Most readers of this column probably know how important bees are for pollinating crops and contributing to global food production. For example, I’m sure everyone has heard that one out of three bites of food we eat is dependent on pollinating insects.

But how often aren’t there enough bees to pollinate those delicious fruits and vegetables we like to eat? And if we look at the types of bees, is it mostly honey bees (Apis mellifera) or wild non-Apis bees that are doing the work? Also, what’s all this crop pollination worth? In other words, if pollinators didn’t exist to pollinate crops in the U.S., how much money would farmers lose? These are the topics for our thirty-fourth Notes from the Lab, where we summarize “Crop production in the USA is frequently limited by a lack of pollinators,” written by James Reilly and colleagues and published in Proceedings of the Royal Society of London B [287:20200922].

For their study, Reilly and colleagues collected an impressive amount of data. Specifically, the authors surveyed pollinators and assessed crop production in seven pollinator-dependent crops: apple, highbush blueberry, sweet cherry, tart cherry, almond, watermelon and pumpkin. In total, they collected data at 131 commercially managed fields in Michigan, Pennsylvania, Washington, Oregon, Florida, British Columbia and California. All fields were stocked with honey bee hives at rates typical for each region, with the exception of apple and pumpkin fields in Pennsylvania. At those apple and pumpkin fields, farmers did not use honey bees because wild bees were thought to provide sufficient pollination.

At each field, the authors assessed pollinator visitation rates via multiple 100 m transect surveys. Observers walked along the transects and recorded the number and types of bees visiting flowers. Bees were identified on-the-wing and lumped into groups such as “bumble bees,” “carpenter bees,” or “green bees.” All honey bees (Apis mellifera) were identified to species because it is easy to make this species-level identification in the field.

Next, Reilly and colleagues assessed efficiency of fruit/vegetable production by comparing flower counts to fruit/vegetable counts post-bloom and during harvest. In other words, production was considered highly efficient if a large proportion of flowers turned into fruits/vegetables, but production was considered inefficient (and therefore potentially limited by pollination) if a small proportion of flowers turned into fruits/vegetables, but production was considered inefficient (and therefore potentially limited by pollination) if a small proportion of flowers turned into fruits/vegetables. For pumpkin and watermelon, production was measured by area and thus corresponded directly to yield, while for other crops the measurement was an approximation of area and therefore referred to more generally as production.

To assess how often pollinator limitation occurred for each crop, the authors related pollinator visitation rates to production efficiency. If there was no relationship, this was taken as evidence for no pollinator limitation (i.e., plenty of pollinators...
were always present). If there was a positive relationship, this was taken as evidence for pollinator limitation (i.e., by adding more pollinators, production increased). When pollinator limitation occurred, the proportion of transects experiencing limitation was determined via the breakpoint where an increase in pollinators did not increase production.

Finally, to assess the relative importance of honey bees and wild bees as crop pollinators, the authors tapped into extensive literature on the efficiency of pollen transfer for each type of bee, multiplying this efficiency by the abundance of the honey bees and wild non-Apis bees that were observed visiting flowers for each crop.

So, what did they find? Are crops in the U.S. limited by pollinators? Yes. For four of the seven crops (apple, tart cherry, sweet cherry and blueberry), insufficient numbers of pollinators frequently limit production. In the apple orchards sampled (Figure 1, light green bars), pollinator limitation occurs all the time; 100% of the samples show that having more pollinators will lead to more fruits. Importantly, this study includes the impact of thinning (i.e., most apple growers remove flowers after pollination so only a fraction of the successfully pollinated flowers will develop into larger fruits). Even when accounting for thinning, greater apple production always occurred with more pollinators.

Boxplots of relative pollen deposition rate of wild non-Apis bees (as a proportion of total pollen deposition) across the crop-region combinations. Estimates of pollen deposition were based on visits × pollen deposition per visit for each type of pollinator observed, with the remainder of pollen deposition provided by honey bees. Black line is the median, whiskers (dashed lines) extend to 1.5 times the most extreme data point, and circles represent outlier data points.

For cherries and blueberries in the northern U.S., production was found to be limited by insufficient pollinators 64-94% of the time (Figure 1, red and blue bars). However, for three of the seven crops (watermelon, pumpkin and almond), pollinators were rarely if ever found to be limiting. In addition, blueberry in Florida was not found to be limited by pollinators. Thus, across all the crops surveyed, some were frequently limited by pollinators and some were not.

Which bees are doing the work? Are honey bees more important than wild non-Apis bees? Both are important, but it depends on the crop and location. As can be seen in Figure 2, wild non-Apis bees were as important as, or more important than honey bees for pollination of pumpkin, watermelon in Florida, and tart cherry and apple. However, honey bees were more important than wild non-Apis bees for pollination of blueberry, almond, watermelon in California, and sweet cherry in Washington. Overall, both types of bee provided comparable amounts of pollination, even in the agriculturally intensive regions sampled for this study.

What does this mean for farmers? Should they be concerned about not having enough pollinators? We can answer this question in two ways. First, Reilly and colleagues’ study shows that for several crops at several locations, farmers would benefit right now from better pollination. For example, apple production was always found to be limited by poor pollination. That’s important since the limited pollination services for apple are already valued at $2.1 billion in the U.S.; if better pollination occurred tomorrow, this number would increase. Since wild non-Apis bees contribute half of the pollination services to apple while honey bees contribute the other half, apple growers may want to consider renting more honey bee colonies and/or growing their apples in ecologically friendly ways that encourage more wild non-Apis bees. Future research will be needed to determine which approaches to improving pollination are the most cost effective.

A second way to answer this question is to consider longer-term trends in pollinator populations and health. For example, it is now well established that range contractions and population declines are occurring for some wild non-Apis pollinators in the U.S. Given Reilly and colleagues’ results...
showing that some fruits and vegetables are already limited by pollinators, it doesn’t take an extensive imagination to see that further reductions of wild non-**Apis** pollinators could exacerbate pollination shortages.

Finally, we also must consider the long-term health of honey bees. For example, almond production was never found to be limited by insufficient pollination and nearly all $4.2 billion in pollination services to almond are provided by honey bees. On the one hand, that’s excellent news; honey bees are currently doing an adequate job supporting the almond industry. On the other hand, if there’s ever a problem with honey bees, those important pollination services are at risk. So, we’d better treat our honey bees well and ensure that beekeeping remains profitable. If not, the almond industry will lose some of the $4.2 billion in pollination services they provide.

Until next time, bee well and do good work.

Scott McArt

**Reference:**