Notes from the Lab: The Latest Bee Science Distilled

by Scott McArt

How climate, weather, and land use shape colony productivity in the Northcentral U.S.

What makes a honey bee colony grow and produce lots of honey? Ask this question to two beekeepers and you're likely to receive more than two answers. Perhaps dozens.

Intuitively, we all know climate, weather, and land use are important. Multi-year droughts (climate) and month-to-month variability in rainfall (weather) each very clearly influence the availability of floral resources in a given landscape. And phrases like "a given landscape" explain at least some of the reason why your bees at one apiary fill twice as many supers as another apiary that's five miles down the road; the land around that first apiary simply has better forage. And, of course there are other factors, such as pesticides and parasites such as varroa.

Gabriela Quinlan

A grassy-herbaceous meadow near one of the experimental honey bee colonies monitored in southern Michigan

So, what does science have to say about this question? If we focus only on climate, weather, and land use, which is the most important for colony growth and honey production? And do these factors interact? In other words, if our climate changes, can certain types of land use buffer the impact of climate on bees? These are the topics for the fifty-sixth Notes from the Lab, where I summarize ***"Grassy-herbaceous land moderates regional climate effects on honey bee colonies in the Northcentral US,"*** written by Gabriela Quinlan and colleagues and published in the journal *Environmental Research Letters* [2022].

For their study, Quinlan and colleagues made use of an impressive multi-state network of experimental honey bee colonies in the Northcentral U.S. (see Figure 1). In total, the authors monitored 644 colonies at 162 apiary locations in 7 states (Michigan, Minnesota, North Dakota, Ohio, Pennsylvania, South Dakota, and Wisconsin) for 5 years (2015-2019).

Each colony was fitted with a scale that continuously logged colony weight at least every hour throughout the peak summer months (July 1-August 31). Approximately 2.9 million logged colony weights were used to assess weight gain — the main response of interest — during the July 1-August 31 time period.

The authors tested how variation in weight gain among colonies in space and time was influenced by 23 climate, weather, and land use factors. This included eight climate factors (30-yr averages of temperature and precipitation for spring, summer, autumn, and winter at each location), nine weather factors (1-yr averages of temperature and precipitation for each season, plus growing degree days), and six land use factors (proportion of grass crops, woody-herbaceous crops, grassy-herbaceous natural land, woody natural land, and developed land within a 2-km flight radius of the colony).

All 23 factors were evaluated for their ability to explain colony weight gain via something called a random forest model. This type of model can be advantageous for large datasets that assess lots of factors (e.g., the 23 factors in the authors' analysis) and have other issues that introduce problems for traditional statistical models. Finally, it's important to note that the 644 colonies enrolled in this study were under a variety of management conditions, but all colonies were managed for varroa and monitored for diseases.

So, what did they find? What were the most important factors explaining colony weight gain? Climate was the most important factor that influenced colony weight gain. Specifically, long-term (i.e., 30-yr) average winter temperature and precipitation were the most important factors, followed by long-term average autumn and spring precipitation. Colonies in wet and warm climates (Wisconsin, Michigan, Ohio, and Pennsylvania) had the lowest weight gain in July and August (see Figure 1) compared to colonies in cool, dry climates (the Dakotas and Minnesota).

What about weather? Was it important? Yes. When summer advanced more quickly (i.e., higher growing degree day accumulation by August 1), colonies gained 2-3 kg less weight in July and August. Interestingly, this is consistent with speculation by several beekeepers about a main cause of year-to-year variation in honey production in upstate New York. Also, in years with warmer preceding autumns, colonies gained 3-4 kg less weight the following summer than in years with cooler preceding autumns.

And how about land use? Were particular types of land use better than others? Yes. The proportion of grassy-herbaceous natural land within a 2-km radius of an apiary positively influenced colony weight gain, while woody natural land negatively influenced weight gain (see Figure 2). Grassy-herbaceous land increased weight gain by up to 3.5 kg across the study and allowed colonies in warm and wet climates to gain as much weight as the worst-performing colonies in cool, dry climates. For this to occur, grassy-herbaceous land needed to be abundant: >25% of land area within 2 km of the apiary, as seen in the steep increase and plateau shown in Figure 2A.

Well that's interesting. So does that mean I should locate my apiaries near grassy-herbaceous lands? If you live in the Northcentral U.S., yes, at least in part. The presence of grassy-herbaceous land was beneficial for colony weight gain in all regions and climates represented in this study. So if your goal is to maximize productivity in July and August, placing your colonies in a location with at least 25% grassy-herbaceous land within a 2-km foraging radius of the apiary is very likely to be beneficial.

But remember that this study only considers weight gain in July and August, largely because that was the time period that data was available from all 644 colonies in all years. In the Northcentral U.S., the months of April,

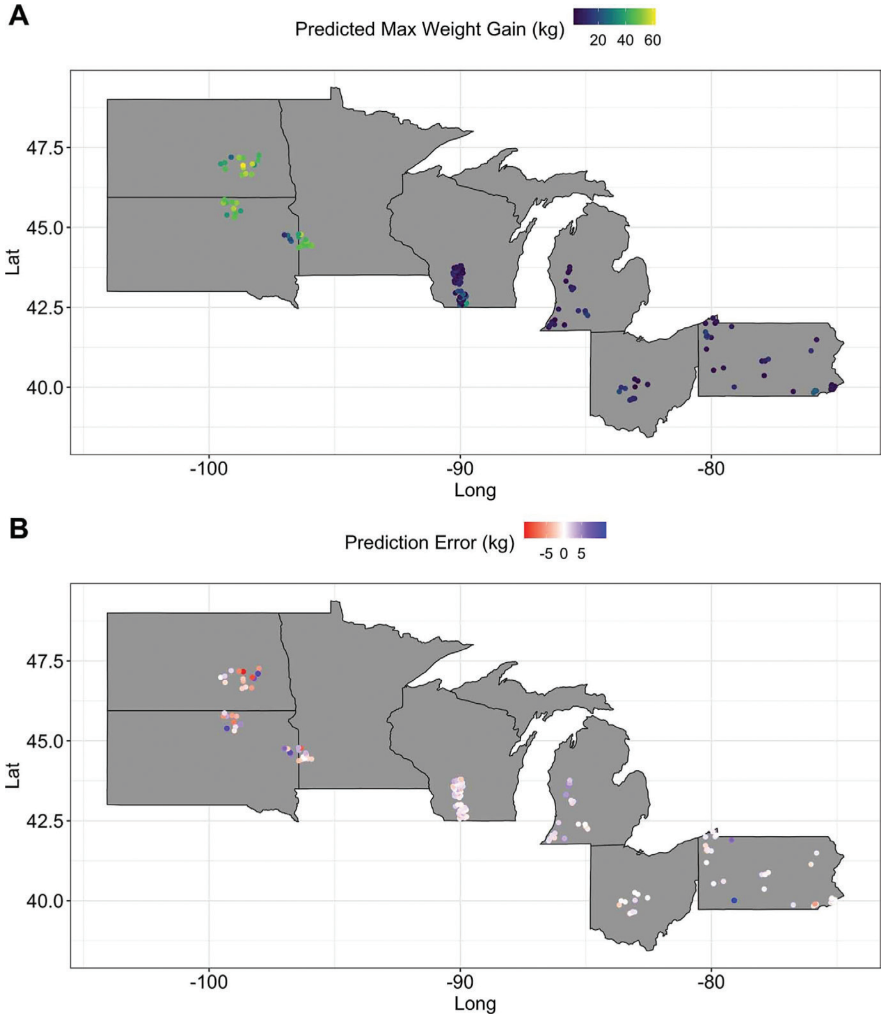

Figure 1. *Predicted rates of honey bee colony maximum weight gain (kg) in July and August (A), and the prediction error (predicted minus actual maximum colony weight gain) (B), plotted across sites in the Northcentral U.S. In panel (A) lighter colors represent greater weight gain. In panel (B) lighter colors represent lower error, with red representing under-prediction (actual weight exceeded model-predicted weight) and blue representing over-prediction (model-predicted weight exceeded actual weight). Predictions are averaged across all colonies and years for each apiary location.*

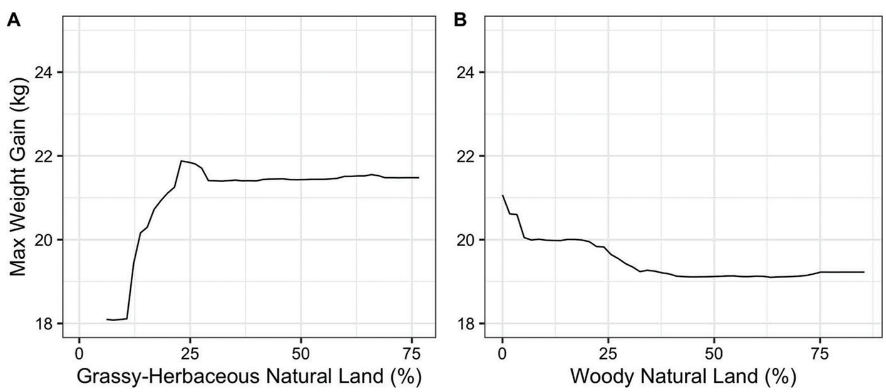

Figure 2. *Partial dependency plot for the proportion of grassy-herbaceous land (A) and woody natural land (B) within 2 km of each honey bee apiary compared to the maximum weight gain of each honey bee colony from July to August in the Northcentral U.S. Model predictions based on a single model run are shown with the black line. These two land use variables were the most important land use variables identified.*

May, and June are also important for colony productivity. Floral resources from trees and shrubs are especially important for honey bees during this time, which is critical for early-season population growth. So don't forget to consider woody natural land when locating your ideal apiary!

At the same time, the authors' data clearly shows that woody natural land is *not* desirable in July and August. Perhaps this shouldn't be a surprise since honey bees are generalists that forage for resources over an entire growing season. Because of this, diverse sources of flowers (and by extension, diverse landscapes) are necessary to maintain consistent season-long resources for colony productivity.

As our climate changes and weather fluctuates from month-to-month and year-to-year, the study by Quinlan and colleagues is a good nudge to pay close attention to grassy-herbaceous fields. By doing so, beekeepers in the Northcentral U.S. will be more resilient to what nature throws at us during the hottest periods of the summer.

Until next time, bee well and do good work.

Scott McArt

Reference

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