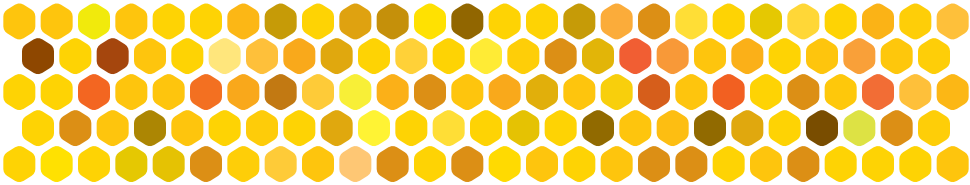
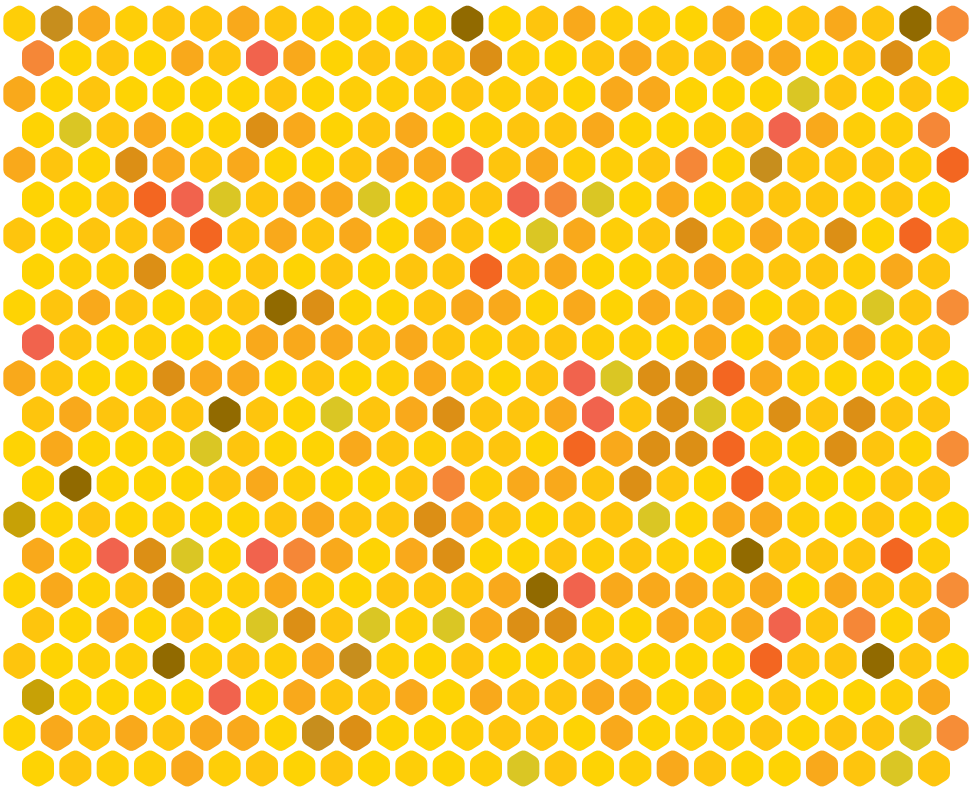
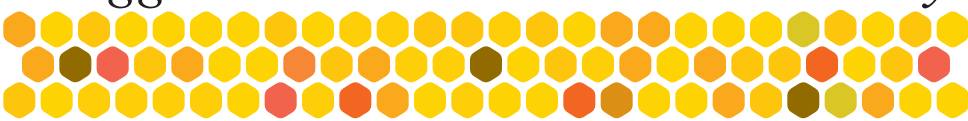


# POLLINATION GUIDELINES

## FOR SMALL FARMS



*Maggie Wachter & Rachel Coventry*





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# Contents




*The Bee Team: Curtis Orchard founder Paul Curtis with authors Rachel Coventry (l) and Maggie Wachter (r).*

*Go to your fields and your gardens, and you shall learn that it is the pleasure of the bee to gather honey of the flower,*
*But it is also the pleasure of the flower to yield its honey to the bee.*
*For to the bee a flower is a fountain of life,*
*And to the flower a bee is a messenger of love,*
*And to both, bee and flower, the giving and the receiving of pleasure is a need and an ecstasy.*

—Kahlil Gibran

*Honey bees hustle to bring pollen into the hive. Pollen provides an important source of protein for young larvae. These bees have found a source of pollen in early spring. Note the snow on the bottom corner of the winter mouseguard.*

## *Introduction*

What beekeeper has never watched in amazement as a worker bee industriously waddled toward the entrance of her hive, loaded with pollen? This moment of beekeeping amazement often takes place on a day too cold for any flowers to bloom. The beekeeper usually shakes their head with puzzlement and mutters, "Where did she get THAT?"

It was such a day and such a moment when the idea of applying for a Sustainable Agriculture Research and Education grant (SARE grant) occurred. Maggie Wachter, beekeeper and owner of Second Nature Honey, and Rachel Coventry, beekeeper for Curtis Orchard and Pumpkin Patch in Champaign, IL, put their heads together and came up with a grant proposal to investigate sustainable pollination techniques supporting small-scale agriculture. The main grant venue was an 80 acre family owned apple orchard in Central Illinois.

Pollination success would be measured through observation of fruit set and harvest size. The honey produced by the bees during the experiment was expected to exhibit varietal characteristics that were commonly attributed to the target crops. Photographs and drawings of pollen from the flowers of some apple varieties would accompany the experiment. Pollen brought into the hive by the bees would be analyzed and matched with its source.


*What is Pollination?*

Pollination is the process of bringing together the male and the female parts of flowers to make babies, commonly known as seeds. Pollinators are the matchmakers that introduce the sperm of the male flower, or pollen, to the ovary residing deep in the heart of the female flower. In some cases, the male and female parts are located in the same flower.

Pollinators, including honey bees, pollinate about one third of the world's crops destined for human consumption. Due to habitat loss and other non-sustainable farming practices, managed honey bee colonies are gradually replacing many of the wild bees that were formerly responsible for crop pollination. (5 u of cal). Healthy, strong honey bee colonies often have large populations, at least 25,000 honey bees in a single colony. The job of pollination falls to the female of the species. Every female honey bee is born with a single-minded zest and determination to do her job well, making honey bees one of agriculture's most enthusiastic partners.

Honey bees pollinate many flowers because they are attracted to nectar, the sweet liquid that is usually found in the center of the flower. In order to find this sweet treasure, bees brush past the male stamens that bear the flowers' pollen. The thorax or chest area of a honey bee are areas covered with tiny hairs that have an electrostatic charge that attracts pollen, so as the bees push through the flower to drink the nectar, some pollen falls on those hairs and sticks to them. When the bee visits the next flower, a few pollen grains might shake loose, falling onto the receptive female parts of the flower, the pistils. Honey bees also harvest pollen from flowers to take home and feed to their young.

When honey bee pollination is successful, everyone is happy: the honey bee returns to her hive with a load of nectar to be

turned into honey or pollen to be turned into baby food for bees, and the flower begins the process of making seeds and bearing well-formed, marketable fruit.

*Pollen grains cover this bumble bee. Planting wildflowers attracts wild pollinators as well as honey bees, promoting pollination on small farms.*

*What Is a Small Farm?*

For this study, we defined a small farm as one in which target crop(s) do not exceed 20 acres. The 40 acre family farm where we conducted most of our research specialized in the cultivation of apples and pumpkins. The farm's apple orchards included 31 varieties of apples on 18 acres. The farm also featured a variety of other flowering crops, such as cherries, blueberries, strawberries, and pumpkins. (Since pumpkins are generally pollinated by native bees, not honey bees, they are not included in the study.)

At the start of the SARE grant, the farm's two apiaries were located close to the apple orchards. Out of ten hives in the main apiary, two were mature hives older than one year, while eight others were new, recently installed from three pound packages of bees. A second, smaller apiary had only two hives, one new and one mature.

*Diversity on a small apple farm usually includes other fruit.*


*Views of Curtis Orchards during apple bloom.*

## *Small Farms Are Different*

Farmers cultivating crops such as fruits, legumes, cruciferous veggies and others are concerned about the quality, set and production of their plants, which usually depend on honey bee pollination. The traditionally "free" services of wild and cultivated bee pollinators are in decline and many farmers, large and small, have turned to migratory pollination services, paying beekeepers to transport honey bees to their crops during the blossom season.

On large farms, migratory pollination might include cutting down or otherwise eliminating competing floral sources and moving hives of honey bees across distances into a large monocultural landscape. Essentially the bees have no choice but to pollinate the only crop available. Their diets are nutritionally restricted, a little like eating hamburger for every meal, week after week.

Small farms are different; they are seldom dedicated to a single crop. Cherries, blueberries and peaches might blossom simultaneously, tempting the honey bee away from a target crop, such as apples. Besides the diversity of crops competing for pollination on a small farm, rogue wildflowers such as dandelions and clover may also lure honey bees from a target crop. While honey bee diets might be diverse on a small farm, farmers could fear that their pollination efforts are spread thin to the detriment of the target crop.

Our two-year NCR SARE project was intended to explore crop pollination techniques in small farm environments. How, we wondered, could we persuade independent-minded honey bees to choose apples over cherries, raspberries or blackberries? Our goal was to "see the world like a bee", examining the diversity of small landscapes from the bees' point of view. We suspected that crops on small farms might offer underexploited opportunities to cooperate with nature so that everyone wins.

Our SARE grant research results are summarized in this booklet. Maggie Wachter and Rachel Coventry, the beekeepers, wish to express their appreciation to the United States Department of Agriculture for the two-year SARE grant that allowed exploration of pollination techniques on small landscapes. The goal of this booklet is to share knowledge gained during the project with small farmers, beekeepers, and others to improve the efficiency of honey bee pollination on small farms while promoting honey bee health.

*Year 1: Migratory Pollination*

The first year of pollination research was devoted to establishing a baseline by testing conventional migratory pollination practices on a small farm. At the start of the apple bloom, all the hives were moved from the farm's two apiaries into the orchard.

Although the hives were moved only a short distance from the apiaries into the orchard (approximately half a mile), transporting them still caused excessive bee losses because many forager bees persisted in returning to the vacated hive locations, conforming to the "two foot-two mile" principle of beekeeping.

This principle suggests that if you move hives more than two feet from their original location, forager bees are likely to return to the space where the old hive used to be located. There, the homeless bees gather in a forlorn cluster, waiting for their hive to reappear. Eventually they die of exposure. However, when hives are moved more than two miles from their former location, the bees quickly orient to the new location and return to their hives.

Conventional migratory pollination on a large farm usually involves transporting honey bees over long distances. The bees typically return to their hives although they might be lost in other ways, such as succumbing to the stress of temperature fluctuations during long distance transport, accidents during transport, dropped hives, confusion in the orchards, bees lost under nets, etc. In addition, the stress of being transported, bumping and rumbling down uneven highways on the back of a truck might weaken the honey bees' immunity, compromising their health should they then be exposed to disease.

*During Year One, hives were placed among the apple trees for pollination. We suggest that the stress of moving hives into the orchards for pollination contributes to weakened populations.*

*Migratory beekeepers move hives long distances to pollinate crops. Since honey bees return to the hive for the evening after working in the fields, hives are often moved at night.*

*Removing Competing Floral Sources*

Prior to and during the apple bloom, in the first year we mowed dandelions and other competing wild flowers that were blooming among the trees to encourage the bees to focus on pollinating the desired crop, the apples. This practice is borrowed from mono-cultural pollination. We speculated that the double whammy of moving hives into the heart of the apple orchard and mowing flowers would improve the chances of honey bees pollinating the desired crop, the apples. We were wrong.

Right from the start, we noticed that many bees strayed from the task of pollinating the apples. When we went bee spotting among the apple blossoms, we located only one or two bees in a five minute period. On the other hand, the nearby cherry trees practically hummed with bees.

*Mowing competing blossoms is a common pollination practice. We questioned its usefulness.*

When we checked out our pollination strategy with apple pollination experts, we realized that the number of hives we were using, 12 hives on 18 acres, did not meet the recommended minimum ratio for pollinating apples, one hive per acre. Additionally, the hives should be strong. Most of the hives that we used for pollination during the first year of the grant were weak first-year hives.

*Bee spotting helps evaluate the attractiveness of your crop. To spot bees, get close to the blossoms, stand still, watch and listen. Count the number of bees you spy in a three minute interval. Don't forget to count native bees and other pollinators, too.*

*What Is a Strong Hive?*

Various methods can be used to evaluate the strength of a hive. A strong hive is a well-managed colony that is free of major diseases or other threats. It has a healthy and vigorous queen who builds the population throughout the summer by methodically laying eggs.

*A queen bee atop her brood.*

Eggs and larvae are also called brood. The brood in a strong hive have access to a high quality diet that is garnered from a landscape of floral diversity where sugar is a supplement, not the main meal.

For pollination, we prefer to describe a strong hive as one in which at least the six top frames are covered with bees when the cover is removed. The population of a strong hive should have 25,000 bees or more, including a large and vital army of scouts and forager bees. In the spring when many types of fruit trees need to be pollinated, new hives from package bees are usually too small to be considered strong enough to offer optimal pollination services. However if these hives are well-managed in their first year, they may emerge in the spring of the second year as strong and mature, ready to provide adequate pollination. We attribute part of the success of our second year of pollination to the increased presence of strong and mature hives.

*We evaluate a strong hive for pollination by the number of frames covered by bees. We expect to see at least six frames of bees when the cover is removed. This is a very strong hive.*

*We consider this hive weak for pollination since it covers only four frames.*

*How a Strong Hive Pollinates*

Honey bees in a strong hive will locate crops to pollinate by sending out scout bees in all directions to seek new sources of nectar. The scouts will return to the hive and dance to communicate information to forager bees about available floral sources. In a small or weak hive, the scout team may overlook some of the less inviting crops whose blossoms offer little nectar or are otherwise unattractive. In contrast, a strong hive will have enough scouts to scour the landscape for diverse sources of nectar. A strong hive will also have enough foragers to follow up the information they receive from scouts to pollinate both crops and wildflowers. When hives are strong and the hive to crop ratio is correct, crops within a distance of up to 20 acres are more likely to receive adequate pollination despite competition from other floral sources.

## *Year 2: Stationary Pollination*

Pollination from a stationary apiary, where hives remain in one spot on the farm for the entire season, was a standard feature of many farms in the 1950s and 1960s. Back then, farms offered a diversity of crops that would sustain honey bees throughout the summer season. In the last decades of the twentieth century monocultural agriculture became dominant and stationary beekeeping for pollination was gradually supplanted by migratory beekeeping. In monoculture, there is little sustenance for bees after the bloom of a single crop, so honey bee colonies must be moved from one crop to another. For example, over 31 billion honey bees are likely to converge on the Central Valley of California for a few weeks in February to pollinate the almond orchards. When the pollination period ends, the bees are usually transported to another crop. Unlike monocultural farms, small farms offer more diversity throughout the growing season, providing a foundation for alternative pollination techniques such as stationary apiaries.

*Beekeepers use smoke to calm bees. When beekeepers inadvertently smoke themselves, they try to stay calm.*

*An apiary can be as small as a single hive, or as large as land will permit. There were two apiaries on Curtis Apple Orchard, one at each end of the apple orchards. Here, Rachel visits the smaller apiary with her twins.*

In the second year of the grant, we decided to risk stationary pollination from the two apiaries already on the farm. We reasoned that strong honey bee populations would have more foragers available to pollinate more crops on the same farm at the same time. We also noted that our stationary apiaries were located no more than a half mile from any point in the orchard. Honey bees can fly three to five miles to collect nectar.

We felt that a stationary apiary offered the honey bees several advantages. For one, stationary apiaries avoid compromising honey bee immunity by eliminating the stress of transportation. By leaving hives stationary on the farm we also hoped to avoid losing foragers to the two-foot two-mile rule. In the calm of stationary beekeeping, we hoped that our hives would have opportunities to further strengthen and build their population resources so they could pollinate other crops later in the season.

In the spring of the second year, the packaged bees from the previous year had emerged from the winter as strong, mature

hives. We reinforced them with other strong hives to meet the minimum ratio of one hive per acre of apples. Altogether we had 18 strong hives that were pollination-ready, 16 in the main apiary and another 2 in the secondary apiary at the other end of the orchard. Both apiaries were located within a half mile of the apple orchards.

We also decided to allow dandelions and other wildflowers to flourish in the orchard instead of mowing them down. Based on other SARE research and a helpful webinar, we learned that wildflowers growing near crops were likely to attract native pollinators who might assist our honey bees in pollinating apples and other crops. We reasoned that pumpkins, not a honey bee favorite, would also benefit from additional native pollinators.

*Flower beds are placed strategically around Curtis Orchard to attract pollinators.*

*Successful apple pollination rewards the farmer with plentiful well-formed fruit and early set.*

During the second year, we observed an increase in honey bees when we went bee spotting among the apple blossoms. Besides spotting more honey bees on the apples, we noted the presence of native bees. Meanwhile the cherry trees nearby continued to hum with pollination activity.

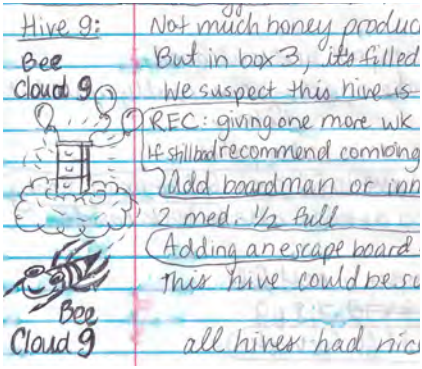
Our apple farm evaluated pollination success by examining a sample of apple ova after petal fall to see how many had been pollinated. While the crop in the first year was considered good, the second year crop was considered very good, even though it coincided with a program of replacement of older trees with younger trees that were not yet productive. In the second year there was also a frost that damaged many king blooms, those that would yield the largest apples. In spite of these unexpected events, the second year apple crop was more plentiful to the point that the farmer remarked that additional thinning would have been appropriate.

*In Year One of our SARE grant, we moved hives into the orchards for pollination. We discovered the two-foot two-mile principle: If the hive is moved less than two miles but more than two feet, many worker bees will return to the space where the hive previously stood instead of the new location. Our bee losses were high and our pollination was average.*


*In Year Two, we kept strong hives in two stationary apiaries on the Curtis Apple Orchard. Strong hives send out scouts to find nectar sources throughout the farm. Teams of forager bees pollinate a variety of crops at the same time. Our bee losses were low and our pollination success was high.*

*This multicolor frame is packed with pollen gleaned from many different crops. Frames of pollen in the hive are often located near the nursery. The future health of baby bees depends on a diverse, high quality diet of pollen and honey, typically available on a small farm.*

*Bees make honey to eat when flowers are scarce. It is their staple food to get through the winter. Here you can clearly see their tongues, which roll like straws to suck honey.*




*Keeping notes for each hive is important. Doodles enliven the text.*

*Some farm personnel might prefer protection when working near crops that attract bees. It is always a good idea to have a spare veil on hand.*

## *Finding a Beekeeper*

Adequate pollination can improve marketability of crops by improving set, uniformity and quantity of fruit. A small farmer has several options, including hiring a beekeeper to pollinate specific crops at an estimated cost of $50-$250 per hive, or keeping a stationary apiary on the farm. We estimate that a single hive, including bees and a two story beehive, will require an initial investment of about $500 or more[1], a cost that will probably be amortized over three or four years under the care of an experienced beekeeper.

While honey bees are likely to thrive under the care of a knowledgeable beekeeper, the investment might be at risk if they are not cared for by a beekeeper with skill and experience. We estimate that the minimum time for beekeeping on a small farm is 15 to 30 hours per hive per year. Since the busiest times on a farm, spring and fall, are also the busiest times for carrying out critical beekeeping tasks, we feel it is hard for a farmer to undertake this task in addition to the chores of running a farm.

A farmer searching for a beekeeper has several options. Several nearby farms might wish to engage a single beekeeper to cooperatively oversee apiaries located on each farm. Failing that, perhaps a friend or family member might be willing to include beekeeping in their routine. If no one steps forward, contacting a local beekeeping club might yield a beekeeper looking for a new apiary site.

If a small farmer is at a loss to find a beekeeper or unwilling to risk investing in honey bees, pollination by native bees might

[1] As of this writing, a 3 pound package of honey bees with a queen can cost around $100 or more. A small established hive (called a "nuc" or nucleus hive) consisting of a 5-frame colony with a laying queen might cost $300-400. Other equipment, including frames, hive bodies, inner cover, outer cover, bottom board, hive tool, gloves, and veil might cost around $350.

offer an alternative solution. Encouraging native bees can be as simple as planting borders of wild flowers around cropland. In the second year of our grant, we chose to allow wildflowers to flourish among the apple trees rather than mowing during pollination. We also planted a pollinator garden on the farm. Research suggests that this easy, low cost investment can pay off in improved crop production.

*Maggie and Rachel trained assistants to help with beekeeping.*

## *Honey Production*

Single varietal honeys usually come from a single nectar source, such as orange blossom or buckwheat. They are often a byproduct of conventional migratory pollination, where the honey bees' diet is limited to a single crop. Even in the wild where large groves of trees such as sourwood, black locust, or basswood reside, single varietal honey production often relies on the transport of hives to various forest locations. We feel that the honey produced by stationary bees from a diverse diet of nectar while pollinating a small farm is a natural, delicious alternative to single varietal honey. We are not alone.

At the close of the first year, when we used conventional pollination techniques, we submitted honey produced from our SARE project to the black jar competition offered by the Center for Honey Bee Research. We were pleased that the honey from Curtis Orchard was selected as first place winner for Central Region of the USA. When we submitted our honey the following year, after using pollination techniques specifically adapted to small farms, our honey was awarded the Center for Honey Bee Research's grand prize, "Best Tasting Honey in the World". We attribute this accolade to the diversity of crops, both wild and cultivated, that lent our honey its natural, multidimensional flavor.


*A marker of success, the honey from Curtis Orchard and Pumpkin Patch was judged "World Grand Prize Winner" is 2016.*

## *Pollen Grains Close Up*

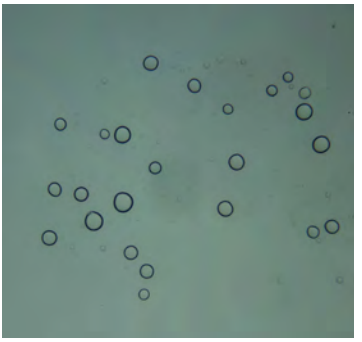
Some nature lovers might enjoy taking a closer look at the pollen in commonly flowering plants. Part of our grant included examining pollen under a microscope.

Start by picking a few fresh blossoms that have opened recently. Older, faded blossoms might not have enough pollen for examination. Avoid contamination with other flowers by keeping the flowers of each type of plant separate. For example, don't mix blueberry blossoms with apple blossoms.

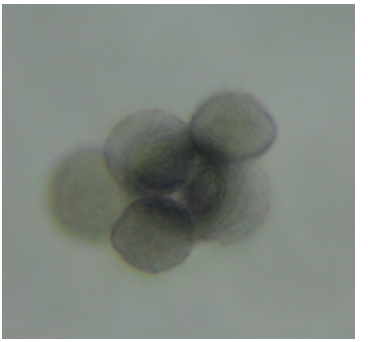
Over a glass microscope slide, shake the part of the blossom where the pollen is located. Alternatively, you might wish to use a small brush to gently brush out some pollen. Don't worry if you don't see anything fall onto the slide. Pollen grains are often very small.

Add a drop or two of distilled water to the slide. Adding a small amount of a microscope stain such as fuschin may also be helpful. Swirl the liquid and pollen slightly with an instrument such as a fine needle to make a drop of slurry.

Add a coverslip and place the prepared slide on the stage of a lit compound microscope. Start with the lowest power – perhaps 10x – to locate the pollen, then gradually increase the power of the scope and focus. We generally used a power of 40x. To find pollen, look for glob-like shapes, ovals, spheres, triangles, usually occurring in small clusters. Try not to confuse pollen with common plant debris or water bubbles. Pollen grains will often have small apertures in the surface, or furrows called colpi. You might wish to consult a library of pollen grains online for comparison or identification.

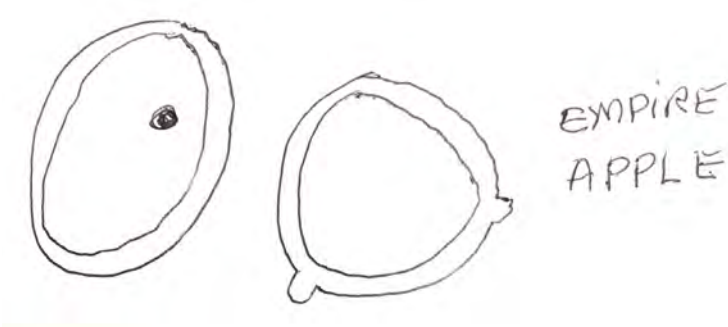


*Water bubbles.*

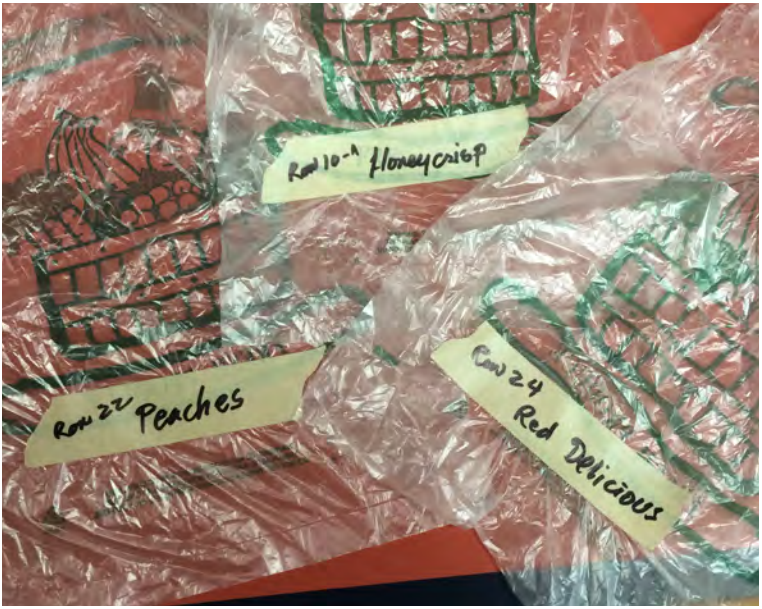


*Pollen grains.*

*We used a compound microscope to examine samples of pollen taken from the orchard.*




*You can create a personal library of pollen grains by drawing the pollen you see under the microscope. Cameras may also be useful to photograph pollen grains through the microscope.*




*Pollen grains can vary widely among different varieties of apples. When collecting pollen to view under the microscope, it is important to label each type of pollen and keep it separate from the pollen from other plants. These baggies will be used to collect blooms from different parts of the Curtis Apple Orchard.*

*Summary Observations and Suggestions*

- Our first year exploration of conventional migratory beekeeping suggested to us that moving bees on a small farm weakened and reduced the available honey bee population for pollination of the target crop and other crops later in the summer.
- Our second year of exploration suggested that a stationary apiary of strong hives located on a small farm was equally if not more effective.
- Our research suggests that an optimal stationary apiary on a small farm should consist of strong hives in a ratio that corresponds to the target crop's size and nectar flow
- The suggested ratio of one hive per acre for pollinating apple orchards seems accurate, although our research would suggest that strong hives could compensate for ratio variations.
- Strong hives require the stewardship of a knowledgeable beekeeper. We recommend that the farmer consider having a dedicated and experienced beekeeper.
- Planting flower gardens on the farm can nourish honey bees and attract wild pollinators.

## *Conclusion*

Our two year exploration of small scale pollination techniques suggests that the agricultural diversity of a small farm landscape is ideal for fostering strong honey bee colonies suitable for diverse crop pollination. Our research suggests that while pollination from conventional migratory beekeeping might be appropriate for large monocultural agriculture, the diversity of a small farm offers honey bees the best opportunities to thrive while pollinating farm crops throughout the summer. The honey produced by honey bees on a small, diverse farm is likely to be healthful to bees and delicious to humans. On a well-managed small farm with well-managed honey bees, the farmer-bee partnership is natural and complete.

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## *About the Authors*

Rachel Coventry's passion for bees started in 2009 when she served as a Peace Corps volunteer in Paraguay, South America. She returned to the USA in 2011 and joined her grandfather in beekeeping at Curtis Orchard & Pumpkin Patch.

Maggie Wachter became a beekeeper in 2008 when someone gave her a hive of honey bees. She is a Master Beekeeper from the University of Florida and studied under biodynamic beekeeper, Gunther Hauk. She is passionate about bees and the environment.

A big thank you to Paul Curtis, Randy Graham and the Curtis-Graham-Coventry families. We are also grateful to the SARE staff, including Joan Benjamin, for their interest and support. Thank you to Peter Bernhardt, who started us thinking about this booklet.

We would also like to acknowledge the bee-friendly population of the world who is concerned about protecting bees and planting flowers.

And of course, a big thanks to the honey bees, whose tireless work makes the earth a better place.