# Environmental Effects on Honey Production

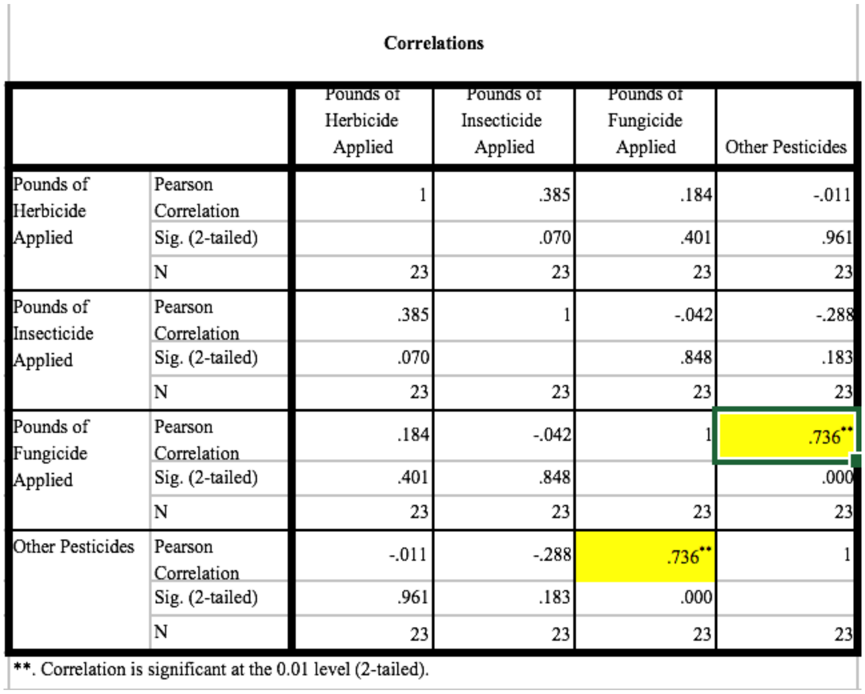
James Stanley

This research has been undertaken with the purpose of raising awareness to the public in the United States of how important bees are in the United States Economy and in the world. Bees are relevant because they are the major pollinators of crops and wild plants and humans need them for survival. Originally, I intended to develop an equation that would show the value of honey bees in the U.S. economy, however, upon doing research, I found an economic thesis that precisely tried to do what I was researching about. I contacted the author and he gave me permission to use his research and offered to help me. Thus, I developed an equation to help determine the value of honey bees using his previous equation and added new variables that I thought were being omitted. The equation developed is ideal but the problem is that there is no data available for the variables needed. Because of this, I decided to stay in the realm of honey bees but refocus my research on how different environmental factors affect honey production. This, in a way, could still indicate in a very small scale, how important honey bees are and by what they are affected. Because of my research on my previous topic, I already had some data gathered which was ideal for my new model.

The data gathered comes from government research and statistics. My sources were United Stated Department of Agriculture (USDA), the National Agricultural Statistics Service (NASS), the Agricultural Statistics Board, and World Bank. I was looking for data on specific crops honey bees pollinate and some of the causes for colony collapse disorder. My theory was that the more crops the bees pollinate, the more honey production there will be considering many causes for colony collapse disorder such as carbon dioxide emissions per year and the use of insecticides, herbicides, fungicides, and other pesticides in the United States.

For my signs, I was expecting all crops to have a positive sign and herbicide, insecticide, fungicide, other pesticides, and $CO^2$ emissions to be negative. My reasoning behind these hypotheses is that all crops should have a positive effect on honey production, the more crops available, the more pollen the bees can extract and produce honey. For the negative signs, all of them are causes of colony collapse disorder which kills bees. The lower the bee population, the less honey is produced per year. Before determining which crops I would use, I had a list of 18 of the major crops that bees pollinate and I decided to do a correlation analysis to see which ones where highly correlated. I determined that any crop that had a Pearson Correlation higher than 0.500, I would exclude from my model. Table 1.1, found in the Appendix, shows the results and the boxes in yellow indicate all the crops that are highly correlated. Once the correlation analysis was finished, I decided to include almonds, apples, lemons, pecans, and watermelons into my model. I also wanted to know if there was any correlation between insecticides, herbicides, fungicides, and other pesticides used in the United States and the results shown in Table 1.2 below demonstrate that the only ones correlated were fungicide and other pesticides.

Table 1.2



**Correlations**

| | | Pounds of Herbicide Applied | Pounds of Insecticide Applied | Pounds of Fungicide Applied | Other Pesticides |
|---|---|---|---|---|---|
| Pounds of Herbicide Applied | Pearson Correlation | 1 | .385 | .184 | -.011 |
| | Sig. (2-tailed) | | .070 | .401 | .961 |
| | N | 23 | 23 | 23 | 23 |
| Pounds of Insecticide Applied | Pearson Correlation | .385 | 1 | -.042 | -.288 |
| | Sig. (2-tailed) | .070 | | .848 | .183 |
| | N | 23 | 23 | 23 | 23 |
| Pounds of Fungicide Applied | Pearson Correlation | .184 | -.042 | 1 | .736** |
| | Sig. (2-tailed) | .401 | .848 | | .000 |
| | N | 23 | 23 | 23 | 23 |
| Other Pesticides | Pearson Correlation | -.011 | -.288 | .736** | 1 |
| | Sig. (2-tailed) | .961 | .183 | .000 | |
| | N | 23 | 23 | 23 | 23 |

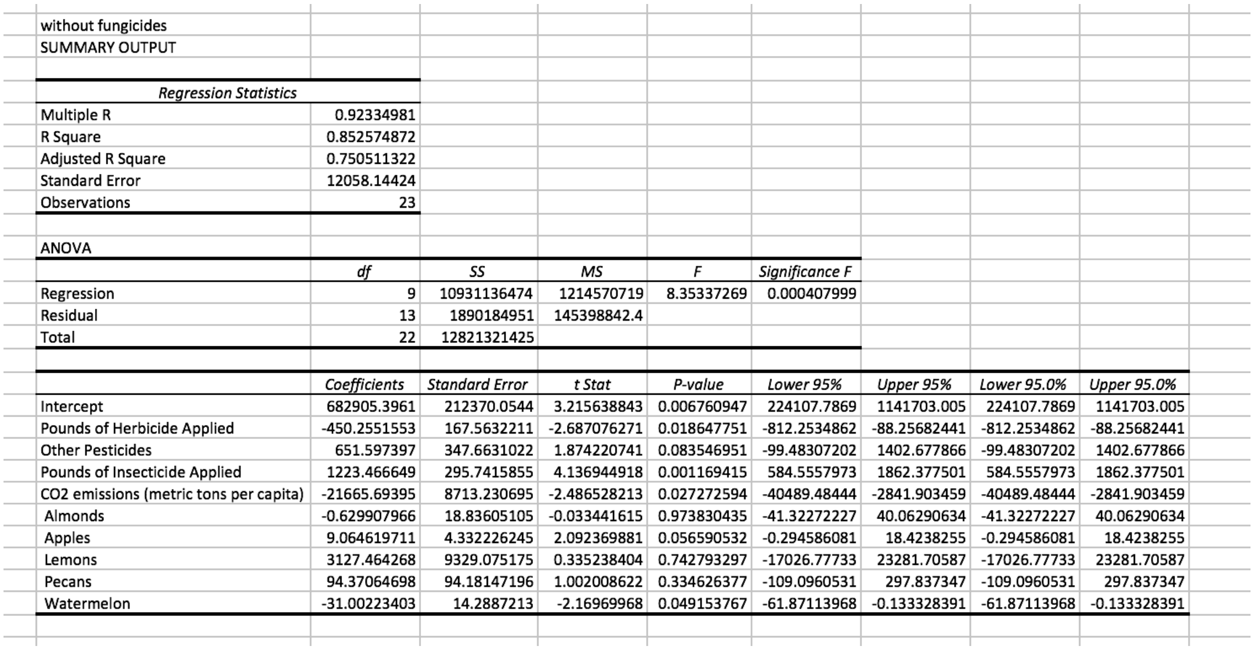
**. Correlation is significant at the 0.01 level (2-tailed).

Table 1.2 Correlation Analysis on Herbicides, Insecticides, Fungicides, and Other Pesticides.

Following that, I wanted to know if there was any correlation between all my independent coefficients and Table 1.3 (Appendix) shows that there is a correlation between watermelons, other pesticides, and fungicides. Because of this, I decided to run four regression analysis, one with all the variables, the second with all the variables previously mentioned except for fungicides, the third with all the variables previously mentioned except for other pesticides, and the fourth with all the variables previously mentioned except for watermelons. The results in tables 2.1, 2.2, and 2.3 show that when those three variables were excluded in their respective equations, more coefficients had the signs change and the r-squared altered.

As seen in Table 2.1 and comparing it with the final regression model which is Table 2.4, it is seen that without fungicides, the adjusted r-squared slightly increased, three of the coefficients still had an unexpected sign, and the t-stats for all of them slightly changed.

Table 2.1



without fungicides

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.92334981 |
| R Square | 0.852574872 |
| Adjusted R Square | 0.750511322 |
| Standard Error | 12058.14424 |
| Observations | 23 |

ANOVA

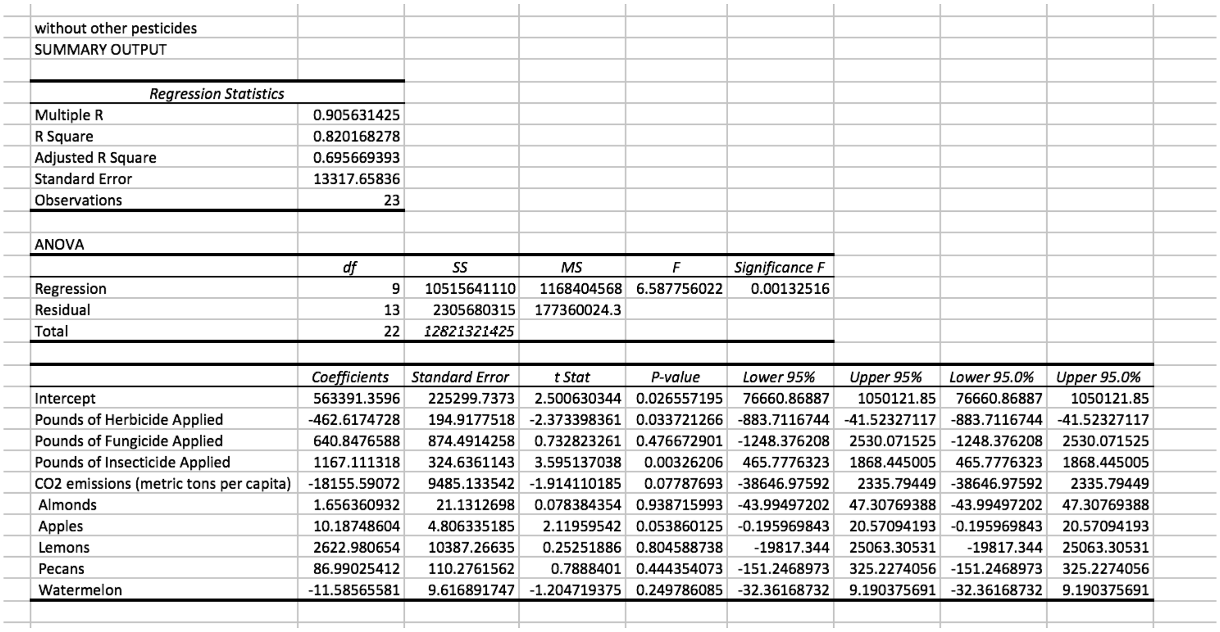
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 9 | 10931136474 | 1214570719 | 8.35337269 | 0.000407999 |
| Residual | 13 | 1890184951 | 145398842.4 | | |
| Total | 22 | 12821321425 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 682905.3961 | 212370.0544 | 3.215638843 | 0.006760947 | 224107.7869 | 1141703.005 | 224107.7869 | 1141703.005 |
| Pounds of Herbicide Applied | -450.2551553 | 167.5632211 | -2.687076271 | 0.018647751 | -812.2534862 | -88.25682441 | -812.2534862 | -88.25682441 |
| Other Pesticides | 651.597397 | 347.6631022 | 1.874220741 | 0.083546951 | -99.48307202 | 1402.677866 | -99.48307202 | 1402.677866 |
| Pounds of Insecticide Applied | 1223.466649 | 295.7415855 | 4.136944918 | 0.001169415 | 584.5557973 | 1862.377501 | 584.5557973 | 1862.377501 |
| CO2 emissions (metric tons per capita) | -21665.69395 | 8713.230695 | -2.486528213 | 0.027272594 | -40489.48444 | -2841.903459 | -40489.48444 | -2841.903459 |
| Almonds | -0.629907966 | 18.83605105 | -0.033441615 | 0.973830435 | -41.32272227 | 40.06290634 | -41.32272227 | 40.06290634 |
| Apples | 9.064619711 | 4.332226245 | 2.092369881 | 0.056590532 | -0.294586081 | 18.4238255 | -0.294586081 | 18.4238255 |
| Lemons | 3127.464268 | 9329.075175 | 0.335238404 | 0.742793297 | -17026.77733 | 23281.70587 | -17026.77733 | 23281.70587 |
| Pecans | 94.37064698 | 94.18147196 | 1.002008622 | 0.334626377 | -109.0960531 | 297.837347 | -109.0960531 | 297.837347 |
| Watermelon | -31.00223403 | 14.2887213 | -2.16969968 | 0.049153767 | -61.87113968 | -0.133328391 | -61.87113968 | -0.133328391 |

Table 2.1 Regression Analysis on the coefficients Yield per Colony, Herbicide, Insecticide, Other Pesticides, $CO^2$ Emissions, Almonds, Apples, Lemons, Pecans, and Watermelons.

Table 2.2 shows the regression results without the other pesticides coefficient. When compared with Table 2.4 it is seen how the adjusted r-squared slightly decreases, three of the coefficients still have the unexpected signs and all of the t-stats slightly changed.

Table 2.2



without other pesticides

SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.905631425 |
| R Square | 0.820168278 |
| Adjusted R Square | 0.695669393 |
| Standard Error | 13317.65836 |
| Observations | 23 |

ANOVA

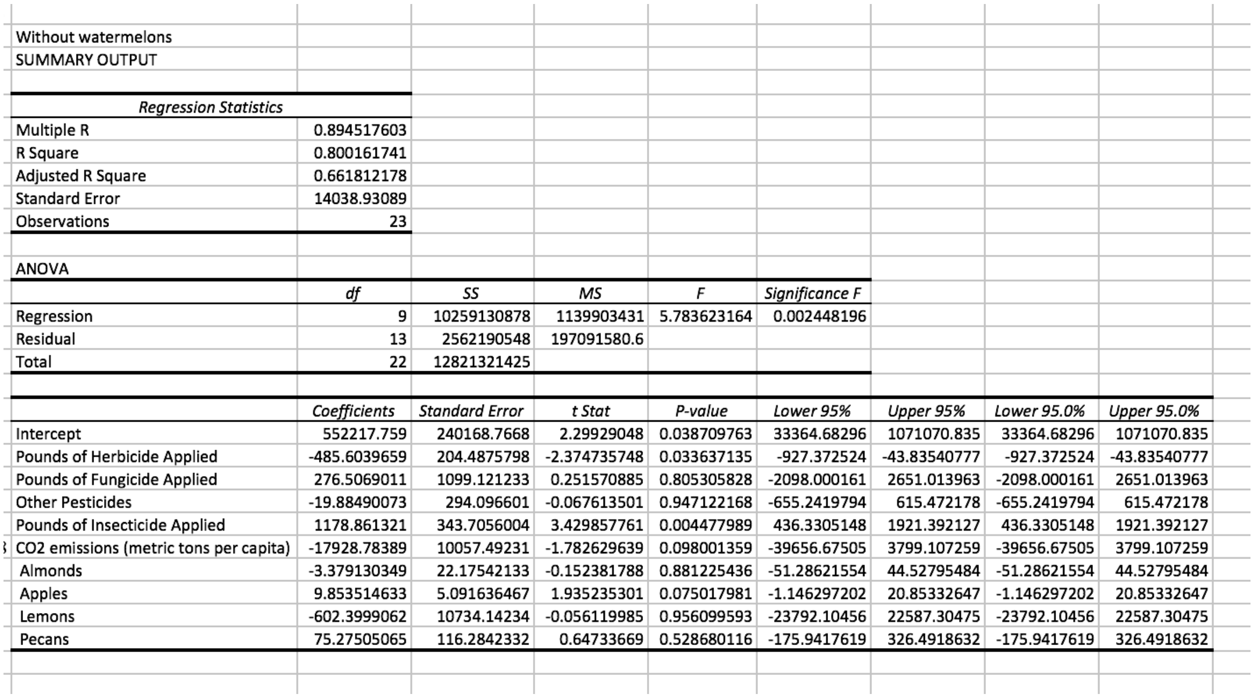
| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 9 | 10515641110 | 1168404568 | 6.587756022 | 0.00132516 |
| Residual | 13 | 2305680315 | 177360024.3 | | |
| Total | 22 | *12821321425* | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 563391.3596 | 225299.7373 | 2.500630344 | 0.026557195 | 76660.86887 | 1050121.85 | 76660.86887 | 1050121.85 |
| Pounds of Herbicide Applied | -462.6174728 | 194.9177518 | -2.373398361 | 0.033721266 | -883.7116744 | -41.52327117 | -883.7116744 | -41.52327117 |
| Pounds of Fungicide Applied | 640.8476588 | 874.4914258 | 0.732823261 | 0.476672901 | -1248.376208 | 2530.071525 | -1248.376208 | 2530.071525 |
| Pounds of Insecticide Applied | 1167.111318 | 324.6361143 | 3.595137038 | 0.00326206 | 465.7776323 | 1868.445005 | 465.7776323 | 1868.445005 |
| CO2 emissions (metric tons per capita) | -18155.59072 | 9485.133542 | -1.914110185 | 0.07787693 | -38646.97592 | 2335.79449 | -38646.97592 | 2335.79449 |
| Almonds | 1.656360932 | 21.1312698 | 0.078384354 | 0.938715993 | -43.99497202 | 47.30769388 | -43.99497202 | 47.30769388 |
| Apples | 10.18748604 | 4.806335185 | 2.11959542 | 0.053860125 | -0.195969843 | 20.57094193 | -0.195969843 | 20.57094193 |
| Lemons | 2622.980654 | 10387.26635 | 0.25251886 | 0.804588738 | -19817.344 | 25063.30531 | -19817.344 | 25063.30531 |
| Pecans | 86.99025412 | 110.2761562 | 0.7888401 | 0.444354073 | -151.2468973 | 325.2274056 | -151.2468973 | 325.2274056 |
| Watermelon | -11.58565581 | 9.616891747 | -1.204719375 | 0.249786085 | -32.36168732 | 9.190375691 | -32.36168732 | 9.190375691 |

Table 2.2 Regression Analysis on the coefficients Yield per Colony, Herbicide, Fungicide, Insecticide, $CO^2$ Emissions, Almonds, Apples, Lemons, Pecans, and Watermelons.

Table 2.3 shows the regression results without the watermelons coefficient. This one causes major changes in the final regression model when it is removed. As seen below, instead of having three coefficients with unexpected signs, there are four and the t-stats are highly affected as well.

Table 2.3



Without watermelons
SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.894517603 |
| R Square | 0.800161741 |
| Adjusted R Square | 0.661812178 |
| Standard Error | 14038.93089 |
| Observations | 23 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 9 | 10259130878 | 1139903431 | 5.783623164 | 0.002448196 |
| Residual | 13 | 2562190548 | 197091580.6 | | |
| Total | 22 | 12821321425 | | | |

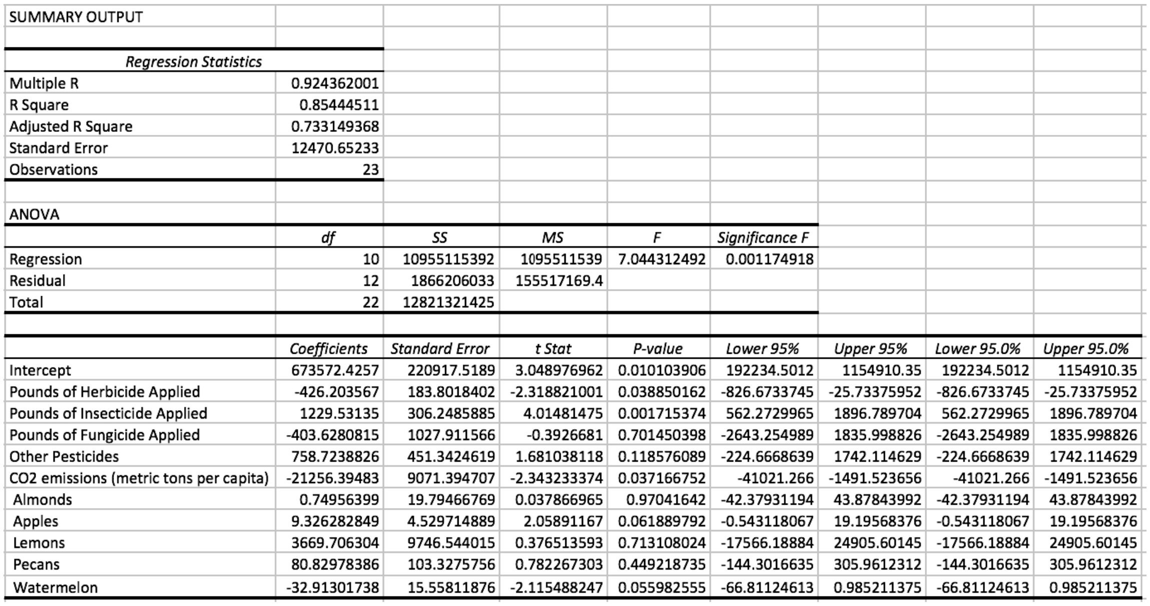
| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 552217.759 | 240168.7668 | 2.29929048 | 0.038709763 | 33364.68296 | 1071070.835 | 33364.68296 | 1071070.835 |
| Pounds of Herbicide Applied | -485.6039659 | 204.4875798 | -2.374735748 | 0.033637135 | -927.372524 | -43.83540777 | -927.372524 | -43.83540777 |
| Pounds of Fungicide Applied | 276.5069011 | 1099.121233 | 0.251570885 | 0.805305828 | -2098.000161 | 2651.013963 | -2098.000161 | 2651.013963 |
| Other Pesticides | -19.88490073 | 294.096601 | -0.067613501 | 0.947122168 | -655.2419794 | 615.472178 | -655.2419794 | 615.472178 |
| Pounds of Insecticide Applied | 1178.861321 | 343.7056004 | 3.429857761 | 0.004477989 | 436.3305148 | 1921.392127 | 436.3305148 | 1921.392127 |
| CO2 emissions (metric tons per capita) | -17928.78389 | 10057.49231 | -1.782629639 | 0.098001359 | -39656.67505 | 3799.107259 | -39656.67505 | 3799.107259 |
| Almonds | -3.379130349 | 22.17542133 | -0.152381788 | 0.881225436 | -51.28621554 | 44.52795484 | -51.28621554 | 44.52795484 |
| Apples | 9.853514633 | 5.091636467 | 1.935235301 | 0.075017981 | -1.146297202 | 20.85332647 | -1.146297202 | 20.85332647 |
| Lemons | -602.3999062 | 10734.14234 | -0.056119985 | 0.956099593 | -23792.10456 | 22587.30475 | -23792.10456 | 22587.30475 |
| Pecans | 75.27505065 | 116.2842332 | 0.64733669 | 0.528680116 | -175.9417619 | 326.4918632 | -175.9417619 | 326.4918632 |

Table 2.3 Regression Analysis on the coefficients Yield per Colony, Herbicide, Fungicide, Insecticide, Other Pesticides, $CO^2$ Emissions, Almonds, Apples, Lemons, and Pecans.

The results after running a regression without fungicides and other pesticides show how there is a slight increase in the adjusted r-squared with an increase of 0.02 and a decrease of 0.6 respectively. The coefficients other pesticides and insecticides still have the unexpected sign. Other coefficients were affected numerically and their value and t-stats changed. Because of these reasons, I decided to include all the five crops I mentioned and the other five factors that cause colony collapse disorder. My equation is an OLS model.

Model Results:

Table 2.4



SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.924362001 |
| R Square | 0.85444511 |
| Adjusted R Square | 0.733149368 |
| Standard Error | 12470.65233 |
| Observations | 23 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 10 | 10955115392 | 1095511539 | 7.044312492 | 0.001174918 |
| Residual | 12 | 1866206033 | 155517169.4 | | |
| Total | 22 | 12821321425 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 673572.4257 | 220917.5189 | 3.048976962 | 0.010103906 | 192234.5012 | 1154910.35 | 192234.5012 | 1154910.35 |
| Pounds of Herbicide Applied | -426.203567 | 183.8018402 | -2.318821001 | 0.038850162 | -826.6733745 | -25.73375952 | -826.6733745 | -25.73375952 |
| Pounds of Insecticide Applied | 1229.53135 | 306.2485885 | 4.01481475 | 0.001715374 | 562.2729965 | 1896.789704 | 562.2729965 | 1896.789704 |
| Pounds of Fungicide Applied | -403.6280815 | 1027.911566 | -0.3926681 | 0.701450398 | -2643.254989 | 1835.998826 | -2643.254989 | 1835.998826 |
| Other Pesticides | 758.7238826 | 451.3424619 | 1.681038118 | 0.118576089 | -224.6668639 | 1742.114629 | -224.6668639 | 1742.114629 |
| CO2 emissions (metric tons per capita) | -21256.39483 | 9071.394707 | -2.343233374 | 0.037166752 | -41021.266 | -1491.523656 | -41021.266 | -1491.523656 |
| Almonds | 0.74956399 | 19.79466769 | 0.037866965 | 0.97041642 | -42.37931194 | 43.87843992 | -42.37931194 | 43.87843992 |
| Apples | 9.326282849 | 4.529714889 | 2.05891167 | 0.061889792 | -0.543118067 | 19.19568376 | -0.543118067 | 19.19568376 |
| Lemons | 3669.706304 | 9746.544015 | 0.376513593 | 0.713108024 | -17566.18884 | 24905.60145 | -17566.18884 | 24905.60145 |
| Pecans | 80.82978386 | 103.3275756 | 0.782267303 | 0.449218735 | -144.3016635 | 305.9612312 | -144.3016635 | 305.9612312 |
| Watermelon | -32.91301738 | 15.55811876 | -2.115488247 | 0.055982555 | -66.81124613 | 0.985211375 | -66.81124613 | 0.985211375 |

Table 2.4 Regression Analysis on the coefficients Yield per Colony, Herbicide, Fungicide, Insecticide, Other Pesticides, CO$^2$ Emissions, Almonds, Apples, Lemons, Pecans, and Watermelons.

Equation:

$673{,}572.43THY = -426.20H + 1229.53I - 403.63F + 758.72OP - 21{,}256.39COEM + 0.75AL + 9.33AP + 3669.71LEM + 80.83PEC - 32.91WA$

t-Stats: –2.32 4.01 –0.39 1.68 –2.34 0.04 2.06 0.38 0.78 –2.11

$R^2 = 0.854$

$\bar{R}^2 = 0.733$

SE = 12,470.65

Significance F = 0.0012

Degrees of Freedom = 22

Observations = 23

Coefficients:

THY = Total Honey Yield in thousands of pounds produced in the United States.

H = Millions of pounds of herbicides used in the United States.

I = Millions of pounds of insecticides used in the United States.

F = Millions of pounds of fungicides used in the United States.

OP = Millions of pounds of other pesticides used in the United States.

COEM = Carbon Dioxide emissions in metric tons per capita in the United States.

AL = Millions of pounds of almonds produced in the United States.

AP = Millions of pounds of apples produced in the United States.

LEM = Millions of pounds of lemons produced in the United States.

PEC = Millions of pounds of pecans produced in the United States.

WA = Millions of pounds of watermelons produced in the United States.

For my final model, I have three unexpected signs in the coefficients I, OP, and WA. For the coefficients, I (Millions of pounds of insecticides used in the United States) and OP (Millions of pounds of other pesticides used in the United States), I was expecting a negative sign because according to my theory, the more use of insecticides and other pesticides, which are causes colony collapse disorder, there would be a decrease in bee population, meaning that there would be less honey produced per year. Surprisingly, the watermelon coefficient was negative when it should be positive. I was expecting that if there were more watermelons produced per year, since they are a crop bees pollinate, it would have a positive effect on honey yield production.

The results on the regression model reveal that the use of insecticides and pesticides as well as the production of almonds, apples, lemons, and pecans will have a positive effect on the honey yield. The other coefficients which are watermelons, carbon dioxide emissions in metric tons per capita, and fungicides and herbicides use, have a negative impact on honey yield.

After I analyzed the results, I wanted to explore more and think of why I had those relationships and why my hypotheses were not as I expected. I looked back in my data and realized that I had the specific number of honey bee stocks per state. A bee stock is defined, according to Dr. David Tarpy, a professor and researcher of North Carolina State University, as "a loose combination of traits that characterize a particular group of bees. Such groups can be divided by species, race, region, population, or breeding line in a commercial operation. Many of the current stock' in the United States can be grouped at one or more of these levels" (Tarpy, 2005). Based on this information, I wanted to find what relationship does the use of insecticides and honey bee stocks have.  I made a graph which can be seen in Table 3.1 which shows the relationship between bee stocks and the use of insecticides.

Table 3.1

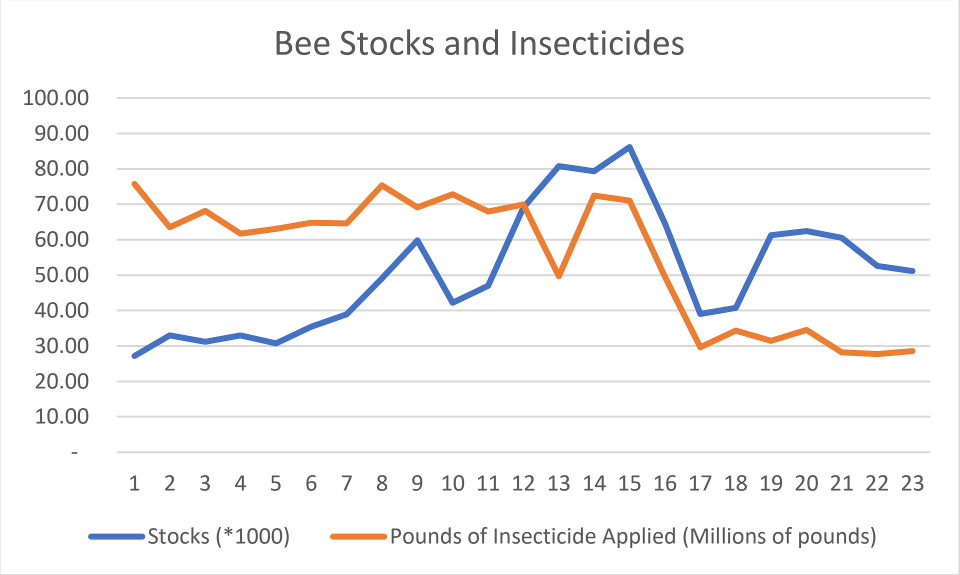


Table 3.1 Relationship between Bee Stock and Insecticide use

The numbers in the horizontal axis are the years of data starting from 1986. It is interesting to see that both have a positive relationship when it should be expected to have a negative one. Data seems to show that when there is more insecticides applied to crops, the amount of honey bee stocks increases and these was seen in the years 7,8, 13, and 14. The most significant year was year 15 when both had a sudden drop and it raises many questions. Do they really have a positive relationship? Is one dependent on the other? Are the claims that insecticides are killing honey bees true? What is the real effects of insecticides on different types of honey bees? Many of these questions have yet to be answered and research is still being done to find out how different insecticides affect different types of honey bees. Based on this relationship, I wanted to see what was the relationship between all of the fungicides, pesticides, insecticides, herbicides, and bee stocks which is shown in Table 3.2.

Table 3.2

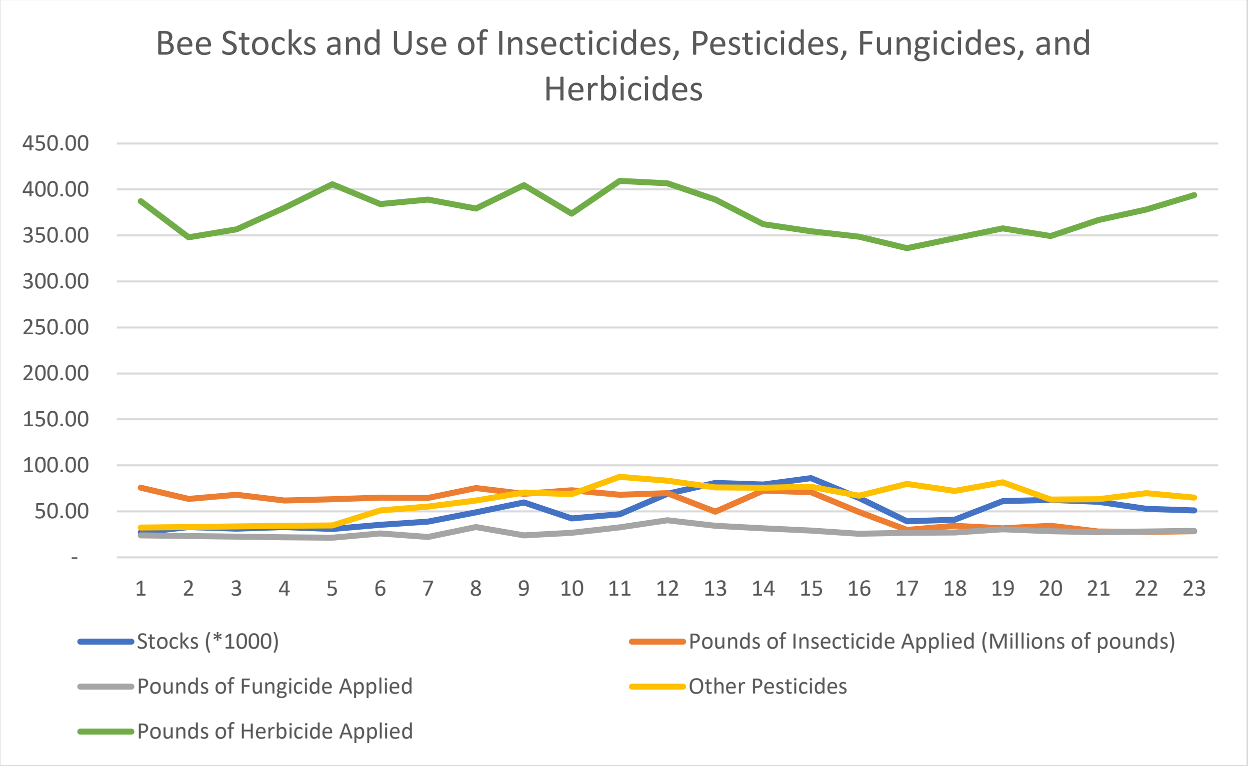


Table 3.2 Relationship between Bee Stock and Use of Insecticides, Pesticides, Fungicides, and Herbicides.

The numbers in the horizontal axis are the years of data starting from 1986. As seen in the graph, fungicide remains constant throughout the years, never surpassing the 50 million pound mark. Other pesticides also remain constant between 100 million pounds and 50 million pounds with a slight decrease in the last years. Insecticides was mentioned in Table 3.1 and the relationship is the same in this graph, now being less than 50 million pounds used per year. The only one that is being used in a significant amount is herbicides with being at approximately 400 million pounds used per year. As it was seen in the model, herbicides has a strong negative coefficient and does affect the yield per colony, but how does it affect the honey bee stocks?

Table 3.3 shows the direct relationship between honey bee stocks and the use of herbicides per year.

Table 3.3

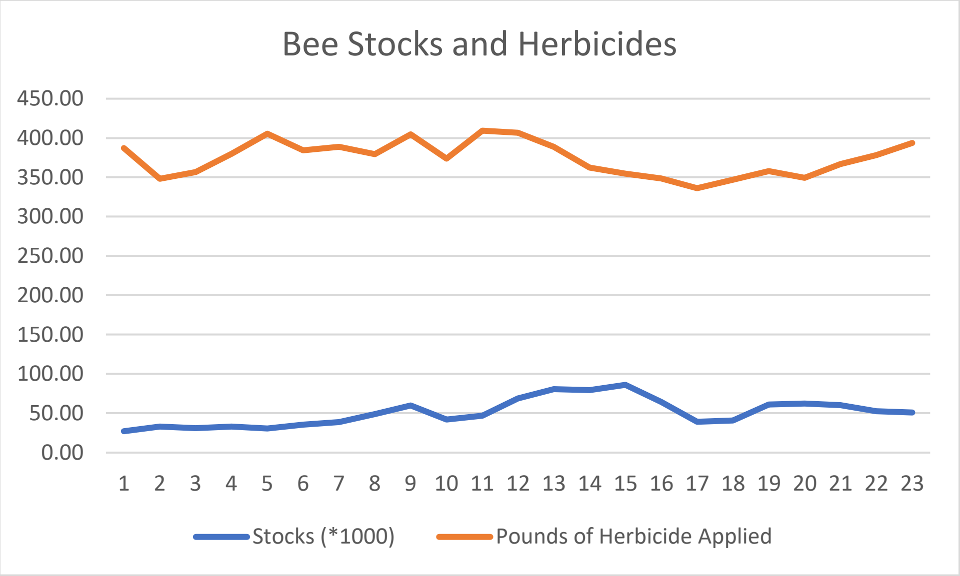


Table 3.3 Relationship between Bee Stock and Herbicide use.

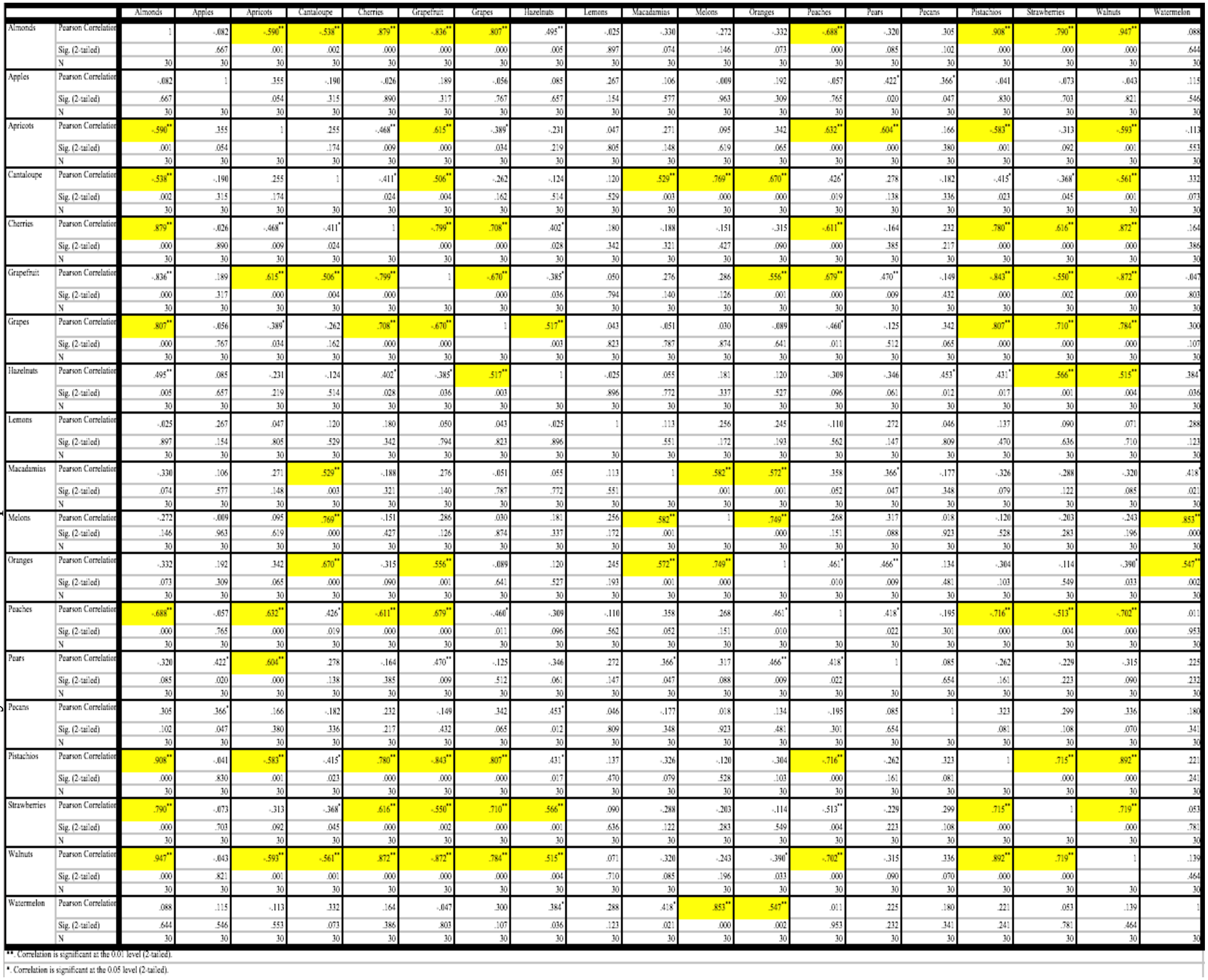
It can be seen by looking at the graph that bee stock and herbicides have an inverse relationship. When the use of herbicides declines, bee stocks have a slight increase. Is this because herbicides have a direct impact on the honey bees? A factor that could be taken into consideration is that the less use of herbicides, the more wild plants will grow and be available for bees to pollinate. The more plants available mean that bees that were not present in the monitored areas are now likely to come back to pollinate those areas.

It is interesting to see what relationship do bee stocks have with many of the variables that I used in my model. There are thousands of different species and they are all affected in a different way with the use of chemicals and toxins. More research is needed to help determine which specific chemicals and toxins affect which specific species.

As to what comes next it is hard to determine. I am really excited to try different methods and gather more data to make a model that is accurate and can help determine the value of honey bees. It is impossible to determine a model now because there is insufficient data but eventually I would like to get a research team and partner with the author of the economic thesis that also made some equations and see if we can eventually determine how valuable honey bees are for the U.S. economy and the rest of the world. I found the research was worthwhile and satisfying. I invested many hours into this research project and it was in a topic of my interest. I wanted to show people that there is a way in which we can measure what affects honey productivity and put into perspective how important honey bees are for humanity. If I had more time, I would have stayed in contact with the author of the economic thesis and partnered with him and other biologists to gather up data and make a more precise and functioning model. Now, it is something that I want to accomplish in my future.

# Appendix

Table 1.1 Correlation Analysis between 18 crops.



| | | Almonds | Apples | Apricots | Cantaloupe | Cherries | Grapefruit | Grapes | Hazelnuts | Lemons | Macadamias | Melons | Oranges | Peaches | Pears | Pecans | Pistachios | Strawberries | Walnuts | Watermelon |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Almonds | Pearson Correlation | 1 | -.082 | -.590** | -.538** | .879** | -.836** | .807** | .495** | -.025 | -.330 | -.272 | -.332 | -.688** | -.320 | .305 | .908** | .790** | .947** | .088 |
| | Sig. (2-tailed) | | .667 | .001 | .002 | .000 | .000 | .000 | .005 | .897 | .074 | .146 | .073 | .000 | .085 | .102 | .000 | .000 | .000 | .644 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Apples | Pearson Correlation | -.082 | 1 | .355 | -.190 | -.026 | .189 | -.056 | .085 | .267 | .106 | -.009 | .192 | -.057 | .422* | .366* | -.041 | -.073 | -.043 | .115 |
| | Sig. (2-tailed) | .667 | | .054 | .315 | .890 | .317 | .767 | .657 | .154 | .577 | .963 | .309 | .765 | .020 | .047 | .830 | .703 | .821 | .546 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Apricots | Pearson Correlation | -.590** | .355 | 1 | .255 | -.468** | .615** | -.389* | -.231 | .047 | .271 | .095 | .342 | .632** | .604** | .166 | -.583** | -.313 | -.593** | -.113 |
| | Sig. (2-tailed) | .001 | .054 | | .174 | .009 | .000 | .034 | .219 | .805 | .148 | .619 | .065 | .000 | .000 | .380 | .001 | .092 | .001 | .553 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Cantaloupe | Pearson Correlation | -.538** | -.190 | .255 | 1 | -.411* | .506** | -.262 | -.124 | .120 | .529** | .769** | .670** | .426* | .278 | -.182 | -.415* | -.368* | -.561** | .332 |
| | Sig. (2-tailed) | .002 | .315 | .174 | | .024 | .004 | .162 | .514 | .529 | .003 | .000 | .000 | .019 | .138 | .336 | .023 | .045 | .001 | .073 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Cherries | Pearson Correlation | .879** | -.026 | -.468** | -.411* | 1 | -.799** | .708** | .402* | .180 | -.188 | -.151 | -.315 | -.611** | -.164 | .232 | .780** | .616** | .872** | .164 |
| | Sig. (2-tailed) | .000 | .890 | .009 | .024 | | .000 | .000 | .028 | .342 | .321 | .427 | .090 | .000 | .385 | .217 | .000 | .000 | .000 | .386 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Grapefruit | Pearson Correlation | -.836** | .189 | .615** | .506** | -.799** | 1 | -.670** | -.385* | .050 | .276 | .286 | .556** | .679** | .470** | -.149 | -.843** | -.550** | -.872** | -.047 |
| | Sig. (2-tailed) | .000 | .317 | .000 | .004 | .000 | | .000 | .036 | .794 | .140 | .126 | .001 | .000 | .009 | .432 | .000 | .002 | .000 | .803 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Grapes | Pearson Correlation | .807** | -.056 | -.389* | -.262 | .708** | -.670** | 1 | .517** | .043 | -.051 | .030 | -.089 | -.460* | -.125 | .342 | .807** | .710** | .784** | .300 |
| | Sig. (2-tailed) | .000 | .767 | .034 | .162 | .000 | .000 | | .003 | .823 | .787 | .874 | .641 | .011 | .512 | .065 | .000 | .000 | .000 | .107 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Hazelnuts | Pearson Correlation | .495** | .085 | -.231 | -.124 | .402* | -.385* | .517** | 1 | -.025 | .055 | .181 | .120 | -.309 | -.346 | .453* | .431* | .566** | .515** | .384* |
| | Sig. (2-tailed) | .005 | .657 | .219 | .514 | .028 | .036 | .003 | | .896 | .772 | .337 | .527 | .096 | .061 | .012 | .017 | .001 | .004 | .036 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Lemons | Pearson Correlation | -.025 | .267 | .047 | .120 | .180 | .050 | .043 | -.025 | 1 | .113 | .256 | .245 | -.110 | .272 | .046 | .137 | .090 | .071 | .288 |
| | Sig. (2-tailed) | .897 | .154 | .805 | .529 | .342 | .794 | .823 | .896 | | .551 | .172 | .193 | .562 | .147 | .809 | .470 | .636 | .710 | .123 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Macadamias | Pearson Correlation | -.330 | .106 | .271 | .529** | -.188 | .276 | -.051 | .055 | .113 | 1 | .582** | .572** | .358 | .366* | -.177 | -.326 | -.288 | -.320 | .418* |
| | Sig. (2-tailed) | .074 | .577 | .148 | .003 | .321 | .140 | .787 | .772 | .551 | | .001 | .001 | .052 | .047 | .348 | .079 | .122 | .085 | .021 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Melons | Pearson Correlation | -.272 | -.009 | .095 | .769** | -.151 | .286 | .030 | .181 | .256 | .582** | 1 | .749** | .268 | .317 | .018 | -.120 | -.203 | -.243 | .853** |
| | Sig. (2-tailed) | .146 | .963 | .619 | .000 | .427 | .126 | .874 | .337 | .172 | .001 | | .000 | .151 | .088 | .923 | .528 | .283 | .196 | .000 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Oranges | Pearson Correlation | -.332 | .192 | .342 | .670** | -.315 | .556** | -.089 | .120 | .245 | .572** | .749** | 1 | .461* | .466** | .134 | -.304 | -.114 | -.390* | .547** |
| | Sig. (2-tailed) | .073 | .309 | .065 | .000 | .090 | .001 | .641 | .527 | .193 | .001 | .000 | | .010 | .009 | .481 | .103 | .549 | .033 | .002 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Peaches | Pearson Correlation | -.688** | -.057 | .632** | .426* | -.611** | .679** | -.460* | -.309 | -.110 | .358 | .268 | .461* | 1 | .418* | -.195 | -.716** | -.513** | -.702** | .011 |
| | Sig. (2-tailed) | .000 | .765 | .000 | .019 | .000 | .000 | .011 | .096 | .562 | .052 | .151 | .010 | | .022 | .301 | .000 | .004 | .000 | .953 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Pears | Pearson Correlation | -.320 | .422* | .604** | .278 | -.164 | .470** | -.125 | -.346 | .272 | .366* | .317 | .466** | .418* | 1 | .085 | -.262 | -.229 | -.315 | .225 |
| | Sig. (2-tailed) | .085 | .020 | .000 | .138 | .385 | .009 | .512 | .061 | .147 | .047 | .088 | .009 | .022 | | .654 | .161 | .223 | .090 | .232 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Pecans | Pearson Correlation | .305 | .366* | .166 | -.182 | .232 | -.149 | .342 | .453* | .046 | -.177 | .018 | .134 | -.195 | .085 | 1 | .323 | .299 | .336 | .180 |
| | Sig. (2-tailed) | .102 | .047 | .380 | .336 | .217 | .432 | .065 | .012 | .809 | .348 | .923 | .481 | .301 | .654 | | .081 | .108 | .070 | .341 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Pistachios | Pearson Correlation | .908** | -.041 | -.583** | -.415* | .780** | -.843** | .807** | .431* | .137 | -.326 | -.120 | -.304 | -.716** | -.262 | .323 | 1 | .715** | .892** | .221 |
| | Sig. (2-tailed) | .000 | .830 | .001 | .023 | .000 | .000 | .000 | .017 | .470 | .079 | .528 | .103 | .000 | .161 | .081 | | .000 | .000 | .241 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Strawberries | Pearson Correlation | .790** | -.073 | -.313 | -.368* | .616** | -.550** | .710** | .566** | .090 | -.288 | -.203 | -.114 | -.513** | -.229 | .299 | .715** | 1 | .719** | .053 |
| | Sig. (2-tailed) | .000 | .703 | .092 | .045 | .000 | .002 | .000 | .001 | .636 | .122 | .283 | .549 | .004 | .223 | .108 | .000 | | .000 | .781 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Walnuts | Pearson Correlation | .947** | -.043 | -.593** | -.561** | .872** | -.872** | .784** | .515** | .071 | -.320 | -.243 | -.390* | -.702** | -.315 | .336 | .892** | .719** | 1 | .139 |
| | Sig. (2-tailed) | .000 | .821 | .001 | .001 | .000 | .000 | .000 | .004 | .710 | .085 | .196 | .033 | .000 | .090 | .070 | .000 | .000 | | .464 |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Watermelon | Pearson Correlation | .088 | .115 | -.113 | .332 | .164 | -.047 | .300 | .384* | .288 | .418* | .853** | .547** | .011 | .225 | .180 | .221 | .053 | .139 | 1 |
| | Sig. (2-tailed) | .644 | .546 | .553 | .073 | .386 | .803 | .107 | .036 | .123 | .021 | .000 | .002 | .953 | .232 | .341 | .241 | .781 | .464 | |
| | N | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

References:

"CO2 emissions (metric tons per capita)." *CO2 emissions (metric tons per capita) | Data*. World Bank, 2017. Web. 10 Apr. 2017. <http://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2013&locations=US&name_desc=false&start=1984>.

David Tarpy, 2005. The Different Types of Honey Bees. AG-645, NC State University, Cooperative Extension

United States Department of Agriculture. *Honey - National Agricultural Statistics Service*. Publications from September 24 1976 to present., n.d. Web. 10 Apr. 2017. <http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1191>.