Cover photos by Lisa Wasko DeVetter

Blueberry Pollination in the U.S.

MANAGEMENT PRACTICES AND CHALLENGES

Suzette P. Galinato[1], Ruby H. Chen[2], Lisa W. DeVetter[3], Rufus Isaacs[4], Rachel E. Mallinger[5], Andony Melathopoulos[6], and Meghan O. Milbrath[4]

WASHINGTON STATE UNIVERSITY
MICHIGAN STATE UNIVERSITY
UF UNIVERSITY of FLORIDA
Oregon State University

1 Agriculture and Natural Resources, Washington State University, Pullman, WA, USA.

2 Social & Economic Sciences Research Center, Washington State University, Pullman, WA, USA.

3 Department of Horticulture, Washington State University, Northwestern Washington Research and Extension Center, Mount Vernon, WA, USA.

4 Department of Entomology, Michigan State University, East Lansing, MI, USA.

5 Department of Entomology and Nematology, University of Florida, Gainesville, FL, USA.

6 Department of Horticulture, Oregon State University, Corvallis, OR, USA.

Contents

1. Introduction

Highbush blueberries are a pollinator-dependent crop, with about 642 million pounds produced across the United States worth approximately $1 billion as of 2023 (USDA NASS 2025). The acreage and crop value have increased by 2% and 5%, respectively, on average per year over the past five years, with major production in Washington and Oregon in the Pacific Northwest, Georgia and Florida in the Southeast United States, and Michigan in the Great Lakes region.

Since the domestication of blueberries in the early 1900s, growers have understood that insects visiting the flowers were essential for pollination (Retamales and Hancock 2018). Pollen transfer is done mostly by bees, with variation in pollination effectiveness across bee species (Javorek et al. 2002). Small blueberry fields may be pollinated mostly by wild bees, but once farms expand into large commercial production scales, managed bees are required to provide enough flower visits during the relatively short bloom (Isaacs and Kirk 2010). Honey bees are not the most efficient insects for moving pollen between blueberry flowers, but their sheer abundance within fields can ensure good pollination under optimal weather conditions. Honey bees typically achieve pollination of blueberries through incidental pollen collection when visiting flowers for nectar (Hoffman et al. 2018). Each blueberry flower is receptive to pollen for only a few days after opening if temperatures are warm, so it is essential that bee activity remains high throughout the bloom period. An acre of mature highbush blueberries can have 6–8 million flowers per acre, and each flower requires multiple visits by honey bees to be pollinated, so commercial growers typically rent several honey bee colonies. These colonies are often spread around farms because it is assumed that pollination will suffer with a single placement location, as suggested for almonds (Cunningham et al. 2016).

Pollination is a critical component of successful and profitable blueberry production. Although there have been major advances in breeding, horticultural practices, and pest management for this crop, extension recommendations for pollination have mostly gone unchanged for decades. Spring weather variability challenges growers' ability to appropriately adjust the timing and density of honey bee colonies, and there is little research-based guidance on how to adapt pollination strategies for specific cultivars, weather conditions, or farm situations.

Developing a profile of blueberry pollination practices is a valuable step for devising recommendations for pollination strategies tailored to grower's production region and farm characteristics. This report, supported by the project, *Optimizing Blueberry Pollination to Ensure Future Yields* (USDA NIFA Specialty Crops Research Initiative award no. 2020-51181-32155), provides results of a survey that investigated pollination management practices of blueberry growers in major production regions. The report also presents the growers' perspectives and concerns regarding blueberry pollination and related management strategies. The subsequent sections of the report give the results of the survey at the national and state levels. Summaries are also provided.

2. Materials and Methods

2.1 Survey Instrument

Between May 21, 2021, and April 30, 2022, a survey was conducted to collect data about blueberry pollination practices and associated challenges. The survey consisted of 23 questions and was distributed to blueberry growers across the United States using Qualtrics survey software (Qualtrics, Provo, UT). To reach the growers, the survey was advertised in trade journals, grower meetings and conferences. Participants were asked about the types of bees they used to pollinate their blueberries during the 2021/2022 growing season, the placement of honey bee colonies in the field, their perspectives on blueberry pollination, and general farm characteristics. A copy of the survey questionnaire is provided in Appendix 1.

2.2 Data Analysis

The survey was reviewed by the Institutional Review Board (IRB) by Washington State University and received exempt status (IRB 18533, Blueberry Pollination Planner - Assessment of Grower Pollination Practices). Data from the survey were tabulated in Excel spreadsheets, cleaned to remove ineligible respondents, inconsistencies, and missing values, then analyzed using IBM SPSS Statistics (Version 29.0.1.0, IBM Corp., Armonk, NY). Descriptive statistics—such as medians, frequencies, and percentages—were used to summarize key variables. Additionally, data visualization techniques, including bar charts, were utilized to illustrate distributions and patterns within the data.

The tables in this report first present data combined across all states with survey responses, including Florida, Michigan, Oregon, and Washington, followed by separate summaries for those four states, which were the project's focus areas.

3. Results

3.1 Overview of Survey Responses

A total of 548 blueberry growers accessed the online survey, with 490 providing partial to complete responses. Of these, 434 growers (89%) reported using managed bees to pollinate blueberries during the 2021/2022 pollination season, while 56 growers (11%) did not. Because the focus of this report is on pollination practices involving managed bees, those 56 respondents were excluded from further analysis. An additional 26 growers were excluded for being located outside the United States, resulting in a final sample of 408 blueberry growers.

Among the 408 respondents, 321 specified a primary state where they commercially produce blueberries, 10 reported multiple states, and 77 did not specify any location. Of the 321 respondents, when broken down by state, Michigan had the highest proportion of respondents (n=107, 33%), followed by Georgia (n=73, 23%), Oregon (n=49, 15%), Florida (n=50, 16%), Washington (n=28, 9%), and other states (n=14, 4%). Figure 1 shows the geographic distribution of survey respondents on a map, with a notable concentration in the eastern United States.

Figure 1. Location of survey respondents in the United States

To gather some fundamental information about blueberry farm operations, three questions were asked: 1) total production area of the blueberry farm, 2) the primary blueberry cultivars grown along with their associated acreages, and 3) the average annual cash cost for the blueberry fields they own or manage.

Table 1 presents the percentage of respondents indicating various ranges for their total production area in four states—Florida, Michigan, Oregon, and Washington, as well as the overall category of "All States," which includes these four states as well as respondents from other regions. Among blueberry growers across all states who reported their production area (n=333), the most common farm size is 6 to 15 acres (24%), followed by 1 to 5 acres (20%), and 16 to 25 acres (15%). In Florida, nearly half (48%) of the respondents reported operating small blueberry farms of 1 to 5 acres. In Michigan, growers predominantly own or manage medium-sized blueberry farms, with 26% reporting 6 to 15 acres, 22% reporting 16 to 25 acres, and 19% reporting 26 to 50 acres. Blueberry farm sizes are diverse in Oregon, with 30% of growers reporting 51 to 100 acres, followed by 18% with 6 to 15 acres, and 16% with 16 to 25 acres. In Washington, blueberry farm sizes varied significantly with approximately 44% of growers managing farms from less than 1 acre to 6 to 15 acres, while 40% reported production areas of 101 to 500 acres.

Table 1. Percentage of growers by highbush blueberry production area across all states and selected states.

Total blueberry production area	All States (n=333)	Florida (n=52)	Michigan (n=109)	Oregon (n=57)	Washington (n=29)
Less than 1 acre	2	2	0	0	10
1 to 5 acres	20	48	7	4	24
6 to 15 acres	24	12	26	18	10
16 to 25 acres	15	3	22	16	3
26 to 50 acres	11	10	19	8	10
51 to 100 acres	14	8	17	30	3
101 to 500 acres	11	14	7	14	40
More than 500 acres	3	3	2	10	0

Notes: The total number of respondents in each location is provided in parenthesis. The "All States" category includes the respondents in the four specific states and other regions.

Table 2 provides a summary of the primary blueberry cultivars grown across all states and within selected states, listing the count or frequency of mentions and corresponding acreage ranges. Across all states, 'Bluecrop' and 'Duke' were the most frequently mentioned cultivars, each with 29 counts and acreage ranges of 0.2–300 and 0.5–400, respectively. In Florida, the most frequently grown cultivars were southern highbush types including 'Emerald', 'Farthing', and 'Jewel'. All other states reported growing northern highbush cultivars. Michigan growers mostly mentioned 'Bluecrop' and 'Elliott'. In Oregon, 'Duke' and 'Draper' were most cited, and in Washington, 'Duke' and 'Bluecrop' were the primary cultivars.

Table 2. Highbush blueberry cultivars most frequently mentioned to be the primary cultivars cultivated across all the United States and select states.

State	Cultivar Name	Count	Acreage
All States	Bluecrop	29	0.2–300
	Duke	29	0.5–400
	Elliott	13	4–45
	Farthing	10	3–400
Florida	Emerald	6	10–25
	Farthing	5	3–400
	Jewel	5	0.5–120
Michigan	Bluecrop	17	2–100
	Elliott	11	4–45
	Jersey	4	17–30
Oregon	Duke	14	8–400
	Draper	6	4–150
	Aurora	4	15–68
Washington	Duke	11	0.75–118
	Bluecrop	5	1–300

Notes: The "All States" category includes the four specific states and other regions.

The average annual cash costs of production—i.e., out-of-pocket expenses for inputs like blueberry bushes, chemicals, fertilizers, and labor—vary by individual growers and location. These variations are influenced by factors such as costs and availability of labor, local climate and soil conditions, land cost, pest and disease pressures, input costs, regulatory compliance fees, and transportation expenses. Table 3 shows that most blueberry growers across all states (36%) report annual per-acre cash costs ranging from $3,000 to $5,999. This cost range was also the most common among growers in Michigan (35%), Oregon (43%) and Washington (48%). However, in Florida, most growers (53%) reported spending less than $3,000 per acre annually.

Table 3. Percentage of growers reporting average annual cash costs per acre for highbush blueberry production by cost range and state.

Average annual cash costs per acre	All States (n=314)	*Florida (n=49)*	*Michigan (n=104)*	Oregon (n=54)	Washington (n=23)
Less than $3,000	22	54	17	6	9
$3,000 to $5,999	36	16	35	43	48
$6,000 to $8,999	28	18	33	33	4
$9,000 to 11,999	10	6	14	7	22
$12,000 to $14,999	3	2	1	7	13
$15,000 or more	1	4	0	4	4

Note: The "All States" category includes the four specific states and other regions. The total number of respondents in each location is provided in parenthesis.

3.2 Blueberry Pollination Practices

3.2.1 Types of bees used for blueberry pollination

Managed honey bees are the primary pollinators of commercial blueberries and are typically brought to farms in colonies by beekeepers. Table 4 shows the percentage of different types of managed bees used for pollinating blueberries during the 2021/2022 season across all states and in selected states. Because some growers use more than one type of managed bees, the percentages reported in each column do not sum to 100%.

Honey bees are the most commonly used pollinator across all states (79%). This percentage is higher in some states: 87% of respondents in Florida, 73% in Michigan, 88% in Oregon; and 100% in Washington rely on honey bees for blueberry pollination.

Table 4. Percentage of growers reporting a particular type of managed bee used to pollinate highbush blueberries during the 2021/2022 pollination season across all states and selected states.

Type of managed bees	All States (n=408)	Florida (n=52)	Michigan (n=109)	Oregon (n=57)	Washington (n=29)
Honey Bees	79	87	73	88	100
Bumble Bees	34	39	39	23	21
Other	3*	0	1	7	14

Note: The "All States" category includes the four specific states and other regions.

* The other managed bees listed are leafcutter bees (Oregon, Washington), mason bees (mostly *Osmia lignaria*, but also *Osmia ribifloris*; Michigan, Oregon, Washington), and natural bumble bees.

Bumble bees are the second most used pollinator, utilized by 34% of growers across all states. Their usage varied by state—39% in Florida and Michigan reported using them, compared to 23% in Oregon and 21% in Washington. Other managed bees, including leafcutter bees, mason bees and natural bumble bees collectively account for 3% across all states, with varying use in selected states—14% in Washington, 7% in Oregon, 1% in Michigan, and none reported by respondents in Florida.

Growers who used honey bees to pollinate blueberries were also asked whether they rent or own them. Table 5 shows the percentage of growers who either rent or own honey bee colonies. In general, renting honey bees is the more common practice, with 74% of growers across all states choosing this option. This trend is consistent in Florida (71%), Michigan (67%), Oregon (80%), and Washington (79%). Owning honey bees is less common, with 21% of growers across all states opting for this method. However, ownership rates vary slightly among the selected states, with Michigan having the highest at 29%, followed by Florida (22%), Oregon (14%), and Washington (7%). Additionally, a small percentage of growers in all states reported using both rented and owned honey bees, ranging from 4% in Michigan to 14% in Washington.

Table 5. Percentage of highbush blueberry growers who rent or own honey bee colonies across all states and selected states.

Rent or Own	*All States (n=309)*	*Florida (n=45)*	*Michigan (n=79)*	*Oregon (n=50)*	*Washington (n=29)*
Rent	74	71	67	80	79
Own	21	22	29	14	7
Both	5	7	4	6	14

Note: The "All States" category includes the four specific states and other regions.

3.2.2 Stocking rate of honey bee colonies

Growers who used honey bees for blueberry pollination were asked about their average honey bee stocking rate, measured in hives per acre. Since the data within each selected state did not follow a normal distribution, we chose to report the median rather than the mean as it provides a more representative measure of central tendency. Table 6 shows the median of average honey bee stocking rates for all states and in selected states.

Table 6. Median and range of average honey bee stocking rates in highbush blueberry fields across all states and selected states.

State	Number of respondents	Median (hives per acre)	Min–Max range (hives per acre)
All States	214	4	0.3–15
Florida	37	8	1–10
Michigan	37	2	0.3–6
Oregon	41	3.5	0.5–7.5
Washington	27	3.7	1–15

Note: The "All States" category includes the four specific states and other regions. The range refers to the minimum and maximum stocking rates provided by respondents.

Across all states, the median of respondents' average stocking rate is 4 hives per acre, with respondent values ranging from 0.3 to 15 hives per acre. In Florida, the median is higher at 8 hives per acre, with a range of 1 to 10 hives per acre. Michigan respondents report the lowest median stocking rate at 2 hives per acre, ranging from 0.3 to 6 hives per acre. In Oregon, the median is 3.5 hives per acre, with a range of 0.5 to 7.5 hives per acre, while Washington has a median stocking rate of 3.7 hives per acre, ranging 1 to 15 hives per acre.

A total of 301 blueberry growers across all states answered the question about whether they use single or multiple stocking rates during the 2021/2022 pollination season (Table 7). Most respondents (82%) indicated using a single stocking rate, while 18% used multiple rates. In Florida and Michigan, 18% and 15% of respondents used multiple rates, respectively. Oregon had the highest percentage, with 35% using multiple rates. In Washington, 21% of the respondents said the same.

Table 7. Percentage of highbush blueberry growers using single or multiple stocking rates in the 2021/2022 pollination season across all states and selected states.

Stocking rate	All States (n=301)	Florida (n=44)	Michigan (n=78)	Oregon (n=49)	Washington (n=29)
Single stocking rate	82	82	85	65	79
Multiple stocking rate	18	18	15	35	21

Note: The "All States" category includes the four specific states and other regions.

3.2.3 Factors associated with above-average honey bee stocking rates

Figure 2 illustrates the factors associated with above-average honey bee stocking rates across all states and within selected states, with "above-average" defined differently by state (e.g., in Florida above ~3.5 hives/acre, in Michigan above 2 hives/acre, in Washington and Oregon above 4 hives/acre). Across all states, 41% of the respondents agreed that a surrounding landscape with bee-attractive plants, which reduces bee activity in blueberry fields, is associated with above-average stocking rates. Roughly one-third of respondents (31%) indicated that a high density of other bee colonies in the area contributes to above-average stocking rates. This observation appears counterintuitive, as elevated colony densities in neighboring properties are generally expected to reduce stocking rates. Local pollination management practices may influence respondents' perceptions beyond what the survey captured. However, the reasoning for this response cannot be determined since no follow-up information was collected.

Additionally, 39% of respondents associated above-average stocking rates with high yield potential. 25% reported above-average stocking rates depending on the blueberry cultivar grown, and 13% indicated that low-quality bee colonies prompted above-average stocking rates.

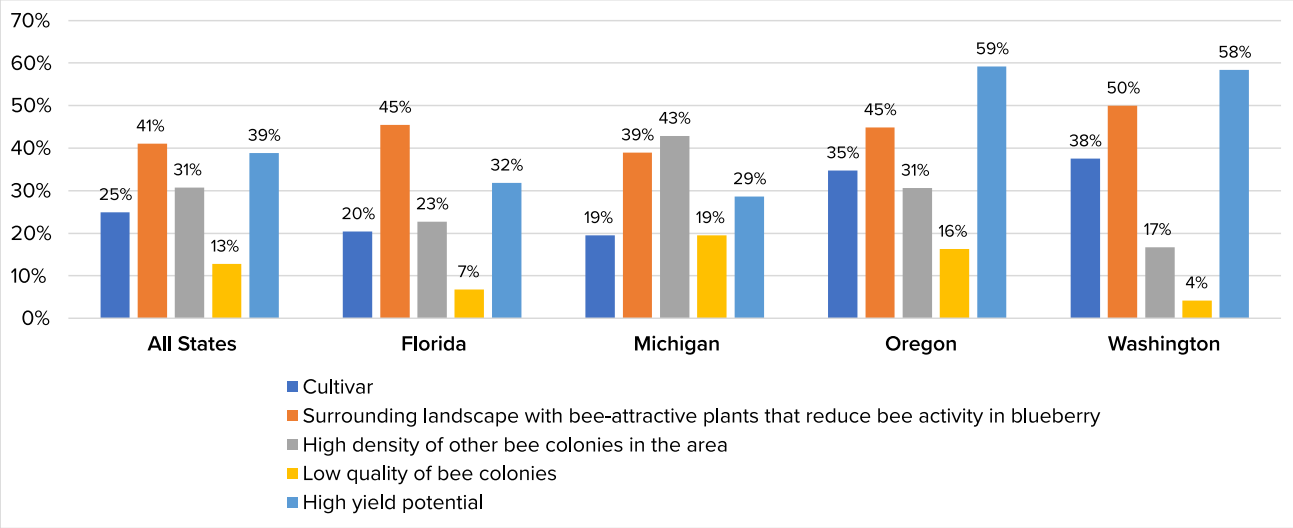

Figure 2. Percentage of highbush blueberry growers choosing the most important factor driving above-average stocking rates across all states and selected states (the "above-average" definition varies by state: in Florida above ~3.5 hives/acre, in Michigan above 2 hives/acre, in Oregon and Washington above 4 hives/acre).

Figure 2 also highlights state-level differences in perceptions of factors influencing above-average honey bee stocking rates. In Florida, respondents ranked the surrounding landscape with bee-attractive plants as the most influential factor (45%), followed by high yield potential (32%). In Michigan, a high density of other bee colonies in the area was the most important factor (43%), a finding that appears contrary to conventional expectations. The underlying rationale cannot be determined as the survey did not include follow-up questions. The second most important factor in Michigan was the surrounding landscape with bee-attractive plants (39%), followed by high yield potential (29%).

Respondents in Oregon considered high yield potential as the primary reason for utilizing above-average stocking rates, with 59% agreement and higher compared to other states. The surrounding landscape with bee-attracting plants (45%) and the choice of cultivar (35%) were also seen as influential factors. In Washington, high yield potential was similarly perceived as the primary factor influencing above-average stocking rates, with 58% agreement; followed by surrounding landscape (50%) and the choice of cultivar (38%). The variations in perceptions may be attributed to the state's specific environmental conditions, the effects of extension programs highlighting these issues, and practices of growers in the area.

3.2.4 Average honey bee rental fees

Table 8 provides the median of average rental fees for honey bee hives across all states and in selected states during the 2021/2022 pollination season. Across all states, the median rental fee was $60 per hive, with reported fees ranging from $0 to $175 per hive among respondents. In Florida and Michigan, the median rental fee were the same at $60 per hive, but with different minimum and maximum fees within each state. In Oregon, the median rental fee was slightly lower at $56 per hive, ranging from $18 to $125. In Washington, the median rental fee was $50 per hive, with fees ranging from $40 to $175 per hive.

Table 8. Median of average rental fees for highbush blueberry pollination across all states and selected states.

State	Number of respondents	Median ($ per hive)	Min–Max range ($ per hive)
All States	162	60	0–175
Florida	30	60	10–100
Michigan	34	60	0–80
Oregon	33	56	18–125
Washington	21	50	40–175

Note: The "All States" category includes the four specific states and other regions. The range refers to the minimum and maximum stocking rates provided by respondents.

3.2.5 Spacing and placement of honey bee colonies

Responses to two specific questions regarding the percentages of growers using specific spacing approaches (Appendix 1, Question C.1.) and placement strategies (Appendix 1, Question C.2.) for honey bee colonies in the blueberry fields were presented as a combination of the percentages (e.g., 100–0–0–0, 75–0–25–0). This is further described below.

Each spacing combination consists of four percentage values (a–b–c–d) that add up to 100 percent:

- The ***first number (a)*** refers to the percentage of all honey bee colonies in the blueberry field that are ***spaced out*** at a rate of 1–2 pallets of bees per drop.
- The ***second number (b)*** refers to the percentage of all honey bee colonies in the blueberry field that are ***moderately spaced*** at a rate of 3–4 pallets of bees per drop.
- The ***third number (c)*** refers to the percentage of all honey bee colonies in the blueberry field that are ***clumped*** or placed at a rate of more than 5 pallets of bees per drop.
- The ***last number (d)*** refers to the percentage of all honey bee colonies in the blueberry field that the respondent is ***not sure*** of the spacing.

Table 9 summarizes the different spacing combinations of honey bee colonies in blueberry fields during the 2021/2022 pollination season across all states and in selected states.

- ***Spaced out (100–0–0–0):*** This spacing, with 1–2 pallets of bees per drop, accounted for 9% of responses across all states. It was more common in Washington (24%) than in other states.
- ***Moderate spacing (0–100–0–0):*** Similar to spaced-out, moderate spacing (3–4 pallets of bees per drop) represented 9% of responses overall. It was more prevalent in Oregon (21%) and Washington (17%) than other states.
- ***Clumped (0–0–100–0):*** The clumped spacing with more than 5 pallets of bees per drop, comprised 16% of responses across all states. It was highest in Washington (32%) and lowest in Oregon (12%).
- ***Not sure (0–0–0–100):*** Three percent of respondents across all states were unsure of the colony spacing. It varied slightly among states, with respondents in Oregon reporting the highest uncertainty at 5%.
- ***Spaced out–Moderate–Clumped–Not sure (25–25–25–25):*** This evenly distributed spacing combination was reported by 31% of respondents across all states. It was notably predominant in Florida (52%) and less common in Washington (0%).
- ***Mixed (a–b–c–d):*** Various mixed spacing combinations not fitting the above categories accounted for 32% of responses across all states. This category was highest in Michigan (46%) and lowest in Florida (13%). This category is further disaggregated to identify the spacing type that accounts for the majority of observed combinations in the field.

Table 9. Percentage of highbush blueberry growers reporting their spacing combinations of honey bee colonies in blueberry fields during the 2021/2022 pollination season across all states and selected states.

Spacing Combination	All States (n=344)	Florida (n=52)	Michigan (n=109)	Oregon (n=57)	Washington (n=29)
Spaced out (100–0–0–0)	9	8	6	14	24
Moderate spacing (0–100–0–0)	9	8	6	21	17
Clumped (0–0–100–0)	16	19	14	12	32
Not sure (0–0–0–100)	3	0	1	5	3
Spaced out–Moderate–Clumped–Not sure (25–25–25–25)	31	52	27	9	0
Mixed (a–b–c–d), total	32	13	46	39	24
Mixed but majority spaced out	*6*	*1*	*7*	*16*	*7*
Mixed but majority moderate spacing	*9*	*4*	*17*	*7*	*7*
Mixed but majority clumped	*8*	*0*	*11*	*9*	*3*
Mixed but majority unsure	*5*	*4*	*3*	*2*	*0*
Mixed, all other	*4*	*4*	*8*	*5*	*7*

As for the spacing combinations above, each placement combination consists of four percentage values (w-x-y-z) that add up to 100 percent:

- The ***first number (w)*** refers to the percentage of all honey bee colonies in the blueberry field that are ***located within or directly on the edge of the crop field.***
- The ***second number (x)*** refers to the percentage of all honey bee colonies in the blueberry field that are ***placed no more than 20 ft from the field edge.***
- The ***third number (y)*** refers to the percentage of all honey bee colonies in the blueberry field that are ***placed more than 20 ft from the edge of the field.***
- The ***last number (z)*** refers to the percentage of all honey bee colonies in the blueberry field that the respondent is ***not sure*** of the placement.

Table 10 summarizes the placement combinations of honey bee colonies in blueberry fields during the 2021/2022 pollination season across all states and in selected states.

- ***Located within or directly on the edge of the crop field (100–0–0–0):*** This placement method accounted for 13% of responses across all states. It was notably higher in Washington (41%) compared to other states.
- ***Spaced 20 ft, at most, from the field edge (0–100–0–0):*** About 10% of respondents across all states used this placement method. It was more common in Oregon (18%) and lowest in Michigan (6%).
- ***Placed more than 20 ft from the edge of the field (0–0–100–0):*** This placement method represented 11% of responses across all states. It was highest in Washington (21%) and lowest in Oregon (4%).
- ***Not sure (0–0–0–100):*** About 2% of respondents across all states were unsure of the placement method. This percentage varied among the selected states, but still generally low.
- ***Within/on–20 ft–More than 20 ft–Not sure (25–25–25–25):*** This evenly distributed placement combination was reported by 32% of respondents across all states. It was prevalent in Florida (52%) and less common in Washington (3%).
- ***Mixed (w–x–y–z):*** Various mixed placement configurations not fitting the above categories accounted for 32% of responses across all states. This category was highest in Michigan and Oregon (44%) and lowest in Florida and Washington (18%), Within this category, the specific type of placement that represents the majority of combinations in the field is further identified.

The results indicated diverse practices in the spacing and placement of honey bee colonies within blueberry farms, reflecting different practices and preferences of growers and their beekeepers.

Table 10. Percentage of growers reporting placement combinations of honey bee colonies in highbush blueberry farms during the 2021/2022 pollination season across all states and selected states.

Placement Combination	All States (n=344)	Florida (n=52)	Michigan (n=109)	Oregon (n=57)	Washington (n=29)
Located within or directly on the edge of the crop field (100–0–0–0)	13	12	12	21	41
Spaced no more than 20 ft from the field edge (0–100–0–0)	10	12	6	18	14
Placed more than 20 ft from the edge of the field (0–0–100–0)	11	6	10	4	21
Not sure (0–0–0–100)	2	0	1	4	3
Within/on–20 ft–More than 20 ft–Not sure (25–25–25–25)	32	52	27	9	3
Mixed (w–x–y–z), total	32	18	44	44	18
Mixed but majority located within or directly on the edge	*7*	*2*	*9*	*11*	*11*
Mixed but majority spaced no more than 20 ft from field edge	*11*	*2*	*17*	*18*	*0*
Mixed but majority placed more than 20 ft from field edge	*6*	*6*	*7*	*12*	*0*
Mixed but majority unsure	*5*	*5*	*8*	*0*	*0*
Mixed, all other	*3*	*3*	*3*	*3*	*7*

4. Specific Blueberry Pollination Practices

Table 11 displays the percentage of each practice used by blueberry growers. The top five practices (marked in bold fonts) in all states include: making pesticide applications only at nighttime or at least two hours before sunset (52%), avoiding insecticide applications during bloom time (45%), refraining from pesticide use when dew is forecasted (24%), maintaining a buffer between known beehive locations and the crop (22%), and avoiding fungicide applications during bloom time (21%).

In Florida, growers primarily applied pesticides only at nighttime or at least two hours before sunset (71%). Additionally, 33% of growers avoided insecticide applications during bloom time, 21% maintained a buffer between beehive locations and the crop, 15% refrained from pesticide use when dew was forecasted, 13% avoided fungicide applications during bloom time, and 13% removed flowering weeds and groundcovers before pesticide spraying.

In Michigan, a comparable trend was evident. The most common practice among growers was making pesticide applications solely at nighttime or at least two hours before sunset (52%). About 41% of growers refrained from using insecticides during bloom time, 27% avoided pesticide applications when dew was in the forecast, and 25% maintained a buffer between known beehive locations and the crop. Additionally, 23% of growers avoided fungicide applications during bloom time.

Grower practices in Oregon and Washington—two neighboring states—differed from those in Florida and Michigan. In both states, the most common practice was avoiding insecticide applications during bloom, reported by 66% of growers in Oregon and an even higher 85% in Washington.

In Oregon, the second most frequently used practice was applying pesticides only at night or at least two hours before sunset (43%). This was followed by maintaining a buffer between known beehive locations and the crop (36%), removing flowering weeds and groundcovers before pesticide spraying (30%), and providing nesting sites for native bees on the farm (30%).

Washington growers also adopted similar practices—flowering weed and groundcover removal before pesticide applications (33%), nighttime or pre-sunset pesticide applications (30%), enhancement of flowering plants around the farm to provide forage for bees (30%), and provision of nesting sites for native bees (30%).

Table 11. Percentage of highbush blueberry growers employing each listed practice across all states and selected states.

Practice	All States (n=351)	Florida (n=52)	Michigan (n=108)	Oregon (n=56)	Washington (n=27)
Make pesticide applications only when temperatures are below 50°F.	9	6	6	18	22
Make pesticide application(s) only at nighttime or no less than two hours prior to sunset	**52**	**71**	**52**	**43**	**30**
Avoid pesticide applications when dew is in the forecast	**24**	**15**	**27**	23	22
Avoid bloom time insecticide applications	**45**	**33**	**41**	**66**	**85**
Avoid bloom time fungicide applications	**21**	**13**	**23**	29	15
Maintain a buffer between known beehive locations and the crop	**22**	**21**	**25**	**36**	19
Remove flowering weeds and groundcovers before spraying pesticides	20	**13**	19	**30**	**33**
Enhance flowering plants to provide food for bees in the surrounding farm	15	6	11	27	**30**
Provide nesting sites for native bees on the farm	16	4	16	**30**	**30**
Spray bee attractants to increase pollination	9	6	16	4	19
Spray gibberellic acid or other plant growth regulators during bloom to set fruit	8	12	12	9	0
Other*	4	4	2	9	11

Notes: The top five practices in all states and selected states are marked in bold. Column values do not sum to 100% because respondents can select multiple practices.

* Respondents selecting "Other" reported using bee-safe insecticides, applying organic materials, spraying only after bees were removed, or not spraying at all.

Growers were also asked about the sources they consulted to help mitigate the off-target impacts of pesticides on bees (Table 12). Across all states, the most commonly cited source was a local expert—such as an Agricultural Cooperative Extension agent or crop consultant—consulted by 46% of respondents. This was followed by nearby beekeepers (37%) and neighboring growers (19%).

State-level data revealed some variation. Local experts were cited as a key resource by 49% and 65% of respondents in Florida and Oregon, respectively. Growers in both states (40% in Florida; 35%, Oregon) also consulted nearby beekeepers, as well as neighboring growers (14% in Florida; 25% in Oregon). In Michigan, nearby beekeepers were the most frequently mentioned source (41%), followed by local experts and State Managed Pollinator Protection Plans, each cited by 33% of respondents. In Washington, local experts were also the top resource (50%), followed by neighboring growers (40%), and nearby beekeepers (35%).

Table 12. Percentage of highbush blueberry growers consulting the following sources to reduce off-target impacts of pesticides to bees during the 2021/2022 pollination season across all states and selected states.

Source of information	All States (n=302)	Florida (n=43)	Michigan (n=94)	Oregon (n=48)	Washington (n=20)
Neighboring growers	**19**	**14**	**19**	**25**	**40**
Nearby beekeepers	**37**	**40**	**41**	**35**	**35**
A local expert, such as an Agricultural Cooperative Extension agent or crop consultant	**46**	**49**	**33**	**65**	**50**
A State Managed Pollinator Protection Plan, or MP3	17	12	**33**	15	0
Driftwatch app or website*	10	2	16	13	5
Other tool(s) to communicate with beekeepers	2	5	0	8	10
Other**	2	2	1	2	20

Note: The top three sources consulted by growers in all states and selected states are marked in bold. Column values do not sum to 100% because respondents can select multiple sources.

*Driftwatch is a hive mapping program and not all states are signed up for it. In Florida and Oregon, for example, Driftwatch is not used, so the figures in these states likely refer to websites. Meanwhile, the program is available for use in Michigan and Washington. Source: https://driftwatch.org/map.

**Other sources include attending various classes and seminars to learn better practices, and common sense.

5. Perspectives about Blueberry Pollination

Table 13 shows the percentage of growers who agreed with the statement, *"The honey bee colonies delivered to my blueberry fields were consistently strong and active."* Overall, 69% of growers across all states agreed (somewhat or strongly) with this statement. Agreement was notably high in Florida (96%) and Washington (94%). In Oregon, 69% of growers agreed, while in Michigan, agreement was somewhat lower at 56%.

Table 13. Percentage of highbush blueberry growers agreeing (at different levels) to the statement, "The honey bee colonies delivered to my blueberry fields were consistently strong and active."

Agreement level	All States (n=339)	Florida (n=52)	Michigan (n=109)	Oregon (n=57)	Washington (n=29)
Agree (Somewhat or Strongly)	69	96	56	69	94
Unsure or Don't know	21	2	28	21	3
Disagree (Somewhat or Strongly)	10	2	16	10	3

Table 14 shows the number of years for which blueberry pollination needs were met across all cultivars combined. Among the respondents from all states, 18% indicated that their needs were met in all five years. Most growers (49%) reported meeting their pollination needs in 3–4 years, while 25% said their needs were met in only 1–2 years. A small percentage (3%) reported that their pollination needs were not met at all, and 5% were unsure or did not know.

Table 14. Percentage of highbush blueberry growers reporting the number of years for which their blueberry pollination needs were met across all cultivars combined.

Years	All States (n=339)	Florida (n=52)	Michigan (n=109)	Oregon (n=57)	Washington (n=29)
All 5 years	18	19	15	26	34
3–4 years	49	64	51	35	49
1–2 years	25	15	31	28	0
None	3	0	2	4	0
Unsure or Don't know	5	2	1	7	17

Note: Column values may not sum to 100% due to rounding.

When broken down by state, similar trends are observed in Florida, where 19% of growers reported their pollination needs were met in all five years, 64% reporting 3–4 years, and 15% in 1–2 years. In Michigan, 15% reported meeting their needs for all 5 years, 51% for 3–4 years, and 31% for 1–2 years. In Oregon, 26% reported all five years, 35% for 3–4 years, and 28% for 1–2 years. Washington had the highest proportion of growers (34%) who reported meeting their needs for all five years, followed by 49% for 3–4 years, and none reported 1–2 years.

These results indicate different satisfaction levels among growers regarding whether their blueberry pollination needs were consistently met. There were also different levels of uncertainty across states, with Washington respondents showing the highest uncertainty (17%), while Michigan had the lowest (1%).

Table 15 shows the percentage of respondents based on the number of different blueberry cultivars they grow. Across all states, more than two-thirds of respondents grow between 1 and 5 (35%) and between 6 and 10 (36%) different cultivars. Twenty-four percent of respondents grow between 11 and 15 cultivars, while 4% grow between 16 and 20 cultivars. Only 1% of respondents grow more than 20 different blueberry cultivars.

Table 15. Percentage of highbush blueberry growers reporting the number of different cultivars grown.

Number of cultivars	All States (n=339)	Florida (n=52)	Michigan (n=109)	Oregon (n=57)	Washington (n=29)
1–5	35	60	20	33	50
6–10	36	31	39	33	41
11–15	24	9	36	21	3
16–20	4	0	4	11	3
More than 20	1	0	1	2	3

Note: Column values may not sum to 100% due to rounding.

Breaking it down by state, Florida shows a greater diversity in the number of cultivars grown. Sixty percent of respondents grow 1 to 5 cultivars, 31% grow 6 to 10 cultivars, and 9% grow 11 to 15 cultivars. In Michigan, 20% of growers have 1 to 5 cultivars, 39% grow 6 to 10 cultivars and 36% grow 11 to 15 cultivars. Oregon has a relatively balanced distribution across all ranges: 33% grow 1 to 5 cultivars, 33% grow 6 to 10 cultivars, 21% grow 11 to 15 cultivars, 11% grow 16 to 20 cultivars, and 2% grow more than 20. In Washington, 50% of growers have 1 to 5 cultivars, 41% grow 6 to 10 cultivars, and smaller percentages grow 11 to 15, 16 to 20, and more than 20 cultivars (about 3% each).

Table 16 presents the percentage of respondents reporting the proportions of their blueberry cultivars that have been consistently well-pollinated over the last five years. Across all states, a significant majority (48%) indicated that 81–100% of their cultivars were consistently well-pollinated during this period. Additionally, one-quarter of growers reported that 61–80% of their cultivars were well-pollinated.

In Florida, most growers (55%) reported that 81–100% of their cultivars have been consistently well-pollinated, while 25% reported that only 0–20% have been well-pollinated. In Michigan, most growers indicated that more than 60% of their blueberry cultivars have been well-pollinated—33% reported 61–80%, and 38% reported 81–100%. Oregon growers showed a similar distribution, with 25% reporting 61–80%, and 53% reporting 81–100%. In Washington, most growers (84%) also reported that more than 60% of their cultivars were well-pollinated, with 38% falling into the 81–100% category, and 46% falling into the 61–80% category.

Table 16. Percentage of highbush blueberry growers reporting the proportion of cultivars consistently well-pollinated over the last five years.

Proportion of consistently well-pollinated cultivars	All States (n=201)	Florida (n=48)	Michigan (n=42)	Oregon (n=36)	Washington (n=26)
0–20	12	25	10	2	12
21–40	6	6	7	6	0
41–60	9	4	12	14	4
61–80	25	10	33	25	46
81–100	48	55	38	53	38

Table 17 presents the average ratings of concerns about the future of blueberry pollination among respondents, measured on a 1–6 scale where 1 is most concerning and 6 least concerning. The top three concerns for growers across all states and selected states are marked in bold font. Overall, the most concerning issues are poor weather during pollination (average rating: 2.3), poor bee health during pollination (average rating: 2.6), and rising prices for bees (average rating: 3.0).

Table 17. Average ratings of concerns about the future of highbush blueberry pollination across all states and in selected states (1 = most concerning, 6 = least concerning).

Concern	All States (n=206)*	Florida (n=46)*	Michigan (n=45)*	Oregon (n=38)*	Washington (n=26)*
Poor bee health during pollination	**2.6**	**1.9**	**2.8**	**3.0**	3.5
Rising prices for bees	**3.0**	**2.4**	3.2	**2.9**	3.7
Poor weather during pollination	**2.3**	**2.4**	**2.1**	**2.2**	**2.3**
Specific blueberry cultivars that are hard to pollinate	3.8	3.9	3.9	3.7	**3.4**
Being able to manage pests during bloom without negatively impacting bees	3.5	4.0	**3.0**	3.7	**2.7**
Other†	3.5	1.0	2.7	3.0	4.8

Note: The top three concerns by growers in all states and selected states are indicated in bold.

*The number of respondents might be different for each concern, and this listed the largest number.

†Only the ratings with specified concerns were included in the calculation. The most concerning challenges include bee availability, health of native bumble bees, overall lack of concern for native bee populations and maintenance of wild areas adjacent to farmland, more exposure of short blooming cultivars if weather is bad, and worry about rented honey bees as a vector for disease

Breaking it down by state, poor weather during pollination emerged as the top concern among growers in Michigan (average rating: 2.1), Oregon (average rating: 2.2), and Washington (average rating: 2.3). In contrast, Florida growers expressed the greatest concern about poor bee health during pollination (average rating: 1.9).

6. Important Issues Related to Blueberry Pollination

Respondents were also asked to identify other important issues affecting blueberry pollination in the United States. Figure 3 shows a word cloud, a visual representation in which the size of each word or phrase reflects how frequently it was mentioned across all responses. Each word or phrase represents a distinct pollination-related issue or management consideration.

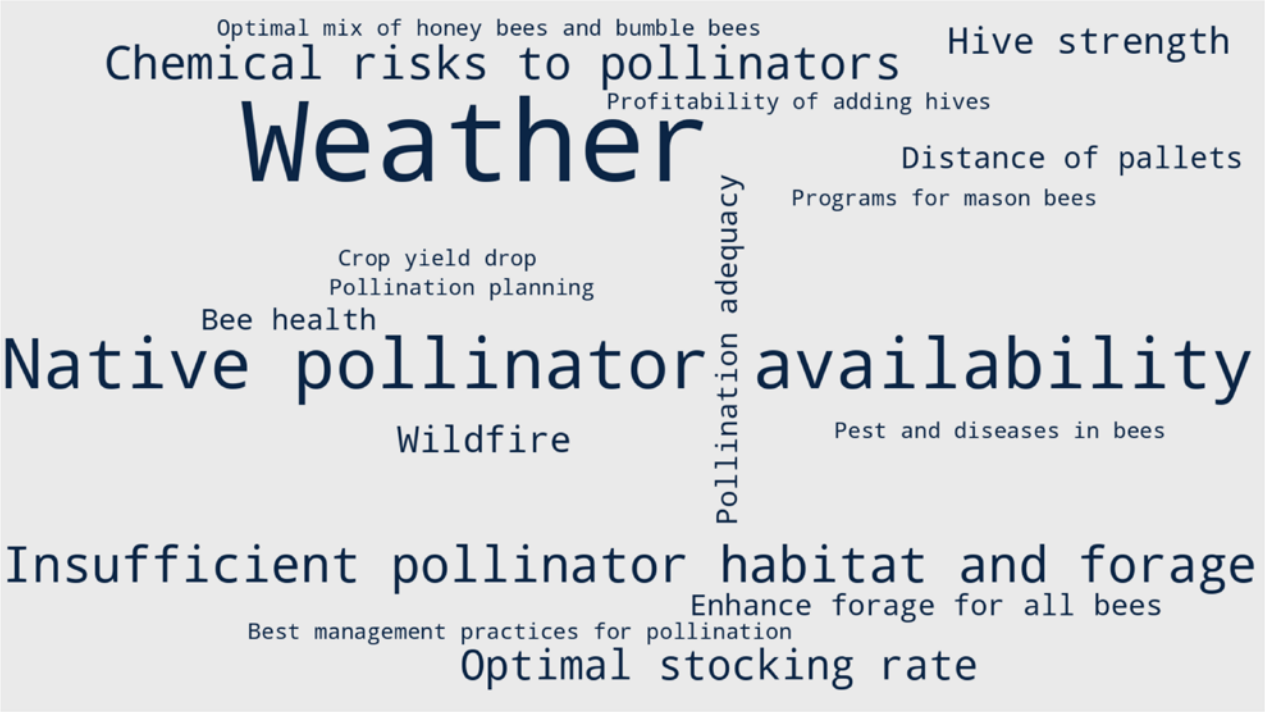

Figure 3. Word cloud of key pollination concerns identified by survey respondents.

The most prominent issues identified include the weather conditions affecting pollination, availability of native pollinators, lack of pollinator habitat and forage, risks of chemical sprays to pollinators, and optimal stocking rates

7. Summary

This report presents the pollination practices and challenges faced by blueberry growers across the U.S. Findings indicated that honey bees were the most widely used pollinators, followed by bumble bees. Most growers rented their honey bee colonies rather than own them, with stocking rates varying in the four selected states—Florida reported the highest median stocking rate (eight hives per acre), while Michigan had the lowest (two hives per acre). Growers mentioned landscape factors, colony density in areas adjacent to the farm, and high yield potential as the most common reasons for increasing stocking rates above the average rate. The median rental fee for honey bee hives across all states was $60 per hive, with median fees ranging from $50 to $60 in the four selected states. Growers also used various management practices, including spacing and placement strategies, to optimize blueberry pollination.

To mitigate pollination risks, growers employed different protective measures, such as applying pesticides at night and avoiding insecticide applications during bloom. Many also turned to expert guidance from local agricultural extension agents and nearby beekeepers.

Most growers reported that their rented honey bee colonies were strong and active, providing consistent pollination for three to four of 5 years. While most growers managed between 6 and 10 different cultivars, the majority of respondents from Florida managed 1 to 5. The biggest concerns regarding the future of pollination included poor weather conditions, declining bee health, and rising hive rental costs. Respondents also highlighted several major issues regarding the overall state of blueberry pollination in the US, such as loss of wild pollinator habitat, weather-related pollination issues, optimal stocking rates, pesticide use near bloom, hive health, and colony placement.

This report offers valuable insights for stakeholders in the blueberry industry. Since managed pollination remains essential for commercial blueberry production, addressing grower's biggest concerns is important. Furthermore, continued research, recommendations for improved management, and policies that support bee health and sustainable farming practices, can help ensure the long-term sustainability of blueberry pollination in the United States.

8. References

1. Cunningham S.A., A. Fournier, M.J. Neave, and D. Le Feuvre. 2016. Improving spatial arrangement of honeybee colonies to avoid pollination shortfall and depressed fruit set. *Journal of Applied Ecology* 53: 350–359.

2. Hoffman G.D., C. Lande, and S. Rao. 2018. A novel pollen transfer mechanism by honey bee foragers on highbush blueberry (Ericales: Ericaceae). *Environmental Entomology* 47: 1465–1470.

3. Isaacs, R. and A.K. Kirk. 2010. Pollination services provided to small and large highbush blueberry fields by wild and managed bees. *Journal of Applied Ecology* 47: 841–849.

4. Javorek S.K., K.E. Mackenzie, and S.P. Vander Kloet. 2002. Comparative pollination effectiveness among bees (*Hymenoptera: Apoidea*) on lowbush blueberry (*Ericaceae: Vaccinium angustifolium*). *Annals of the Entomological Society of America* 95: 345–351.

5. Retamales, R. and J.F. Hancock. 2018. Blueberries, 2nd Edition. *Volume 27, Crop production science in horticulture*. CABI, 423 pages.

6. USDA NASS (United States Department of Agriculture, National Agricultural Statistics Service). 2025. Blueberries—U.S. Acreage and Utilization. Accessed from **Quick Stats database**: https://quickstats.nass.usda.gov/.

9. Acknowledgement

This work is supported by the Specialty Crops Research Initiative Award, project award no. 2020–51181–3215, from the U.S. Department of Agriculture's National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy.

Appendix 1

Blueberry Pollination Survey

Please complete this survey to help our multi-state research team to document your current blueberry pollination practices and challenges. Your contribution will allow us to understand pollination challenges in blueberry production, document impact and provide direction to future research and extension efforts.

This survey will take you approximately 10–15 minutes to complete. Participation is voluntary and your data will be kept strictly confidential. This survey is part of a USDA-Specialty Crop Research Initiative project titled *"Optimizing blueberry pollination to ensure future yields"* being conducted by Michigan State University, the University of Florida, Washington State University and Oregon State University.

After completing the survey, you will have the opportunity to win one of 12 gift cards valued at $50 each. The raffle form will be separate from the survey, thus your survey responses will remain anonymous.

In answering the following questions, please consider your whole farm and your pollination practices during the most recent pollination season.

A. Types of Bees Used for Blueberry Pollination

A.1. Did you use managed bees to pollinate blueberries during the most recent pollination season?

- ☐ Yes
- ☐ No

A.2. What types of managed bees did you use to pollinate your blueberries during the most recent pollination season? *Please select all that apply.*

- ☐ Honey bees
- ☐ Bumble bees
- ☐ Other (provide name) _____

A.3. Do you rent or own honey bees?

- ☐ Rent
- ☐ Own
- ☐ Both

A.4. What was your average honey bee stocking rate (hives/acre) during the most recent pollination season?

_____

A.5. Do you use a single stocking rate or multiple stocking rates in the most recent pollination season?

- ☐ Single stocking rate
- ☐ More than one stocking rate

A.6. What are the lowest and highest stocking rates of honey bees that you have used? Also, please specify the blueberry cultivar for which the lowest or highest stocking rate was used (if applicable).

	Hives/acre	For which cultivar?
Highest rate used	_____	_____
Lowest rate used	_____	_____

A.7. What factors are associated with increasing stocking rates above average (in FL above ~3.5 hives/acre, in MI above 2 hives/acre, in WA and OR above 4 hives/acre)? *Please select all that apply.*

- ☐ Cultivar
- ☐ Surrounding landscape with bee-attractive plants that reduce bee activity in blueberry
- ☐ High density of other bee colonies in the area
- ☐ Low quality of bee colonies
- ☐ High yield potential
- ☐ I do not use higher than average stocking densities

A.8. If you rent honey bees, what was the average rental fee per hive?

_____

A.9. How many of the following bees do you purchase per year? *Please enter "0" if none.*

	Number
Bumble bees (quads per acre)	_____
Leafcutter bees (gallons per acre)	_____
Mason bees (cocoons per acre)	_____
Other (please specify): _____	_____

B. Blueberry Pollination Practices in the Most Recent Growing Season

B.1. What practices did you use in the most recent pollination season? *Please select all that apply.*

- ☐ Make pesticide applications only when temperatures are below 50°F.
- ☐ Make pesticide application(s) only at nighttime or no less than two hours prior to sunset.
- ☐ Avoid pesticide applications when dew is in the forecast.
- ☐ Avoid bloom time insecticide applications.
- ☐ Avoid bloom time fungicide applications.
- ☐ Maintain a buffer between known beehive locations and the crop.
- ☐ Remove flowering weeds and groundcovers (e.g., mowing dandelions in row middles) before spraying pesticides.
- ☐ Enhance flowering plants to provide food for bees in the surrounding farm.
- ☐ Provide nesting sites for native bees on the farm.
- ☐ Spray bee attractants to increase pollination.
- ☐ Spray gibberellic acid or other plant growth regulators during bloom to set fruit.
- ☐ Other (please specify): _____

B.2. In an effort to reduce off-target impacts of pesticides to bees, did you consult with any of the following sources in the most recent pollination season?

- ☐ Neighboring growers
- ☐ Nearby beekeepers
- ☐ A local expert, such as an Agricultural Cooperative Extension agent or crop consultant
- ☐ A State Managed Pollinator Protection Plan, or MP3
- ☐ Driftwatch app or website
- ☐ Other tool(s) to communicate with beekeepers (please specify): _____
- ☐ Other (please specify): _____

C. Placement of Honey Bee Colonies

C.1. What proportion of the honey bee colonies in your blueberry fields had the following spacing during the most recent pollination season? *(Total should add up to 100%.)*

Spaced out (1–2 pallets of bees at a drop) _____

Moderate spacing (3–4 pallets of bees at a drop) _____

Clumped (more than 5 pallets of bees at a drop) _____

Not sure _____

Total _____

C.2. What proportion of the honey bee colonies in your blueberry fields were placed in the following pattern during the most recent pollination season? *(Total should add up to 100%.)*

Located within or directly on the edge of the crop _____

Placed at least 20 ft from the field edge _____

Placed more than 20 ft from the edge of the field _____

Not sure _____

Total _____

D. Perspectives about Blueberry Pollination

D.1. In the most recent pollination season, how much do you agree that the honey bee colonies delivered to your blueberry fields were consistently strong and active?

- ☐ Strongly agree
- ☐ Somewhat agree
- ☐ Unsure/Don't know
- ☐ Somewhat disagree
- ☐ Strongly disagree

D.2. Considering the last five years, how many years have you felt that your blueberry pollination needs were met across all cultivars combined?

- ☐ All 5 years
- ☐ 3–4 years
- ☐ 1–2 years
- ☐ None
- ☐ Unsure/Don't know

D.3. How many different cultivars do you grow?

- ☐ 1–5
- ☐ 6–10
- ☐ 11–15
- ☐ 16–20
- ☐ More than 20

D.4. What proportion (%) of cultivars have been consistently well pollinated over the last 5 years?

_____

D.5. Please rank the following concerns about the future of blueberry pollination (1–most concerning, 6–least concerning).

_____ Poor honey bee health during pollination

_____ Rising prices for bees

_____ Poor weather during pollination

_____ Specific blueberry cultivars that are hard to pollinate

_____ Being able to manage pests during bloom without negatively impacting bees

_____ Other (please specify): _____

E. Please tell us about your blueberry operation.

E.1. What is the total production area of your blueberry farm(s)?

- ☐ Less than 1 acre
- ☐ 1–5 acres
- ☐ 6–15 acres
- ☐ 16 to 25 acres
- ☐ 26 to 50 acres
- ☐ 51 to 100 acres
- ☐ 101 to 500 acres
- ☐ More than 500 acres

E.2. Please list the top four blueberry cultivars on your farm(s) and their associated acreages.

	Cultivar	Production area (acres)
No. 1 Cultivar	_____	_____
No. 2 Cultivar	_____	_____
No. 3 Cultivar	_____	_____
No. 4 Cultivar	_____	_____

E.3. What is the average annual cash cost for the blueberry fields that you own or manage?

- ☐ Less than $3,000/acre
- ☐ $3,000 to $5,999/acre
- ☐ $6,000 to $8,999/acre
- ☐ $9,000 to $11,999/acre
- ☐ $12,000 to $14,999/acre
- ☐ $15,000 or more per acre

E.4. In what state(s) do you cultivate commercial blueberries?

- ☐ Florida
- ☐ Georgia
- ☐ Michigan
- ☐ Oregon
- ☐ Washington
- ☐ Other/s (please specify): _____

F. Comments

If you have comments or concerns about blueberry pollination that you would like to share with us, please write them in the space below.

_____

_____

_____

G. Raffle

Would you like to enter the raffle to win one of 12 gift cards valued at $50 each? If yes, you will be directed to a form that is entirely separate from this survey. Your survey responses will remain anonymous.

- ☐ Yes
- ☐ No

Raffle Form

Please provide your contact details so you can be entered into the raffle for a $50 Amazon.com eGift Card. We will select 12 total winners at the end of the survey period. If you win, we will send the electronic gift card to the email address you provide.

First Name: _____

Last Name: _____

Email Address: _____

Location of farm (State): _____

Thanks for your participation! If you win in the raffle, an Amazon.com eGift Card will be sent to your email address.