We did this because there were no bees placed on either the north or east sides and the nearest almonds were 0.5 miles distant. This reduced the ECD values for the east side of the orchard. Pollination was monitored for these two sides. The ECD values for the east side were 0.95 and the west 1.75 colonies/acre. On Premier/Westchester differences in the ECD values for the early and late variety pairs of orchards were 0.84 and 0.49 colonies/acre, respectively. Similarly, South Valley Farm differences were 0.47 and 0.40 for the pairs of early and late variety orchards, respectively.   The east and west end of the early variety orchard at Bidart Bros. had ECD values of 0.45 and 1.07 colonies/ acre, respectively (**Table 1**).

Bee Strength. Colonies on the two Wegis late-variety orchard had strengths at the end of pollination of 6.0 – 6.9 frames of adult bees which were not significantly different ($P > 0.05$, FPLSD, Fisher’s Protected Least Significant Difference, Appendix B) . Those placed on the early variety orchards had strength of 7.6 frames on the low-bee density orchard and 5.2 frames on the high-bee density orchard ($P < 0.05$, FPLSD, Appendix B). This difference between the two orchards unfortunately complicated the interpretation of the data. Colonies on the King/Gardiner orchards were strong (for the season) and average strength ranged from 11.1 to 13.0 frames of bees ($P > 0.05$, FPLSD). Premier/Westchester colonies ranged from 7.1 to 9.8 frames of bees. Differences between pairs of orchards were not significant ($P > 0.05$, FPLSD). Colonies on South Valley Farm (SVF) early variety orchards were on average 8.6 – 8.9 frames of bees ($P > 0.05$, FPLSD). The SVF late variety orchards were stocked primarily with the colonies of one beekeeper and they were of poor quality (3.2 - 4.9 frames of bees) and many were dead. Pollination of these two late variety orchards was questionable. The Bidart Bros. orchard was stocked with the colonies of one beekeeper and they were large (average of 14.9 frames of bees).

New blossom counts on the high density early-variety and low density late-variety orchards of Wegis Farms. The number of buds monitored per tree daily for new blossoms ranged from 79.0 - 205.0 for the early varieties and 80.0 – 286.0 for the late varieties. The number of new flowers for Fritz, Nonpareil, and Monterey peaked near 3 March (**Figures 2 - 4; Table 2**). This was seven days later than that observed in these orchards in 2012. Similarly, the number of new blossoms for the late-variety orchard peaked during 2-5 March (**Figures 5 & 6; Table 2**). That is, peak bloom for both the early and late varieties were similar. This overlap tended to depress the bee-to-bloom ratio in these orchards. We did not record new bloom in the other orchards, but our impression was that the overlap between early and late varieties was more complete in 2013 than during the 2012 season. Additionally, bloom density in our study area during the 2013 season was visibly higher than the 2012 season.

<u>Petal fall in the high density, early-variety and low density late-variety orchard of Wegis Farms</u>. For the early varieties, Monterey, and Nonpareil, peak petal fall occurred on 11 Mar. or eight days after the peak of new blossoms appearing (**Figures 2 & 3**). Wind conditions were quite mild (0 to 2 mph) on 11 Mar. and increased petal fall was probably not caused by it. Correlation between the number of new blossoms and subsequent number of petals falling eight days later was significantly correlated for Monterey ($r = 0.80$, $P < 0.05$) and Nonpareil ($r = 0.81$, $P < 0.05$). Fritz petal fall was not as tightly correlated ($r = 0.53$, $P < 0.05$). This variety held withered petals for an extended time. Petal fall for all varieties was affected by windy conditions on 20 Mar.

Petal fall for the late varieties Butte and Padre peaked on 11 March (as did the early varieties). Peak blossoming came on quickly after the first blossoms opened. Peak drop followed eight days later (similar to the early varieties). Correlation between the number of new blossoms opened and subsequent number of petals falling eight days later was significant for Butte ($r = 0.69$, $P < 0.05$) and Padre ($r = 0.78$, $P < 0.05$).

Our transect counts and bucket arrays both found that petal fall diminishes gradually as the distance increases from the tree toward the center of the aisle between the tree rows. Though gentle breezes occurred, we did not find significant differences in petal fall between the east or west side of the trees (orchards had north/south tree rows). Petal density on the ground perpendicular to the tree bole and extending to the center of the tree row aisle, did not differ significantly from the number of petals perpendicular to the tree line when measured midpoint between trees. That is, petal dispersion was in the main, fairly uniform. This was true of both orchards. Petal fall was greatest under the trees. The average r^2 values for the regressions calculated for petal fall dispersion was 0.87. For most days, petal fall was not significantly different on either side of the tree ($P > 0.05$, t-test, Appendices C – I).

Using the summed petal numbers falling into the array of buckets under and near individual trees, the calculated total number of petals falling from each monitored tree in the rectangle 12’ x 16’ both east and west of the tree, we found that the average number of flowers from Nonpareil trees was 33, 400.4 ± 7,196.3 (**Table 3**). Among the early varieties, Monterey had a significantly higher number of flowers ($x = 53{,}431.4 \pm 7{,}378.4$, $P < 0.05$, FPLSD) than either Nonpareil or Fritz ($x = 37{,}093.3 \pm 7{,}392.5$). Flowers for trees of late varieties Butte and Padre were, on average, 62,163.8 ± 4,993.7 and 70,211.3 ± 5,480.1. These averages were significantly different ($P < 0.05$, FPLSD, **Table 3**). These numbers are considerably larger than those often noted. It seems likely that some previous published flower estimates were based on the harvest weight of almonds (both individual nut meat and total harvest weight) and then working backwards towards the number of flowers. This technique would work if the % pollination, nut drop throughout the growing season, and harvest data were accurate. In a given year with a less dense bloom than that of 2013, these numbers may have been correct for some of the early varieties. It is unclear whether this is also true of Butte and Padre.

Flower numbers allows an estimate of the number of visits required by bees to set varying percentages of almonds. We have extensive data sets on number of foraging trips made by colonies of various sizes, amounts of pollen collected, weights of pollen loads per bee throughout the bloom cycle, and flight hours. We have some data on the number of visits required to set a flower for two of the varieties. Complicating factors involve the percentage of returning pollen loads with more than one variety represented. One Australian study (Vezvaei and Jackson 1997) estimated this to be as low as 10-20%. We plan to review our data and refine our estimates of bees needed to pollinate almonds.

If we knew tree canopy volumes, we could calculate flower density. Hutchinson (1978) used a simple formula for calculating almond tree volumes. Hoffman et al. (1989) uses a technique that we are still evaluating. Romero et al. (2004) adopted a formula used for calculating citrus tree canopies (Tumbo, et al. 2001) and applied it to almond trees. If we use this technique and apply it to the dimensions of an average 8-year old early variety tree (**Table 3**), we find that the number of flowers/$ft^3$is 13.1, 21.0, and14.6 for Nonpareil, Monterey, and Fritz 2013 data, respectively. This calculation for Butte and Padre is 24.4 and 27.6 ft^3, respectively. These numbers are only approximations as tree canopy volumes are based on estimates.

<u>Flower visitations and nut set</u>. Data for this study is still being collected. December report will show results.

<u>Flower visitation in high and low bee density orchards</u>. Data for this study is still being collected. December report will show results.

<u>Orchard Pollination: Early Varieties</u>.

Wegis Farms. Nonpareil trees in the high density orchard, had a 15% increase in pollination ($P < 0.05$, FPLSD, **Table 4**). This was considerably more than the 5.6% in 2012 and slightly more than the 12.1% observed found in 2011. A 15.6 and 5.9% increase (($P < 0.05$, FPLSD; **Table 4**) was observed for the high bee density Fritz and Monterey trees, respectively.

King/Gardiner. Pollination was significantly higher on the 2.0 colonies/acre block for all the early varieties ($P < 0.05$, FPLSD, **Table 4**). Differences between the low and high colony densities were 10.3, 16.9, 11.6% for Nonpareil, Fritz, and Monterey, respectively.

Premier. Early variety pollination was significantly higher on high bee density blocks for Nonpareil and Fritz ($P < 0.05$, FPLSD, **Table 4**). Nonpareil, Fritz pollination was higher by 7.1 and 7.5%, respectively. Sonora pollination was not improved significantly, possibly for lack of compatible pollen in the early phase of bloom.

South Valley Farms. All early varieties were significantly improved by increasing colony density ($P < 0.05$, FPLSD, **Table 4**). Nonpareil, Monterey, and Aldrich showed increased pollination by 7.8, 7.9, and 6.6%, respectively.

Bidart Bros. Nonpareil was the only variety tested in this impromptu study. The eastern side of the orchard had a significantly lower level of pollination compared with the western side ($P < 0.05$, FPLSD, **Table 4**). The western side had a 13.6% higher rate.

Across all five ranches significant positive correlations were found between the level of pollination and the effective colony density. Correlation coefficients were 0.758 for Nonpareil, 0.807 for Fritz, and 0.741 for Monterey. There are many variables involved in these data across different ranches. We are still discussing this with our statistician to determine their validity.

<u>Orchard Pollination: Late Varieties</u>.

Wegis Farms. Butte trees in the high density orchard had a 20.4% pollination rate which was a 5.7% increase in pollination above the low bee density orchard ($P < 0.05$, FPLSD, **Table 5**). The pollination rates for Padre in this orchard were nearly that observed for Butte. In our opinion, this is a well maintained orchard and we would be very interested to see harvest data if it received additional colonies. Levels of pollination are below average. Differences in the ECD between the two orchards were a modest 0.25 colonies/acre.

King/Gardiner. Pollination was significantly higher on the 1.25 colonies/acre block (ECD = 1.75 colonies/acre) for Butte and Padre ($P < 0.05$, FPLSD, **Table 5**). Differences between the low and high colony densities were 16.2, 15.4% for Butte and Padre, respectively. Differences in the ECD between the two orchards were 0.97 colonies/acre. The reason for the substantial difference in the ECD was that orchards adjacent to the low bee density orchard were themselves low and the reverse true of the high density orchard.

Premier. Pollination was significantly higher on the 2.5 colonies/acre block for Butte and Padre ($P < 0.05$, FPLSD, **Table 5**). Differences between the low and high colony densities were 13.8, 18.4%, and 8.8% for Butte, Padre and Mission, respectively. ECD was similar to the nominal stocking rate. This was apparently caused by surrounding orchards having fairly high stocking rates.

South Valley Farms. The pollination rate for this pair of orchards is problematic in that the higher nominal and ECD stocking levels resulted in lower pollination (significantly so for Butte). However, we think the data for this pair of orchards has been seriously compromised as a result of the poor quality of the colonies involved. We think the important observation from this pair of orchards is how badly pollination rates suffer even when stocked with a high number of boxes.

Remark. We sometimes hear beekeepers and growers say that the colonies set in the early varieties will redirect their foragers to the late varieties as they bloom. This is undoubtedly true to some extent. Perhaps it is true to a great extent in years when the early and late varieties don't overlap in their bloom time as they did in 2013. However, the number of foragers that remain in the early varieties apparently collecting nectar while the late varieties are blooming is substantial. We had hoped to get an assessment of this, but realized that the overlap of bloom in our study during the 2013 season would probably not be typical. The extent of the overlap during the 2013 season may have, and probably did, divide the attention of foragers. If conditions are more typical during the 2014 season we will again try to measure this.

Research Effort Recent Publications:

Eischen, F.A., R.H. Graham, and R. Rivera. Almond pollination and honey bee colony density. Jour. Econ. Entomol. (submitted)
Eischen, F.A., R.H. Graham, and R. Rivera. Foraging range of honey bees during almond pollination. Jour. Econ. Entomol. (submitted)

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Appendices:

Appendices A, B, C, and J were referenced in the report above. The following appendices were included by the researcher providing additional information for your review:

Appendix D. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the Monterey variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

Appendix E. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the Fritz variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

Appendix F. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the first tree at each location of Nonpareil variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

Appendix G. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the second tree at each location of Nonpareil variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

Appendix H. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the Butte variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

Appendix I. Quantity of flowers per tree determined by our collection of every petal1, and our calculations[2] for the Padre variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

Figure 1. Test almond orchards stocked at 1.0 colonies per acre. Late variety orchard on left. Early variety orchard on right (both outlined in red). Test tree rows (n=3) indicated with white dots

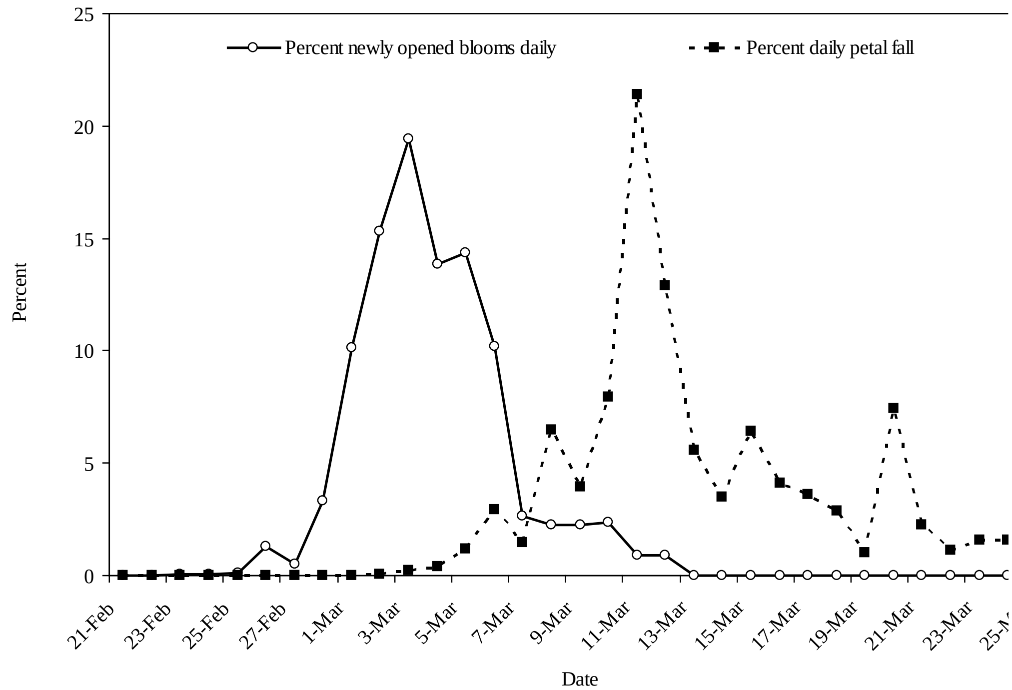


Figure 2. Comparison of the percentage of newly opened blossoms with the daily petal fall for the early variety Monterey. Petal fall after eight days was significantly correlated with blossoming (r=0.8., P<0.05). Windy conditions on 20 March.

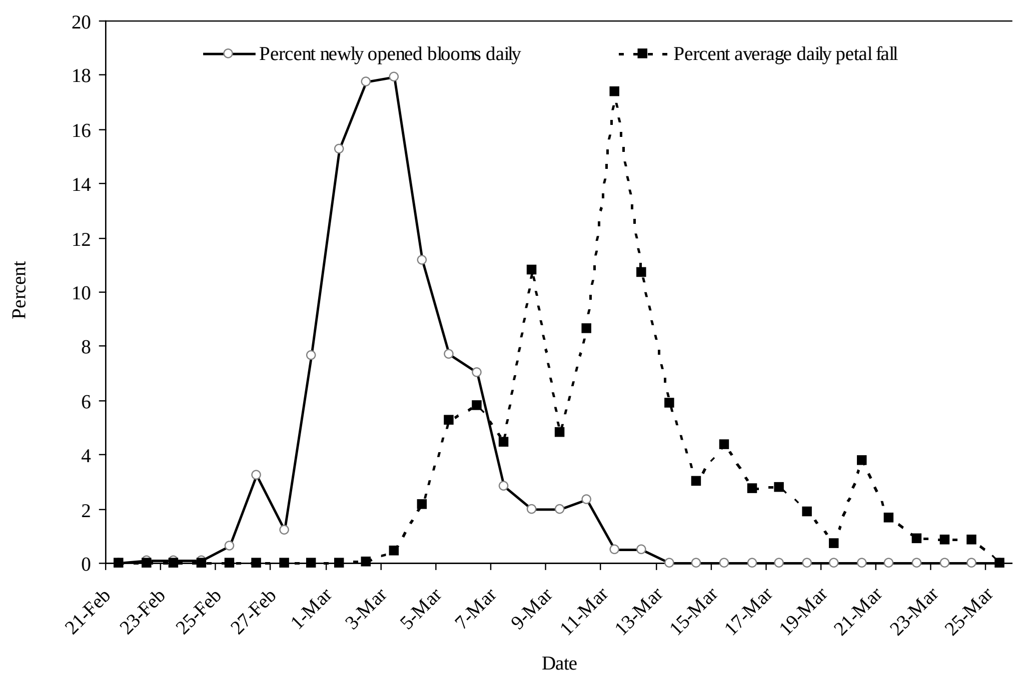


Figure 3. Comparison of the percentage of newly opened blossoms with the daily petal fall for the early variety Nonpareil. Petal fall after eight days is significantly correlated with blossoming (r=0.81, P<0.05). Windy conditions on 20 March.

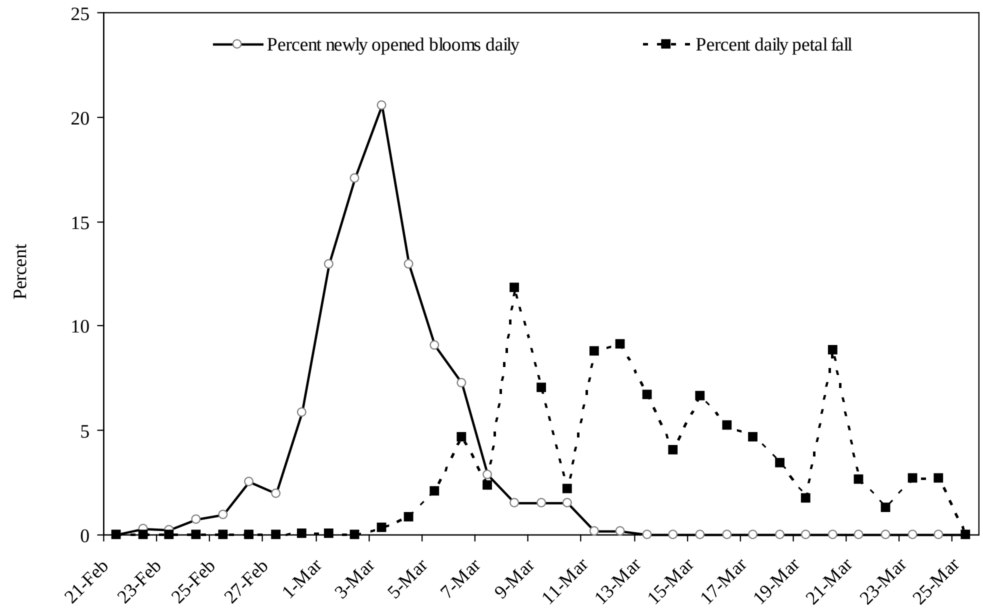


Figure 4. Comparison of the percentage of newly opened blossoms with the daily petal fall for the early variety Fritz. Petal fall after eight days is significantly corrected with blossoming (r=0.53, P<0.05). Windy conditions on 20 March.

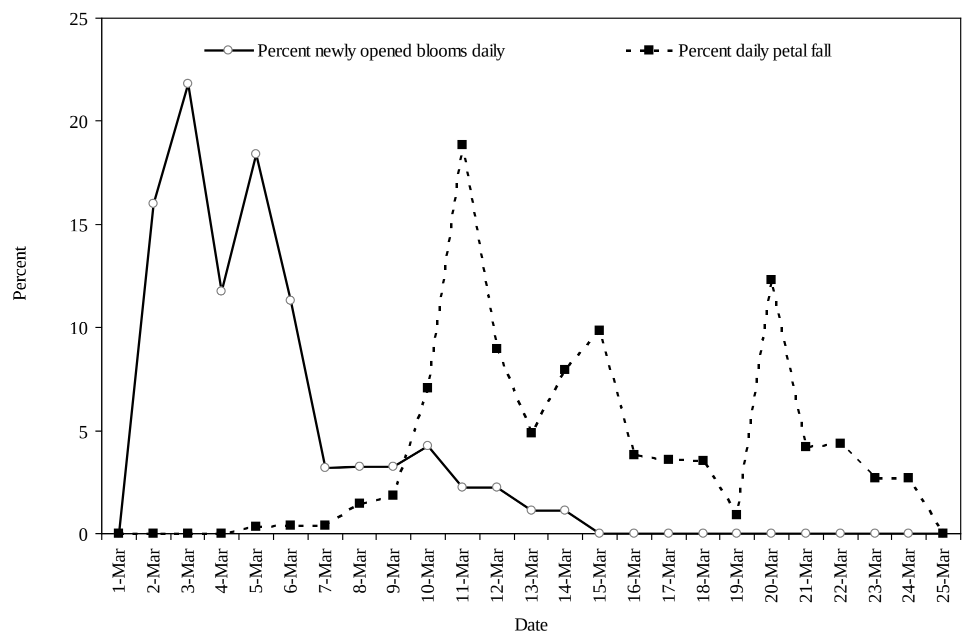


Figure 5. Comparison of the percentage of newly opened blossoms with the daily petal fall for the late variety Butte. Petal fall after eight days is significantly correlated blossoming (r=0.69, P<0.05). Windy conditions on 20 March.

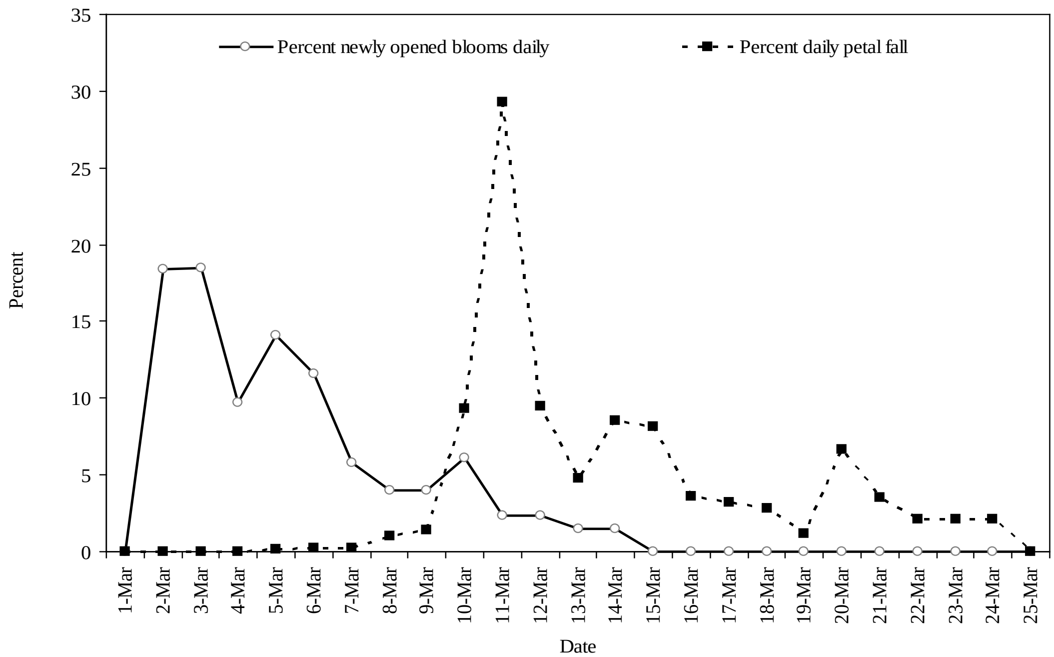


Figure 6. Comparison of the percentage of newly opened blossoms with the daily petal fall for the late variety Padre. Petal fall after eight days is significantly correlated with blossoming ($r=0.78$, $P<0.05$). Windy conditions on 20 March.

Table 1. The nominal and effective[1] colony density on test orchards.

<table>
<tr><th>Orchard: Nominal colony density (colonies per acre) and varieties</th><th>Colonies set at orchard</th><th>Additional colonies placed ≤ 1.5 miles from test orchard[2]</th><th>Nominal colony density (per acre)</th><th>Effective colony density (per acre) ECD</th><th colspan="2">Differences of average ECD</th></tr>
<tr><td>Wegis: 1.125 colony/acre
Early varieties</td><td>168</td><td>4,276</td><td>1.125</td><td>1.16 ± 0.17</td><td colspan="2" rowspan="2">0.59</td></tr>
<tr><td>Wegis: 2 colonies/acre
Early varieties</td><td>390</td><td>5,393</td><td>2.0</td><td>1.75 ± 0.28</td></tr>
<tr><td>Wegis: 1.125 colony/acre
Late varieties</td><td>216</td><td>5,665</td><td>1.125</td><td>1.25 ± 0.10</td><td colspan="2" rowspan="2">0.15</td></tr>
<tr><td>Wegis: 1.16 colonies/acre
Late varieties (pollen trapped = x2)</td><td>36 (x2)-pollen trapped</td><td>2,764</td><td>1.16</td><td>1.40 ± 0.25</td></tr>
<tr><td>King/Gardiner: West
1.0 colony/acre; Early varieties</td><td>120</td><td>3,746</td><td>1.0</td><td>0.94 ± 0.17</td><td colspan="2" rowspan="2">0.91</td></tr>
<tr><td>King[1]: Northeast
2.0 colonies/acre; Early varieties</td><td>336</td><td>3,659</td><td>2.0</td><td>1.85 ± 0.31</td></tr>
<tr><td>King/Gardiner: West
1.0 colony/acre; Late varieties</td><td>120</td><td>3,844</td><td>1.0</td><td>0.78 ± 0.11</td><td rowspan="2">0.17</td><td></td></tr>
<tr><td>King/Gardiner: Northeast 1.3 colony/acre;
Late varieties (pollen trapped = x2)</td><td>24 (x2)
pollen trapped</td><td>4,088</td><td>1.3</td><td>0.95 ± 0.13</td><td rowspan="2">0.80</td></tr>
<tr><td>King/Gardiner: Northeast 1.3 colonies/acre;
Late varieties (pollen trapped = x2)</td><td>24 (x2)
pollen trapped</td><td>4,088</td><td>1.3</td><td>1.75 ± 0.12</td><td></td></tr>
</table>

Table 1. The nominal and effective[1] colony density on test orchards (con't).

Orchard: Nominal colony density (colonies per acre) and varieties	Colonies set at orchard	Additional colonies placed ≤ 1.5 miles from test orchard[2]	Nominal colony density (per acre)	Effective colony density (per acre)	Differences of average ECD
Premier-Westchester 1.75 colonies/acre; Early varieties	174	7,014	1.75	1.64 ± 0.23	0.84
Premier-Westchester 2.5 colonies/acre; Early varieties	256	6,472	2.5	2.48 ± 1.26	
Premier-Westchester 1.75 colonies/acre; Late varieties	348	7,086	1.75	1.78 ± 0.17	0.49
Premier-Westchester 2.5 colonies/acre; Late varieties	256	4,874	2.5	2.27 ± 1.02	
South Valley Farms 2.0 colonies/acre; Early varieties	120	7,730	2.0	1.68 ± 0.12	0.47
South Valley Farms 2.5 colonies/acre; Early varieties	152	8,356	2.5	2.15 ± 0.15	
South Valley Farms 2.0 colonies/acre; Late varieties	108.6	7,730	2.0	1.14 ± 0.14	0.40
South Valley Farms 3.0 colonies/acre; Late varieties	142.5	4,658	3.0	1.54 ± 0.11	
Bidart SE Block 0.5 colony/acre; Early varieties	36	1,105	0.5	0.45 ± 14	0.62
Bidart SW Block 0.5 colony/acre; Early varieties	36	4,227	0.5	1.07 ± 0.18	

[1] Nominal colony density is the number of colonies rented for the orchard. Effective colony density is based on pollen foraging range of bees near Bakersfield, CA during the 2009 and 2010 almond pollination seasons.
[2] Our data indicates that 94.8% of pollen foraging trips were made within 1.5 miles of the colony. We assume colonies beyond the orchard boundaries met an 8-frame average.

Table 2. Percent newly opened blossoms monitored daily 22 February - 14 March at Wegis North early and late variety orchards.

Date	Nonpareil N=15 $\bar{x}$ ± SD	Fritz N=15 $\bar{x}$ ± SD	Monterey N=15 $\bar{x}$ ± SD	Butte N=15 $\bar{x}$ ± SD	Padre N=15 $\bar{x}$ ± SD
22 February	0.1 ± 0.3	0.3 ± 0.5	0	0	0
23 February	0.1 ± 0.3	0.2 ± 0.4	0.1 ± 0.2	0	0
24 February	0.1 ± 0.4	0.7 ± 1.7	0.1 ± 0.2	0	0
25 February	0.6 ± 1.6	1.0 ± 1.9	0.1 ± 0.2	0	0
26 February	3.2 ± 4.8	2.5 ± 2.8	1.3 ± 1.4	0	0
27 February	1.2 ± 2.1	1.9 ± 3.1	0.5 ± 0.7	0	0
28 February	7.6 ± 5.7	5.9 ± 5.8	3.3 ± 2.5	0	0
1 March	15.3 ± 8.6	12.9 ± 5.8	10.1 ± 6.5	0	0
2 March	17.7 ± 6.3	17.1 ± 5.3	15.3 ± 6.9	16.0 ± 12.0	18.4 ± 12.8
3 March	17.9 ± 5.5	20.6 ± 7.2	19.4 ± 3.9	21.8 ± 9.0	18.5 ± 7.6
4 March	11.2 ± 5.7	12.9 ± 6.4	13.9 ± 4.3	11.8 ± 4.6	9.7 ± 3..6
5 March	7.7 ± 4.5	9.0 ± 5.6	14.4 ± 7.3	18.4 ± 7.1	14.1 ± 5.0
6 March	7.0 ± 4.4	7.3 ± 5.0	10.2 ± 4.9	11.3 ± 5.4	11.6 ± 5.2
7 March	2.9 ± 2.7	2.9 ± 2.2	2.7 ± 1.4	3.2 ± 1.3	5.8 ± 2.7
8 March	2.0 ± 1.8	1.5 ± 1.3	2.2 ± 1.5	3.3 ± 1.7	4.0 ± 2.1
9 March	2.0 ± 1.8	1.5 ± 1.3	2.2 ± 1.5	3.3 ± 1.7	4.0 ± 2.1
10 March	2.4 ± 2.3	1.5 ± 2.3	2.4 ± 2.2	4.2 ± 2.2	6.1 ± 2.9
11 March	0.5 ± 1.0	0.2 ± 0.5	0.9 ± 1.5	2.2 ± 1.6	2.4 ± 1.6
12 March	0.5 ± 1.0	0.2 ± 0.5	0.9 ± 1.5	2.2 ± 1.6	2.4 ± 1.6
13 March	0	0	0	1.1 ± 1.0	1.5 ± 2.0
14 March	0	0	0	1.1 ± 1.0	1.5 ± 2.0

Table 3. Quantity of flowers per tree and per acre based upon petals collected during the entire petal fall period 2013.

Variety	N number of test trees	Flowers per tree $\bar{x} \pm SD$	Trees per acre within test orchard	Flowers per acre	Flowers per ft^3 of tree canopy[2] $\bar{x} \pm SD$
Nonpareil	36	33,400.4 ± 7,196.3a[1]	57	1,903,822.8	13.12 ± 2.83a
Monterey	18	53,431.4 ± 7,378.4b	28.5	1,522,794.9	20.99 ± 2.90b
Fritz	18	37,093.3 ± 7,392.5a	28.5	1,057,159.1	14.57 ± 2.90a
Total Early Varieties			114	4,483,776.8	
Butte	18	62,163.8 ± 4,993.7a	57	3,543,336.6	24.42 ± 1.96a
Padre	18	70,211.3 ± 5,480.1b	57	4,002,044.1	27.58 ± 2.15b
Total Late Varieties			114	7,545,380.7	

[1] Means in a column followed by the same letter are not significantly different (P > 0.05, FPLSD).
[2] A rough estimate of flowers per ft^3 of tree canopy.

Table 4. Percent of pollination for early almond varieties.

Ranch Colonies/acre	Effective colony density (per acre)	Nonpareil $\bar{x}$ ± SD	Fritz $\bar{x}$ ± SD	Monterey $\bar{x}$ ± SD	Sonora $\bar{x}$ ± SD	Aldrich $\bar{x}$ ± SD
Wegis South 1.125/acre	1.16	35.5 ± 11.4a B	46.6 ± 15.2a A	26.8 ± 13.7a C	N/A	N/A
Wegis North 2.0/acre	1.75	50.5 ± 15.1b B	62.2 ± 15.9b A	32.7 ± 13.9b C	N/A	N/A
King/Gardiner West 1.0/acre	0.94	33.2 ± 9.2a B	52.3 ± 9.7a A	32.8 ± 13.5a B	N/A	N/A
King/Gardiner Northeast 2.0/acre	1.85	43.5 ± 9.7b B	69.2 ± 14.9b A	44.4 ± 12.9b B	N/A	N/A
Premier West 1.75/acre	1.64	57.3 ± 11.1a A	57.9 ± 11.7a A	N/A	50.3 ± 14.3a B	N/A
Premier East 2.5/acre	2.48	64.4 ± 12.5b A	65.4 ± 15.0b A	N/A	51.8 ± 8.2a B	N/A
South Valley 2.0/acre	1.68	49.5 ± 15.0a B	N/A	59.9 ± 11.4a A	N/A	46.0 ± 11.5a B
South Valley 2.5/acre	2.15	57.3 ± 16.5b B	N/A	67.8 ± 15.7b A	N/A	52.6 ± 15.9b B
Bidart East 1.0 /Acre	0.45	39.1 ± 12.3a	N/A	N/A	N/A	N/A
Bidart West 1.0/Acre	1.07	52.7 ± 10.5b	N/A	N/A	N/A	N/A

[1] Means in a column followed by the same lower case letter are not significantly different (P > 0.05, FPLSD).
[2] Means in a row followed by the same upper case letter (blue) are not significantly different (P > 0.05, FPLSD).

Table 5. Percent of pollination for late almond varieties.

Ranch Colonies/acre	Effective colony density (per acre)	Butte $\bar{x} \pm SD$	Padre $\bar{x} \pm SD$	Mission $\bar{x} \pm SD$
Wegis North 1.125/acre	1.25	14.7 ± 7.5a A	15.2 ± 6.9a A	N/A
Wegis South 1.16/acre	1.40	20.4 ± 6.8b A	20.9 ± 6.1b A	N/A
King/Gardiner West 1.0/acre	0.78	23..9 ± 6.5a B	37.9 ± 12.8a A	N/A
King/Gardiner Northeast East Side 1.3/acre	0.95	27.1 ± 7.9a B	38.0 ± 12.9a A	N/A
King/Gardiner Northeast West Side 1.3/Acre	1.75	40.1 ± 9.1b B	53.3 ± 13.8b A	N/A
Premier West 1.75/acre	1.78	35.7 ± 10.1a AB	39.4 ± 9.0a A	32.3 ± 9.9a B
Premier East 2.5/acre	2.27	49.5 ± 8.6b B	57.8 ± 12.9b A	41.1 ± 7.5b C
South Valley 2.0/acre	1.14	36.2 ± 13.4a A	37.2 ± 9.8a A	N/A
South Valley 3.0/acre	1.54	22.4 ± 8.6b B	34.8 ± 10.6a A	N/A

[1] Means in a column followed by the same letter are not significantly different (P > 0.05, FPLSD).
[2] Means in a row followed by the same upper case letter (blue) are not significantly different (P > 0.05, FPLSD).

Appendix A. Orchard size, varieties and tree densities.

Orchard	Acres	Varieties	Tree age (yrs)	Trees per acre[1]	Row spacing	Within row tree space
Wegis North Early varieties	160	50% Nonpareil, 25% Fritz, 25% Monterey	8	114	24'	16'
Wegis South Early varieties	160	50% Nonpareil, 25% Fritz, 25% Monterey	8	114	24'	16'
Wegis North Late varieties	160	50% Butte, 50% Padre	8	114	24'	16'
Wegis South Late varieties	32	50% Butte, 50% Padre	8	114	24'	16'
King Northeast Early varieties	76.5	50% Nonpareil, 25% Fritz, 25% Monterey	8	109	22'	18'
King West Early varieties	76.5	50% Nonpareil, 25% Fritz, 25% Monterey	8	109	22'	18'
King West Late varieties	74.9	66% Butte, 34% Padre (2 Butte trees alternated with 1 Padre)	8	114	22,	16'
King Northeast Late varieties	17.8	66% Butte, 34% Padre (2 Butte trees alternated with 1 Padre)	8	114	22,	16'
SVF North Early varieties	40.1	50% Nonpareil, 25% Monterey, 25% Aldrich		85.8	24'	21'

Appendix A. Orchard size, varieties and tree densities (con't).

Orchard	Acres	Varieties	Tree age (yrs)	Trees per acre[1]	Row spacing	Within row tree space
SVF South Early varieties	40.1	50% Nonpareil, 25% Monterey, 25% Aldrich		85.8	24'	21'
SVF North Late varieties	40.8	50% Butte, 50% Padre	6	114	24'	16'
SVF South Late varieties	40.8	50% Butte, 50% Padre	6	114	24'	16'
Premier East Early varieties	58.1	50% Nonpareil, 25% Sonora, 25% Fritz	19	75.2	24'	24'
Premier West Early varieties	70.6	50% Nonpareil, 25% Sonora, 25% Fritz	19	75.2	24'	24'
Premier East Late varieties	62.1	50 Butte, 25% Padre, 25% Mission	19	75.2	24'	24'
Premier West Late varieties	69.5	50 Butte, 25% Padre, 25% Mission	19	75.2	24'	24'
Bidart Southeast Early variety	39.7	50% Nonpareil, 25% Fritz, 25% Monterey	5	86.1	24'	21'
Bidart Southwest Early variety	39.5	50% Nonpareil, 25% Fritz, 25% Monterey	5	86.1	24'	21'

Appendix B. Adult bee strength at the end of pollination for a random sampling of colonies. Measurements in standard deep frames of bees.

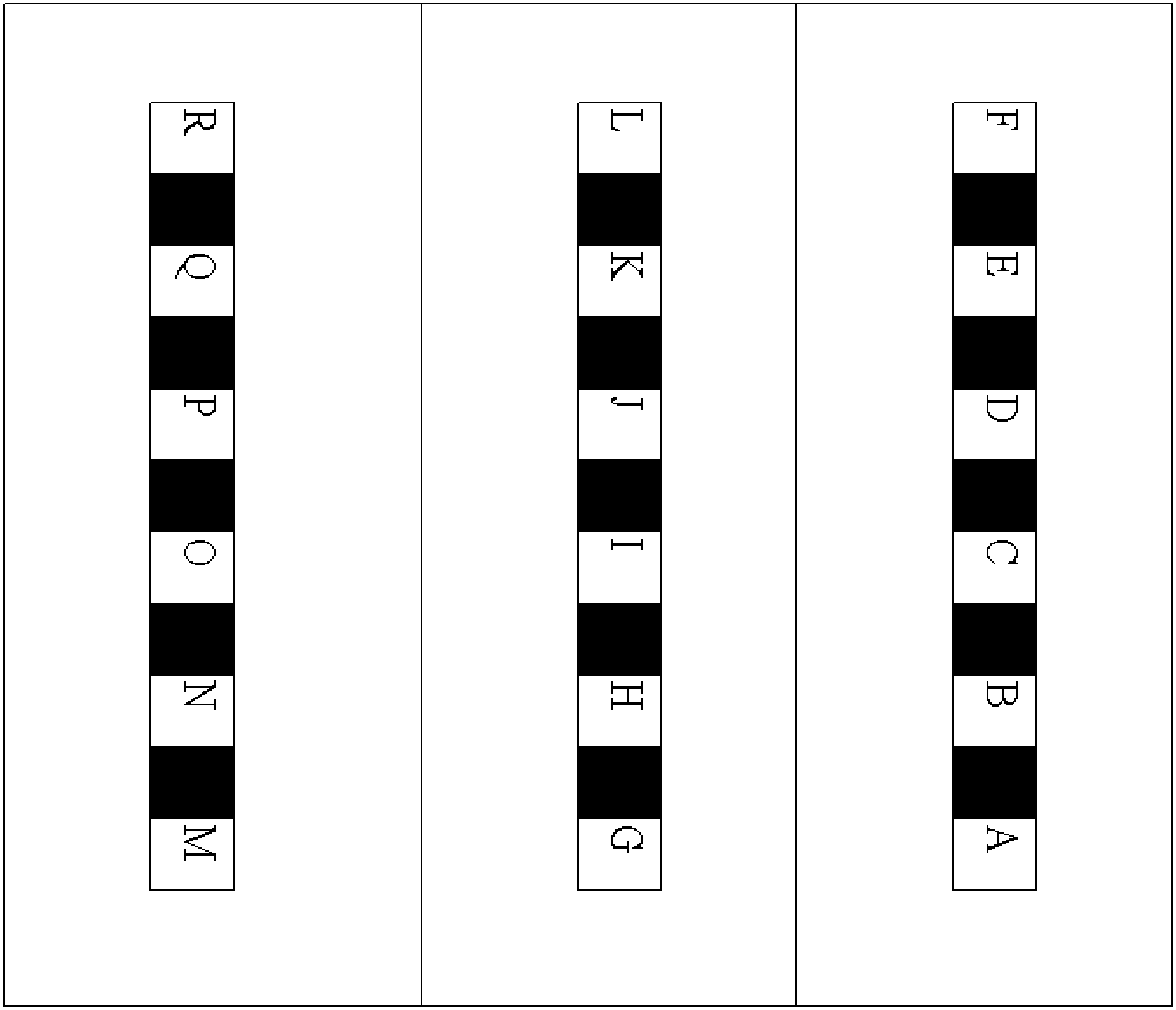
Orchard: colony density (colonies per acre) and varieties	n	End $\bar{x} \pm SD$
Wegis: 1.125 colony/acre Early varieties	20	7.6 ± 3.3a[1]
Wegis: 2.0 colonies/acre Early varieties	21	5.2 ± 1.6b
Wegis: 1.125 colonies/acre Late varieties	10	6.9 ± 3.2a
Wegis: 1.16 colonies/acre Late varieties (pollen trapped)	10	6.0 ± 2.2a
King/Gardiner: West 1.0 colony/acre; Early varieties	30	11.1 ± 3.2a
King[1]: Northeast 2.0 colonies/acre; Early varieties	20[2]	11.9 ± 3.4a
King/Gardiner: West 1.0 colony/acre; Late varieties	12	12.3 ± 4.3a
King/Gardiner: Northeast 1.3 colonies/acre; Late varieties	21[2]	13.0 ± 4.4a
Premier-Westchester 1.75 colonies/acre; Early varieties	10	8.9 ± 1.8a

Appendix B. Adult bee strength at end of pollination for a random sampling of colonies. Measurements in standard deep frames of bees (con't)

Orchard: colony density (colonies per acre) and varieties	n	End $\bar{x} \pm SD$
Premier-Westchester 2.5 colonies/acre; Early varieties	31[2]	7.1 ± 4.2a
Premier-Westchester 1.75 colonies/acre; Late varieties	10	9.8 ± 3.1a
Premier-Westchester 2.5 colonies/acre; Late varieties	30	7.6 ± 3.3a
South Valley Farms 2.0 colonies/acre; Early varieties	26	8.9 ± 3.3a
South Valley Farms 2.5 colonies/acre; Early varieties	30	8.6 ± 3.9a
South Valley Farms 2.0 colonies/acre; Late varieties	21[3]	3.2 ± 2.6a[4]
South Valley Farms 3.0 colonies/acre; Late varieties	32[3]	4.9 ± 3.0b[5]
Bidart Southeast 0.5 colony/acre; Early varieties	11	14.9 ± 2.5a
Bidart Southwest 0.5 colony/acre; Early varieties	10	14.9 ± 2.6a

[1] Within groups of blue or black data, means followed by the same letter in a column are not significantly different P > 0.05, FPLSD.
[2] One colony found queenless
[3] Two colonies found dead
[4] Colony quality was poor and 9.5% were dead.
[5] Colony quality was poor and 6.25% were dead.

Appendix C. The orchards were divided into three equal sections for the petal fall collections. Letters correspond to positions indicated in the following tables.



Appendix D. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the Monterey variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

Location of monitored trees within the orchard[3]																			
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Slope East side of tree		-12.568	-15.181	-15.405	-6.1165	-11.687	-15.153	-13.733	-14.58	-17.02	-9.6554	-18.099	-9.0813	-19.98	-18.105	-10.668	-17.319	-15.565	-12.397
Intercept East side of tree		201.901	257.511	254.282	128.8	190.018	238.331	238.353	244.956	274.702	161.809	272.48	180.104	309.172	279.241	192.778	273.251	231.873	211.745
Slope West side of tree		-9.3713	-14.426	-13.767	-7.5026	-12.324	-14.85	-11.092	-12.816	-13.785	-7.9373	-18.397	-8.7512	-20.517	-15.676	-10.886	-15.572	-15.12	-12.673
Intercept West side of tree		209.536	221.414	229.29	147.757	226.516	228.447	224.399	226.966	239.518	176.503	261.198	179.785	313.078	249.233	196.513	251.179	227.421	229.697
Flowers per ft^2 at each distance from tree center on the east side of the tree	1	189.3	242.3	238.9	122.7	178.3	223.2	224.6	230.4	257.7	152.2	254.4	171.0	289.2	261.1	182.1	255.9	216.3	199.3
	2	176.8	227.1	223.5	116.6	166.6	208.0	210.9	215.8	240.7	142.5	236.3	161.9	269.2	243.0	171.4	238.6	200.7	187.0
	3	164.2	212.0	208.1	110.5	155.0	192.9	197.2	201.2	223.6	132.8	218.2	152.9	249.2	224.9	160.8	221.3	185.2	174.6
	4	151.6	196.8	192.7	104.3	143.3	177.7	183.4	186.6	206.6	123.2	200.1	143.8	229.3	206.8	150.1	204.0	169.6	162.2
	5	139.1	181.6	177.3	98.2	131.6	162.6	169.7	172.1	189.6	113.5	182.0	134.7	209.3	188.7	139.4	186.7	154.0	149.8
	6	126.5	166.4	161.9	92.1	119.9	147.4	156.0	157.5	172.6	103.9	163.9	125.6	189.3	170.6	128.8	169.3	138.5	137.4
	7	113.9	151.2	146.4	86.0	108.2	132.3	142.2	142.9	155.6	94.2	145.8	116.5	169.3	152.5	118.1	152.0	122.9	125.0
	8	101.4	136.1	131.0	79.9	96.5	117.1	128.5	128.3	138.5	84.6	127.7	107.5	149.3	134.4	107.4	134.7	107.3	112.6
	9	88.8	120.9	115.6	73.8	84.8	102.0	114.8	113.7	121.5	74.9	109.6	98.4	129.3	116.3	96.8	117.4	91.8	100.2
	10	76.2	105.7	100.2	67.6	73.1	86.8	101.0	99.2	104.5	65.3	91.5	89.3	109.4	98.2	86.1	100.1	76.2	87.8
	11	63.7	90.5	84.8	61.5	61.5	71.6	87.3	84.6	87.5	55.6	73.4	80.2	89.4	80.1	75.4	82.7	60.7	75.4
	12	51.1	75.3	69.4	55.4	49.8	56.5	73.6	70.0	70.5	45.9	55.3	71.1	69.4	62.0	64.8	65.4	45.1	63.0
Flowers per ft^2 at each distance from tree center on the west	1	200.2	207.0	215.5	140.3	214.2	213.6	213.3	214.1	225.7	168.6	242.8	171.0	292.6	233.6	185.6	235.6	212.3	217.0
	2	190.8	192.6	201.8	132.8	201.9	198.7	202.2	201.3	211.9	160.6	224.4	162.3	272.0	217.9	174.7	220.0	197.2	204.4
	3	181.4	178.1	188.0	125.2	189.5	183.9	191.1	188.5	198.2	152.7	206.0	153.5	251.5	202.2	163.9	204.5	182.1	191.7
	4	172.1	163.7	174.2	117.7	177.2	169.0	180.0	175.7	184.4	144.8	187.6	144.8	231.0	186.5	153.0	188.9	166.9	179.0
	5	162.7	149.3	160.5	110.2	164.9	154.2	168.9	162.9	170.6	136.8	169.2	136.0	210.5	170.9	142.1	173.3	151.8	166.3
	6	153.3	134.9	146.7	102.7	152.6	139.3	157.8	150.1	156.8	128.9	150.8	127.3	190.0	155.2	131.2	157.7	136.7	153.7

	7	143.9	120.4	132.9	95.2	140.2	124.5	146.8	137.3	143.0	120.9	132.4	118.5	169.5	139.5	120.3	142.2	121.6	141.0
	8	134.6	106.0	119.2	87.7	127.9	109.6	135.7	124.4	129.2	113.0	114.0	109.8	148.9	123.8	109.4	126.6	106.5	128.3
	9	125.2	91.6	105.4	80.2	115.6	94.8	124.6	111.6	115.5	105.1	95.6	101.0	128.4	108.1	98.5	111.0	91.3	115.6
	10	115.8	77.2	91.6	72.7	103.3	79.9	113.5	98.8	101.7	97.1	77.2	92.3	107.9	92.5	87.7	95.5	76.2	103.0
	11	106.5	62.7	77.9	65.2	90.9	65.1	102.4	86.0	87.9	89.2	58.8	83.5	87.4	76.8	76.8	79.9	61.1	90.3
	12	97.1	48.3	64.1	57.7	78.6	50.2	91.3	73.2	74.1	81.3	40.4	74.8	66.9	61.1	65.9	64.3	46.0	77.6
Flowers	Per 24Ft[2] (aisle to aisle)	3,226.0	3,437.7	3,527.5	2,256.4	3,125.5	3,261.1	3,616.6	3,526.1	3,767.8	2,687.5	3,557.5	2,927.7	4,308.2	3,706.8	2,990.3	3,727.7	3,118.0	3,341.9
	Tree (114/ Acre)	51,615.3	55,003.5	56,439.3	36,102.4	50,008.2	52,177.8	57,866.1	56,417.8	60,285.4	43,000.3	56,919.2	46,843.7	68,931.6	59,308.9	47,844.7	59,642.8	49,888.4	53,470

[1] Daily petal fall was monitored for all varieties at 18 locations within two orchards (160 acre early and 160 acre late blooming varieties). At each location five gallon buckets (early blooming three variety orchard, 16 buckets; late blooming two variety orchard, 8 buckets) were placed at different intervals and petals counted and removed daily; tree line center (0 feet), both sides of a tree (3' from tree line center), and both center isles between tree rows (12' from tree line center). Petal counts from each bucket for all day's collections were totaled, and then divided by five (five petals per flower) to determine the total number of flowers for each bucket position.

[2] Petal fall was monitored for five days in a continuous transect of buckets on each tree side to determine the value of each bucket position. The data was subjected to a regression analysis and the average r^2 was 0.87 ± 0.14, $p < 0.05$. This suggests that the petals fell in a continuum from the tree line center. Separate transects (tree line center to aisle center) of petal counts were made at the tree and the center between trees, this data was subjected to a test $p > 0.05$. There was no difference in the number of petals at the tree or at the center between trees. We then subjected all buckets on each tree side to a regression analysis to determine the slope and intercept for each tree side so that the number of flowers at each ft^2 position (24, tree rows spaced 24' apart) could be calculated. We then added the flowers per ft^2 for each of the 24 ft^2 positions and multiplied by 16 (distance (feet) between trees within a row) to calculate flowers per tree.

[3] The orchard was divided into three equal sections, then the center four tree rows in each section had six equally spaced locations that were monitored for petal fall, totaling 18 different locations (A-R) monitored.

Appendix E. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the Fritz variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

		Location of monitored trees within the orchard[3]																	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Slope East side of tree		-8.1819	-6.2497	-6.94081	-7.0502	-6.0602	-5.7444	-10.5428	-6.6669	-9.3681	-6.4456	-7.6896	-1.7798	-9.5470	-5.8072	-8.0581	-5.0197	-12.5054	-9.702
Intercept East side of tree		166.7	116.2	155.1	122.5	135.0	117.8	207.0	150.4	169.4	139.8	134.5	88.0	150.1	123.9	161.8	112.7	205.7	188.8
Slope West side of tree		-9.8555	-6.8794	-8.0788	-8.0085	-8.2674	-8.0506	-10.8992	-8.2087	-10.2097	-6.5309	-6.3061	-3.9364	-9.4200	-7.4646	-10.4968	-5.2783	-11.6344	-11.6466
Intercept West side of tree		162.5	120.8	141.7	143.6	129.9	125.7	205.3	163.7	167.8	140.5	137.3	81.7	162.9	119.1	180.1	106.6	204.5	187.7
Flowers per ft^2 at each distance from tree center on the east side of the tree	1	158.5	109.9	148.2	115.4	129.0	112.1	196.5	143.7	160.0	133.3	126.8	86.2	140.6	118.1	153.7	107.7	193.2	179.1
	2	150.4	103.7	141.3	108.4	122.9	106.3	185.9	137.0	150.6	126.9	119.1	84.4	131.0	112.3	145.6	102.7	180.7	169.4
	3	142.2	97.4	134.3	101.3	116.9	100.6	175.4	130.4	141.2	120.4	111.4	82.6	121.5	106.5	137.6	97.7	168.2	159.7
	4	134.0	91.2	127.4	94.3	110.8	94.8	164.9	123.7	131.9	114.0	103.8	80.8	112.0	100.7	129.5	92.7	155.7	150.0
	5	125.8	84.9	120.4	87.2	104.7	89.1	154.3	117.0	122.5	107.5	96.1	79.1	102.4	94.9	121.5	87.6	143.2	140.2
	6	117.6	78.7	113.5	80.2	98.7	83.3	143.8	110.4	113.1	101.1	88.4	77.3	92.9	89.1	113.4	82.6	130.7	130.5
	7	109.4	72.4	106.6	73.1	92.6	77.6	133.2	103.7	103.8	94.6	80.7	75.5	83.3	83.3	105.4	77.6	118.2	120.8
	8	101.3	66.2	99.6	66.1	86.6	71.9	122.7	97.0	94.4	88.2	73.0	73.7	73.8	77.5	97.3	72.6	105.7	111.1
	9	93.1	59.9	92.7	59.0	80.5	66.1	112.1	90.4	85.0	81.8	65.3	71.9	64.2	71.7	89.2	67.6	93.2	101.4
	10	84.9	53.7	85.7	52.0	74.4	60.4	101.6	83.7	75.7	75.3	57.6	70.2	54.7	65.9	81.2	62.5	80.7	91.7
	11	76.7	47.4	78.8	44.9	68.4	54.6	91.1	77.0	66.3	68.9	49.9	68.4	45.1	60.1	73.1	57.5	68.2	82.0
	12	68.5	41.2	71.9	37.9	62.3	48.9	80.5	70.4	56.9	62.4	42.2	66.6	35.6	54.3	65.1	52.5	55.7	72.3
Flowers per ft^2 at each distance from tree	1	152.7	113.9	133.6	135.6	121.7	117.6	194.4	155.5	157.6	134.0	131.0	77.7	153.5	111.6	169.7	101.3	192.8	176.0
	2	142.8	107.0	125.5	127.6	113.4	109.6	183.5	147.3	147.4	127.5	124.7	73.8	144.1	104.2	159.2	96.0	181.2	164.4
	3	133.0	100.2	117.4	119.6	105.1	101.5	172.6	139.1	137.2	120.9	118.4	69.9	134.7	96.7	148.7	90.8	169.6	152.7
	4	123.1	93.3	109.4	111.6	96.9	93.5	161.7	130.9	127.0	114.4	112.1	65.9	125.3	89.2	138.2	85.5	157.9	141.1
	5	113.2	86.4	101.3	103.6	88.6	85.4	150.8	122.7	116.7	107.9	105.8	62.0	115.8	81.8	127.7	80.2	146.3	129.4

	6	103.4	79.5	93.2	95.6	80.3	77.4	139.9	114.5	106.5	101.3	99.5	58.1	106.4	74.3	117.2	74.9	134.7	117.8
	7	93.5	72.6	85.1	87.6	72.1	69.3	129.0	106.2	96.3	94.8	93.2	54.1	97.0	66.9	106.7	69.6	123.0	106.2
	8	83.7	65.8	77.0	79.6	63.8	61.3	118.1	98.0	86.1	88.3	86.9	50.2	87.6	59.4	96.2	64.4	111.4	94.5
	9	73.8	58.9	69.0	71.6	55.5	53.2	107.2	89.8	75.9	81.7	80.6	46.2	78.2	51.9	85.7	59.1	99.8	82.9
	10	64.0	52.0	60.9	63.5	47.3	45.2	96.3	81.6	65.7	75.2	74.3	42.3	68.8	44.5	75.2	53.8	88.1	71.2
	11	54.1	45.1	52.8	55.5	39.0	37.1	85.4	73.4	55.5	68.7	68.0	38.4	59.3	37.0	64.7	48.5	76.5	59.6
	12	44.3	38.3	44.7	47.5	30.7	29.1	74.5	65.2	45.3	62.2	61.7	34.4	49.9	29.5	54.2	43.3	64.9	47.9
Flowers	Per 24Ft[2] (aisle to aisle)	2,543.9	1,819.4	2,390.4	2,018.6	2,062.0	1,846.0	3,275.3	2,608.7	2,518.7	2,351.3	2,170.8	1,589.7	2,277.7	1,881.4	2,655.6	1,828.6	3,039.7	2,852.1
	Tree (114/ Acre)	40,703.0	29,110.6	38,246.4	32,297.8	32,992.5	29,536.7	52,405.1	41,738.7	40,298.6	37,621.4	34,732.1	25,435.2	36,442.9	30,102.2	42,490.2	29,257.6	48,634.5	45,633.3

[1] Daily petal fall was monitored for all varieties at 18 locations within two orchards (160 acre early and 160 acre late blooming varieties). At each location five gallon buckets (early blooming three variety orchard, 16 buckets; late blooming two variety orchard, 8 buckets) were placed at different intervals and petals counted and removed daily; tree line center (0 feet), both sides of a tree (3' from tree line center), and both center isles between tree rows (12' from tree line center). Petal counts from each bucket for all day's collections were totaled, and then divided by five (five petals per flower) to determine the total number of flowers for each bucket position.

[2] Petal fall was monitored for five days in a continuous transect of buckets on each tree side to determine the value of each bucket position. The data was subjected to a regression analysis and the average r^2 was 0.87 ± 0.14, $p < 0.05$. This suggests that the petals fell in a continuum from the tree line center. Separate transects (tree line center to aisle center) of petal counts were made at the tree and the center between trees, this data was subjected to a test $p > 0.05$. There was no difference in the number of petals at the tree or at the center between trees. We then subjected all buckets on each tree side to a regression analysis to determine the slope and intercept for each tree side so that the number of flowers at each ft^2 position (24, tree rows spaced 24' apart) could be calculated. We then added the flowers per ft^2 for each of the 24 ft^2 positions and multiplied by 16 (distance (feet) between trees within a row) to calculate flowers per tree.

[3] The orchard was divided into three equal sections, then the center four tree rows in each section had six equally spaced locations that were monitored for petal fall, totaling 18 different locations (A-R) monitored.

Appendix F. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the first tree at each location of Nonpareil variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft² horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

		Location of monitored trees within the orchard[3]																	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Slope East side of tree		-2.44688	-1.58361	-4.18336	-2.15198	-2.97401	-3.4188	-2.72482	-6.32453	-4.68061	-10.51835	-6.07599	-3.48515	-5.21152	-3.04	-10.46798	-7.64267	-8.23263	-6.77303
Intercept East side of tree		114.79911	60.17691	119.81378	76.25769	106.42979	91.09311	124.42569	154.6271	127.99486	204.62556	120.56023	114.36059	122.05259	95.34949	191.80365	156.28229	144.45367	148.77563
Slope West side of tree		-4.46123	-2.39055	-3.54371	-3.8393	-3.24727	-3.70976	-3.9279	-6.25054	-6.15458	-11.5669	-6.15523	-3.10179	-7.09538	-3.43854	-9.27958	-8.24323	-7.92421	-6.59079
Intercept West side of tree		124.15126	73.15947	113.10119	84.66757	100.1334	100.69835	122.12778	146.19882	130.11239	206.57052	118.68871	103.64593	130.2591	100.04993	175.26955	158.04085	145.31127	150.90719
Flowers per ft² at each distance from tree center on the east side of the tree	1	112.4	58.6	115.6	74.1	103.5	87.7	121.7	148.3	123.3	194.1	114.5	110.9	116.8	92.3	181.3	148.6	136.2	142.0
	2	109.9	57.0	111.4	72.0	100.5	84.3	119.0	142.0	118.6	183.6	108.4	107.4	111.6	89.3	170.9	141.0	128.0	135.2
	3	107.5	55.4	107.3	69.8	97.5	80.8	116.3	135.7	114.0	173.1	102.3	103.9	106.4	86.2	160.4	133.4	119.8	128.5
	4	105.0	53.8	103.1	67.6	94.5	77.4	113.5	129.3	109.3	162.6	96.3	100.4	101.2	83.2	149.9	125.7	111.5	121.7
	5	102.6	52.3	98.9	65.5	91.6	74.0	110.8	123.0	104.6	152.0	90.2	96.9	96.0	80.1	139.5	118.1	103.3	114.9
	6	100.1	50.7	94.7	63.3	88.6	70.6	108.1	116.7	99.9	141.5	84.1	93.4	90.8	77.1	129.0	110.4	95.1	108.1
	7	97.7	49.1	90.5	61.2	85.6	67.2	105.4	110.4	95.2	131.0	78.0	90.0	85.6	74.1	118.5	102.8	86.8	101.4
	8	95.2	47.5	86.3	59.0	82.6	63.7	102.6	104.0	90.5	120.5	72.0	86.5	80.4	71.0	108.1	95.1	78.6	94.6
	9	92.8	45.9	82.2	56.9	79.7	60.3	99.9	97.7	85.9	110.0	65.9	83.0	75.1	68.0	97.6	87.5	70.4	87.8
	10	90.3	44.3	78.0	54.7	76.7	56.9	97.2	91.4	81.2	99.4	59.8	79.5	69.9	64.9	87.1	79.9	62.1	81.0
	11	87.9	42.8	73.8	52.6	73.7	53.5	94.5	85.1	76.5	88.9	53.7	76.0	64.7	61.9	76.7	72.2	53.9	74.3
	12	85.4	41.2	69.6	50.4	70.7	50.1	91.7	78.7	71.8	78.4	47.6	72.5	59.5	58.9	66.2	64.6	45.7	67.5
Flowers per ft² at each distance from tree center on the west side of the tree	1	119.7	70.8	109.6	80.8	96.9	97.0	118.2	139.9	124.0	195.0	112.5	100.5	123.2	96.6	166.0	149.8	137.4	144.3
	2	115.2	68.4	106.0	77.0	93.6	93.3	114.3	133.7	117.8	183.4	106.4	97.4	116.1	93.2	156.7	141.6	129.5	137.7
	3	110.8	66.0	102.5	73.1	90.4	89.6	110.3	127.4	111.6	171.9	100.2	94.3	109.0	89.7	147.4	133.3	121.5	131.1
	4	106.3	63.6	98.9	69.3	87.1	85.9	106.4	121.2	105.5	160.3	94.1	91.2	101.9	86.3	138.2	125.1	113.6	124.5
	5	101.8	61.2	95.4	65.5	83.9	82.1	102.5	114.9	99.3	148.7	87.9	88.1	94.8	82.9	128.9	116.8	105.7	118.0

	6	97.4	58.8	91.8	61.6	80.6	78.4	98.6	108.7	93.2	137.2	81.8	85.0	87.7	79.4	119.6	108.6	97.8	111.4
	7	92.9	56.4	88.3	57.8	77.4	74.7	94.6	102.4	87.0	125.6	75.6	81.9	80.6	76.0	110.3	100.3	89.8	104.8
	8	88.5	54.0	84.8	54.0	74.2	71.0	90.7	96.2	80.9	114.0	69.4	78.8	73.5	72.5	101.0	92.1	81.9	98.2
	9	84.0	51.6	81.2	50.1	70.9	67.3	86.8	89.9	74.7	102.5	63.3	75.7	66.4	69.1	91.8	83.9	74.0	91.6
	10	79.5	49.3	77.7	46.3	67.7	63.6	82.8	83.7	68.6	90.9	57.1	72.6	59.3	65.7	82.5	75.6	66.1	85.0
	11	75.1	46.9	74.1	42.4	64.4	59.9	78.9	77.4	62.4	79.3	51.0	69.5	52.2	62.2	73.2	67.4	58.1	78.4
	12	70.6	44.5	70.6	38.6	61.2	56.2	75.0	71.2	56.3	67.8	44.8	66.4	45.1	58.8	63.9	59.1	50.2	71.8
Flowers	Per $24Ft^2$ (aisle to aisle)	2,328.6	1,290.1	2,192.3	1,463.8	1,993.5	1,745.5	2,439.7	2,629.1	2,252.1	3,211.7	1,917.0	2,102.3	2,067.8	1,839.5	2,864.6	2,532.8	2,216.9	2,553.8
	Tree (114/Acre)	37,257.1	20,640.8	35,076.3	23,420.5	31,896.0	27,927.5	39,035.7	42,064.9	36,034.3	51,387.3	30,671.2	33,636.8	33,084.8	29,431.5	45,833.1	40,524.4	35,471.1	40,861.1

1 Daily petal fall was monitored for all varieties at 18 locations within two orchards (160 acre early and 160 acre late blooming varieties). At each location five gallon buckets (early blooming three variety orchard, 16 buckets; late blooming two variety orchard, 8 buckets) were placed at different intervals and petals counted and removed daily; tree line center (0 feet), both sides of a tree (3' from tree line center), and both center isles between tree rows (12' from tree line center). Petal counts from each bucket for all day's collections were totaled, and then divided by five (five petals per flower) to determine the total number of flowers for each bucket position.

2 Petal fall was monitored for five days in a continuous transect of buckets on each tree side to determine the value of each bucket position. The data was subjected to a regression analysis and the average r^2 was 0.87 ± 0.14, $p < 0.05$. This suggests that the petals fell in a continuum from the tree line center. Separate transects (tree line center to aisle center) of petal counts were made at the tree and the center between trees, this data was subjected to a test $p > 0.05$. There was no difference in the number of petals at the tree or at the center between trees. We then subjected all buckets on each tree side to a regression analysis to determine the slope and intercept for each tree side so that the number of flowers at each ft^2 position (24, tree rows spaced 24' apart) could be calculated. We then added the flowers per ft^2 for each of the 24 ft^2 positions and multiplied by 16 (distance (feet) between trees within a row) to calculate flowers per tree.

3 The orchard was divided into three equal sections, then the center four tree rows in each section had six equally spaced locations that were monitored for petal fall, totaling 18 different locations (A-R) monitored.

Appendix G. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the second tree at each location of Nonpareil variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

		Location of monitored trees within the orchard[3]																	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Slope East side of tree		-4.36	-5.61	-5.70	-4.82	-2.25	-2.73	-5.75	-4.97	-7.09	-9.18	-6.66	-2.67	-4.13	-6.52	-6.07	-9.47	-8.53	-7.33
Intercept East side of tree		99.59	104.74	111.75	103.04	58.25	63.83	137.27	121.42	128.69	175.00	145.15	67.96	102.99	111.05	123.68	162.26	163.87	134.78
Slope West side of tree		-4.46	-4.30	-4.90	-3.05	-0.61	-0.77	-6.08	-4.19	-6.12	-11.27	-6.87	-0.30	-2.80	-5.52	-4.71	-8.55	-9.39	-6.23
Intercept West side of tree		97.38	111.88	121.89	95.06	59.75	62.19	141.73	115.24	129.18	184.73	141.14	68.73	95.42	116.60	120.03	156.11	154.87	132.58
Flowers per ft^2 at each distance from tree center on the east side of the tree	1	95.2	99.1	106.0	98.2	56.0	61.1	131.5	116.5	121.6	165.8	138.5	65.3	98.9	104.5	117.6	152.8	155.3	127.4
	2	90.9	93.5	100.3	93.4	53.7	58.4	125.8	111.5	114.5	156.6	131.8	62.6	94.7	98.0	111.5	143.3	146.8	120.1
	3	86.5	87.9	94.6	88.6	51.5	55.6	120.0	106.5	107.4	147.5	125.2	60.0	90.6	91.5	105.5	133.9	138.3	112.8
	4	82.1	82.3	88.9	83.7	49.2	52.9	114.3	101.6	100.3	138.3	118.5	57.3	86.5	85.0	99.4	124.4	129.7	105.5
	5	77.8	76.7	83.2	78.9	47.0	50.2	108.5	96.6	93.2	129.1	111.9	54.6	82.3	78.5	93.3	114.9	121.2	98.1
	6	73.4	71.1	77.5	74.1	44.7	47.4	102.8	91.6	86.1	119.9	105.2	52.0	78.2	72.0	87.3	105.4	112.7	90.8
	7	69.1	65.5	71.8	69.3	42.5	44.7	97.0	86.7	79.0	110.8	98.5	49.3	74.1	65.4	81.2	96.0	104.1	83.5
	8	64.7	59.9	66.1	64.4	40.2	42.0	91.3	81.7	72.0	101.6	91.9	46.6	69.9	58.9	75.1	86.5	95.6	76.1
	9	60.3	54.2	60.4	59.6	38.0	39.2	85.5	76.7	64.9	92.4	85.2	44.0	65.8	52.4	69.1	77.0	87.1	68.8
	10	56.0	48.6	54.7	54.8	35.7	36.5	79.8	71.8	57.8	83.2	78.6	41.3	61.7	45.9	63.0	67.6	78.5	61.5
	11	51.6	43.0	49.0	50.0	33.5	33.8	74.0	66.8	50.7	74.1	71.9	38.6	57.5	39.4	56.9	58.1	70.0	54.2
	12	47.3	37.4	43.3	45.1	31.2	31.0	68.3	61.8	43.6	64.9	65.3	36.0	53.4	32.9	50.9	48.6	61.5	

																			46.8
Flowers per ft² at each distance from tree center on the west side of the tree	1	92.9	107.6	117.0	92.0	59.1	61.4	135.7	111.0	123.1	173.5	134.3	68.4	92.6	111.1	115.3	147.6	145.5	126.4
	2	88.5	103.3	112.1	89.0	58.5	60.6	129.6	106.9	116.9	162.2	127.4	68.1	89.8	105.6	110.6	139.0	136.1	120.1
	3	84.0	99.0	107.2	85.9	57.9	59.9	123.5	102.7	110.8	150.9	120.5	67.8	87.0	100.0	105.9	130.5	126.7	113.9
	4	79.5	94.7	102.3	82.9	57.3	59.1	117.4	98.5	104.7	139.7	113.7	67.5	84.2	94.5	101.2	121.9	117.3	107.7
	5	75.1	90.4	97.4	79.8	56.7	58.3	111.3	94.3	98.6	128.4	106.8	67.2	81.4	89.0	96.5	113.4	107.9	101.5
	6	70.6	86.1	92.5	76.8	56.1	57.6	105.2	90.1	92.5	117.1	99.9	66.9	78.6	83.5	91.8	104.8	98.5	95.2
	7	66.2	81.8	87.6	73.7	55.5	56.8	99.2	85.9	86.4	105.9	93.1	66.6	75.8	78.0	87.1	96.3	89.1	89.0
	8	61.7	77.5	82.7	70.7	54.8	56.0	93.1	81.7	80.3	94.6	86.2	66.3	73.0	72.4	82.4	87.7	79.8	82.8
	9	57.3	73.2	77.8	67.7	54.2	55.2	87.0	77.5	74.1	83.3	79.3	66.0	70.2	66.9	77.6	79.2	70.4	76.6
	10	52.8	68.9	72.9	64.6	53.6	54.5	80.9	73.3	68.0	72.0	72.5	65.7	67.4	61.4	72.9	70.7	61.0	70.3
	11	48.3	64.6	68.0	61.6	53.0	53.7	74.8	69.1	61.9	60.8	65.6	65.4	64.6	55.9	68.2	62.1	51.6	64.1
	12	43.9	60.3	63.1	58.5	52.4	52.9	68.8	64.9	55.8	49.5	58.7	65.1	61.8	50.3	63.5	53.6	42.2	57.9
Flowers	Per 24Ft² (aisle to aisle)	1,675.8	1,826.5	1,976.7	1,763.4	1,192.5	1,238.7	2,425.1	2,125.7	2,064.2	2,722.0	2,380.5	1,408.8	1,840.1	1,793.0	2,083.9	2,415.3	2,426.8	2,151.0
	Tree (114 /Acre)	26,812.9	29,223.6	31,627.7	28,213.8	19,079.7	19,819.0	38,801.7	34,011.1	33,026.9	43,552.8	38,087.2	22,541.4	29,441.6	28,687.7	33,341.8	38,645.0	38,829.3	34,416.2

1 Daily petal fall was monitored for all varieties at 18 locations within two orchards (160 acre early and 160 acre late blooming varieties). At each location five gallon buckets (early blooming three variety orchard, 16 buckets; late blooming two variety orchard, 8 buckets) were placed at different intervals and petals counted and removed daily; tree line center (0 feet), both sides of a tree (3' from tree line center), and both center isles between tree rows (12' from tree line center). Petal counts from each bucket for all day's collections were totaled, and then divided by five (five petals per flower) to determine the total number of flowers for each bucket position.

2 Petal fall was monitored for five days in a continuous transect of buckets on each tree side to determine the value of each bucket position. The data was subjected to a regression analysis and the average r^2 was 0.87 ± 0.14, $p < 0.05$. This suggests that the petals fell in a continuum from the tree line center.

Separate transects (tree line center to aisle center) of petal counts were made at the tree and the center between trees, this data was subjected to a test p > 0.05. There was no difference in the number of petals at the tree or at the center between trees. We then subjected all buckets on each tree side to a regression analysis to determine the slope and intercept for each tree side so that the number of flowers at each ft^2 position (24, tree rows spaced 24' apart) could be calculated. We then added the flowers per ft^2 for each of the 24 ft^2 positions and multiplied by 16 (distance (feet) between trees within a row) to calculate flowers per tree.

[3] The orchard was divided into three equal sections, then the center four tree rows in each section had six equally spaced locations that were monitored for petal fall, totaling 18 different locations (A-R) monitored.

Appendix H. Quantity of flowers per tree determined by our collection of every petal[1], and our calculations[2] for the Butte variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft^2 horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

		Location of monitored trees within the orchard[3]																	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Slope East side of tree		-10.51	-10.99	-13.03	-13.73	-13.78	-13.95	-12.85	-12.39	-15.80	-12.06	-14.41	-16.29	-16.05	-18.48	-14.53	-14.75	-13.32	-14.23
Intercept East side of tree		216.96	212.27	222.69	247.19	228.19	239.92	243.65	240.02	269.27	241.47	248.02	280.62	286.50	303.21	252.59	251.10	224.04	225.94
Slope West side of tree		-6.74	-12.00	-12.77	-12.88	-11.89	-11.35	-12.06	-12.47	-11.73	-11.21	-6.10	-15.51	-14.30	-16.10	-14.01	-14.56	-11.71	-12.17
Intercept West side of tree		197.16	239.02	238.28	248.66	245.81	227.29	239.04	248.89	246.08	229.87	243.54	283.75	283.13	289.88	262.49	262.10	231.23	237.52
Flowers per ft^2 at each distance from tree center on the east side of the tree	1	206.5	201.3	209.7	233.5	214.4	226.0	230.8	227.6	253.5	229.4	233.6	264.3	270.4	284.7	238.1	236.3	210.7	211.7
	2	195.9	190.3	196.6	219.7	200.6	212.0	218.0	215.2	237.7	217.4	219.2	248.0	254.4	266.2	223.5	221.6	197.4	197.5
	3	185.4	179.3	183.6	206.0	186.9	198.1	205.1	202.8	221.9	205.3	204.8	231.7	238.3	247.8	209.0	206.8	184.1	183.2
	4	174.9	168.3	170.6	192.3	173.1	184.1	192.3	190.4	206.1	193.2	190.4	215.4	222.3	229.3	194.5	192.1	170.8	169.0
	5	164.4	157.3	157.5	178.6	159.3	170.2	179.4	178.1	190.3	181.2	176.0	199.2	206.2	210.8	180.0	177.3	157.4	154.8
	6	153.9	146.4	144.5	164.8	145.5	156.2	166.6	165.7	174.5	169.1	161.6	182.9	190.2	192.3	165.4	162.6	144.1	140.5
	7	143.4	135.4	131.4	151.1	131.8	142.3	153.7	153.3	158.7	157.0	147.2	166.6	174.1	173.8	150.9	147.8	130.8	126.3
	8	132.9	124.4	118.4	137.4	118.0	128.3	140.9	140.9	142.9	145.0	132.8	150.3	158.1	155.3	136.4	133.1	117.5	112.1
	9	122.4	113.4	105.4	123.7	104.2	114.4	128.0	128.5	127.1	132.9	118.4	134.0	142.0	136.9	121.8	118.3	104.2	97.9
	10	111.9	102.4	92.3	109.9	90.4	100.4	115.2	116.1	111.3	120.9	103.9	117.7	126.0	118.4	107.3	103.6	90.8	83.6
	11	101.4	91.4	79.3	96.2	76.6	86.5	102.3	103.7	95.5	108.8	89.5	101.4	109.9	99.9	92.8	88.8	77.5	69.4
	12	90.8	80.4	66.3	82.5	62.9	72.5	89.5	91.3	79.7	96.7	75.1	85.1	93.9	81.4	78.3	74.1	64.2	55.2
Flowers per ft^2 at each distance from	1	190.4	227.0	225.5	235.8	233.9	215.9	227.0	236.4	234.4	218.7	237.4	268.2	268.8	273.8	248.5	247.5	219.5	225.3
	2	183.7	215.0	212.7	222.9	222.0	204.6	214.9	223.9	222.6	207.5	231.3	252.7	254.5	257.7	234.5	233.0	207.8	213.2
	3	176.9	203.0	200.0	210.0	210.1	193.3	202.9	211.5	210.9	196.3	225.2	237.2	240.2	241.6	220.5	218.4	196.1	201.0
	4	170.2	191.0	187.2	197.2	198.2	181.9	190.8	199.0	199.2	185.0	219.1	221.7	225.9	225.5	206.4	203.9	184.4	188.8
	5	163.4	179.0	174.4	184.3	186.3	170.6	178.8	186.5	187.5	173.8	213.1	206.2	211.6	209.4	192.4	189.3	172.7	176.7

	6	156.7	167.0	161.7	171.4	174.4	159.2	166.7	174.0	175.7	162.6	207.0	190.7	197.3	193.3	178.4	174.7	161.0	164.5
	7	149.9	155.0	148.9	158.5	162.6	147.9	154.6	161.6	164.0	151.4	200.9	175.1	183.0	177.2	164.4	160.2	149.3	152.3
	8	143.2	143.0	136.1	145.7	150.7	136.5	142.6	149.1	152.3	140.2	194.8	159.6	168.7	161.1	150.4	145.6	137.6	140.2
	9	136.5	131.0	123.4	132.8	138.8	125.2	130.5	136.6	140.5	129.0	188.7	144.1	154.4	145.0	136.4	131.1	125.9	128.0
	10	129.7	119.1	110.6	119.9	126.9	113.8	118.5	124.2	128.8	117.8	182.6	128.6	140.1	128.9	122.4	116.5	114.2	115.8
	11	123.0	107.1	97.8	107.0	115.0	102.5	106.4	111.7	117.1	106.6	176.5	113.1	125.8	112.8	108.4	102.0	102.5	103.6
	12	116.2	95.1	85.1	94.2	103.1	91.1	94.4	99.2	105.4	95.4	170.4	97.6	111.5	96.7	94.4	87.4	90.7	91.5
Flowers	Per 24Ft^2 (aisle to aisle)	3,623.6	3,622.9	3,519.0	3,875.3	3,685.7	3,633.4	3,849.7	3,927.3	4,037.6	3,841.3	4,299.3	4,291.4	4,467.9	4,419.5	3,955.0	3,872.0	3,511.2	3,502.1
	Tree (114/Acre)	57,978.3	57,965.8	56,303.9	62,004.6	58,971.3	58,134.4	61,595.5	62,836.3	64,601.6	61,461.1	68,789.1	68,662.3	71,487.1	70,711.3	63,280.0	61,952.6	56,179.4	56,033.4

[1] Daily petal fall was monitored for all varieties at 18 locations within two orchards (160 acre early and 160 acre late blooming varieties). At each location five gallon buckets (early blooming three variety orchard, 16 buckets; late blooming two variety orchard, 8 buckets) were placed at different intervals and petals counted and removed daily; tree line center (0 feet), both sides of a tree (3' from tree line center), and both center isles between tree rows (12' from tree line center). Petal counts from each bucket for all day's collections were totaled, and then divided by five (five petals per flower) to determine the total number of flowers for each bucket position.

[2] Petal fall was monitored for five days in a continuous transect of buckets on each tree side to determine the value of each bucket position. The data was subjected to a regression analysis and the average r^2 was 0.87 ± 0.14, $p < 0.05$. This suggests that the petals fell in a continuum from the tree line center. Separate transects (tree line center to aisle center) of petal counts were made at the tree and the center between trees, this data was subjected to a test $p > 0.05$. There was no difference in the number of petals at the tree or at the center between trees. We then subjected all buckets on each tree side to a regression analysis to determine the slope and intercept for each tree side so that the number of flowers at each ft^2 position (24, tree rows spaced 24' apart) could be calculated. We then added the flowers per ft^2 for each of the 24 ft^2 positions and multiplied by 16 (distance (feet) between trees within a row) to calculate flowers per tree.

[3] The orchard was divided into three equal sections, then the center two tree rows in each section had six equally spaced locations that were monitored for petal fall, totaling 18 different locations (A-R) monitored.

Appendix I. Quantity of flowers per tree determined by our collection of every petal1, and our calculations[2] for the Padre variety at Wegis north during almond bloom 2013. We present the slope and intercept from each tree side used to calculate the number of flowers at each ft² horizontal to the tree row, then multiplied by 16' (distance between trees within a row).

		Location of monitored trees within the orchard[3]																	
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Slope East side of tree		-15.54	-13.87	-18.87	-13.32	-17.37	-14.37	-15.83	-19.00	-18.12	-14.16	-11.28	-14.59	-14.29	-18.46	-14.18	-18.10	-20.94	-17.54
Intercept East side of tree		302.60	247.62	300.35	250.84	300.76	263.64	284.05	321.41	326.76	267.73	296.30	270.51	286.44	323.50	260.42	303.43	336.94	304.02
Slope West side of tree		-19.57	-14.99	-21.15	-15.52	-20.10	-17.24	-17.94	-18.69	-21.67	-15.12	-21.46	-16.15	-14.60	-20.23	-15.22	-18.13	-22.52	-18.21
Intercept West side of tree		327.01	259.18	320.85	273.75	298.36	281.01	312.28	308.48	340.66	281.15	334.38	281.42	263.86	325.69	259.99	289.55	329.20	267.34
Flowers per ft² at each distance from tree center on the east side of the tree	1	287.1	233.7	281.5	237.5	283.4	249.3	268.2	302.4	308.6	253.6	285.0	255.9	272.1	305.0	246.2	285.3	316.0	286.5
	2	271.5	219.9	262.6	224.2	266.0	234.9	252.4	283.4	290.5	239.4	273.7	241.3	257.9	286.6	232.1	267.2	295.1	268.9
	3	256.0	206.0	243.7	210.9	248.7	220.5	236.6	264.4	272.4	225.3	262.5	226.7	243.6	268.1	217.9	249.1	274.1	251.4
	4	240.4	192.1	224.9	197.6	231.3	206.2	220.7	245.4	254.3	211.1	251.2	212.1	229.3	249.6	203.7	231.0	253.2	233.9
	5	224.9	178.2	206.0	184.3	213.9	191.8	204.9	226.4	236.2	196.9	239.9	197.5	215.0	231.2	189.5	212.9	232.2	216.3
	6	209.3	164.4	187.1	170.9	196.5	177.4	189.1	207.4	218.0	182.8	228.6	183.0	200.7	212.7	175.4	194.8	211.3	198.8
	7	193.8	150.5	168.2	157.6	179.2	163.1	173.2	188.4	199.9	168.6	217.3	168.4	186.4	194.3	161.2	176.7	190.4	181.2
	8	178.3	136.6	149.4	144.3	161.8	148.7	157.4	169.4	181.8	154.5	206.1	153.8	172.1	175.8	147.0	158.6	169.4	163.7
	9	162.7	122.7	130.5	131.0	144.4	134.3	141.6	150.4	163.7	140.3	194.8	139.2	157.8	157.3	132.8	140.5	148.5	146.2
	10	147.2	108.9	111.6	117.7	127.1	119.9	125.7	131.5	145.6	126.1	183.5	124.6	143.5	138.9	118.6	122.4	127.6	128.6
	11	131.6	95.0	92.7	104.4	109.7	105.6	109.9	112.5	127.4	112.0	172.2	110.0	129.2	120.4	104.5	104.3	106.6	111.1
	12	116.1	81.1	73.9	91.0	92.3	91.2	94.1	93.5	109.3	97.8	160.9	95.4	114.9	101.9	90.3	86.2	85.7	93.5
Flowers per ft² at each distance from tree center on	1	307.4	244.2	299.7	258.2	278.3	263.8	294.3	289.8	319.0	266.0	312.9	265.3	249.3	305.5	244.8	271.4	306.7	249.1
	2	287.9	229.2	278.6	242.7	258.2	246.5	276.4	271.1	297.3	250.9	291.5	249.1	234.6	285.2	229.5	253.3	284.2	230.9
	3	268.3	214.2	257.4	227.2	238.1	229.3	258.5	252.4	275.6	235.8	270.0	233.0	220.0	265.0	214.3	235.2	261.6	212.7
	4	248.7	199.2	236.3	211.7	218.0	212.1	240.5	233.7	254.0	220.7	248.6	216.8	205.4	244.8	199.1	217.0	239.1	194.5
	5	229.2	184.2	215.1	196.1	197.9	194.8	222.6	215.0	232.3	205.6	227.1	200.7	190.8	224.6	183.9	198.9	216.6	176.3
	6	209.6	169.2	194.0	180.6	177.8	177.6	204.7	196.3	210.6	190.5	205.6	184.5	176.2	204.3	168.7	180.7	194.1	158.1

	7	190.1	154.2	172.8	165.1	157.7	160.4	186.7	177.6	189.0	175.3	184.2	168.4	161.6	184.1	153.4	162.6	171.6	139.9
	8	170.5	139.2	151.7	149.6	137.6	143.1	168.8	159.0	167.3	160.2	162.7	152.2	147.0	163.9	138.2	144.5	149.0	121.7
	9	150.9	124.3	130.5	134.1	117.5	125.9	150.8	140.3	145.6	145.1	141.3	136.1	132.4	143.7	123.0	126.3	126.5	103.5
	10	131.4	109.3	109.4	118.5	97.4	108.6	132.9	121.6	123.9	130.0	119.8	119.9	117.8	123.4	107.8	108.2	104.0	85.3
	11	111.8	94.3	88.3	103.0	77.3	91.4	115.0	102.9	102.3	114.9	98.4	103.8	103.2	103.2	92.6	90.1	81.5	67.1
	12	92.2	79.3	67.1	87.5	57.2	74.2	97.0	84.2	80.6	99.8	76.9	87.6	88.6	83.0	77.3	71.9	59.0	48.9
Flowers	Per 24Ft[2] (aisle to aisle)	4,816.8	3,830.0	4,332.9	4,045.7	4,267.2	4,070.5	4,521.9	4,619.1	4,905.2	4,303.2	5,014.7	4,225.2	4,349.5	4,772.4	3,951.8	4,289.7	4,603.8	4,068.1
	Tree (114/Acre)	77,069.1	61,279.8	69,326.1	64,731.1	68,274.6	65,127.8	72,350.4	73,905.4	78,483.9	68,851.4	80,235.0	67,602.8	69,592.3	76,358.6	63,228.7	68,634.6	73,661.3	65,089.9

[1] Daily petal fall was monitored for all varieties at 18 locations within two orchards (160 acre early and 160 acre late blooming varieties). At each location five gallon buckets (early blooming three variety orchard, 16 buckets; late blooming two variety orchard, 8 buckets) were placed at different intervals and petals counted and removed daily; tree line center (0 feet), both sides of a tree (3' from tree line center), and both center isles between tree rows (12' from tree line center). Petal counts from each bucket for all day's collections were totaled, and then divided by five (five petals per flower) to determine the total number of flowers for each bucket position.

[2] Petal fall was monitored for five days in a continuous transect of buckets on each tree side to determine the value of each bucket position. The data was subjected to a regression analysis and the average r^2 was 0.87 ± 0.14, $p < 0.05$. This suggests that the petals fell in a continuum from the tree line center. Separate transects (tree line center to aisle center) of petal counts were made at the tree and the center between trees, this data was subjected to a test $p > 0.05$. There was no difference in the number of petals at the tree or at the center between trees. We then subjected all buckets on each tree side to a regression analysis to determine the slope and intercept for each tree side so that the number of flowers at each ft^2 position (24, tree rows spaced 24' apart) could be calculated. We then added the flowers per ft^2 for each of the 24 ft^2 positions and multiplied by 16 (distance (feet) between trees within a row) to calculate flowers per tree.

[3] The orchard was divided into three equal sections, then the center two tree rows in each section had six equally spaced locations that were monitored for petal fall, totaling 18 different locations (A-R) monitored.

Appendix J. Pollination exclusion sleeve.