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Evaluating Honey Bee Colonies for Pollination

A Guide for Commercial Growers and Beekeepers

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Honey bees are accurately described as indispensable pollinators. In the United States alone, the worth of honey bee pollination is estimated at $15 billion.

In this publication, commercial growers who rent honey bees for pollination and beekeepers who provide pollination services will find information on honey bee colony strength evaluation, average number of colonies needed for pollination, basic honey bee biology in context of pollination, and pollination contracts.

The success of honey bees as pollinators is due to certain aspects of their biology.

- Honey bees forage for nectar and pollen from many thousands of plant species, so they efficiently pollinate a wide variety of important food and seed crops.
- While foragers from one hive may visit many species of plants in a given day, individual foragers display flower fidelity or constancy. When a forager begins collecting nectar or pollen from the flowers of one species of plant, she will continue to visit flowers of only that species for at least one foraging trip and more often for several days or until the resource is no longer producing nectar or pollen. This is important to the plant she visits, as it requires pollen from a flower of the same species for pollination.
- Honey bee colonies are mobile. Hives are easily moved to locations where there are not enough native pollinators to adequately pollinate a specific crop.

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What is a colony?

Honey bees are social insects. Look at a colony of honey bees as a family unit. A colony has a single queen, who is the sole female reproductive in the hive and is the mother of the sexually sterile female workers. Drones (male honey bees) are also present in a healthy colony during spring and summer when food is abundant. In addition to the adult bees, a healthy colony also has **brood**, the collective term for eggs, larvae, and pupae (the immature stages in the life cycle of bees).

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The population of a single honey bee colony is not static. During the course of a normal year, a colony's lowest population of adult workers (approximately 10,000 to 15,000) is in January and February. The colony can grow to a maximum of 50,000 to 60,000 workers by midsummer. Drones typically compose 5 percent of the total adult population in a colony. The control and management of colony growth most frequently depends upon the age and health of the queen, foraging environment, time of year, and skill of the beekeeper.

Worker bees

Worker bees are short-lived. During the active foraging season (from March to October in the Pacific Northwest), a worker lives about 5 to 6 weeks.

After an adult worker emerges from a pupal cell, her first 3 weeks are spent inside the colony serving as a "house" bee. She goes through a series of tasks that includes cleaning comb, feeding larvae, secreting wax, building comb, accepting nectar loads from foragers, ripening nectar, ventilating the hive, and (for a short time) acting as a guard bee at the entrance of the colony.

When a worker bee is about 21 days old, she begins to take short orientation flights. This marks the beginning of her 2- to 3-week life as a forager bee, seeking nectar and pollen to bring back to the colony.

Honey bee flight

Bees must have suitable light and temperature before they begin foraging. A general observation is that stronger, more populous hives begin foraging at a lower temperature than weaker, smaller colonies. Even so, honey bees only rarely fly at temperatures below 55°F. As the outside temperature increases to about 70°F, the number of bees foraging from a given colony increases. Here's a guide for relating **springtime** temperatures to foraging:

- 55–60°F—some foraging
- 60–65°F—moderate to fair amount of foraging
- 65–70°F and above—maximum amount of foraging

During **midsummer**, the same colonies often will not start foraging until the temperature reaches 70°F. The bees' "acceptable foraging temperature" apparently shifts with colony requirements and the season. Colonies receiving morning sun in the entrance forage earlier than colonies that do not. Growers in wet regions (e.g., western Oregon) are advised to rent a relatively higher number of colonies (one extra hive per acre) than suggested in Table 1 (page 3) as insurance against poor foraging weather.

Colony size and efficiency

As the worker population increases in a colony, the proportion of bees old enough for foraging increases. As a general rule, smaller colonies send out a smaller percentage of their bees as foragers. On the other hand, larger colonies send out not only more bees but also a higher proportion of the population as foragers.

The greater value of larger colonies for pollination can be illustrated by the amount of honey produced by colonies of different populations. A colony's ability to store surplus honey is a direct result of the number of bees foraging and the amount of forage available — and the foragers are the ones that pollinate the flowers. Research has demonstrated that:

- One colony of 30,000 bees produces 1½ times as much honey as the sum of *two* colonies with 15,000 bees each.
- One colony of 45,000 bees produces 1½ times as much honey as *three* colonies with 15,000 bees each.
- One colony of 60,000 bees produces 1½ times as much honey as *four* colonies with 15,000 bees each.

The strength of the colonies a grower rents will be influenced by several factors:

1. **Time of year.** Colonies rented earlier in the season will not be as strong as the same colonies rented later in the season to pollinate another crop.
2. **Colony management.** Beekeepers can speed up or slow down the natural growth of their hives with a variety of techniques.
   - Colonies given supplemental food (such as sugar syrup) and/or pollen supplement early in the season are stimulated to grow more rapidly.
   - Colonies taken to California in December or January (primarily for almond pollination) begin foraging earlier. Later on, they may be stronger than colonies that overwintered in the

Pacific Northwest. When the beekeeper brings these colonies back to the PNW area, they are in better condition for early season pollination service.

- When beekeepers consider colonies to be overly strong early in the year, they often split them into several colonies, adding new queens to the new colonies. Most beekeepers use this method to increase their total number of colonies.

How many to use?

Perhaps the most important question the commercial grower asks is: How many colonies are necessary to ensure maximum pollination of a given crop? This is a difficult question to answer.

- Absolute pollination requirements are not established for most agriculturally important plant species.
- Bloom periods, bloom density, bloom attractiveness, blossom structure, competing bloom, and weather determine how well honey bees will forage on and pollinate a given crop.
- The number of hives to use depends on the quality of individual colonies.

The average numbers of hives employed per acre for pollination in some important crops in the Pacific Northwest and for almonds in California are listed in Table 1.

Table 1. Average number of hives needed for pollination in the Pacific Northwest (per acre).

Crop	Number of hives
Almond (in California)	2.5
Apples	1.5
Blueberry	3
Blackberry	2.5
Cranberry	3
Cherry	2
Pear	1.5
Clover	2
Vegetable seed (carrot, onion, etc.)	3
Meadowfoam	2

Colony-strength regulations

Oregon and Washington departments of agriculture, in 1960 and 1978 respectively, mandated colony-strength regulations for hives involved in commercial pollination of agricultural crops. The regulations were designed to assure growers that colonies they rent meet minimum biological standards. Currently, these regulations are not being enforced, but the standards set forth can still serve as minimum colony-strength requirements and help identify colony quality. **Consider these regulations as recommendations and use them to define colonies in pollination contracts.**

The Oregon and Washington regulations set forth several years ago appear on pages 7–8. Note that while there are two grades (A and B), there are also two grade **types**, Field and Orchard. This recognizes the natural growth pattern of a honey bee colony. Colonies rented for tree fruit pollination early in the season will not be as strong as the same colonies rented later in the year for field or row crop pollination.

The colony grades, as defined by the regulations, can be more easily understood with a few explanations.

Disease

Two bacterial infections are significant for beekeepers, and it takes an experienced beekeeper to tell them apart. **American foulbrood** is the most serious bee disease in North America. It simply means the death of the infected colony—it can't be tolerated at any time. **European foulbrood** can be tolerated at low levels of infection, especially early in the season. It usually disappears in a month.

Amount of comb

Rather than mandate that a pollination unit be a specific type or physical size, Oregon sets out the **amount of comb** required. This is preferable, as different sizes of hive bodies are regularly used.

A standard unit, used by most beekeepers, is the Langstroth deep hive body (Figure 1, page 4). When used with 10 frames, it provides 2,700 square inches of comb. A common variation is 8 frames deep, with 2,160 square inches of comb. Oregon requires 3,000 square inches of comb. Therefore, a pollination colony must have more than one standard deep hive body or its equivalent. A commonly used unit is two

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Figure 1. A standard one-story colony consisting of one 10-frame-deep super. This unit would not meet the minimum requirements for amount of comb under the Oregon regulations.

standard deeps (Figure 2) or one deep (2,700 square inches) with an additional semideep hive body (2,000 square inches).

For efficient foraging and pollination, beekeepers should also provide honey bee colonies with ample storage space; that is, enough empty supers (super is a hive body that accommodates ten frames of comb) so the bees do not stop foraging due to lack of storage space.

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Figure 2. A standard two-story colony consisting of two 10-frame-deep supers. This colony has 5,400 square inches of comb. Typical pollination colonies might substitute a semideep or western super in place of the second deep super. In either case, the unit would meet Oregon Department of Agriculture regulations for amount of comb in a standard pollination unit.

Amount of brood

As mentioned above, a healthy honey bee colony during the foraging season has eggs, larvae, and pupae. Brood indirectly influences the pollinating efficiency of a colony. Larvae require food, especially pollen. Many studies have shown a direct correlation between the amount of brood in a colony and the amount of pollen returned to the hive by the foragers and also overall foraging activity.

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Figure 3. A standard deep Hoffman comb with brood. For illustrative purposes, the worker bees have been removed. This comb is approximately 50 percent filled with capped brood (pupae). The picture is only half of the comb; for inspection purposes, both sides of the comb would need to be examined.

Grade A Orchard colonies are required to have 600 square inches of comb occupied by brood. Grade A Field colonies must have 1,000 square inches (one standard deep comb, if fully occupied, would have 270 square inches of brood). Brood combs are rarely, if ever, completely filled by brood, but a good queen on a good comb will create a brood area that often occupies 90 to 95 percent of the comb space (Figure 3, page 4). A Grade A Field colony should have six combs well filled with brood, and a Grade A Orchard should have four frames well filled.

Number of bees

Since the older bees in a colony do the pollination, the regulations take into account the relative number of bees a colony should have. Grade A Orchard colonies require six standard Langstroth combs to be well covered by adult bees; Grade A Field, ten standard Langstroth combs. (A Hoffman comb is a standard deep comb, 270 square inches.)

How many bees are on a well-covered standard comb? Studies at Oregon State University have shown that one standard comb, when completely covered, accommodates about 2,400 adult bees (Figures 4 and 5). Simple multiplication then shows that a Grade A Orchard colony must have 14,000 adult bees. The Grade A Field colony must have 24,000 adults. According to Washington's standard, there should be six frames, with two-thirds of each frame covered with bees at a temperature of 65°F. This does not reflect all the bees in the colony, as about one-third of adults would be out foraging at that temperature. Therefore, the total number of adults in a minimum standard colony would approximately cover six frames fully (approximately 14,400 bees).

Figure 5. Top view of a standard deep hive with 10 frames and bees. There are approximately 24,000 bees in this picture.

Beekeepers should avoid making splits just before the pollination period, as new colonies will not be able to pollinate the target crop as efficiently as established ones. Newly established colonies will have skewed population distribution and may need at least 2 weeks to stabilize their foraging force.

Food requirement

A colony of honey bees requires nectar and pollen for normal growth. A hive's food requirement is met in two ways: by the daily activities of foraging bees, and from food stored in the combs.

Never allow an overwintered colony's stored food reserves to drop below 10 pounds. Inclement weather frequently accompanies early flowering crops such as tree fruit. A colony unable to forage for even 2 or 3 days during poor weather can easily exhaust 10 pounds of honey in that short period of time. Starvation could rapidly cause the death of the hive and the loss of its benefits for pollination.

Figure 4. A standard deep Hoffman comb with brood and adult bees. This comb side would be rated as 100 percent covered with adult bees. To estimate the amount of brood accurately, the bees would need to be shaken off the comb. There are approximately 1,200 worker bees in this photograph.

A normal queen

The queen is the sole egg layer in a healthy colony and the heart of the hive. Without her, a colony will not increase in size, because replacement bees are not produced

to compensate for the natural mortality of the older bees. Eventually, a queenless colony will have no brood and, therefore, no stimulus for bees to collect pollen.

As a general rule, production colonies should have queens younger than 2 years old. As a queen ages, her capacity for laying eggs decreases. The egg-laying capacity of a queen 3 or more years old is usually not enough to maintain a colony at proper strength for pollination or honey production.

Grade B colonies

In the regulations, these are hives that fail to meet Grade A standards on the number of bees and brood by **not more** than 25 percent, but do meet all other requirements of a Grade A colony. Grade B units for orchard pollination would have at least 450 square inches of brood, 4½ frames of bees, and approximately 10,800 adults. A colony this size would be of minimum pollination value. A Grade B Field crop unit would have a minimum of 750 square inches of brood and 7½ frames of bees, or approximately 18,000 adults. Notice that a Grade B Field crop unit is stronger than a Grade A Orchard colony.

Colony strength inspections

It is relatively simple to describe colony-strength standards for pollination in words. In the field, colony-strength inspections require opening the hives and removing combs to examine the biological activity within the colonies.

Beekeepers who rent colonies for commercial pollination should be willing to open their hives and show the grower the quality of the units for rent. Beekeepers will usually provide the grower with the necessary protective garments, such as a veil and gloves. We suggest that growers ask their beekeepers to randomly open portions of the hives, so that the growers can indeed see what they are paying for. Growers should *not* attempt to conduct in-hive inspections without the beekeeper's permission.

Ideally, colony inspections should take place in mild weather that allows for good bee flight. Even gentle bees will offer a stiff defense if they're examined in cool, windy, or rainy weather, especially by an inexperienced person.

Colonies can also be examined with some degree of accuracy *without* opening them and inspecting combs. On a good foraging day, when the temperature is above 60°F (preferably above 65°F), a grower can observe colony flight activity. Good colonies have relatively uniform flight from each hive. Preliminary data from Washington State University indicate that the colony is a good pollinating unit if there are more than 100 incoming bees per minute at 65°F and above, with winds less than 10 miles per hour.

By standing close to (but *not* in front of) the hive entrances, growers can scan incoming bees for the presence of pollen pellets attached to the pollen baskets of their hind legs. On the average, one-fourth to one-third of the returning bees are pollen foragers, as opposed to nectar collectors. This percentage varies depending on the crop, time of year, time of day, and amount of brood in a hive.

Rented colonies should be of uniform physical size, but remember that the quality of the colony *inside* the hive is not always related to the *outward* appearance of the hive bodies. A fresh coat of paint — or the lack of it — has no relationship to the number of bees in a hive!

Recommendations for renting bees

It is wise to contact your beekeeper long before the anticipated bloom period of your crop. In order to schedule the movements of their hives, beekeepers need to know well in advance when their colonies will be used.

Use a contract

For many growers and beekeepers, a written pollination contract has not been necessary. However, a written contract is often advisable for growers who use a new beekeeper or for beekeepers who service a new grower. Whatever the situation, both grower and beekeeper need to understand various aspects of the rental. A contract should include, but is not limited to, the following points:

1. **Number of colonies** to be provided
2. **Guaranteed colony strength**
3. **Timing** of colony movement into and out of the crop
4. **Placement** or distribution of the colonies within the crop
5. Colony **rental fee** and **schedule of payment**
6. **Right of entry** to the beekeeper, for colony maintenance

7. **Advance notice** to the beekeeper if any pesticide that is toxic to bees will be applied while the colonies are in the crop. Growers must keep in mind that several fungicides, herbicides, and growth regulators are also toxic to bees. These chemicals can cause lethal and sub-lethal effects. Their residues can accumulate and remain in the beehive for a long time, causing extended damage even after the hives are removed from the fields. For questions about how to reduce bee poisoning, please refer to the publication *How to Reduce Bee Poisoning from Pesticides* (PNW 591) http://extension.oregonstate.edu/catalog/pdf/pnw/pnw591.pdf.

We recommend that there be a stipulation in the contract regarding colony inspections by a mutually acceptable third party if need arises.

Growers need to appreciate the value of a strong colony of honey bees in maximizing crop yields. Consider the rental of honey bees not as a guarantee of crop success, but rather as a guarantee against crop failure. A working partnership between grower and beekeeper best assures the most effective use of honey bees as pollinators.

Oregon and Washington colony-strength regulations

Oregon

From Oregon Administrative Rules, Chapter 603, Section 55-005, filed with the Secretary of State August 17, 1960, as Administrative Order AD 643.

55-005 BEES.

(1) As used in this section:

(a) European foulbrood shall be deemed serious if 20 or more larvae are found dead from this disease and more than 20% of the cells in the capped brood area are vacant.

(b) A queen shall be deemed a normal laying queen if her eggs that are in the worker cells are producing worker bees as indicated by the brood present.

(2) Oregon *Standard* (or Grade A) Field colony of bees for pollination shall be one that meets the following requirements:

(a) Free from American foulbrood and not seriously infected with European foulbrood or other bee disease.

(b) 3,000 square inches of comb, 1,000 square inches of which shall be occupied by live brood.

(c) Bees to cover well all brood. There shall be enough bees to cover well 10 standard Hoffman frames of comb or their equivalent.

(d) 10 pounds of honey or its equivalent of suitable bee food other than pollen or pollen substitute.

(e) A normal laying queen present.

(3) Oregon *B grade* Field colony of bees for field crop pollination shall be one that fails to meet the requirements of a standard field colony on amount of bees and brood by not over 25% but does meet all other requirements of a standard field colony.

(4) Oregon *Standard* (or Grade A) Orchard colony of bees for orchard pollination purposes shall be one that meets the following requirements:

(a) Free from American foulbrood and not seriously infected with European foulbrood or other bee disease.

(b) 3,000 square inches of comb space of which 600 square inches shall be occupied by live brood.

(c) Bees to cover well all brood. Bees to cover well at least 6 standard Hoffman frames of comb or their equivalent.

(d) 10 pounds of honey or its equivalent in suitable bee food other than pollen or pollen substitute.

(e) A normal laying queen present.

(5) Oregon *B grade* Orchard colony of bees for orchard pollination shall be one that fails to meet requirements for a standard orchard colony by not more than 25% on amount of bees and brood but does meet all other requirements of a standard orchard colony.

(6) To allow for variations incident to proper grading, a tolerance of 10% shall be allowed on all defects other than diseases and queens.

Washington

From Washington Department of Agriculture Apiary regulations, Chapter 15.60, order No. 1582. Effective October 27, 1978

WAC 16-602-030 Colony Strength.

The official minimum standard required for colony strength certification in the State of Washington shall be six frames, two-thirds covered with bees at a temperature of 65°F.

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