MR445: Maine Wild Blueberry Growers: A 2010 Economic and Sociological Analysis of a Traditional Downeast Crop in Transition

Anya Rose

Francis A. Drummond
frank.drummond@umit.maine.edu

David E. Yarborough
davey@maine.edu

Eric Asare

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Any Rose
Francis A. Drummond
David E. Yarborough
Eric Asare
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A 2010 Economic and Sociological Analysis of a Traditional Downeast Crop in Transition

Anya Rose¹
Research Assistant

Francis A. Drummond¹,³
Professor

David E. Yarborough²,³
Professor

and

Eric Asare⁴
Graduate Student

¹School of Biology and Ecology, University of Maine, Orono, ME
²School of Food and Agriculture, University of Maine, Orono, ME
³Cooperative Extension, University of Maine, Orono, ME
⁴School of Economics, University of Maine, Orono, ME

College of Natural Sciences, Forestry & Agriculture
5782 Winslow Hall
University of Maine
Orono, ME 04469-5782
ACKNOWLEDGMENTS

We would like to thank Ms. Phoebe Nylund of University of Maine Cooperative Extension for helping us to construct and send out the survey and compile the results. In addition, Dr. James Acheson provided much important insight into this project. The Wild Blueberry Commission provided financial support and encouragement. We also appreciate the blueberry growers in Maine who responded to our survey. As a group they are surveyed often, but they graciously continue to participate. This study was funded in part by USDA SCRI Grant No. 2009-51181-05845—“Systems approach to improving sustainability of wild blueberry production,” by USDA Hatch projects ME08464-10—“Management of the commercial bumble bee, Bombus impariens, for lowbush blueberry” and ME08364-10—“Sustainable solutions to problems affecting bee health,” and USDA grant MAS0201101389—“Pollination security for fruit and vegetable crops in the Northeast.”

ABSTRACT

An extensive mail survey of Maine wild blueberry growers was conducted in spring 2010, the first extensive survey of growers in almost three decades (1974). The objective of the survey was to quantify the diversity of growers’ philosophies, management practices, and perspectives on their priorities in producing blueberries. We also wanted to identify the sources of new information upon which growers rely. Our results are based on 100 responses from a grower population of 353. We asked growers to place themselves into one of four categories representing distinct approaches to management: conventional (12%), integrated pest management (IPM, 65%), organic (13%), or no-spray (11%). Conventional and IPM growers incorporated more pesticides into their production than organic and no-spray growers. IPM growers, however, were more likely than conventional growers to monitor their fields for pests and need for fertilizer. Conventional growers harvested fewer acres, made less money from blueberries, and were less likely to attend University of Maine Cooperative Extension (UMCE) meetings than IPM growers. No-spray growers were similar to organic, with a few differences. No-spray growers used herbicides and fertilizers whereas organic growers used sulfur and pulled weeds by hand. No-spray growers made less of their income from blueberries, were less likely to grow blueberries full time, and were less likely to attend UMCE meetings regularly than organic growers. Conventional and IPM growers (pesticide adopters) shared similar goals: making a profit, maintaining land value, providing healthy food for the public, and leaving a legacy for their family. Pesticide-avoiders (organic and no-spray)—characterized by their minimal use of pesticides and lower likelihood to rent or purchase commercial bees—also shared similar goals: providing healthy food for the public, making a profit, and being a steward of the environment. In general a few trends were observed for all growers. Field size was associated with management intensity and education level, and years as a grower had little influence on production practices.

Compared to growers in 1975, current growers manage a higher proportion of both smaller and larger fields. In addition, current growers rely much more heavily upon fertilizers, herbicides, and commercial bees for pollination than growers in 1975. They also enhance habitat for native bees more than the growers in the 1975 survey. Although growers in our survey had adopted practices that rely upon natural enemies and minimize the amount of insecticide used, the percentage of growers using insecticides in blueberry production has not changed since 1975. More land is under organic production now, and the economic factors that made some growers pursue organic production in 1975 remain responsible for the rapid increase of organic production in the past decade. This new analysis will provide a baseline for gauging change in the wild blueberry industry and the grower community in the next few decades.
Contents

INTRODUCTION 1

Factors Limiting Production 1
Growers’ Pest Management Strategies 2

OBJECTIVES AND APPROACH 3

METHODS 3

Survey 3
Toxicity-Rating Scale 4
Data Exclusion and Outliers 4
Statistical Analysis 4

RESULTS AND DISCUSSION 5

Managers vs Owners 5
Pest Management Categories of Growers 5
Demographic Characteristics 6
Production Practices 8
Toxicity Ratings 12
Management Intensity 13
Grower Priorities 14
Opinions about Pesticide Safety 16
Grower Sources of Production Information 16

COMPARISON OF BLUEBERRY GROWERS: 1974 AND 2010 18

SUMMARY 19

LITERATURE CITED 21
**Figures**

1. The relationship between acres harvested per year and the percentage of annual income derived from blueberry production.  
2. Pest management category and average pesticide toxicity rating  
3. The relationship between percentage of annual income coming from blueberries for individual growers and the toxicity rating for their farm  
4. The relationship between years spent growing blueberries by a grower and toxicity rating of pesticides used by that grower  
5. The relationship between acres harvested yearly by each grower and toxicity rating

**Tables**

1. Farm size, experience, age, education and income  
2. Pruning practices  
3. Soil fertility and weed control practices  
4. Use of commercially purchased bees and hive ownership  
5. Methods for enhancing native bee populations  
6. Use of pesticides to control pests, agreement with statements about beneficial insects, and pesticide license status  
7. Growers who follow pesticide laws and their reasons  
8. Management intensity of a typical grower  
9. Factors of personal importance  
10. Opinions about pesticide safety  
11. Average rating of influential factors  
12. Grower attendance in UMCE workshops or field meetings, and reasons for attending or not attending  
13. Comparison of management practices in 1974 vs 2010  
15. Main concerns of blueberry growers
INTRODUCTION

Maine produces 97% of the wild blueberries, *Vaccinium angustifolium* Aiton, in the United States (Strick and Yarborough 2005), and is the largest producer of wild blueberries in the world, followed closely by the provinces Québec, Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador in eastern Canada. In Maine, more than 60,000 acres are managed for wild blueberry, producing an average of more than 70 million pounds of berries annually (Yarborough 2012). Wild blueberry production contributes about $250 million (directly and indirectly) to Maine’s economy (based upon 2007 statistics, Yarborough 2012).

Wild blueberries can be managed minimally by burning fields to keep them in the early stages of succession, a “slash and burn” form of agriculture. This is the method that Native Americans used (Strick and Yarborough 2005). As Europeans began to settle New England, they also took advantage of blueberries that grew wild. In the mid-1800s, with the construction of railroads in the Northeast that opened markets in Boston and New York, Maine’s commercial blueberry production began, with more than 200,000 acres of blueberries being harvested (Drummond 2000). By the 1960s, production methods had intensified with increased pruning, and by the 1970s, most growers had started fertilizing, controlling weeds, and using integrated pest management strategies (Drummond 2000; Yarborough 2009).

Factors Limiting Production

Pollination is the most important factor limiting wild blueberry yield. In Maine, the Canadian Maritimes, and Québec, bees are the only pollinators of wild blueberry (Drummond 2002, 2012a; Drummond and Stubbs 2003). Most blueberry growers in Maine rent honey bees to increase yield (Metzger and Ismail 1976; Strick and Yarborough 2005; Files et al. 2008). After blueberry flowers have been pollinated, the bees are then taken to pollinate other crops (often cranberry, squash, pumpkins, or canola). In the past few years, however, honey bee colony numbers have decreased due to many potential causes such as colony collapse disorder (CCD), fungal and mite infections, pesticide exposure, habitat alteration, changing weather patterns, and long-distance trucking (Cox-Foster et al. 2007; Aronstein et al. 2010; Eitzer et al. 2010; Drummond et al. 2012). On an individual bee basis, however, honey bees are not as efficient at pollinating blueberry as native bees; they take longer to pollinate a single flower than bumble bees or other native bees (Stubbs et al. 1997; Drummond and Stubbs 2003; Drummond 2012a). To improve blueberry pollination, it is important to conserve both native and nonnative pollinators by providing nesting habitat and flowering plants other than blueberries to serve as alternative food sources (Drummond and Stubbs 2003). Research has also shown that native bees are found more often in small fields (<50 acres) than large ones, possibly due to the ratio of field edge habitat to blueberry habitat (Drummond and Stubbs 2003). In general, the more diverse the habitat, the more diverse the plant community will be in the habitat, which will result in more native bees, thereby helping improve pollination.

Weeds—serving as competition for nutrients, water, and light—are another major limiting factor in blueberry production (Jensen and Yarborough 2004). Growers can manage weeds by applying herbicides, or hand pulling, mowing, or cutting. Herbicides can be applied at the beginning of the growing season before weeds emerge (pre-emergence), or after the weeds have sprouted (post-emergence) (Jensen and Yarborough 2004). Improvements in weed management have allowed blueberry yields to double and triple in some areas over the past several decades (Yarborough 2004).

Fungal diseases also pose a threat to blueberries, especially during foggy or rainy weather. The major diseases are mummy berry caused by *Monilinia vaccinii-corymbosi* (Reade) and red leaf disease caused by *Exobasidium vaccinii* Wor. (Annis and Stubbs 2004). In 2009, a new pathogen of wild blueberries caused by the fungus *Vuldensinia heterodoxa* Peyronel was found in Maine (Annis and Yarborough 2012). To control fungal diseases, fungicides can be applied at specific times each year. Growers time their applications of fungicides by monitoring for fungal infections or using an online disease-forecasting service, which notes current weather conditions and estimates likelihood of mummy berry infections (Annis et al. 2012). Burning can also suppress some fungal diseases (DeGomez et al. 1990; Yarborough and Annis 2010).

Insect pests also limit wild blueberry yield. Growers can control insect pests by burning, applying insecticides, or relying on natural enemies to act as biological controls. Different species of insect pests and specific insect pest life stages are targeted using particular
control tactics (Yarborough et al. 2001; Dill et al. 2001; Yarborough and Drummond 2010). Knowledge of ecology and insect biology is essential in determining which method to use. For example, Bt, or Bacillus thuringiensis Kurstaki, is a bacterium that produces a toxin specific to insect pests in the order Lepidoptera. This order includes blueberry spanworm (Itame argillaceria [Packard]) and red-striped fireworm (Aroga triablamaculella Cham.), both leaf-feeding pests of wild blueberry. Leaves sprayed with Bt are ingested by the pest, which results in the inhibition of digestion in the larvae. This toxin will affect non-pest immature moths and butterflies (D’Appolonio et al. 2010), but will not affect the caterpillars of blueberry sawflies (Neopareophora litura [Klug]), a pest of wild blueberry (Collins et al. 1994). It is important, therefore, for growers to have knowledge about specific insects that appear in their fields.

**Growers’ Pest Management Strategies**

Wild blueberry growers have different philosophies that guide their farming practices. Some growers do not use synthetic chemical inputs at all, others use them sparingly, and still others use them intensively. Harmful side effects to humans or other non-target organisms depend on the type of pesticide used, the application method, dose, timing, weather conditions during application, and a host of other factors (Banerjee 1999; Margini et al. 2002; Pedigo and Rice 2006). For example, the insecticide acetamiprid effectively controls blueberry maggot (Collins and Drummond 2009, 2010; Yarborough and Drummond 2010), but may also harm honey bees if applied in conjunction with fungicides that contain the active ingredient propiconazole (Iwasa et al. 2004; D’Appolonio et al. 2010). Pesticides can have complex ecological effects along with subtle externalities, and many side effects are still unknown (Pimentel et al. 1998; Eitzer et al. 2010). D’Appolonio et al. (2010) summarizes a list of pesticides used in wild blueberry and their toxicological effects on non-target organisms. Fertilizers applied to wild blueberries can also result in indirect unintended negative effects, such as soil degradation and increases in weed resistance (Jensen and Yarborough 2004). For these reasons, some growers may choose to limit the use synthetic chemical inputs on their fields and others may choose to use no synthetic chemical inputs at all.

Looking at wild blueberry production, we can group growers in to one of four categories of pest management based on growers’ practices and philosophies: conventional, integrated pest management (IPM), organic, no-spray (Drummond 2000).

**Conventional**

There are some risk-averse wild blueberry growers who use pesticides in a prophylactic manner, meaning that management practices are employed without full knowledge of pest presence, pest vulnerability, ecological disruption, or economic cost/benefits of the control tactic (Fernandez-Cornejo and Jans 1999; Comer et al. 1999). They may spray according to arbitrary dates in the calendar year, applying pesticide on the same dates every year, or according to “rules of thumb,” such as after the last heavy spring rain. Conventional growers are typically thought of as having a lower concern for environmental impact than other growers, with high inputs of synthetic pesticide and fertilizer (Comer et al. 1999). This may or may not be true for wild blueberry growers.

**IPM**

Integrated pest management involves using many different pest-management tactics in an integrated framework. These pest management tactics are only used when the cost of pest damage exceeds the cost of control (Yarborough et al. 2001). The original goal of IPM was to reduce unnecessary pesticide applications to increase farmer profitability. More recently, the reasons for reducing pesticide applications have changed in response to demands from the general public and consumers. Concerns over environmental quality and human health are now major reasons for IPM adoption (Fernandez-Cornejo and Jans 1999).

**Organic**

Worldwide momentum for organic farming started building in the 1960s with the back-to-the-land movement and with Rachel Carson’s publication of *Silent Spring* (Vos 2000). Organic farming does not rely upon synthetic pesticides or fertilizers and is steeped in a tradition of land stewardship. In Maine, approximately 850 acres of wild blueberry are managed organically (Drummond et al. 2009b). Files et al. (2008) and Drummond et al. (2009a) summarize the management and economics of organic wild blueberry production in Maine. The requirements for becoming a certified organic grower in Maine are stringent. Not only must growers...
comply with the National Organic Rule, they must also meet standards established by the Maine Organic Farmers and Gardeners Association (MOFGA), many of which are more stringent than USDA rules.

**No-spray**

Because the organic certification process can be costly and time-consuming, some farms in Maine use few or no chemicals but may not be officially certified as organic. Some growers may use low-input methods for philosophical reasons; others may do it because they happen to have blueberries on their land, but do not wish to actively manage them. These farmers have consumers who simply trust them, even without the official certification (Constance et al. 2008).

**OBJECTIVES AND APPROACH**

New information about healthy food, nutrition, and toxicity of pesticides in relation to human health and the environment may cause consumers to make conscious choices about what they eat (Anderson et al. 1996; Pimentel et al. 1998; Margini et al. 2002; Aliouane et al. 2009). Whether the dangers of pesticides are real or only perceived (Pimentel et al. 1998; Wilson and Tisdell 2001; FAO 2009), personal beliefs have been documented in many studies as affecting consumer behavior (Blake 1995; Williams and Hammitt 2001). In addition, new research on the health benefits of blueberries (Smith et al. 2000; Kristo et al. 2010) follows this increase in consumer demand for healthy food. In light of these changes in consumer demand, we wondered if blueberry growers are taking part in the movement to reduce use of pesticides. If so, which growers, and how? Since blueberries can be managed with low-input or organic methods and given the high demand for the crop, we thought blueberry growers would be prime candidates for examining how farmers adapt to new demands and changing technologies. To this end, our study attempts (1) to develop a conceptual model of the blueberry grower community by comparing their attitudes and perceptions toward different pest-management and pollination practices; and (2) to determine the reasons associated with the selection of specific pest management and pollination management tactics.

We used a survey to examine demographic characteristics and philosophical priorities of wild blueberry growers, summarize their beliefs regarding pesticide safety, and analyze factors that influence their decision making. We then used the self-designated pest-management categories as a means of partitioning Maine growers into groups. In this publication we attempt to provide insight into whether IPM growers are different from conventional growers, and whether no-spray growers are different from organic growers. This analysis will be useful as a baseline description of the Maine wild blueberry industry as it continues to change rapidly.

**METHODS**

**Survey**

We sent a survey with a self-addressed, stamped return envelope in April 2010 to all 343 growers on the University of Maine Cooperative Extension (UMCE) wild blueberry producers list (see Rose [2011] for detailed survey form). This list included growers of both small (part-time) and large (full-time) farms, and growers who own blueberry land in Maine but live out of state. We also included growers who manage blueberries on someone else’s land. Surveys were anonymous. The authors attended two UMCE Wild Blueberry Schools in Maine during March 2010 to explain the purpose of the survey. At these meetings, we gave a preliminary survey to eight growers as a way to improve the clarity of final survey instrument.

Respondents were asked to respond to the survey by 15 May 2010. We sent reminder postcards during the week of 2 May 2010. On 21 July 2010, we handed out additional surveys during the University of Maine Annual Wild Blueberry Field Day at Blueberry Hill Farm, Jonesboro. Participants were offered a free hat in return for completing the survey. In total, we received 126 completed surveys and were able to use 100 of them, resulting in a 29% response rate.

The survey consisted of 38 questions on 12 single-sided 8½×11 inch pages. We collected information on demographics, background, scale of production, and pest management and pollination practices of each grower. One question on the survey asked, “How would you categorize your pest management style overall?” Growers could choose organic, no-spray, conventional, or IPM, and each category contained subcategories by which they could further define what they meant by their categorization. The survey also included several
questions in three additional areas: “scientist-grower relationships,” “factors of personal importance,” and “influences and communication.” Questions in the first area asked respondents to rate their level of agreement, from 1 to 5, with statements relating to their interactions with the University of Maine faculty in regards to pesticide application and safety. Questions in the second area required growers to rank a series of 10 goals, from most important to least important. In the third area, questions asked respondents to rate, on a scale of 1 to 5, avenues of information acquisition that range from least to most influential in adopting new farming practices.

Toxicity-Rating Scale

In the survey, growers were asked to list all pesticides they used and the number of times per year they applied each pesticide. We did not ask for rates of pesticides (amounts applied per acre) on the survey. We assumed that growers apply the rate within the legally required range of rates specified on the pesticide label. Each pesticide was given an ordinal ranking according to level of toxicity, using the 2010 UMCE Maine Wild Blueberry Pesticide Chart (D’Appollonio et al. 2010). The chart includes the relative pesticide toxicity to non-target organisms such as fish, bees, birds, and humans. We assigned three points to pesticides that are regarded “extremely toxic to fish,” whereas we gave two points to those that are “moderately toxic to fish.” The same point scale was applied to extreme and moderate toxicity for bees and birds. We assigned three points and four points, respectively, to those pesticides with moderate and extreme human toxicity. We allotted one point for pesticides for which no known harmful effects have been noted and a score of zero for growers who used no pesticides. We did not include fertilizer and sulfur in the pesticide-toxicity rating. We summed toxicity indices for each pesticide, and surveys (i.e., growers) were assigned ratings composed of indices from the types of pesticides used multiplied by the number of times per year they applied each pesticide. The lowest toxicity rating a grower could receive was zero (for using no pesticides at all). The herbicides ranked lowest on the index; most had levels of 1, except for fluazifop-P-butyl, which received a score of 6. The most toxic pesticide was the insecticide phosmet, which received a score of 11 (all scores are a product of toxicity rank and application frequency).

Data Exclusion and Outliers

We excluded 26 of the returned surveys from our analysis. Three respondents lived out of state (Michigan, Texas, and Quebec) and maintained no fields in Maine. Eleven said that they hire a private company to manage their fields. Some of these respondents also left many questions blank. Since the survey was designed to assess how blueberry growers make decisions, we eliminated respondents who did not appear to be actively involved in the management decision-making process. However, we did include these respondents in some analyses (as discussed later). Three more individuals were excluded because they left many questions blank. Five growers (two conventional and three IPM) who hired a manager were left in the analysis because they had specific knowledge of how their fields were managed and answered the survey questions in depth.

Nine more growers were excluded because they did not clearly categorize themselves under the headings of IPM, conventional/traditional, organic, and no spray. Five did not select any category to describe their operation, and four growers selected boxes under both IPM and conventional. Had there been more people who had left this area blank, or who had checked multiple boxes, we might have assigned them additional categories. However, because there were only four or five in each group, and because these nine individuals varied greatly in their alignment to the other four categories when analyzed, we excluded them to increase power in the analysis. A total of 100 surveys were used for most analyses.

Statistical Analysis

All statistical analyses were conducted using the statistical software JMP (SAS Institute 2007). We conducted linear correlation (Pearson and Spearman’s rho) to determine association between continuous and continuous or rank-order variables (Yule and Kendall 1950). We performed analysis of variance (least squares approach, to account for unbalanced designs, Kariya and Kurata (2004)) followed by Tukey’s multiple comparison test (Miller 1981) to determine differences between categorical factors with continuous dependent or response variables. We also used logistic regression (nominal and ordinal, Hilbe (2009)) to estimate the likelihood and identify the factors that determine whether growers
will use bumble bees or employ practices to enhance native bees.

A comparison-wise error rate of $\alpha = 0.05$ was used for all tests, but we reported exact $P$-values in the text. We did not correct these error rates for multiple sequential tests (Bonferroni correction, [Abdi 2007]) and acknowledge that when conducting multiple statistical analyses at a comparison-wise error rate of $\alpha = 0.05$, the experiment-wise error rate is greater than $\alpha = 0.05$. Instead of using Bonferroni correction to adjust the comparison-wise error rates, we used a conservative and cautious approach when making conclusions from a multitude of sequentially related analyses by only considering effects that were highly significant ($P < 0.001$).

RESULTS AND DISCUSSION

Managers vs Owners

The 11 respondents who do not manage fields they own were excluded from the overall analyses. We included only respondents who could be considered “growers” and who were making decisions about blueberry-growing practice. We found that the 16 non-managers (11 of which were later excluded, five of which were included in the overall analyses) differed in some regards from the 95 respondents who manage wild blueberry fields. Landowners who don’t actively participate in field management (non-managers) are less likely to incorporate UMCE recommendations ($F_{(1,112)} = 5.47; P = 0.02$) and are more influenced by media, such as newspaper articles, TV, or movies than other blueberry growers and managers ($F_{(1,112)} = 4.31; P = 0.04$). Non-managers are also less concerned about stewardship of the land ($F_{(1,101)} = 5.16; P = 0.02$), less concerned about helping to further scientific research ($F_{(1,96)} = 6.65; P = 0.01$), but more concerned about leaving land open and undeveloped ($F_{(1,103)} = 5.54; P = 0.02$) than managers. Non-managers also, on average, were older ($F_{(1,116)} = 14.38; P < 0.01$).

Explanations for this pattern might be that wild blueberries will grow naturally and can be maintained with minimal investment (Drummond et al. 2009a); on the other hand, intensive management increases yields (Yarborough 2004). Therefore, some landowners may wish to maintain their land as a natural undeveloped blueberry landscape, thereby maintaining land value for future sale; at the same time, they generate revenue by harvesting the minimally managed land. People who were once growers and still own blueberry land may also elect to have their fields managed by someone else as they get older.

Pest Management Categories of Growers

Growers were distributed among pest management categories as follows: 12 growers considered themselves as conventional; 64 as IPM; 13 as organic; and 11 as no-spray. Eighty-seven percent (n = 56) of the IPM growers defined IPM to mean that they scout and monitor fields for pests to determine when and where pesticides are needed. Of the 13 organic growers, eight said they applied no pesticides to their land; five said that they used pesticides organically approved by MOFGA and the Organic Materials Review Institute (OMRI). Ten of the 11 no-spray growers defined their category as not “organic,” but “no chemicals sprayed”; however, two no-spray growers used the herbicides glyphosate and sethoxydim, which seems to contradict their no-spray status. Some no-spray blueberry growers may not consider herbicides as “pesticides,” as they are often less toxic to vertebrate wildlife and human beings than insecticides and fungicides (D’Appollonio et al. 2010). Or they may use these pesticides at a low rate and frequency and do not consider them a significant part of their management practice. Also, since most herbicides are applied only during the vegetative year (Yarborough 2009), the probability of residues being on fruit is low.

Conventional growers varied in how they defined their category. They were given choices such as, “I spray according to the calendar year” and “I spray according to when pesticide applicators are available.” These growers checked multiple boxes under the conventional heading. Of the 12 growers, four said they sprayed according to the calendar year; five said they sprayed when pesticide applicators were available; four said they spray, but try to use less; and two said they sometimes hire a contractor to spray for them (note: several respondents checked multiple responses).

Growers in this study were given the above-mentioned four choices for categorizing their pest management philosophies; however, other published studies have suggested different ways of categorizing growers. Chouinard et al. (2008) grouped growers according to their motivations: “profit maximizing” (those motivated by profit); “ego-utility” (those motivated by environmental effects but only if personally beneficial to them); and “social stewardship,” (those motivated...
by duties to family, society, and/or future generations). Another study by Brodt et al. (2004) split growers into “environmental stewards,” “production maximizers,” and “networking entrepreneurs,” according to what each grower prioritized. Researchers have found that growers rarely fall discretely into one category and that the average farmer’s motivations are heterogeneous (Chouinard et al. 2008; Kaine and Bewell 2008). Brodt et al. (2004: 246) suggest that “while scientists and policymakers might desire everyone to adopt a whole spectrum of practices, a more effective approach might be to work with growers to aggregate practices into groups that correspond with specific management goals.” The problem with this is that growers may have trouble placing their priorities in a ranked order. In our survey, many blueberry growers expressed frustration at being asked to do this, and some ranked more than one factor as a priority. In our analysis, grower priorities were weakly correlated with income (those with more income place more importance on maintaining the value of the land) and with years of experience (those with more years place more importance on continuing their family’s legacy), but no other significant relationships were found with grower priorities.

Priorities, like management styles, also shift according to various cultural and financial incentives. Padel (2001) examined multiple instances of organic farm conversion and found that the decision was initially based on the desire to maintain the value of the land and the future of the farm. Religious reasons were also cited. Other decisions to convert seem to be based on financial incentives and on concern for the environment (Burton et al. 1999; Padel 2001). Similar changes in motivation have been noted in IPM growers. Nationwide, evidence suggests that IPM growers may have initially adopted IPM practices for profit reasons, but their goals may be shifting to be “more in line with the public’s desire to reduce risks associated with pesticide use” (Fernandez-Cornejo and Jans 1999: 3). Because the priorities of wild blueberry growers are heterogeneous and linked to few other factors, we categorized growers by pest management style instead of personal priorities.

Demographic Characteristics

Of the 100 survey respondents, 71% were from Washington County, 9% were from Hancock County, 6% from Knox County, and 4% from Penobscot County. Waldo, Lincoln, and Franklin counties each had 2% representation; Somerset, Aroostook, Cumberland, and Kennebec counties each had 1% representation. This survey ranking of county location does reflect the distribution of growers in the state.

Eighty percent of respondents were male, and growers were evenly distributed in age between 32 and 81. The average wild blueberry grower surveyed was about 60 years old and had either attended some college or completed a bachelor’s degree. Mean grower age was not associated with pest management categorization ($F_{(3,96)} = 0.11; P = 0.95$). There was also no difference in education between pest management categories (Table 1).

Growers were also asked if they had a partner in their blueberry operation. Forty percent farmed with their spouse, 20% farmed with a relative, and 30% had no partner. Most operated under a sole ownership (74%), and some were organized as a corporation (13%) or partnership (10%). One respondent was the manager of fields owned by the Passamaquoddy tribe.

Half of the growers surveyed made less than 15% of their annual income from blueberries. Only 11 respondents reported that blueberries generated 90% to 100% of their income. Of these, one was conventional and one was organic; the other nine were IPM growers. Six of the 13 organic growers were full time (46%), while 37% of IPM growers were full time. Organic and IPM growers relied slightly more on blueberries for their annual income than no-spray and conventional growers ($F_{(3,89)} = 2.64; P = 0.054$); however, more than 50% of all the grower groups earned income from a job other than blueberry growing (Table 1).

Growers were asked how many acres they harvest a year. Half of all growers harvested fewer than 20 acres per year and three-quarters harvested 50 acres or fewer. Six respondents harvested more than 500 acres per year, and three of those harvested in excess of 1000 acres. We investigated farm size (in acres) as it relates to IPM practices using a categorical contingency analysis. Farm size was represented as a series of acre categories. For these statistical analyses, we included only IPM and conventional growers since many organic and no-spray growers either left these sections blank or wrote “N/A.” Conventional and IPM growers who managed or owned more acres practiced integrated crop management (ICM) ($\chi^2 = 16.4; P < 0.0001$) and IPM ($\chi^2 = 23.4; P < 0.0001$) less than those who owned fewer acres. Integrated crop management refers to the use of blueberry-production-management methods that embrace the philosophy of
There were differences between pest management categories as related to income from wild blueberries, part- or full-time status, years spent as a grower, and acreage (Table 1). No-spray and organic growers have been managing blueberries for less time than IPM and conventional growers. The data on income were highly variable. Three growers noted a loss from blueberries, and 13 indicated that blueberries contribute 0% to their yearly income. There is no difference between the percentage of annual income that IPM and organic growers earn from blueberries annually, but both groups appear to depend more on blueberries for their income than growers who practice no-spray. IPM growers, as a group, harvested more acres than the other three groups. As might be expected, those with more acreage earned a higher percentage of their annual income directly from wild blueberries (Figure 1).

A previous survey of organic wild blueberry growers in 2006 found that most farm part time, earn additional income from other jobs, and have smaller farms than conventional or IPM growers (Files et al. 2008). The present survey showed similar findings in regards to organic growers and farm size. We also found that most growers, independent of pest management category, earned income elsewhere, and that more IPM and organic growers were full-time farmers compared to conventional or no-spray growers. Other studies of organic growers of various crops have found that they are younger, newer to farming, and more highly educated than conventional growers (Shennan et al. 2000; Drummond and Collins 2004).

### Table 1. Farm size, experience, age, education and income by pest management category. Categories followed by the same letter are not different ($P > 0.05$). Mean in bold, standard deviation follows in brackets [ ], and range in parentheses ()

<table>
<thead>
<tr>
<th>Averages</th>
<th>Conventional</th>
<th>IPM</th>
<th>Organic</th>
<th>No-Spray</th>
<th>p-value</th>
<th>F-Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acres harvested*</td>
<td>2.0b [0.6]</td>
<td>3.3a</td>
<td>2.0b</td>
<td>1.3b</td>
<td>&lt;0.001</td>
<td>8.67 (3,89)</td>
</tr>
<tr>
<td>(6–20 acres)</td>
<td>(21–50 acres)</td>
<td></td>
<td>(6–20 acres)</td>
<td>(5–5 acres)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years growing*</td>
<td>3.8a [1.11]</td>
<td>3.7a</td>
<td>2.8b</td>
<td>2.8b</td>
<td>0.016</td>
<td>3.59 (3,99)</td>
</tr>
<tr>
<td>(11–20 years)</td>
<td>(11–20 years)</td>
<td></td>
<td>(5–10 years)</td>
<td>(5–10 years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage income from blueberries</td>
<td>14.67 [28.16]</td>
<td>34.43</td>
<td>33.50</td>
<td>6.00[7.83]</td>
<td>0.054</td>
<td>2.64 (3,89)</td>
</tr>
<tr>
<td>Age</td>
<td>60.75 [8.36]</td>
<td>58.75</td>
<td>58.50</td>
<td>59.10</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Education*</td>
<td>3.58 [1.44]</td>
<td>3.86</td>
<td>3.62</td>
<td>4.18</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Education—2: graduated high school; 3: attended college; 4: completed a bachelor’s degree; 5: some graduate school; 6: graduate degree.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time growers (n)</td>
<td>0</td>
<td>24</td>
<td>6</td>
<td>0</td>
<td>ns³</td>
<td></td>
</tr>
</tbody>
</table>

*Responses were grouped into categories based on the following ranges:

- **Years growing**—1: <5 years; 2: 5–10 years; 3: 11–20 years; 4: 21–40; 5: > 40 years.
- **Education**—2: graduated high school; 3: attended college; 4: completed a bachelor’s degree; 5: some graduate school; 6: graduate degree.

1. Difference detected with student’s T-test. All others: Tukey’s.
2. ns indicates no difference ($P > 0.05$) and numbers in parentheses indicate degrees of freedom for ANOVA.
3. Chi-square between IPM and organic.
and age or education, but we did find that organic and no-spray growers were newer to blueberry production than growers in the other two grower groups (Table 1). We did not ask growers for estimates of their income in dollars, we only asked for the proportion of their income that comes from blueberries.

**Production Practices**

**Pruning**

Growers still use a variety of techniques to prune blueberry plants (Table 2). About one-third of growers in each pest management category practiced straw burning. A greater percentage of conventional and IPM than organic and no-spray growers used oil to burn their fields. Most growers, independent of category, pruned at least some of their fields by mowing. Eighty-seven percent of all growers pruned some or all of their fields this way. Ninety-three percent of respondents pruned individual fields every other year. The remaining respondents pruned individual fields less often, every 3 to 4 years, despite information that shows that this is not an optimal economic practice (DeGomez 1998).

**Weeds**

The largest pest problems for wild blueberry growers are weeds, and nearly all growers practice weed management. A high percentage of conventional and IPM growers used herbicides and fertilizers (Table 3). Fewer of the no-spray and organic growers used these products, but no-spray growers used fertilizer more than organic growers. For weed management, 85% of organic growers added sulfur to the soil to increase the acidity of their fields, thereby creating a suboptimal growing environment for grasses and many broad-leaf weeds (Yarborough 2001; Drummond et al. 2009b). The two organic growers who didn’t use sulfur used organic herbicides instead and were among the five organic growers who sprayed certified organic pesticides. Forty-six growers, 40 of whom are IPM, took leaf samples for the purpose of deciding whether to apply a fertilizer to their field.

**Pollination**

A prerequisite for yield with wild blueberries is adequate pollination (Drummond 2002). Unlike highbush blueberry, parthenocarpic fruit formation (fruit in the absence of pollination) has not been observed in lowbush blueberry (Bell et al. 2009). An optimal integrated pollination strategy involves renting honey bees, purchasing commercial bumblebee hives, conserving native bees by providing habitat and alternative forage, and applying pesticides when bees are less active or not foraging in blueberry fields (Stubbs et al. 2002; Drummond and Stubbs 2003). Seventy-nine percent of survey respondents indicated that they

### Table 2. Pruning practices by pest management category. Total counts by category are given, followed, within parentheses, by percentages for each group.

<table>
<thead>
<tr>
<th>Pest Management Category</th>
<th>Straw Burn</th>
<th>Oil Burn</th>
<th>Mow</th>
<th>Prune Every Other Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional (n = 12)</td>
<td>4 (33%)</td>
<td>7 (58%)</td>
<td>10 (83%)</td>
<td>12 (100%)</td>
</tr>
<tr>
<td>IPM (n = 64)</td>
<td>22 (34%)</td>
<td>34 (53%)</td>
<td>58 (91%)</td>
<td>62 (97%)</td>
</tr>
<tr>
<td>No-Spray (n = 11)</td>
<td>3 (30%)</td>
<td>1 (10%)</td>
<td>9 (90%)</td>
<td>9 (90%)</td>
</tr>
<tr>
<td>Organic (n = 13)</td>
<td>4 (31%)</td>
<td>2 (15%)</td>
<td>10 (77%)</td>
<td>10 (77%)</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>44</td>
<td>87</td>
<td>93</td>
</tr>
</tbody>
</table>
purchased or rented commercially available bees (Table 4). Conventional, IPM, and no-spray growers were more likely to use honey bees over bumble bees. A difference between IPM and conventional growers and between organic and no-spray growers can be seen in the adoption of bumble bees: 17 IPM growers used commercial bumble bees compared to one conventional grower, and four organic growers used commercial bumble bees vs zero no-spray growers. Both IPM and organic growers were more likely than conventional and no-spray growers to purchase bumble bee hives. Using a logistic model to assess grower demographics characteristics related to the purchase of bumble bees, we found that full-time growers are 34.2% more likely to rent bumble bees than part-time growers ($\beta = 0.48, P < 0.001$). Farm size also influenced the purchase of bumble bees. As farm size increased, there was a concomitant 9% decrease in the likelihood of purchasing bumble bees ($\beta = -0.54, P < 0.01$).

A higher percentage of organic growers owned their own honey bee hives, whereas growers in the other three categories were more likely to rent hives. IPM and conventional growers deployed the highest density of hives per acre, indicating a more capital-intensive management. Honey bee rental is one of the highest input costs in producing wild blueberries (Yarborough 2011). Organic growers may use fewer honey bee hives and may be more likely to own than rent hives because of the expense. Organic farms were also smaller, on average, than IPM farms, and smaller farms usually have more edge habitat, where native pollinators nest and thrive (Drummond and Stubbs 2003). Therefore, importing large numbers of honey bees or bumble bees may not be as necessary on smaller farms (Stubbs et al. 1992). More research is needed on whether pesticide use—including fungicides—increases the need for imported pollinators in wild blueberry. There is only limited information on the effects of pesticides on honey bees and native bees in the wild blueberry system (Drummond and Stubbs 1997; Stubbs et al. 1997; Drummond 2012b–e).

There are several practices that growers can use to encourage wild, native bees, including hanging nest boxes, leaving standing dead wood, allowing other

Table 3. Soil fertility and weed control practices by pest management category. Total counts by category are given, followed, within parentheses, by total percentages of each group.

<table>
<thead>
<tr>
<th>Pest Management Category</th>
<th>Fertilizer Use</th>
<th>Leaf Samples for Fertility Analysis</th>
<th>Herbicide Use</th>
<th>Sulfur Use</th>
<th>Cut Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional (n = 12)</td>
<td>10 (83%)</td>
<td>4 (33%)</td>
<td>9 (75%)</td>
<td>4 (33%)</td>
<td>10 (83%)</td>
</tr>
<tr>
<td>IPM (n = 64)</td>
<td>57 (89%)</td>
<td>40 (63%)</td>
<td>62 (97%)</td>
<td>31 (48%)</td>
<td>52 (81%)</td>
</tr>
<tr>
<td>No-spray (n = 11)</td>
<td>5 (50%)</td>
<td>1 (10%)</td>
<td>3 (30%)</td>
<td>3 (30%)</td>
<td>10 (91%)</td>
</tr>
<tr>
<td>Organic (n = 13)</td>
<td>2 (15%)</td>
<td>1 (8%)</td>
<td>2 (15%)</td>
<td>11 (85%)</td>
<td>11 (85%)</td>
</tr>
<tr>
<td>Total</td>
<td>74</td>
<td>46</td>
<td>76</td>
<td>49</td>
<td>83</td>
</tr>
</tbody>
</table>

Table 4. Use of commercially purchased bees and hive ownership by pest management category. Total counts by category are given, followed, within parentheses, by total percentage for each group.

<table>
<thead>
<tr>
<th>Pest Management Category</th>
<th>Commercial Bees</th>
<th>Honey Bee Hives</th>
<th>Buy Bumble Bee Hives</th>
<th>Own Honey Bee Hives</th>
<th>Average Hives per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional (n = 12)</td>
<td>10 (83%)</td>
<td>9 (75%)</td>
<td>1 (8%)</td>
<td>0 (0%)</td>
<td>1.83</td>
</tr>
<tr>
<td>IPM (n = 64)</td>
<td>56 (88%)</td>
<td>55 (86%)</td>
<td>17 (27%)</td>
<td>4 (6%)</td>
<td>2.02</td>
</tr>
<tr>
<td>No-spray (n = 11)</td>
<td>5 (50%)</td>
<td>5 (50%)</td>
<td>0 (0%)</td>
<td>1 (10%)</td>
<td>1</td>
</tr>
<tr>
<td>Organic (n = 13)</td>
<td>8 (62%)</td>
<td>5 (38%)</td>
<td>4 (31%)</td>
<td>4 (31%)</td>
<td>0.75</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>74</td>
<td>22</td>
<td>9</td>
<td>1.79</td>
</tr>
</tbody>
</table>

1 Either honey bee, bumble bee, or alfalfa leaf cutting bee
2 Own or rent honey bee colonies
flowers to grow nearby which provide alternative food sources, and using insecticides that are less harmful to pollinators (Stubbs et al. 2000; Drummond and Stubbs 2003). Our survey found that growers—especially no-spray and organic growers—most commonly left standing deadwood and provided alternative forage as ways to encourage native bee populations (Table 5).

We used a logistic model to assess demographic characteristics of growers who were more likely to make efforts to enhance native bees. The resulting model suggested that farmers with higher educational levels are more likely to enhance native bee populations on their farms by 6.4% ($\beta = 0.431$, $P < 0.01$) as are farmers who attend UMCE meetings regularly (by about 30%, $\beta = 2.016$, $P < 0.05$). Using an ordinal logistic model to determine the likelihood a farmer will actively attempt to enhance native bee populations, we found that part-time farmers are less likely to do more to enhance native bee populations on their farm ($\beta = -3.04$, $P < 0.01$). In addition, larger farms are less likely to be associated with growers who actively enhance native bee populations ($\beta = -0.496$, $P < 0.01$).

Both IPM and organic growers were more likely than conventional and no-spray growers to encourage native pollinators on their land. This may be evidence that IPM and organic growers are early adopters. Four no-spray and organic growers and three IPM growers noted adequate abundance of native pollinators on their land. Nine IPM growers mentioned other ways they encourage native bees such as by planting “bee pastures,” or in the case of one grower, placing old mattresses around the edge of his field in which bees can nest. One no-spray grower planted flowering bushes along the edge of his field, and one organic grower left straw bales near bumble bee quads for the queens to occupy over the winter.

It is possible that more IPM and conventional growers imported honey bees because their greater use of pesticides reduces native bee populations. Although this is speculative, it is known that pesticides can kill native pollinators along with beneficial non-target organisms (Drummond and Stubbs 2003; Devillers et al. 2003; Valdovinos-Núñez et al. 2009). We found positive linear correlations between the numbers of hives per acre with which growers stocked their fields and the number of pesticides they used ($r = 0.353; P < 0.01$) and with the total number of pesticide applications ($r = 0.328; P < 0.01$). It is also highly likely that growers who apply more pesticides use more honey bee hives because they manage more intensively and introduce more pollinators to increase yields. Also, their fields are generally larger and might have less edge habitat per field area, where native pollinators thrive and find alternative forage.

**Pesticide use**

Not surprising, we found that conventional and IPM growers were more likely to use pesticides than no-spray and organic growers, even though there are organically approved pesticides for wild blueberry (D’Appollonio et al. 2010). Growers who apply “restricted-use” pesticides and/or spray pesticides commercially for other growers are required to have a Maine pesticide applicator’s license. There are very few “restricted-use” pesticides that are registered in Maine for lowbush blueberry production (Yarborough 2009). In our survey 33% of conventional and 83% IPM growers had an applicator’s license, whereas most organic and no-spray growers did not (Table 6). Four organic and three no-spray growers, however, have held this license for three years or more, which may be attributed to some growers having recently switched to organic or no-spray production.

Table 5. **Methods for enhancing native bee populations, by pest management category. Total counts by category are given, followed, within parentheses, by total percentages of each group.**
Additionally, one grower, who labeled himself organic, managed multiple fields, not all of which were organic.

We asked growers whether they believe insect predators, such as ants and spiders, control insect pests. In our survey, 80% of no-spray growers believed insect predators are effective control agents, as did all organic growers, except possibly for one grower who left the question blank. Fewer conventional (67%) and IPM (69%) growers believed this. One explanation is that organic growers are more likely to observe the effects of beneficial insect interactions. Growers who manage their land more intensely with pesticides may not see the benefits of insect predators. Another reason might be that no-spray and organic growers have fewer insect pest management practices available to them and so they may tend to believe strongly in the few tactics that they can rely upon. Conventional growers were also not as likely as other growers to see the need for more research on predatory insects, possibly because they attended UMCE meetings where this research is discussed less often.

Farmers are required by law to keep detailed records of pesticide applications. This includes noting specific environmental factors present at the time of application. Our survey asked growers whether they note nearby water sources and wind direction before spraying and whether they refrain from spraying during certain weather conditions, as required by Maine state law (Table 7). No grower answered “no” to this question, but a small number left it blank—two from the conventional category and two from IPM. One conventional grower did not spray any pesticides and had a toxicity rating of zero. The other indicated that someone else sprays for him. One of the IPM growers said that he does not spray; the other said she is new to blueberry growing and is deciding how to manage her fields.

The organic and no-spray growers may have desired a “not applicable” response choice. Some of these growers may have left the question blank because they do not spray at all. Fourteen of the no-spray and organic growers wrote in “N/A.” Three no-spray growers indicated that they note environmental conditions before they spray, which is curious because it implies that they actually spray. Two no-spray growers specifically noted that they spray the herbicides sethoxydim and glyphosate, but not “pesticides.” The third grower is just starting out and does not spray pesticides. He does not have a Maine pesticide applicator’s license, and only applies sulfur and organic fertilizer.

Growers were also asked their reasons for noting or not noting the

<table>
<thead>
<tr>
<th>Pest Management Category</th>
<th>Use Pesticides</th>
<th>Insect Natural Enemies Control</th>
<th>More Research Needed on Insect Natural Enemies</th>
<th>Possess Maine Pesticide Applicators License</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional (n=12)</td>
<td>10 (83%)</td>
<td>8 (67%)</td>
<td>9 (75%)</td>
<td>4 (33%)</td>
</tr>
<tr>
<td>IPM (n=64)</td>
<td>47 (73%)</td>
<td>44 (69%)</td>
<td>52 (81%)</td>
<td>53 (83%)</td>
</tr>
<tr>
<td>No-spray (n=11)</td>
<td>0 (0%)</td>
<td>8 (80%)</td>
<td>10 (100%)</td>
<td>3 (27%)</td>
</tr>
<tr>
<td>Organic (n=13)</td>
<td>3 (23%)</td>
<td>12 (92%)</td>
<td>11 (85%)</td>
<td>4 (31%)</td>
</tr>
<tr>
<td>Total grower count</td>
<td>60</td>
<td>72</td>
<td>82</td>
<td>64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pesticide Management Category</th>
<th>Follow Spray Laws</th>
<th>Reasons for Following Laws</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Have to</td>
<td>Want to</td>
</tr>
<tr>
<td>Conventional (n=12)</td>
<td>10 (83%)</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>IPM (n=64)</td>
<td>62 (97%)</td>
<td>51 (80%)</td>
</tr>
<tr>
<td>No-spray (n=11)</td>
<td>3 (30%)</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Organic (n=13)</td>
<td>5 (38%)</td>
<td>4 (31%)</td>
</tr>
<tr>
<td>Total</td>
<td>80</td>
<td>63</td>
</tr>
</tbody>
</table>
environmental conditions before spraying; they could check multiple boxes. The most cited reasons for following the laws were because they have to and because they want to have less of an impact on the environment. A greater percentage of IPM growers than conventional growers were concerned about the water table. Conventional growers were more worried about relations with neighbors than they were about the water table. If there were any growers who do not follow these laws, they did not indicate it on the survey.

Toxicity Ratings

Toxicity rating increases if a farmer uses a highly toxic pesticide, or uses a less toxic pesticide but uses it often. We found toxicity rating to be positively correlated with the number of different pesticides used ($r = 0.78; P < 0.0001$) and with the total number of applications made of all pesticides ($r = 0.82; P < 0.0001$). This is not surprising, since by definition, toxicity rating is a function of application frequency (see Methods). Only one grower applied two different pesticides three times each. This reflects the low frequency of pesticide use in wild blueberry production (Drummond 2000); most growers who used pesticides applied individual pesticides once per growing season. Propiconazole, a fungicide that scored a “3” on the index, and phosmet, an insecticide with an 11 on the index, were two exceptions of note. Propiconazole was applied by 26 growers: two conventional and 24 IPM growers. Fifteen growers applied propiconazole twice per year, one applied it three times per year, and 10 applied it once per year. This fungicide is important for the control of mummy berry disease and often needs to be applied more than once (Yarborough and Annis 2010). Phosmet, used by 34 IPM and conventional growers, is one of the more toxic pesticides used in Maine wild blueberry. In terms of acute toxicity to humans, this insecticide is classified as moderately toxic (Yarborough and Drummond 2010). Eight growers (all IPM) used phosmet twice, and 26 used it once per growing season. One grower had a toxicity rating of 18 because he/she used azinophos-methyl, an insecticide that is highly toxic to humans. Although it can no longer be purchased for use in wild blueberry, existing supplies of azinophos-methyl may still be used legally. Both azinophos-methyl and phosmet are the older standard controls for the blueberry maggot fly (Yarborough and Drummond 2010).

In the majority of cases, our toxicity ratings reflected the number of different pesticides used (pesticide diversity) and the number of total applications per year, combined with the toxicity index of each pesticide. But caution needs to be used in basing conclusions on the toxicity rating system that we developed. This rating system does not take into account the size of the farm, but assumes treatments are done per acre, which means that a “toxicity rating” does not consider farmers who apply a pesticide only to a portion of their field (such as in perimeter or spot treatments) vs those who apply pesticides to the entire field (Yarborough and Drummond 2010). Our rating system also does not consider the breakdown rate of each pesticide in the environment. For example, two pesticides could each have the same acute toxicity levels, but different modes and rates of breakdown in the environment. One might take one to two days to completely disappear, e.g., Spinosyn A & D (formulated as Entrust™), the other might take seven to 10 days, e.g., phosmet (formulated as Imidan™). For a more accurate picture of environmental toxicity in blueberry production, we need to obtain more complete data on pesticide use.

Toxicity rating ranged from 0 to 40 in our survey and varied according to farm type (Figure 2). IPM growers
had significantly higher ratings than organic and no-spray growers ($F_{(3,88)} = 12.05; P < 0.0001$). Toxicity ratings of IPM and conventional growers were not significantly different ($P > 0.05$) from each other. Ratings within groups showed high variation. Three conventional respondents had a rating of 0, and four were between 13 and 32. IPM growers also varied in toxicity rating (mean: 15.05; SD: 10.63). No IPM grower had a rating of 0, but 14 had ratings of less than 6; 40 were between 6 and 40; eight did not fill out this section of the survey. The highest rating among organic growers was 3. Nine no-spray growers had ratings of 0, and two used the herbicides glyphosate and/or sethoxydim, giving them ratings of 2 and 3. Increased toxicity rating, when pooled across pest management category, was positively associated with income from blueberries, years spent growing, and acres harvested each year (Figures 3–5). There was no correlation between toxicity rating and age ($P = 0.38$) or education ($P = 0.57$). Those who have spent more years growing wild blueberries had a higher toxicity rating ($r=0.3; P<0.01$), yet toxicity cannot be predicted by age. This could mean that growers use more pesticides the more years they spend as growers, or that inexperienced growers are not necessarily younger, or that new growers are deciding to use fewer pesticides, or that relationships are too variable to detect patterns with this index.

**Management Intensity**

Table 8 presents the practices of the growers summarized by pest management category. In Rogers’s *Diffusion of Innovations Theory* (1971), a practice is considered to be moving towards widespread adoption when more than 15% to 20% of the community adopts it. Here, to be conservative, we used 50% as a cutoff point to indicate whether we considered a practice to be characteristic of the group. There were some practices that were characteristic of all growers, independent of pest management category. Fifty percent or more from each group prune their fields by mowing, prune every other year, use some type of bee for pollination, and earn income from another job aside from blueberry growing.

No-spray growers and organic growers had similar toxicity ratings and practices; however, there are subtle differences between these two groups. The typical no-spray grower uses fertilizer (organic and nonorganic), but not sulfur; whereas the typical organic grower uses sulfur, but not fertilizer. One possible explanation for this is that more organic growers attend UMCE meetings, where sulfur is recommended. Organic growers might also be more wary of fertilizer because it promotes weed growth, and they cannot use nonorganic OMRI-approved herbicides. This leaves them with only expensive weed control options: labor-intensive hand
weeding or burning. Another difference between the two categories is that organic growers are more likely to grow blueberries full time and make more of their income from blueberries. No-spray growers might be thought of as low-input organic growers who are not officially certified by MOFGA, and who do not depend on wild blueberries for as much of their income.

Conventional and IPM growers are likewise similar except for a few differences. The typical IPM grower harvests more acreage, makes more income from blueberries, and has a higher toxicity rating than a typical conventional grower. IPM growers also use sulfur whereas conventional growers do not. IPM growers might be considered higher-input conventional growers who manage more intensively and depend on blueberries for more of their income. Conventional and no-spray growers might also be thought of as subcategories of the IPM and organic categories. The main difference is that the growers in these lower-input categories do not attend meetings as regularly and do not earn as much of their income from wild blueberries.

**Grower Priorities**

Participants were asked to rank ten factors that are important to them in regards to producing blueberries. Some growers expressed frustration at having to place a rank on these factors because all were important to them and no one aspect could be placed above others. For the most part, factors that farmers considered important generally did not differ between pest management categories.

“Maintaining the value of the land” and “making a profit” ranked high on everyone’s priority list,

![Graph showing the relationship between acres harvested yearly by each grower and toxicity rating.](image)

**Figure 5. The relationship between acres harvested yearly by each grower and toxicity rating (r = 0.44; P < 0.0001).**

**Table 8. Management intensity of a typical grower, by pest management group**

<table>
<thead>
<tr>
<th>Conventional</th>
<th>IPM</th>
<th>Organic</th>
<th>No-Spray</th>
<th>All Growers</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Prunes by oil burn</td>
<td>• Prunes by oil burn</td>
<td>• Prunes by mowing</td>
<td>• Prunes by mowing</td>
<td>• Prunes by mowing</td>
</tr>
<tr>
<td>• Prunes by mowing</td>
<td>• Prunes by mowing</td>
<td>• Prunes by mowing</td>
<td>• Prunes by mowing</td>
<td>• Prunes every other year</td>
</tr>
<tr>
<td>• Uses fertilizer</td>
<td>• Uses fertilizer</td>
<td>• Uses herbicides</td>
<td>• Uses sulfur</td>
<td>• Uses fertilizer</td>
</tr>
<tr>
<td>• Uses herbicides</td>
<td>• Uses herbicides</td>
<td>• Uses herbicides</td>
<td>• Uses sulfur</td>
<td>• Uses fertilizer</td>
</tr>
<tr>
<td>• Rents honey bees</td>
<td>• Rents honey bees</td>
<td>• Uses some type of bee</td>
<td>• Rents honey bees</td>
<td>• Uses some type of bee</td>
</tr>
<tr>
<td>• Uses more than 1 hive per acre</td>
<td>• Uses more than 1 hive per acre</td>
<td>• Uses some type of bee</td>
<td>• Rents honey bees</td>
<td>• Uses some type of bee</td>
</tr>
<tr>
<td>• Uses pesticides</td>
<td>• Uses pesticides</td>
<td>• Has pesticide license</td>
<td>• Uses pesticides</td>
<td>• Uses pesticides</td>
</tr>
<tr>
<td>• Harvests more than 21 acres average</td>
<td>• Harvests more than 21 acres average</td>
<td>• Harvests more than 15% of income from berries.</td>
<td>• Harvests more than 21 acres average</td>
<td>• Harvests more than 21 acres average</td>
</tr>
<tr>
<td>• Makes more than 15% of income from berries.</td>
<td>• Makes more than 15% of income from berries.</td>
<td>• Toxicity rating &gt; 14</td>
<td>• Toxicity rating &gt; 14</td>
<td>• Toxicity rating &gt; 14</td>
</tr>
<tr>
<td>• Earns income from another job</td>
<td>• Earns income from another job</td>
<td>• Earns income from another job</td>
<td>• Earns income from another job</td>
<td>• Earns income from another job</td>
</tr>
</tbody>
</table>

1 A characteristic was added under the pest management category if more than 50% of those growers maintained that practice.
Table 9.  Factors of personal importance by pest management category, ranked in order of personal importance, with 1 as most important and 10 as least important. Numbers are percentage of growers who placed the factor among their top three choices.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Conventional (n = 12)</th>
<th>IPM (n = 64)</th>
<th>Organic (n = 13)</th>
<th>No-Spray (n = 11)</th>
<th>All Growers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Making a profit</td>
<td>31</td>
<td>57</td>
<td>57</td>
<td>46</td>
<td>58</td>
</tr>
<tr>
<td>Maintaining land value</td>
<td>50</td>
<td>50</td>
<td>43</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>Providing healthy food for public</td>
<td>19</td>
<td>43</td>
<td>71</td>
<td>46</td>
<td>48</td>
</tr>
<tr>
<td>Continuing family’s legacy</td>
<td>44b</td>
<td>37b</td>
<td>14a</td>
<td>31a</td>
<td>38</td>
</tr>
<tr>
<td>Spending time outdoors</td>
<td>38</td>
<td>29</td>
<td>29</td>
<td>31</td>
<td>34</td>
</tr>
<tr>
<td>Being a steward of the environment</td>
<td>13</td>
<td>28</td>
<td>57</td>
<td>38</td>
<td>34</td>
</tr>
<tr>
<td>Keeping land open/undeveloped</td>
<td>13</td>
<td>28</td>
<td>29</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td>Being a part of ME’s blueberry culture</td>
<td>6</td>
<td>24</td>
<td>14</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Helping to further scientific research</td>
<td>13</td>
<td>13</td>
<td>21</td>
<td>38</td>
<td>19</td>
</tr>
<tr>
<td>Maintaining community relations</td>
<td>13</td>
<td>18</td>
<td>14</td>
<td>15</td>
<td>18</td>
</tr>
</tbody>
</table>

1 Differences between categories were estimated using Tukey’s multiple comparisons test. Pest management category percentages marked by the same letter are not different and rows with no letters refer to factors where there were no differences (P ≤ 0.05).

independent of pest management category (Table 9). Most growers placed community, culture, and scientific research at the bottom of their priorities. The only difference between pest management categories was that IPM and conventional growers were more concerned about continuing their family’s legacy than organic and no-spray growers ($F_{(3,79)} = 3.04; P = 0.03$). When the categories are combined, however, so that conventional is together with IPM and organic is with no-spray, maintaining the value of the land becomes more important to IPM/conventional growers than to organic/no-spray ($F_{(1,94)} = 5.15; P = 0.02$).

Growers were allowed to add their own comments to this section. One organic grower noted, “Lessening input of all pesticides is key—we are all stewards, not owners, of the land. Educating conventional growers towards this mind-set is crucial.” Another organic grower added, “Practicing my ideas without supervision” and “Independence in land management” to the list of important factors. Three IPM growers added comments: “I feel good about making a living wage while being productive”; “I take pride in being part of the Blueberry Industry and being an American Farmer”; and “Providing a safe work environment for us and those who help during the harvest.” One no-spray grower added, “Supporting education and years growing ($r = 0.046; P = 0.64$), and no correlation between education and the number of generations farming ($r = 0.039; P = 0.71$). There also were no correlations between education and part- or full-time status, or between education and income acquired from another job. It was difficult to determine whether we should analyze the responses of growers with partners according to the highest level of education achieved between them, or whether we should use only the education level of the respondent. Some partnerships may be making decisions together, while others may have one member making the majority of the management decisions. We analyzed this data both ways and found no correlation between joint years of education and income or full-time status.

It appeared that as education increased among growers, priorities such as “furthering scientific research,” and “keeping land open and undeveloped” decreased. However, this was found to be a case of Simpson’s paradox (Simpson 1951). The outcome was different when we blocked the data first by management style and then analyzed for education level. We analyzed the education levels of the respondents and grouped their priorities according to pest management category. Among IPM growers, as education level increased, the priorities of the small farm... growers who have been ‘shut out’ by large companies” as an important factor.

There were no relationships between personal beliefs and grower age or acres farmed. When analyzed in regards to income, those who earn a higher percentage of their income from blueberries placed more importance on maintaining the value of their land ($r = 0.22; P = 0.05$). Similarly, growers who have been growing blueberries for longer, rate their family higher on their scale of importance ($r = 0.234; P=0.03$). There was no correlation between education and years growing ($r = 0.046; P = 0.64$), and no correlation between education and the number of generations farming ($r = 0.039; P = 0.71$). There also were no correlations between education and part- or full-time status, or between education and income acquired from another job. It was difficult to determine whether we should analyze the responses of growers with partners according to the highest level of education achieved between them, or whether we should use only the education level of the respondent. Some partnerships may be making decisions together, while others may have one member making the majority of the management decisions. We analyzed this data both ways and found no correlation between joint years of education and income or full-time status.

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furthering scientific research ($r = -0.422; P = 0.002$), keeping land open and undeveloped ($r = -0.287; P = 0.04$), and maintaining community relations ($r = -0.401; P = 0.004$) decreased. Among organic growers, those with more education valued spending more time outdoors ($r = 0.622; P = 0.04$) and increasingly being a steward of the environment ($r = 0.612; P = 0.04$).

## Opinions about Pesticide Safety

One question on the survey attempted to gauge growers’ belief that new pesticides will always be available. Another was aimed at understanding growers’ beliefs about the safety of legal pesticides (Table 10). IPM growers agreed more with the statement, “Scientists will be able to research new pesticides when insects become resistant to old ones” than organic and no-spray growers did ($F(3, 92) = 6.17; P < 0.01$). IPM growers also agreed more with the statement that “Legal pesticides must be safe since they were approved by the pesticide board” than did organic and no-spray growers ($F(3, 94) = 9.10; P < 0.01$). One IPM grower wrote: “Safe use of approved pesticides depends on applicator’s education and experience.” Conventional growers were distinguishable from no-spray growers in the first question and from organic growers in the second question. The differences became even stronger when conventional and IPM growers were combined into one group and no-spray and organic growers were combined into another, with the IPM/conventional growers having more confidence in scientists’ research ability ($F(1, 91) = 20.25; P < 0.0001$) and more confidence in the safety of legal pesticides than organic/no-spray growers ($F(1, 93) = 23.68; P < 0.0001$).

Opinions about research and pesticide safety could not be predicted by any of the following factors: education, age, years growing blueberries, or income. However, those with more wild blueberry acreage have more confidence in the safety of legal pesticides than those with fewer ($r = 0.217; P = 0.03$), and as previously discussed, those with more acres also have a higher toxicity rating and make more of their income from blueberries. Studies have shown that those who use pesticides have more confidence in their safety than those who do not use them (Coppin et al. 2002; Nieuwenhuijsen et al. 2005), and that women, younger adults, and more highly educated people trust the reported safety of pesticides less (Coppin et al. 2002). Organic and no-spray growers may know less about pesticide environmental toxicity since they rarely, if ever, use them, or they may purposely seek out information regarding pesticide toxicity.

## Grower Sources of Production Information

Growers were asked to rate the factors that were most influential in causing them to change their practices or to learn new information. A rating of 5 indicated a factor was highly influential, 1 indicated no influence, and 3 indicated a moderate influence. Growers overall were most influenced by recommendations from UMCE, including fact sheets and workshops, and least influenced by pressure from agricultural/industrial companies and media such as newspapers and television (Table 11). Growers who practice IPM were significantly more influenced by UMCE than conventional growers, but not more than organic or no-spray growers.

Respondents who have been growing blueberries longer are more influenced by blueberry grower web sites ($r = 0.209; P = 0.056$) and more influenced by UMCE fact sheets ($r = 0.202; P = 0.05$). Growers with more acres are less influenced by the media ($r = -0.216; P = 0.03$), and those who depend on blueberries for more of their income are more highly influenced by demonstration plots.

### Table 10. Opinions about pesticide safety by pest management category. Growers rated their opinions according to: 1= strongly disagree; 2= slightly disagree; 3= neutral; 4= slightly agree; and 5= strongly agree. Pest management categories followed by the same letter are not significantly different. Standard deviation in brackets [ ].

<table>
<thead>
<tr>
<th>Statement</th>
<th>Conventional</th>
<th>IPM</th>
<th>Organic</th>
<th>No-Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Scientists will be able to research new pesticides when insects become resistant to old ones.”</td>
<td>3.91ab [0.944]</td>
<td>3.85a [1.046]</td>
<td>2.7bc [1.418]</td>
<td>2.55c [1.695]</td>
</tr>
<tr>
<td>“Legal pesticides must be safe since they were approved by the pesticide board.”</td>
<td>3.33ab [1.073]</td>
<td>3.27a [1.339]</td>
<td>1.42c [0.996]</td>
<td>2.09bc [1.300]</td>
</tr>
</tbody>
</table>
than those who depend on them for less ($r = 0.247; P = 0.03$). Older growers are more strongly influenced by UMCE workshops ($r = 0.233; P = 0.02$) and fact sheets ($r = 0.294; P = 0.004$) than younger growers. In summary, UMCE may be more likely to reach IPM and organic growers who have been growing for a longer time, growers who make more money from blueberries, or who are older.

Our study found that IPM and organic growers attend UMCE meetings more regularly than no-spray and conventional growers and that both groups depend on blueberries for more of their income than no-spray or conventional growers (Table 12). A possible explanation for this finding may be that growers who depend on blueberries for their livelihood may put more effort into learning about research-based practices and may be more likely to incorporate suggestions from university-based findings. Similar results were reported in 2000 by researchers in Greece, who found that growers with more income tend to be more involved with extension programs (Papadaki-Klavdianou et al. 2000).

IPM growers were most likely of all groups to attend UMCE grower meetings, workshops, and events regularly (84%), followed by organic growers (54%), conventional growers (42%), and no-spray growers (30%). IPM growers stated that they attend because they wish to earn credits towards their pesticide applicator’s license (Table 12). But they also cited curiosity and convening with other growers as reasons for attendance. The organic growers who attend these meeting are interested in increasing

Table 11. Average rating of influential factors for each pest management category, ordered highest to lowest according to pooled rankings of all growers together. ANOVA and Tukey analyses were conducted. Category means not followed by the same letter are significantly different.

<table>
<thead>
<tr>
<th>Factors Influencing Decision-Making</th>
<th>Conventional</th>
<th>IPM</th>
<th>No-Spray</th>
<th>Organic</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Extension recommendations</td>
<td>4.00b</td>
<td>4.69a</td>
<td>4.09ab</td>
<td>4.42ab</td>
<td>4.30</td>
</tr>
<tr>
<td>2 Fact sheets/bulletins</td>
<td>4.00</td>
<td>4.60</td>
<td>4.45</td>
<td>4.00</td>
<td>4.26</td>
</tr>
<tr>
<td>3 Other farmers, family, or neighbors</td>
<td>3.83</td>
<td>3.74</td>
<td>3.67</td>
<td>4.08</td>
<td>3.83</td>
</tr>
<tr>
<td>3 Workshops/meetings</td>
<td>3.18b</td>
<td>4.38a</td>
<td>3.89ab</td>
<td>3.82ab</td>
<td>3.82</td>
</tr>
<tr>
<td>4 Demonstration plots</td>
<td>2.45b</td>
<td>3.70a</td>
<td>3.70ab</td>
<td>2.91ab</td>
<td>3.19</td>
</tr>
<tr>
<td>5 Web sites</td>
<td>2.67</td>
<td>3.06</td>
<td>2.60</td>
<td>2.30</td>
<td>2.66</td>
</tr>
<tr>
<td>6 State or federal government</td>
<td>2.17</td>
<td>2.93</td>
<td>2.27</td>
<td>2.08</td>
<td>2.36</td>
</tr>
<tr>
<td>7 Media (newspaper, TV, movies)</td>
<td>2.25</td>
<td>2.18</td>
<td>2.80</td>
<td>2.15</td>
<td>2.35</td>
</tr>
<tr>
<td>8 Agricultural/pesticide companies</td>
<td>2.08</td>
<td>2.42</td>
<td>2.00</td>
<td>1.58</td>
<td>2.02</td>
</tr>
</tbody>
</table>

Rating = 1: not influential at all; 3: neutral; 5: highly influential

Table 12. Grower attendance in UMCE workshops or field meetings, and reasons for attending or not attending, by grower group. Total counts by category are given, followed, within parentheses, by total percentages of each group.

<table>
<thead>
<tr>
<th>Pest Management Category</th>
<th>Attends Regularly</th>
<th>Reason for Attending</th>
<th>Reason for Not Attending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Earn Credits</td>
<td>Learn</td>
<td>Convene with Others</td>
</tr>
<tr>
<td>Conventional</td>
<td>5 (42%)</td>
<td>4 (33%)</td>
<td>3 (25%)</td>
</tr>
<tr>
<td>IPM</td>
<td>54 (84%)</td>
<td>51 (80%)</td>
<td>46 (72%)</td>
</tr>
<tr>
<td>No-spray</td>
<td>3 (30%)</td>
<td>3 (30%)</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Organic</td>
<td>7 (54%)</td>
<td>4 (31%)</td>
<td>6 (46%)</td>
</tr>
</tbody>
</table>
| Total                    | 69                | 62                   | 57                      | 48         | 2       | 17         | 2
their knowledge. Approximately 42% of the conventional and 40% or the no-spray growers said they live too far from where meetings are held. Currently, blueberry grower meetings are held in six locations (Waldoboro, Union, Orland, Ellsworth, Jonesboro, and Machias) so that most growers do not have too far to travel. Only two growers did not find the meetings useful, and they were no-spray growers. Sixty percent of no-spray growers did not attend UMCE meetings regularly, perhaps because they are low-input growers and the University of Maine faculty usually addresses labor-, capital-, or knowledge-intensive management techniques. In regard to the diffusion of innovations theory, these data suggest that no-spray and conventional growers have less contact with change agents and with avenues of influence outside of their own communities and, therefore, may be slower to learn of and adopt new technologies.

The grower groups who attend the UMCE meetings regularly (IPM and organic) are also the grower categories that depend on wild blueberries for a considerable part of their income. IPM growers earn an average of 34.4% of their income from blueberries, while organic growers earn an average of 33.5%. This dependence on blueberry income may make them more interested in learning new, effective management techniques.

Studies in other U.S. states and of other cropping systems have suggested that organic growers feel extension has little to offer them (MacRae et al. 1990; Agunga 1995; Hanson et al. 1995; Padel 2001; Tavernier and Tolomeo 2004). Additionally, many operators of smaller farms hold other jobs and might not be available during the times when extension meetings are offered. These studies suggest that organic growers rely more on each other as sources for information, and on smaller sustainable agriculture groups. Egri (1999) reported that extension services spent little time promoting organic practices. This was not found to be true for Maine wild blueberry growers, as evidenced by the percentage of growers who attend UMCE meetings regularly (54%) and by the level of influence that UMCE has in their decision making (Table 12). Furthermore, organic growers and growers in all pest management categories rate UMCE positively. This may be due to the special effort made by the faculty of the Maine wild blueberry group to hold meetings in the evening or on weekends. They also offer one or more meetings per year specifically geared toward organic practices. Even though attendance is not required, since most organic growers do not need a pesticide applicators license, about half of Maine’s organic growers attend regularly. One would expect no-spray growers to not be as influenced by UMCE, but they also attend the meetings regularly to some degree (30%) and are more influenced by UMCE than they are by other factors.

A 2006 survey of organic wild blueberry growers in Maine showed that their preferred method of learning varied from hands-on demonstrations to University of Maine lectures and workshops, to trade journals, or the Internet (Files et al. 2008). In our current study, we asked for information about what sources influenced growers’ decision making. IPM growers were significantly more influenced than other growers by UMCE, but that all growers rated university outreach as highly influential. Other farmers, family, or neighbors were also influential to all growers. The effects of mass media when it comes to farmer practices have been poorly studied, especially in cases where mass media is not readily available to community members (Ricker-Gilbert et al. 2008). Maine wild blueberry growers may have limited access to the Internet and other media sources, as growers in all pest management categories rated the Internet and media as not very influential.

**COMPARISON OF BLUEBERRY GROWERS: 1974 AND 2010**

A study by Metzger and Ismail (1976) summarized management practices of wild blueberry growers in 1974, based on a survey of wild blueberry growers on a UMCE mailing list. In 1974, most growers used a two-year pruning cycle, letting half of their crop fruit while pruning the other half. The 1976 study differentiated between types of burning, including burning by hay, burning by hay and either gas or oil, and straw and gas or oil (Table 13). It is therefore difficult to say whether burning with oil and burning with straw have increased since 1974. What is recorded in Table 13 as “other” actually includes burning with oil in conjunction with other materials. In fact, the use of oil could have decreased from 1974 to 2010 if one considers that oil was counted under various headings in the earlier study. It is also likely that oil use was low in 1974, due to the 1973 oil embargo and increased oil prices worldwide (Roeder 2005). Burning with straw alone also seems to have increased since
1974 by 25%. This may seem surprising because of the amount of labor involved, especially when other options are now available, but in the earlier survey straw was also combined with hay and gas under “other,” and the increase is probably less than 25%.

Mowing, use of fertilizers and herbicides, and use of rental bees have increased since 1974. The data from our 2010 study include those who are actively depending upon honey bees and bumble bees. It is most likely that Metzger and Ismail (1976) were referring only to honey bee rental. Native bee conservation was not mentioned because the idea was not introduced until the 1990s (Stubbs et al. 1997). Rental of honey bees has been steadily increasing since the 1960s (Drummond 2002), and studies since then show positive relationships between yield and honey bees (Aras et al. 1996). Table 13 shows the decrease in the percentage of growers who use insecticides since 1974. This may not be a real decrease (i.e., statistically significant), but compared to increases in all of the other management technologies, it is interesting that insecticide use has gone down. We believe that this decrease is due to the adoption of IPM and the increase in organic and no-spray growers since 1974 (Drummond et al. 2009a).

Interestingly, the number of growers harvesting less than 20 acres and more than 100 acres has increased slightly since 1974 (Table 14), whereas the number with medium-sized farms has decreased slightly. Metzger and Ismail (1976) also collected information about costs per acre of each practice in 1974. They found that both medium- and small-sized operations spent more per acre on herbicide applications than large-sized farms, while small- and large-sized farms spent more per acre on burning than medium-sized farms. Medium-sized farms in 1974 were spending less per acre on burning, but more on herbicides. The researchers did not find any associations between size of operation and costs of fertilization or pollination. The decrease in medium-sized farms and the increase in small- and large-sized farms might be explained by increased profitability of organic produce. Marra et al. (1995) support this idea. They looked at profitability of three production styles of Maine wild blueberry growers and found that organic production was actually more profitable than either IPM or conventional. The higher value of organic blueberries, coupled with lower input costs, high demand, and limited supply are essential to the survival of small blueberry farms (Marra et al. 1995). This economic advantage is most likely the factor that has resulted in the major increase in organic acreage during the last 15 years (Drummond et al. 2009b).

**SUMMARY**

Our 2010 survey of wild blueberry growers resulted in several findings. We learned that managers and/or growers have different perspectives from blueberry landowners. Growers are more concerned about land stewardship and adoption of new scientific advances in blueberry production. In addition, managers/growers are more likely to improve management to enhance profit. The survey also confirmed that Washington County has the largest acreage of wild blueberry and represents the largest concentration of growers. Additionally, the survey showed that wild blueberry growers are fairly old—average age of 60—and most have either attended some college or completed a bachelor’s degree, and 40% of growers farm with their spouse. According to survey

<table>
<thead>
<tr>
<th>Practice</th>
<th>% in 1974</th>
<th>% in 2010</th>
<th>Difference in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mowing</td>
<td>78</td>
<td>87</td>
<td>+9</td>
</tr>
<tr>
<td>Burning: oil</td>
<td>29</td>
<td>44</td>
<td>+15</td>
</tr>
<tr>
<td>Burning: straw</td>
<td>8</td>
<td>33</td>
<td>+25</td>
</tr>
<tr>
<td>Burning: other</td>
<td>58</td>
<td>not reported</td>
<td></td>
</tr>
<tr>
<td>Fertilizer use</td>
<td>19</td>
<td>74</td>
<td>+55</td>
</tr>
<tr>
<td>Insecticide use</td>
<td>73</td>
<td>60</td>
<td>-13</td>
</tr>
<tr>
<td>Herbicide use</td>
<td>42</td>
<td>76</td>
<td>+34</td>
</tr>
<tr>
<td>Use of bees</td>
<td>23</td>
<td>79</td>
<td>+56</td>
</tr>
</tbody>
</table>

**Table 13. Comparison of management practices in 1974 vs 2010. “Other” includes burning with: hay, gas, straw-hay, straw-gas, straw-oil.**

<table>
<thead>
<tr>
<th>Acres</th>
<th>% in 1974</th>
<th>% in 2010</th>
<th>Difference in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>52</td>
<td>58</td>
<td>+6</td>
</tr>
<tr>
<td>21–50</td>
<td>23</td>
<td>20</td>
<td>-3</td>
</tr>
<tr>
<td>51–100</td>
<td>17</td>
<td>10</td>
<td>-7</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>7</td>
<td>11</td>
<td>+4</td>
</tr>
</tbody>
</table>

**Table 14. Amount of acres harvested per grower in 1974 vs 2010 represented as a distribution of the grower community.**
results, about half of growers farm part time and earn only 15% of their annual income through blueberry farming, which may have implications as future markets and requirements of crop production change. For example, as blueberry production becomes more knowledge intensive, remaining competitive and producing a high-quality product will require more education and more logistical planning; which may be more difficult for growers who have to spend a large proportion of their time and effort in a job off the farm.

Our survey allowed a diverse set of blueberry growers to categorize themselves into one of four production philosophies—conventional, IPM, organic, and no-spray—reflecting their perspectives and practices. Although growers in any one of these four categories differed from growers in other categories, they also shared many perceptions and behaviors, and their similarities allowed us to align the four categories into two overarching groups.

We found several similarities between IPM and conventional growers, for example. According to our survey results, there was no difference between them with regard to leaving an unsprayed buffer around their fields; selecting pesticides that are less harmful to the environment; or using perimeter insecticide applications to manage pests. Because of these similarities, we can consider IPM and conventional as constituting one group—“pesticide adopters.” Our survey found several similarities between no-spray and organic growers, particularly involving their pesticide management strategies, pesticide toxicity ratings, and beliefs about pesticide safety. These similarities allow us to consider organic and no-spray growers as a second group—“pesticide avoiders.”

These two groups—pesticide adopters and pesticide avoiders—can also be thought about in terms of high-intensity management vs low-intensity management. The pesticide-adopter group is characterized by their use of fertilizers, pesticides, and honey bees, their higher toxicity rating, and their confidence in the safety of pesticides. As a group, these growers value making a profit, maintaining land value, and providing healthy food for the public and a legacy to pass on to their family. Pesticide-avoiders are characterized by their no or minimal use of pesticides and by their lower likelihood to rent or purchase commercial bees. These growers value providing healthy food for the public, making a profit, and being a steward of the environment (Table 15). Growers in both major groups, however, place a high value on producing healthy food for the public. It is this concern and pride by growers about producing a high-quality food that ensures a healthy agricultural production system for the future.

It is difficult to predict how growers might change their philosophies, perspectives, and practices in the coming decades as global markets increase in market share, competition increases from the producers of highbush blueberry, more stringent restrictions on pesticide residues on fruit are enacted, and climate change alters plant and pest growth and development in Maine. However, based upon our analysis of grower diversity it appears that the Maine wild blueberry grower community has a foundational strength in its current diversity. This diversity should enable rapid adaptation to change in an increasingly uncertain future.

### Table 15. Main concerns of blueberry growers (percentage selecting answer as one of their top three).

<table>
<thead>
<tr>
<th>Grower Groups</th>
<th>Land Value</th>
<th>Profit</th>
<th>Healthy Food</th>
<th>Maine Culture</th>
<th>Family Legacy</th>
<th>Being Outdoors</th>
<th>Stewards</th>
<th>Research</th>
<th>Open Land</th>
<th>Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide Adopters</td>
<td>77%</td>
<td>80%</td>
<td>61%</td>
<td>34%</td>
<td>59%</td>
<td>48%</td>
<td>41%</td>
<td>23%</td>
<td>45%</td>
<td>29%</td>
</tr>
<tr>
<td>Pesticide Avoiders</td>
<td>54%</td>
<td>63%</td>
<td>71%</td>
<td>25%</td>
<td>29%</td>
<td>38%</td>
<td>58%</td>
<td>38%</td>
<td>42%</td>
<td>25%</td>
</tr>
</tbody>
</table>

It is difficult to predict how growers might change their philosophies, perspectives, and practices in the coming decades as global markets increase in market share, competition increases from the producers of highbush blueberry, more stringent restrictions on pesticide residues on fruit are enacted, and climate change alters plant and pest growth and development in Maine. However, based upon our analysis of grower diversity it appears that the Maine wild blueberry grower community has a foundational strength in its current diversity. This diversity should enable rapid adaptation to change in an increasingly uncertain future.
LITERATURE CITED


Kristo, A.S., A.Z. Kalea, D.A. Schuschke and D. J. Klimis-Zacas. 2010. A wild blueberry-enriched diet (Vaccinium


