

A Pollination Toolbox for Wild Blueberry Growers

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Frank Drummond^{1,2}, Kourtney Collum³, Sam Hanes³, Michael Wilson⁴, John Skinner⁴, and Judith Collins¹

¹ School of Biology and Ecology, University of Maine

² Cooperative Extension, University of Maine

³ Department of Anthropology, University of Maine

⁴ Department of Entomology and Plant Pathology, University of Tennessee

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ABSTRACT

A pollination “toolbox” was developed to facilitate workshops for wild blueberry (*Vaccinium angustifolium* Aiton) growers. The purpose of the workshop is to provide “hands-on” education about: 1) reproductive biology of wild blueberry; 2) the major pollinators, their life history and identification; 3) conservation and protection of native and commercial bee pollinators; 4) methodology for estimating fruit set, fruit drop, and pollinator field abundance; and 5) the use of a regression model for determining adequacy of pollinator field abundance. The workshop supplies a pollination toolbox to the growers which is comprised of the following materials: 1) a reference bee collection imbedded in plastic; 2) a “field-ready” fruit set estimation kit; 3) a “field-ready” pollinator abundance sampling quadrat; 4) five wild blueberry pollination and pollinator Extension color factsheets; and 5) a video (made in 2013) describing the estimation of fruit set and pollinator field abundance. A survey was given to growers at two workshops in 2014 to assess the workshop and pollination toolbox. This is an on-going project aimed at increasing the knowledge of wild blueberry pollination by growers so that sound decisions can

be made in suitable pollination strategies and investments that fit the farm's management philosophy.

INTRODUCTION

The wild blueberry (*Vaccinium angustifolium* Aiton) fields of Downeast Maine represent a unique agroecosystem that differs significantly from other blueberry production systems in the United States (rabbiteye, highbush, and southern highbush). Wild blueberry is native to North America, growing in the understory of native boreal forests and in the sandy acidic soils associated with rocky outcrops, pine barrens and bogs (Hall et al. 1979, Vander Kloet 1988). Fields of blueberry are established by clearing forest, then reducing the presence of plants that compete with wild blueberry (Yarborough 2009). Currently, more than 25,000 hectares of managed stands of wild blueberry are in production (Yarborough 2012).

Insect mediated pollination is required for wild blueberry fruit set and subsequent reproduction due to mostly obligate outcrossing among clones (Lee 1958, Aalders and Hall 1961, Aras et al. 1996, Usui et al. 2005, Bell et al. 2010). Bees are the primary pollinators of this plant, although other insect taxa including beetles (Coleoptera), flies (Diptera), ants (Formicidae) and moths (Lepidoptera) have been hypothesized to be additional pollinators (Choate and Drummond 2012, Cutler et al. 2012, Bushmann 2013). There have been more than 100 bee species collected in wild blueberry fields (Bushmann 2013, Jones et al. 2014).

The anatomical structure of the poricidal anthers in wild blueberry and other *Vaccinium* spp. limit a visiting insect's access to the pollen (Bell et al. 2009). Bumble bees (*Bombus*) and other native bee genera associated with wild blueberry (namely, *Andrena*, *Halictus*, *Osmia*, *Megachile*, and *Lasioglossum*) commonly exhibit buzz pollinating (Buchmann 1983) or drumming behaviors to enhance release of pollen (Javorek et al. 2002, Bushmann 2013). Honey

bees (*Apis mellifera* L.) are not known to buzz pollinate wild blueberry (Drummond 2012).

Therefore, honey bees are not considered efficient pollinators on an individual bee basis (Javorek et al. 2002, Drummond 2012), although the large numbers of foraging bees per colony make honey bees important pollinators (Aras et al. 1996, Drummond 2002, Drummond 2012, Eaton and Nams 2012, Asare 2013).

Historically, wild blueberry growers relied upon the native bee fauna for pollination. However, even as far back as the 1930's as larger tracks of land were brought into production and insecticides were developed for pest control, native bees were noted to be in decline (Boulanger 1964, Boulanger et al. 1967). As a result of these declines research was initiated to assess the efficacy of honey bees as pollinators of wild blueberry. Between the mid 1950's to the 1960's, research with honey bees showed that a migratory honeybee system could provide increases in yield, sometimes doubling the yield (Boulanger 1964). Honey bee importation into Maine has increased from about 500 colonies in 1965, to over 60,000 colonies placed in blueberry fields in 2000 (Drummond 2002), and reached an all-time high of more than 80,000 colonies in 2014 (Yarborough pers. comm.). In the past two decades research on two other commercial bees, the alfalfa leafcutting bee (*Megachile rotundata*) and the impatient bumble bee (*Bombus impatiens*) has demonstrated economic utility of these species for pollination of wild blueberry (Stubbs and Drummond 1997a, 1997b, Stubbs et al. 2001, Javorek et al. 2002, Desjardins and De Oliveira 2006, Drummond 2012). Conservation of native bees has also been an area of research in wild blueberry. Strategies for enhancing native bee communities through conserving bee plant forage, as well as providing leafcutting *Osmia* spp. bees nesting sites and minimizing bee exposure to pesticides have been explored (Stubbs et al. 1992, Drummond and Stubbs 1997a, Drummond and Stubbs 1997b, Stubbs and Drummond 1997, Stubbs et al. 1997b,

Stubbs and Drummond 1998, 1999, Stubbs et al. 2000, Drummond 2012a, 2012b, 2012c, 2012d).

Educational materials that explain wild blueberry pollination (Drummond 2002), conservation of native bees (Stubbs et al. 2000), bee forage plants (Stubbs et al. 1992), protecting pollinators from pesticide exposure (D'Appollonio-Cote et al. 2013), and the use of honey bees (Drummond 2002), alfalfa leafcutting bees, and bumble bees (Stubbs et al. 1997a, Stubbs et al. 2001) have been published for wild blueberry growers. Wild blueberry growers have adopted many of these varied tactics for improvement of pollination (Hanes et al. 2013, Rose et al. 2013). However, investment in both time and capital for pollination is one of the highest single production costs for wild blueberry growers (Yarborough 2011, Rose et al. 2013). Because of this, in 2013 it was decided to develop a field workshop during bloom that would provide information on wild blueberry pollination biology and hands on training in bee identification, measuring bee foraging force in the field, and estimation of fruit set. This report describes the structure of the workshop and the “toolbox” made for eventual distribution to growers for use in their fields.

MATERIALS AND METHODS

This project was started in 2013 and continues through 2015. Pollination toolboxes were made for 100 growers, were trialed at field pollination workshops in 2014 and will be distributed to growers in 2015. The chronology of method and materials development for a pollination toolbox is described below.

During May and June 2013, a pollination video was designed and shot during the wild blueberry pollination season. This video is an instruction tutorial that aims to demonstrate methods for field estimation of fruit set and bee density (bees / m² / min). In addition, use of a

regression model to estimate fruit set from bee density was explained and the assessment of set flowers that have a high likelihood of becoming fruit was illustrated. Also during the 2013 bloom period honey bees and native bees were collected on blueberry flowers and stored at 20° C until spring 2014. These collections provided the specimens that comprised a grower reference collection. The raw video was sent to Mr. Michael Wilson and Dr. John Skinner for editing and production during the 2013 fall and 2014 winter.

In February through March 2013, most of the components of the pollination toolbox were assembled. Bee sampling frames were made from white PVC plumber's tubing (0.5 inch OD diam) and elbows. The tubing was cut and fit to make 1.0 yd² quadrats. Metal plant tags and twisty wires were purchased and sorted into groups of 30 and bagged in Ziplock[®] bags. One bag is intended for each grower. A bee ID reference collection for growers was constructed from plastic bee molds (clear polyester resin with hardener, Castin' Craft[®], poured into plastic square molds). The plastic mold reference collections included a single honeybee, bumble bee, sweat bee (mostly *Augochlorella aurata*), and sand bee (*Andrena* spp.). These specimens were selected because they represent the most commonly occurring bee genera and families in Maine wild blueberry fields (Bushman 2013). Literature was printed for background reading for growers. The following publications were compiled as part of the toolbox:

- a. Stubbs, C.S. and N. Coverstone. 2001. Understanding native bees, the great pollinators. University of Maine Cooperative Extension, Bulletin #7153.
- b. Stubbs, C.S., F.A. Drummond, and D. Yarborough. 2001. Commercial bumble bee, *Bombus impatiens*, management for lowbush blueberry. Wild blueberry fact sheet No. 302 (Bulletin No. 2421). University of Maine Cooperative Extension Publication. 4 pp.
- c. Drummond, F.A. and C.S. Stubbs. 2003. Wild bee conservation for wild blueberry fields. Univ. Maine Coop. Ext. Fact Sheet 630. 12 pp.
- d. Drummond, F.A. 2002. Honeybees and Lowbush Blueberry Pollination. <http://wildblueberries.maine.edu/FactSheet/NEW629HBPollin.pdf>
- e. D'Appollonio-Cote, J., D. E. Yarborough, and F. Drummond. 2013 Maine Wild blueberry pesticide chart – 1 of 3.

<http://umaine.edu/blueberries/files/2010/05/2013-ME-Wild-BB-Pesticide-Chart-Insecticides.pdf>

- f. Stubbs, C.S., F.A. Drummond, and D. Yarborough. 2000. Field conservation management of native leafcutting and mason *Osmia* bees. Wild blueberry fact sheet No. 301 (Bulletin No. 2420). University of Maine Cooperative Extension Publication. 6 pp.
- g. Wild Blueberry Pollinator Poster. Wild Blueberry Producers Association of Nova Scotia.

Two grower workshops were scheduled for approximate dates of peak wild blueberry bloom in two Maine growing regions, Coastal and Downeast regions. In the Coastal region a grower's farm in Warren, Maine was selected for the workshop and in the Downeast region the site selected was the University of Maine Blueberry Hill Research Farm. Prior advertisement of the workshop was at the three spring Blueberry Schools in March 2014, in the Wild Blueberry Newsletter, and on multiple Northeast Sustainable Agriculture Research and Education (SARE) and UMaine Cooperative Extension webpages. Drs. Drummond and Hanes, and Ms. Kourtney Collum conducted the workshop.

SURVEY METHODOLOGY

To evaluate the workshop and toolkit, in spring 2014 pre- and post-workshop surveys were developed and edited (Collum, Hanes and Drummond), then approved for distribution by the University of Maine. The pre-survey is included in the appendix. At the beginning of each workshop the investigators distributed the pre-survey to all participants. Prior to the workshops, the survey instrument was pre-tested by six wild blueberry growers at an integrated crop management (ICM) meeting in Warren, Maine, to ensure that the survey content and wording were clear. In total, the pre-survey included ten fixed-scale and close-ended questions and one open-ended question, and took participants about five minutes to complete. Each survey was given a code number to keep responses confidential.

In July, 2014, workshop participants will be mailed a post-survey containing questions designed to measure their: 1) use of pollination strategies following the workshop, 2) obstacles encountered when attempting to implement these strategies, 3) plans to use these strategies in the future, and 4) change in perceptions of native bee efficacy. The post-surveys will be administered using the Dillman Tailored Design Method (1978).

RESULTS

Two workshops were held in wild blueberry fields in bloom on May 28 and June 4, 2014. Eight people attended the workshop at Blueberry Hill Farm and 18 people attended the workshop at Seven Tree View Farm. Workshop attendees included blueberry growers and representatives from agricultural agencies such as Cooperative Extension, the Natural Resources Conservation Service, and local beekeepers' associations. In total, between the two workshops held in 2014, 19 blueberry growers completed the Pollination Workshop Survey (approximately 3.6 % of the total Maine wild blueberry grower community, Rose et al. 2013). Only one blueberry grower declined to complete the survey. The attendance was encouraging, but less than most workshops, probably because credits for pesticide applicator certification were not given for attending the two meetings.

The growers who attended the pollination workshop manage between a quarter of an acre and 700 acres of wild blueberries. The majority are part-time growers (72.2%; n=13), and 68% percent (n=13) are 55 or older. Less than 11% of respondents are younger than 35 years old. Thirty-two percent of respondents (n=6) have been working in agriculture for more than 30 years, and 26% (n=5) have been working in agriculture for 5 years or less. The remaining 42% of respondents have been working in agriculture between 6 and 25 years. A majority of respondents (68%; n=13) practice IPM, while 11% (n=2) describe their pest management as

conventional/traditional, 5% (n=1) certified organic, and 16% (n=3) no-spray. Ninety-five percent of respondents (n=18) said that they regularly attend Cooperative Extension meetings or workshops, and of those, 78% (n=14) said they attend three or more meetings or workshops per year. Given the high rate of participation at Cooperative Extension events among survey respondents, we have classified workshop participants as potential early adopters of agricultural innovations. We therefore assume that survey respondents are more likely than the average Maine wild blueberry grower to currently use a diversity of pollination management practices, and more likely to adopt new pollination management practices in the future.

To learn about growers' perceptions of native pollinators, survey respondents were asked how effective they think native bees are for pollinating their wild blueberry crop, on a scale from *very ineffective* to *very effective*. Overall, 74% of respondents reported that native bees are *somewhat effective* to *very effective*. Respondents were also asked to indicate how often they think they would be able to get sufficient pollination from native bees alone. Despite respondent's positive perceptions of native bees' effectiveness at pollinating their blueberry crop, more than 40% (n=8) of respondents indicated that they would never be able to get sufficient pollination from native bees alone, and only 11% (n=2) of respondents feel that they could get sufficient pollination from native pollinators every year. This result supports our premise that knowledge of the role of both honey bees and native bees is important for wild blueberry growers to assess pollination strategies for their specific farms (Asare 2013, Bushmann 2013).

The survey also contained a list of pollination management practices and respondents were asked to indicate whether they regularly use each practice, whether they tried the practice in the past but later discontinued it, or whether they never used the practice at all. They were also asked to indicate which practices they were using in 2014. Among the wild blueberry growers

surveyed, the most popular regularly used pollination management practices are: altering pesticide applications to avoid harming pollinators (88.2%; n=15), avoiding mowing wildflowers in order to provide food for pollinators (41.2%; n=7), leaving standing deadwood for pollinators (38.9%; n=7), and identifying different kinds of native bees in blueberry fields (38.9%; n=7). With the exception of altering pesticide applications to avoid harming pollinators, a majority of respondents have never used the pollination management practices listed in Table 1.

Table 1. List of pollination tactics and the frequency of adoption by grower respondents.

Pollination Management Practice	Regularly Use	Tried & Discontinued	Never Used	Plan to Use This Year
Identify different kinds of native bees in my fields	38.9% (n=7)	5.6% (n=1)	55.6% (n=10)	53.3% (n=8)
Monitor the size of the native bee population in my fields in any way	5.6% (n=1)	11.1% (n=2)	83.3% (n=15)	26.7% (n=4)
Estimate bees' contribution to fruit-set in my crops	11.8% (n=2)	11.8% (n=2)	76.5% (n=13)	40% (n=6)
Use leafcutting bee nest boxes or bumblebee nesting items	5.6% (n=1)	16.7% (n=3)	77.8% (n=14)	6.7% (n=1)
Avoid mowing wildflowers to provide food for pollinators	41.2% (n=7)	5.9% (n=1)	52.9% (n=9)	13.3% (n=2)
Plant wildflowers or bee meadows specifically for pollinators	11.8% (n=2)	0% (n=0)	88.2% (n=15)	33.3% (n=5)
Leave standing deadwood for pollinators	38.9% (n=7)	0% (n=0)	61.1% (n=11)	26.7% (n=4)
Alter pesticide application to avoid harming pollinators	88.2% (n=15)	0% (n=0)	11.8% (n=2)	N/A
Limit floral competition during bloom by cutting wildflowers or other blooming plants	17.6 (n=3)	0% (n=0)	82.4% (n=14)	20% (n=3)

As Table 1 shows, more than half of respondents (53.3%; n=8) said that they plan to identify different kinds of native bees in their fields next season, and 40% (n=6) said they plan to estimate bees' contribution to fruit set in their crops next year. These two management practices

were the focus of the pollination workshops, and several of the tools in the Pollination Toolbox were designed to help growers administer these practices. Aside from these two practices, intention to use the pollination management practices listed on the survey was low among respondents. This suggests that some form of intervention will be necessary to increase blueberry growers' use of pollination management practices other than stocking commercial honey bees, which is currently the dominant pollination management strategy practiced by more than three quarters of Maine blueberry growers (Hanes et al. 2013, Rose et al. 2013).

Table 2. Perceptions of labor investments into pollination assessment by wild blueberry growers.

Pollination Management Practice	Very Easy	Easy	Neutral	Difficult	Very Difficult	Not Sure
Identifying different kinds of native bees in my field(s)	5.3% (n=1)	26.3% (n=5)	31.6% (n=6)	26.3% (n=5)	0% (n=0)	10.5% (n=2)
Monitoring the size of the native bee population in my field(s)	0% (n=0)	15.8% (n=3)	31.6% (n=6)	26.3% (n=5)	15.8% (n=3)	10.5% (n=2)
Estimating bees' contribution to fruit-set in my crop(s)	0% (n=0)	10.5% (n=2)	26.3% (n=5)	42.1% (n=8)	5.3% (n=1)	15.8% (n=3)

Given that the 2014 wild blueberry pollination workshops' focused on identifying, monitoring, and assessing native bees' contribution to fruit set, respondents were asked to indicate how easy or difficult they think it would be to identify native bees, monitor the size of native bee populations, and estimate the contribution of bees to fruit set, on a scale from *very easy* to *very difficult*. Results are shown in Table 2. The high rate of responses of “*neutral*” and “*not sure*” suggests that some growers may feel uncertain about the time or skill required to implement these management practices. Furthermore, approximately 47% (n=9) of respondents

indicated that estimating bees' contribution to fruit-set would be *difficult* or *very difficult*, and 42% (n=8) said the same of monitoring the size of the native bee population in their fields. The intention of the workshops was to expose growers to these management practices. Therefore, with the results of the Pollination Workshop Post-Survey, which will be mailed to workshop participants at the end of July 2014, we hope to see a decrease in growers' perceptions of the difficulty of implementing these management practices.

DISCUSSION AND CONCLUSIONS

Despite the relatively small sample size, the results of the survey do characterize the Maine wild blueberry industry. This conclusion is based upon the similarity of the responses specific to bees and pollination summarized in a recent 2010 survey that included more than 100 grower respondents (Rose et al. 2013), and a 2012 survey of early adopters among Maine lowbush blueberry growers (Hanes et al. 2013).

Overall, the growers enjoyed the workshops and feedback was positive. The video was well received and is now posted on the Maine wild blueberry website at:

<http://umaine.edu/blueberries/factsheets/production/wild-blueberry-videos/>

Follow-up post-workshop surveys will be mailed out to the participants to obtain written feedback on the workshop and further information about their pollination strategies. In addition, semi-structured one-on-one interviews will be conducted (K. Collum) with several of the workshop attendees in September 2014, to allow growers to discuss their experiences attempting to measure bee abundance and diversity, estimate potential fruit set based on bee visitation, and implement native bee conservation strategies. The information obtained from these interviews will be shared in a factsheet for growers made available on the University of Maine Cooperative

Extension website. The factsheet will serve as a resource for fellow growers who are interested in experimenting with different pollination practices in their own blueberry enterprise.

Use of *Osmia spp.* nest blocks and pollen trapping to determine honey bee constancy on wild blueberry was of additional interest to growers, despite the fact that several previous workshops have been presented on this topic since the mid-1990s. Most growers appeared to have a moderate to good understanding of pollinator protection from pesticide exposure. This was reassuring since much of the past decade's extension focus has been devoted to minimizing pesticide exposure and effects on bees and other beneficial insects.

The pollination toolbox is popular with wild blueberry growers in Maine. We intend to have an "out-of-season" pollination workshop this summer at the annual Maine Wild Blueberry Field Day, July 16, 2014. At this meeting a query to the growers will be made to assess the desire for replication of the workshops in 2015.

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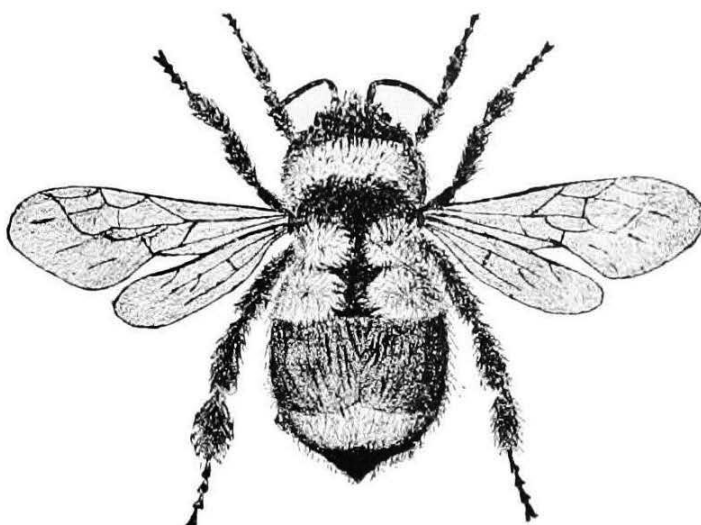
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APPENDIX

POLLINATION WORKSHOP SURVEY—2014

PLEASE READ FIRST:

This survey is part of a study administered by researchers at the University of Maine and funded by the Northeast Sustainable Agriculture Research & Education (SARE) program. The purpose of the study is to find ways to improve pollination outreach and education for Maine fruit and vegetable growers. The survey should take about ten minutes to complete. **All data from this survey will be kept confidential. Your privacy is our priority.** Thank you in advance for helping to improve pollination in Maine agriculture!



Workshop location _____ Date _____ # _____

Section I. Pollination Management

1. What are the primary crops that you grow? *Please check all that apply and indicate how many total acres you manage of each crop.*

<input type="checkbox"/> Apples	Total acres managed: _____
<input type="checkbox"/> Blueberries	Total acres managed: _____
<input type="checkbox"/> Mixed vegetables	Total acres managed: _____
<input type="checkbox"/> Other	Total acres managed: _____

2. What are your main concerns about pollination? *Please write your thoughts in the space below.*

3. How effective do you think native bees are for pollinating your primary crop(s), on a scale from *very ineffective* to *very effective*? *Please check one.*

☐ Very ineffective
☐ Somewhat ineffective
☐ Neutral
☐ Somewhat effective
☐ Very effective
☐ Not sure

4. In your opinion, how often would you be able to get sufficient pollination from native bees alone? *Please check one.*

☐ Never
☐ 1 year in 4
☐ 2 years in 4
☐ 3 years in 4
☐ Every year
☐ Not sure

- | Current and Past Use of Practices
(Please ✓ the best answer for each practice) | | | | (Please ✓ if you plan to use this year) |
|---|--------------------------|--------------------------|--------------------------|---|
| Pollination Management | Regularly Use | Tried & Discontinued | Never Used | Plan to Use This Year |
| Identify different kinds of native bees in my fields | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Monitor the size of the native bee population in my fields in any way | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Estimate bees' contribution to fruit-set in my crops | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Use leafcutting bee nest boxes or bumblebee nesting items | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Avoid mowing wildflowers to provide food for pollinators | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Plant wildflowers or bee meadows specifically for pollinators | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Leave standing deadwood for pollinators | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Alter pesticide application to avoid harming pollinators | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Limit floral competition during bloom by cutting wildflowers or other blooming plants | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

- [illegible]

Section II. Grower & Farm Enterprise Information

7. Do you consider yourself a full-time or part-time grower? *Please check one.*
- ☐ Full-time
 - ☐ Part-time
8. How many years have you been working in agriculture? *Please check one.*
- ☐ 1-5 years
 - ☐ 6-10 years
 - ☐ 11-15 years
 - ☐ 16-20 years
 - ☐ 21-25 years
 - ☐ 26-30 years
 - ☐ More than 30 years
9. Which of the following best describes your pest management style? *Please check one.*
- ☐ Conventional/traditional
 - ☐ IPM (Integrated Pest Management)
 - ☐ Certified organic
 - ☐ No-spray
10. What is your age? *Please check one.*
- ☐ Younger than 25
 - ☐ 25-34
 - ☐ 35-44
 - ☐ 45-54
 - ☐ 55-64
 - ☐ 65 or older
11. Not counting today, do you regularly attend Cooperative Extension meetings or workshops? *Please check one.*
- ☐ Yes
 - ☐ No
- 11a. If **YES**, on average, how many meetings do you attend per year? *Please check one.*
- ☐ 1-2
 - ☐ 3-4
 - ☐ 5 or more
- 11b. If **YES**, what is your primary purpose in attending? *Please check all that apply.*
- ☐ To attain credits toward my pesticide applicator's license
 - ☐ To learn new things
 - ☐ To meet with other growers
 - ☐ Other: _____

THANK YOU FOR COMPLETING THIS SURVEY!

Please return your complete questionnaire to the person who distributed to you. If you would like more information about this survey, please contact Kourtney Collum, Department of Anthropology, University of Maine, 5773 South Stevens Hall, Orono, ME 04469, or by phone at (734) 625-0794 or email at kourtney.collum@maine.edu