FY 2013 Specialty Crop Block Grant Program

Maine Department of Agriculture, Conservation and Forestry

Final Report

AMS Agreement No. 12-25-B-1674

Submitted by:

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Project 1: Supporting Maine Specialty Crop Producers with Good Agricultural Practice and Good Handling Practice (GAP/GHP) Audit Preparation; Produce GAP's Harmonized Audit Preparation, and Assistance with Other Third Party Food Safety Audits

Final Report – Previously Submitted

Project Summary

Maine has 1572 Specialty Crop farms (NASS 2012) and averages approximately 106 Food Safety GAP audits per year. AgMatters LLC worked with 35 of them. This year there were 4 Produce GAPs Harmonized Audits performed. AgMatters worked with three of them.

Supporting Maine Specialty Crop Producers with Audit Preparation Year 2 focused on assisting Specialty Crop growers with preparation for GAP/GHP and Produce GAPs Harmonized audits.

It built on and was a result of needs we noted for a grant we wrote and were funded for the year before.

It is especially timely because Food Safety is always in the news, especially with FSMA and the Produce Safety Rules. We note that the science behind the audits has not changed over the last few years; however we are sure that when FSMA is done, scientific based expectations will affect current audits.

AgMatters LLC would like to acknowledge and thank our project partners, the Maine Vegetable and Small Fruit Growers Association and the Maine Pomological Society. Both groups have gone out of their way to offer opportunities for us to share at their meetings. Many of their memberships have utilized the services of this grant and shared their knowledge with others. Both groups have been there whenever they were asked for assistance.

Project Approach

AgMatters LLC began the work of this grant on October 1, 2013 and concluded it on September 30, 2014. We prepared and revised GAP and GAP Harmonized materials for distribution to growers. Copies were sent via email, regular mail, and brought to every audit training session held. We have distributed approximately 45 pages of materials to each person we have trained. We have worked with over 115 people with this grant. We talked with and worked with Hannaford Markets to clarify their expectations for growers. Other markets (Shaw's, Whole Foods, distribution centers like SYSCO; Crown of Maine; & Martha Putnam) also became accepting and trusting of GAP audits for their growers. We have worked with and presented to Maine Farmland Trust's Food Hub, The New American Sustainable Agriculture Project (NASAP) Cultivating Community, University of Maine's Extension Food Safety Programs, the Certified Crop Advisors of New England training, The New England Food Policy Building A Sustainable Food System's Webinar #9 "Food Safety: The Elephant on the Farm", as well as with Kennebec Valley Community College's Agricultural Program and leadership.

AgMatters LLC has spent time educating themselves about the future direction of food safety, FSMA, and lessons learned from other's food recall experiences. We have helped to disseminate information about the Produce Safety Rule to Maine growers.

Maine auditors have been very helpful in making us aware of issues that arise with GAP/GHP and Produce GAPs Harmonized audits, so that we can take steps to train growers more appropriately.

Evaluations have been given out when appropriate and their content was studied and applied to future presentations.

AgMatters LLC presented to over 600 Maine growers during this grant year. One on one Food Safety Audit Training was given to 115 individuals. Four growers were assisted as they prepared for Produce GAPs Harmonized Audits. This preparation is more time consuming, simply because of the detail required in the audits.

Each meeting was unique. Each farm is different and needs to understand how they fit into the GAP picture. Growing and harvesting tomatoes is very different than beets. Each crop has its own special requirements. Growers need an idea of what is expected by an auditor, so that they can meet those requirements. AgMatters LLC's template for Food Safety Plans is a beginning point in each training. As we proceed through the process, it becomes easier to tailor the plan to the individual farm and process.

AgMatters LLC would like to acknowledge and thank our project partners, the Maine Vegetable and Small Fruit Growers Association and the Maine Pomological Society. Both groups have gone out of their way to offer opportunities for us to share at their meetings. Many of their memberships have utilized the services of this grant and shared their knowledge with others. Both groups have been there whenever they were asked for assistance.

AgMatters LLC feels that we have been very successful in our task of assisting growers with Food Safety Audit preparation. All allocated monies have been spent.

Goals and Outcomes Achieved

Measureable Outcomes

Supporting Maine Specialty Crop Producers with Good Agricultural Practice and Good Handling Practice (GAP/GHP) Audit Preparation; Produce GAP's Harmonized Audit Preparation, and Assistance With Other Third Party Food Safety Audits. Year 2

A minimum of 40 growers who participate with this grant will receive assistance preparing for Food Safety audits such as GAP/GHP , Produce GAP's Harmonized Audits, Global GAP, and GSFI recognized programs such as SQF 1000 or other third party audits. This will include recertification, new certification, or increased certification levels for these farms.

Outcome: A list of participants for the grant and a list of certifications earned during the year will be maintained by AgMatters LLC.

Reality: AgMatters LLC did outreach and training and reached over 700 individuals. 115 people were trained through one-on-one meetings.

35 of those trained chose to pursue follow up certification and received it.

It is safe to say that all improved their knowledge of food safety, whether they pursued certification or not.

The one on one grower work will continue to evolve and improve, based on grower feedback.

Outcome: Evaluations will be given to each grower. Resulting feedback will be studied and incorporated into the program. Results will be saved and summarized so they can be reported in the grant's final report.

Reality: Evaluations were very positive. Of 102 returned evaluations, 96 rated the quality of our work as good to excellent. 85 rated the importance of food safety as high. As a result of our work, 97 felt more confident about their knowledge of food safety.

There was one suggestion for improvement that was to schedule more than three hours for a session and there was another that stated it was just the right amount of time. Many comments echoed the relief in finally knowing what was real and what was rumor in food safety. All were appreciative of our materials and their easy access on our web site.

AgMatters LLC will hold a large group meeting at the Maine Agricultural Show held in January, 2014.

Outcome: Agendas for the programs will be kept and attendance numbers will be saved.

Reality: AgMatters LLC spoke to the Maine Small Fruit and Vegetable Growers (60) and the Maine Pomological Society (30) Annual meetings held at the show.

The agenda included reminders that AgMatters LLC was available to help growers learn more about and or prepare for GAP or Harmonize GAP audits at their convenience. It included a comparison between GAP and GAP Harmonized audits. It included an update on what was new with the audits. It also alerted growers about a proposal to increase the cost of the audits by several hundred dollars and organized an effort for growers to respond to that. As a result, the move to increase the costs was defeated.

AgMatters LLC will speak to at least three other grower meetings during the year, sharing information about the grant and encouraging others to undertake a Food Safety Audit.

Outcome: Records will be kept of speaking engagements, as well as numbers in the audience.

Reality: AgMatters LLC presented food safety information at many meetings throughout the year.

Presented at a Crop Advisor's Training in Portsmouth, NH. (25 attendees)

Met with Under Secretary Edward Avalos who acknowledged and appreciated AgMatters LLC's efforts and commitment to helping growers obtain GAP certification through Specialty Crop Grants.

Presented at Extension Vegetable School in Portland-GAP basics (93 attendees)

Presented at Extension Vegetable School in Bangor-GAP basics (77 attendees)

Presented at Oxford County Extension Office a complete GAP training (20 attendees)

Trained Somalian ESL class on the Basics of Food Safety and GAP audits (30 attendees)

Trained area farmers in Sweden area on GAP audit expectations/walkabout (8 attendees)

Spoke at MVSFGA Twilight Meeting in Richmond (30 attendees)

Trained KVCC class on basics of GAP Audits (10 attendees)

Participated as a presenter in New England Food Policy Webinar #9, Food Safety: The Elephant on the Farm (70 enrolled)

Materials put together by AgMatters LLC to assist growers with this process will be shared on their website (www.agmattersllc.com) and updates will be sent out in regular email notifications to growers on a regular basis.

Outcome: A summary of these materials will be made in the final report.

Reality: All materials related to Food Safety and audits on our website (AgMattersLLC.com) have been updated this grant year.

An email distribution list has allowed us to share important information with those we have worked with. We have sent out five email updates this year. We try not to overuse the tool. We have gotten good feedback to date, thanking us for sending out that information.

In January, the hot topic was a proposal to have a blanket price increase for the cost of an audit by several hundred dollars. Email helped raise awareness of the situation and eventually helped to squelch the effort by USDA to increase the cost of audits.

Bleach and its use on food contact surfaces and on food have been the hot topic most of the summer because it has become a directive to auditors to make sure growers are following the label restrictions of the chemical and that they have the label in hand. AgMatters LLC has researched the issue and shared their findings with growers so they are prepared for this portion of the audit.

Materials on our website:

Food Safety Plan Templates for GAP 1, 2 & 3

USDA GAP Audit Verification Checklist

Food Safety Plan Template for Harmonize GAP Harvest and Post-harvest

GAP Harmonized Standards and Audit forms for Harvest and Post-harvest

We have other materials that we have put together that we distribute to growers as needed. These include alternative mock recall forms for specific retailers; advisories on cleaning and sanitizing; links to other resources, hints on where to locate specific supplies, how to organize the growing year in relation to audit recommendations…

Beneficiaries:

This project directly benefitted all Maine Specialty crop growers. Although only 35 growers chose to be certified. AgMatters LLC worked with 75 others who wanted to know more about food safety but who chose not to certify.

Most who do not certify verbally cite the cost of the certification as the cause. It is our experience that growers want to do the best job they can to grow the best produce they can. They learn and use what they feel will make the biggest impact on the quality of their product.

In summary,

Over 700 producers were exposed to some knowledge of Food Safety by AgMatters LLC through talks at different venues.

115 growers met with AgMatters LLC one -on -one to be trained to be prepared for an audit.

35 of those trained actually went on to achieve their certification.

We feel that this grant was hugely successful and more than met all of its goals.

The potential impact of the grant is the knowledge of food safety imparted in the training, and the ability of growers who do become certified to grow their markets.

When there have been funds to reimburse growers for part of the cost of the audits, there were more audits done for small growers. That reimbursement funding disappeared two years ago, and that loss also caused many small growers to stop getting audited, simply because of the cost.

Lessons learned:

Offering food safety training assistance is only part of what is needed to encourage small growers to be audited. Somewhere, there has to be the ability to recoup some of the costs of the audit.

AgMatters LLC received 8 calls and emails asking for assistance from NH and MA growers. We have never refused. Most of these trainings occurred over the phone, each taking several hours and we did not count these encounters in our totals for this grant because they were not Maine growers.

However, because we believe there is an understanding that we are part of New England and we were prepared, we just did it.

This project began on October 1, 2013 and ended on September 30, 2014.We have received a Specialty Crop Grant for 2014-15. We have been funded at a half-time level for one more year.

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Project 2: Providing Food Safety Training in the Era of the Food Safety Modernization Act

Final Report – Previously Submitted

Project Summary

The Food and Drug Administration's (FDA) food safety regulations are currently in the proposal and comment phase, it is clear that the need for food safety protocols and verification of plans for many markets will soon be the norm. While many farms selling to wholesale markets have made a commitment to some type of food safety verification others are not aware of the need for food safety plans or how to go about producing or complying with them. Whether farmers sell to markets requiring food safety verifications or not, awareness of industry standards and potential regulations will be critical to success in the years ahead.

Project Approach

The FDA released its proposed food safety rule (FSMA) in January 2013. MOFGA Staff members David Colson and Cheryl Wixson were part of the National Sustainable Agriculture Coalition Food Systems Integrity working group reviewing the proposal, participating in weekly conference calls. Staff then initiated discussion with the Maine Department of Agriculture, Conservation and Forestry on the FDA's proposal. Consequently MOFGA submitted a proposal to the Department, which was submitted through the Federal Specialty Crop Block Grant. The following is the activity report on that grant. The following goals were proposed for the project:

Goal 1: MOFGA will design, plan, and implement Four to Six training sessions on basic food safety protocols around the State of Maine.
Outcomes: Trainings sessions were provided at MOFGA's Farmer-to-Farmer Conference, at the 2014 Agricultural Trade Show, at growers meetings in York and Aroostook Counties and at the Maine Federation of Farmer's Markets winter convention.
Performance Measure: 150 farms sign up for training sessions in basic food safety protocols and potential impacts from the Produce Rule.
Bench Mark: 75 farms participate in training sessions
Target: 5 farms schedule audit of their food safety plan
Outcomes: Food safety technical assistance was provided to 18 farms, 8 processors, and 3 facilities.

Goal 2: MOFGA staff will develop and make available to farms a template for basic Food Safety Plans.
Performance Measure: Fifty direct market farms will use this template to create plans for their operations.
Bench Mark: 20 farms report use of template
Target: MOFGA will provide ten farmers with outside verification or audit of their food safety plan.
Outcomes: A checklist was developed (See Attachment 1) for use by farmers to use with produce buyers such as stores, restaurants and institutions that did not require GAP or other food safety verification. Additional materials on Packing Shed Design (Attachment 2) and Writing the Recall Plan (attachment 3) were also developed and made available through MOFGA educational events and individual technical assistance to farmers, processors and buyers.

Goal 3:MOFGA will work with the Department of Agriculture to develop and make available the outline of a Maine Food Safety Regulation for Raw Agricultural Products.
Performance Measure: Six agricultural organizations in Maine representing farmers request a survey of food safety regulations.
Bench Mark: Four agricultural organizations respond to a survey of food safety regulations, MOFGA tabulates results.

Target: Develop an outline, with Maine Department of Agriculture, of a Maine Food Safety Guideline for Raw Agricultural Products.

This project was designed and funded from November 2013 through December 2014. The original goal of creating an outline as guidance for Maine's small to mid size farms was envisioned in the spring of 2013 after the January release of FDA's first proposed rules on Produce Safety and Preventative Controls for Human Food. After holding listening sessions around the country, including one in Maine, and receiving thousands of comments FDA withdrew the proposed produce rule to write supplemental guidelines, which were released as a final rule in November 2015. During this time both the Maine Department of Agriculture, Conservation and Forestry and MOFGA were engaged in reviewing and alerting Maine farmers to the potential impact of the rules and notifying constituents of the timeline for comments. During the 2013/2014 timeframe it became obvious that MOFGA would need to wait until a final rule was issued before an accurate guidance document could be created.

Goals and Outcomes Achieved

The primary outreach began in 2013 with raising awareness through speaking engagements with interested groups and organizations. For these Cheryl participated in the Belfast Community Supported Agriculture Fair, the Husson University Health Fair, the Waldo County YMCA health fair as well as speaking at two Maine high schools, and participating as a keynote speaker at the Maine Consumer & Family Science annual meeting.

Food service and institutional buyers contemplating purchasing more local foods were another avenue MOFGA Staff approached. For this staff developed menus and recipes, sourcing from local, certified organic Maine farms. The object was to present local foods to these purchasers and to discuss both menu development and food safety issues. These were presented to an Ellsworth Food Service Workers workshop that reached 22 workers at 12 area schools. Additional presentations were given at five Unity College hands-on cooking workshops for 112 sustainable Agriculture students.

Other projects included participation in collaborative meetings with Maine Farmland Trust on developing food safety strategies for food hubs, trainings at MOFGA's Farmer-to-Farmer Conference and at the 2014 Agricultural Trade Show. Cheryl initiated a conversation with the Northern Maine Development Corporation on agriculture as an economic driver for Aroostook County, resulting in a new working-group. As part of Slow Money Maine meetings, Cheryl provided four tours of the Coastal Farms and Foods Processing Facility in Belfast and presented a workshop on developing a recall plan with the Maine Food Producers Alliance.

Farmer outreach included workshops on farm food safety and access to markets for beginning farmers, adding a section on farm food safety to MOFGA's Intro to Organic Farming and a Farm Training Project session on marketing and food safety. MOFGA Agricultural Services Staff participated in four separate trips to Aroostook County, and four trips to southern Maine to provide technical assistance to producers on production and food safety issues. Cheryl provided technical assistance (e-mail, telephone and in person) to 46 producers on licensing and food safety, plus working with 4 producers to bring value-added products to market. Additionally Cheryl participated on a portion of a film produced by Cooperative Extension on Good Manufacturing Practices.

The focus of work for 2014 was food safety under the broad umbrella of marketing the Maine Local Twenty, which includes farm food safety plans, food hub and aggregating analysis, food processing technical assistance, and food service recipe development.

With funding under the Specialty Crop Block Grant, Cheryl provided technical assistance to 18 farms, 8 processors, and 3 facilities. As part of this Cheryl developed food safety training and education handouts on Packing Shed Design and Writing the Recall Plan for growers meetings and general distribution through the

MOFGA network. Both Cheryl and Dave Colson, MOFGA's Agricultural Services Director participated in the Farm to Institution New England (FINE) Farm to College Conference on basics of farm food safety for wholesale markets and spoke of the Maine Local Twenty concept as a way of developing cost/income analysis for farms to assess marketing to institutions. Additionally, Cheryl worked with the Hinckley School in Fairfield on development of farm to cafeteria food safety and prepared a case study on an analysis of food safety education and the wholesale markets of six producers.

Statewide involvement included speaking at a Waldo County Cooperative Extension meeting, participating in two Healthy Food in Healthcare Working Group meetings, and a presentation at the Washington County Food Summit. In the late fall MOFGA Staff presented at the Mainstreaming Conference held at Colby College and sponsored by the Maine Farmland Trust. These presentations included food safety concerns for the institutional market, the Maine Local Twenty concept, food hubs for aggregation and processing, crop modeling and cost analysis for institutional purchasing.

Aroostook County (Maine's largest crop production region) saw MOFGA Staff participate in three Northern Maine Development Corporation agriculture working group meetings. This group is pursuing researching of markets and product development for Aroostook county farmers.

During the year Cheryl participated in collaborative meetings with Orono and Orland on developing strategies for food hubs. Cheryl was again this year a participant in three Slow Money meetings, leading two tours of the facility providing technical assistance to Coastal Farms. At the annual Agricultural Trades Show Staff presented on farm food safety and held a panel discussion of buyers and shippers who access wholesale and institutional markets. Cheryl worked with Maine Department of Agriculture, Conservation and Forestry on the 2015 Agricultural Trade Show on menu development for the Commissioner's Luncheon and producer demonstrations.

After the 2013 FDA Proposed Rule comment period ended the FDA made the decision to rewrite portions of the rule and reissue a supplementary for comment in 2014. MOFGA Staff reviewed the supplementary proposal and worked with the National Sustainable Agriculture Coalition to refine comments and to provide resources for farmers to submit comments. In November Dave traveled to Vermont to attend the only FDA listening session in New England to ask questions and present brief recommendations for FDA's consideration. Dave also submitted written organizational comments to FDA from MOFGA.

Beneficiaries

Cheryl provided technical assistance (e-mail, telephone and in person) to 46 producers in 2013 on licensing and food safety, plus working with 4 producers to bring value-added products to market. Additionally Cheryl participated on a portion of a film produced by Cooperative Extension on Good Manufacturing Practices

For direct farm assistance in food safety plans, Cheryl provided technical assistance (e-mail, telephone and on farm consulting) to 26 producers on licensing and food safety in 2014. She also worked with 4 producers on food safety needs in order to bring value-added products to market.

In January 2015, MOFGA Staff convened a "peer learning group" of organic blueberry producers on marketing aggregation and food safety. In the spring the staff offered a peer learning groups on winter greens production and hoophouse tomatoes.

Lessons Learned

At the time of the submission for this project no accurate baseline information was available to determine how many of the 8,100 farms in Maine would be affected by the new rules or how many of them had food safety plans. MOFGA and others estimated at that time that possibly 100 of those farms would need to have GAP

certification but it was unclear what the remaining 8,000 farms would need for food safety plans or who could qualify for the exemptions outlined in the various rules.

Farmers want to produce safe food. Regardless of the size of the farm operation farmers take pride in producing food to feed their community and state. Farmers are looking for clear, common sense directions when it comes to food safety regulations. Farmers and farm workers are often unaware of how food borne illnesses can enter into the food system. The first step in assuring a safe food system starts with education and that begins on the farm.

While many aspects of the FDA's original proposal remained intact, some areas which could have a major impact on farming activities were changed in the supplementary rule. Obviously providing a training manual for farms to use to navigate the food safety rules was not practical given the uncertainty of what would be included in a final rule.

Contact Person

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Attachment 1 **Inspection Checklist: Food Safety for Farmers**

Establishment Name: _____

Address: _____

Owner's Name: _____

Purpose of Inspection: _____

Yes: In Compliance **No**: Not In Compliance

N/A: not applicable **N/O**: not observed **COS**: corrected on site during inspection **R**: repeat violation

Yes	No	N/A	N/O	Employee Health and Hygiene	COS	R
				Adequate Toilet Facilities		
				Proper Handwashing/Hand Sanitation		
				Signage for Handwashing		
				Documented training of employees in health and hygiene		
				Wellness Policy in Place		
				SSOP with Corrective action reports (part 5 Farm Safety Plan)		
				Water and Sewer		
				Potable water used for washing produce		
				Water tested annually		
				Septic/Sewer up to Local and State codes		
				Manure and Compost Management		
				Follows MOFGA regulations (Organic only)		
				Appropriate waiting period observed		
				Safe location of piles		
				Wildlife Flagging/Management in place		
				Irrigation and Water		
				Uses Class A or Class B water		
				No manure or compost run-off		
				Processing/Packing Shed		
				Hazards identified and controls in place		
				1 up/1 down traceability - Records maintained of inputs and harvest		
				Pesticide/herbicide application records		
				Training for personnel who do applications of pesticides/herbicides		
				Checklist for cleaning and sanitization procedures		
				Farm Specific		
				Has a farm food safety plan in place		

Comments:

Follow Up Date:

Farm Owner (signature) Date

Inspector (signature) Date

Attachment 2

PACKING SHED DESIGN CONSIDERATIONS

MINIMUM CONSIDERATIONS:

- Roof
- Potable water
- Access to toilet & hand-washing facilities
- System to sanitize equipment & tools
- Pest control system
- Cold storage
- Dedicated facility: not shared with field tools, machine storage or repair

CONVERTED, NEW & ALTERNATIVE OPTIONS

- Cost, risk & benefits analysis

FACILITY DESIGNED TO PROCESS & DELIVER A SAFE & HIGH- QUALITY PRODUCT

- Space to expand in the future
- Options: Pole barns, Dairy barns, Lean-to, Machine shed, Greenhouse

DESIGN CONSIDERATIONS:

- Location & access
- Functions & tools: wet areas, cooling equipment, curing, produce storage, work tables & packing areas, scales, supply storage, cleaning tool storage, labeling & record keeping, signage
- Electricity
- Lighting
- Water
- Walls & floor
- Drains
- Cleanliness & food safety
- Separation of functions
- Ergonomics
- Workflow

Product handling

RESOURCES

"WHOLESALE SUCCESS: A Farmer's Guide to Food Safety, Selling,

Postharvest Handling, and Packing Produce", FamilyFarmed.org, Packing Shed

Design, page 94

Work Efficiency Tip Sheet: Packing shed layout. University of Madison Wisconsin

http.//bse.wisc.edu/hfhp/tipsheets_pdf/shed4web.pd

Attachment 3

WRITING THE RECALL PLAN

WHY HAVE A RECALL PLAN

Farm implicated in food bourne illness

Quality control

COMPONENTS OF A RECALL PLAN

Recall "Team"

Traceability

Documentation / Records

CAR: Corrective Action Report

RECALL PLAN IMPLEMENTATION

Receive complaint / notification

Assemble team

Investigate

Document

Notification policy

RESOURCES

"WHOLESALE SUCCESS: A Farmer's Guide to Food Safety, Selling,

Postharvest Handling, and Packing Produce", FamilyFarmed.org, Recall Policy,

Page 119

"Weathering a Food Safety Recall, Are your Records Ready?"
http://www.mofga.org/Publications/MaineOrganicFarmerGardener/Spring2012/FoodSafety/tabid/2139/Default.aspx.

www.Mainefoodproducers.com

Final Report – Previously Submitted

PROJECT SUMMARY

The $500 million potato industry is the largest agricultural sector in Maine. The management of insects, diseases, weeds, and other pests is integral in sustaining a healthy Maine potato crop. Without reliable and sustainable pest management strategies, Maine's potato industry faces the potential of severe crop losses resulting in significant reductions in profits and threats to long-term viability. The current market demand for perfect, pest and damage-free produce and crops, combined with the public's desire to decrease pesticide use for human health and environmental reasons, comes at a time when Maine potato growers face ever increasing production costs and pest pressure. Potato growers are increasingly relying on a multidisciplinary Integrated Pest Management (IPM) approach to ensure that Maine's potato crop is pest and damage free while attempting to minimize the amount of pesticides that are applied.

The increasing number of emerging pests and diseases in Maine, including potato mop-top virus, potato wart (a quarantinable pest), necrotic strains of potato virus Y (PVY), white mold, nematodes, and new strains of potato late blight, indicate a significant need for research and educational outreach. In order to mitigate the risks associated with existing and emerging potato pests, a close and direct connection between growers and the University of Maine Cooperative Extension Potato Integrated Pest Management (IPM) Program is vital. Through this project, information gathered through multiple sources, including direct observation, trapping, weather data, and predictive modeling, was delivered to stakeholders in Maine and throughout the region via electronic and standard newsletters, websites, and telephone message centers. The data produced continues to help IPM scientists track potential pest outbreaks and provides growers with current information on specific and timely treatments in order to minimize the number of pesticide applications and maximize potato yield. This project builds upon previous project funding from the Specialty Crop Block Grant Program (SCBGP) that have allowed for continuation of University of Maine Cooperative Extension's potato pest monitoring and research efforts.

PROJECT APPROACH

Staff involved:

James Dwyer, Crops Specialist, University of Maine Cooperative Extension
Griffin Dill, IPM Professional, University of Maine Cooperative Extension
James Dill, Pest Management Specialist, University of Maine Cooperative Extension
Steve Johnson, Crops Specialist/Plant Pathologist, University of Maine Cooperative Extension
Bruce Watt, Disease Diagnostician, University of Maine Cooperative Extension
Sean McAuley, Scientific Technician, University of Maine Cooperative Extension
Meghan Dill, Administrative Assistant, University of Maine Cooperative Extension
Donald Flannery, Maine Potato Board
Tim Hobbs, Maine Potato Board
Twelve seasonal program aides

Activities Performed:

In cooperation with the Maine Potato Board, University of Maine Cooperative Extension implemented a comprehensive integrated pest management program for potato growers. Twelve seasonal program aides

surveyed 62 potato fields on a weekly basis during the growing season. These fields were located in the potato producing areas of northern and central Maine. Information from the surveying effort was communicated to the Potato Industry via a weekly newsletter, a website and a telephone hotline. During the growing season, monthly meetings were held with the field and technical staff of local companies, which provide service to potato growers.

A special program was held for field workers to identify Potato Virus Y and Potato leaf Roll Virus symptoms. This "Roguing School" was targeted towards field workers who surveyed fields for diseased plants. An annual Potato Conference was held in January and an annual Potato Pest Management Conference was held in December to update technical field staff and growers on the latest potato pest management research from the University of Maine.

Project Results

For the 2014 crop season the University of Maine Cooperative Extension's Potato IPM program:

- Monitored: 62 potato fields on a regular basis.
- Operated: 50 Heliothis style pheromone traps for European corn borer.
- Operated: 60 sticky type pheromone traps for European corn borer.
- Operated: 70 yellow pan water traps for aphid collection.
- Operated: 8 pheromone traps for Black cutworm detection.
- Operated: 5 Black light traps for European corn borer

Client contacts made:

- 2,500 individual personal grower contacts, May through September.
- A weekly newsletter with current regional pest updates was emailed to approximately 375 industry staff in Maine, New Brunswick and Eastern United States. 9 issues were written.
- Three issues of Spudlines, a periodic newsletter regarding pertinent potato pest/crop management matters, was distributed to a mailing list of approximately 780 individuals.
- Pest information was posted on www.mainepotatoipm.com
- Pest information was posted on a telephone hotline which received nearly 2,000 calls June through September.

Cooperation:

- Maine Potato Board hosted six monthly meetings for the field and technical staff of companies and agency staff that work with potato growers to get the latest information on pest issues.
- Seventy grower cooperators directly participated in the program by having field scouts survey their farms.
- Consultants brought disease and insect samples to the Presque Isle Cooperative Extension office and the Pest Management Office in Orono for identification.

Monitored Chain Retailer Stores:

- Plant material capable of hosting potato late blight was monitored at chain retailer stores in northern and central Maine. Stores were monitored on a weekly basis. In 2009 potato late blight was detected at multiple big box stores throughout the state of Maine. The infected plant material was being sold and distributed throughout the state. No potato late blight was detected at these stores in 2014.

Trained at Potato IPM Scout School:

- Trained twenty individuals who included chemical sales staff, on-farm employees, consultants and others. Training included information on:

1. Potato Late Blight identification

2. aphid identification
3. European corn borer identification
4. Colorado potato beetle identification
5. secondary pest identification
6. economic thresholds
7. scouting techniques
8. insect models for Maine producers
9. disease models for Maine producers

Trained at Potato Pest Management Conference:

- 125 individuals attended the 2014 Maine Potato Pest Management Conference, which updated growers and technical staff on the latest pest management research information, which included:
    1. Aphid collection results and management strategies
    2. PVY survey and results
    3. Update on insecticide control studies
    4. Update on potato storage diseases
    5. Update from the Maine Board of Pesticides Control
    6. Slug Issues and Management
    7. Late blight update

Trained at Maine Potato Conference:

- 250 individuals attended the January 2014 Maine Potato Conference, which provided growers, technical staff, and potato industry personnel with information regarding:

1. PVY management
2. Potato late blight management
3. Detection and management of wireworms
4. Detection and management of aphids

Grant Expenditures:

All funds have been utilized at this date.

Personnel:

IPM Professional (3 months)

Expended amount ……. $ 8,493

Scientific Research Specialist (3 months)

Expended amount ……...…….. $ 7,842

Scientific Technician (9 months)

Expended amount ……. $ 20,223

Seasonal Employees

Ten Seasonal Program Aides ($8.35/hr x 4,800 hrs)

Expended amount…….... $ 40,080

Subtotal…… $ 76,638

Fringe Benefits

IPM Professional (3 months)

Expended Fringe (at 54.5%) ...…….. $ 4,629

Scientific Research Specialist (3 months)

Expended Fringe (at 54.5%) ...…….. $ 4,274

Scientific Technician (9 months)

Expended Fringe (at 54.5%) ...…….. $ 11,022

Subtotal…… $ 19,925

Travel

Seasonal Extension employees operated from Fort Kent, Maine to Palmyra, Maine, which lie approximately 300 miles apart. The IPM program operated 5 vehicles (4x2 pickups) for personnel transportation. An average of 6,134 miles were traveled per vehicle over the course of 70 days at the University of Maine Motor Pool rate of $0.27 per mile with a $27.45 daily charge per vehicle.

Mileage ($0.27 per mile, $27.45 daily charge x 5 vehicles) …… **$ 16,516**

Supplies

- Microscope slides
- Sample vials
- Disposable beakers
- Pheromones ECB
- Vaportape for traps
- Grower report sheets
- Yellow sticky card traps
- PVY test strips
- Yellow paint for water pan traps
- Office supplies
- Hardboard sheets to place traps on
- Flags
- Switches for black light traps
- Sample bags
- Safety equipment
- Eye wash
- Gloves
- Boots
- Leggings

Total expended…….. $ 11,921
Total Direct Charges ……. $125,000
Indirect Charges…… (None Allowed)
Total Expended ……...$125,000

GOALS AND OUTCOMES ACHIEVED

A primary goal of this project was to effectively identify and respond to the insect, weed, and plant disease issues facing Maine's potato growers. Through the intensive monitoring program and subsequent educational outreach (via informational websites, hotlines, newsletters, conferences, and grower meetings) associated with this project, potato pest issues were effectively managed, ultimately resulting in a multimillion dollar economic impact on Maine's potato industry (as described in the BENEFICIARIES section).

Through the educational outreach associated with this project, additional objectives including an increase in grower awareness of potato pest issues, increased grower knowledge of pesticide risks, and minimization of pesticide use through the implementation of IPM practices, were achieved.

BENEFICIARIES

The beneficiaries of this project include all of Maine's 400 commercial potato growers and their approximately 57,000 acres of potatoes, national and international growers who rely on Maine's seed potato crop, hobby farmers and backyard gardeners, as well as a multitude of researchers and industry personnel who utilize the information generated from this project.

Economic Impact:

- 12 seasonal program aides were provided with summer employment.

- During the 2014 growing season in Maine potatoes colonizing aphid populations were active at moderate levels during most of the season, but in August colonizing aphid populations, especially Green peach aphids, rose significantly. Non-colonizing aphid populations were very active during the entire growing season. The Potato Industry was alerted to this activity. Some seed growers utilized stylet oil, a non-traditional insecticide because non-colonizing aphids are capable of transmitting Potato Virus Y and traditional insecticides do not prevent these aphids from transmitting virus.

- Potato flea beetle:
  - 55,000 acres x 275 cwt x $8/cwt x 5% potential yield loss = **$665,500 losses avoided**
- Aphids and Potato virus Y
- 11000 acres of seed
- 7.5% difference in the seed readings from 2012 to 2013
- Taking 10% of the credit for the reduction would mean 82.5 acres of seed remained certified
- 275 cwt/a x 82.5 a x $10/cwt value preserved = **$ 226,875 losses avoided**

- During the 2014, growing season European corn borer activity was generally low; however, some areas of elevated activity were detected. Information collected by the University of Maine Cooperative Extension Potato IPM program indicated that:

- 38% of the potato growers did not apply a material for ECB
- 38% of the potato growers applied 1 application of a material for ECB
- 15% of the potato growers made 2 applications
- 9% of the potato growers made 3 application to control ECB

Using this data to calculate insecticide materials saved and losses avoided, the European corn borer component of the University of Maine Cooperative Extension Potato IPM program had a **$1,083,000** positive impact on the Maine Potato Industry.

- Colorado potato beetles: Seven farms exceeded economic threshold levels for Colorado Potato beetles:
- 55,000 acres x 11% of farms exceeding threshold = 6050 acres potentially impacted
- 6050 acres x 275 cwt x $8/cwt x 10% potential yield loss = **$1,331,000 losses avoided**

Economic impact from the insect monitoring aspect of the program for the 2014 season is currently being estimated at $3,528,375, an approximately 28 to 1 return on investment.

LESSONS LEARNED

As a result of this project, the changing nature of potato pest dynamics has become more evident to the project staff. The emergence of new pest threats as well as the ever changing weather variables forces project staff, growers, and potato industry personnel to adapt pest management techniques to a rapidly evolving system. Weather and changes in pest profiles present a challenge when implementing a crop pest management system. New strains of potato late blight have been introduced into the state of Maine. These new strains have differences in how they react to the weather and their sensitivity to some fungicides.

The issue of non-persistent virus transmission and non-colonizing aphids is a topic on which more research is needed. New strains of potato virus Y have been introduced into North America, which can cause an internal necrosis in potato tubers. These new virus strains have the potential to cause a significant negative impact for seed, table and processing producers.

The European corn borer population in the northern part of the state of Maine appears to be different from the population in central and southern Maine. In the northern area, there appears to be a strain difference, therefore a combination of pheromone traps and black light traps are utilized. Black light trapping is highly effective, but very costly and very time consuming.

Rain events make keeping regular field monitoring schedules impossible at times. Adapting to weather events is one of the challenges which any field based program encounters.

There is an anticipation that IPM programs will always reduce pesticide usage, due to changing weather and pest pressures, sometimes pesticide usage is reduced and sometimes the usage is increased in order to maintain produce quality. The utilization of an IPM approach in potato cultivation remains popular and continues to increase in use.

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Project 4: Unlocking Higher Cranberry Yields with Boron: A Key Element in Fruit Set

Final Report – Previously Submitted

PROJECT TITLE:

Unlocking Higher Cranberry Yields with Boron: A Key Element in Fruit Set

PROJECT SUMMARY:

Boron is a micronutrient that, among other things, plays a critical role in both pollination and fertilization in flowering plants. **The purpose of this project was to attempt to ascertain if there might be a deficiency of boron occurring in commercial cranberry plants in Maine during the pollination and fruit set period, when the need for boron within the plants is at its highest point during the year.** Given that the normal time for collecting cranberry leaf samples is not until late August/early September—well beyond the flowering period that occurs in late June/early July—there was no data for Maine cranberry leaf nutrient levels available from any other time period *except* from the standard 'late-season/Sept.' time period. In addition, it was discovered that every single Maine cranberry soil test report on file at the university's cranberry extension office—spanning many years—indicated an average boron level of just *half* of what is considered to be the optimum level. Therefore, the question arose as to whether Maine's commercial cranberry plants might be experiencing a boron deficiency during bloom.

One of Maine's commercial cranberry growers, in 2011 and 2012, obtained unusually high fruit set levels (59% and 55%, respectively) and was getting nearly double the number of berries per upright or stem than all of the other sites that were being checked. The other sites averaged between 33% and 40% for fruit set levels during that time, which is right in line with what the cranberry industry, nationwide, considers to be "average." One thing that was unique about the single high fruit-set site, was that the grower had used a calcium-boron spray during each of those two seasons, during bloom. An obvious question emerged: *could that be the reason for the consistently high fruit set levels being observed there?* Research out of Massachusetts had shown that when a true boron deficiency exists in the plants, a grower should expect to see about a 5% increase in yield as a result of using a calcium-boron foliar spray (ideally two applications), during bloom; one application at early bloom, and another at mid-bloom. This slight increase in Massachusetts cranberry yields is obtained even though their cranberry soils already have adequate boron levels to begin with, whereas Maine is notorious for having low boron soil levels (to which Maine's cranberry soil lab reports bear testimony). **Thus, it stood to reason that if our Maine cranberry leaf results from this study were to indicate a deficiency during bloom, that by using a foliar boron spray (or**

sprays) during that critical time when boron is needed most, a grower might be able to increase his or her yield by at least 5% and possibly significantly more. In the face of low cranberry prices, a discovery of an inexpensive means to increase one's yield by 5% or more, would be a useful and timely finding for Maine's struggling cranberry industry.

PROJECT APPROACH:

A total of six eastern Maine cranberry farms, growing the same variety of cranberry ("Stevens" variety) agreed to serve as a study site for this project. There were two sites chosen at one of the farms, because the grower there agreed to use a foliar boron spray on one of the plantings, while keeping it off another planting that was right beside the other one (for comparative purposes). Thus, in total, there were **seven study sites** originating from six different cranberry farms.

Principle Data Collection: Leaf samples were collected during three separate weeks in 2014 spanning the entire bloom period from each of the study sites (July 1st & 2nd, 9th & 11th, and 23rd & 24th). The leaves were taken from flowering stems only. A final round of leaf samples were collected during the routine or 'normal' leaf-collection time at the end of the 2014 season, for comparative purposes (week of Sept. 9th). A soil sample was also taken at that time from each of the study sites, in case that should reveal anything of note amongst the sites, and to have a record of what the soil boron level was for each of the study sites.

Additional Data Collection: Coinciding with the first visit to each site, 20 to 30 flowering cranberry stems were randomly tagged or 'marked' using plastic zip ties. This was done such that the fate of each flower on those stems could be monitored throughout the bloom period, and so during each of the subsequent three visits to all of the sites, each of the tagged stems (a.k.a. uprights) was examined, such that by the end of the growing season, the following additional questions could be answered for each site:

1) Were the flowers on the stems pollinated?
2) What was the fruit set? (as a percentage of the starting flowers on those stems)
3) How many of the flowers were matured into berries, i.e. what was the final 'berries per upright' count from those stems by harvest time?

On July 11th, one sample of just cranberry leaves, another of just cranberry stems, and one more of just cranberry flowers, were collected from one of the study sites, in order to answer a 'side' question that came up before the project began, which was to find out how boron is partitioned within a flowering cranberry stem. In other words, how do the boron levels in the leaves, flowers, and stems, compare to one another, and which of those plant parts (leaves, flowers, or stems) has the highest concentration of the boron? A sample of just cranberry blossoms was also collected from the historically high-performance site, on July 24th, to see how the boron level in those flowers would compare with the flowers sampled from the other site.

Lab Analyses and Sharing of Study's Findings: All of the cranberry plant tissue and soil samples were submitted to the UMaine Analytical Laboratory and Soil Testing Service lab

[http://anlab.umesci.maine.edu/] within one day, at most, of being collected. The lab findings unique to each site were shared with the corresponding grower each time the results were issued from the lab. On Oct. 24th, 2014, *all of the lab results from each site* were shared with each of the participating growers, so they could see how their own values compared with everyone else's values. At the same time, the participating growers were asked to submit key information still needed by the project, such as whether or not they had used a boron foliar spray during the bloom period, and the date(s) and rates of the material(s) (*if* a product was used), numbers of bees used per acre for pollination, and any other fertilizer types and rates that they may have used during the season. This was especially useful information to obtain, because four of the sites *did* use a foliar boron spray during the season, and the other three sites did *not*, making it possible to do some comparisons with the data. On May 8th, having completed and analyzed all of the project's findings, a PowerPoint presentation was given at UMaine's Blueberry Hill Experiment Station in Jonesboro, Maine. Within the following few days, a summary of the project's findings (plus printouts of the May 8th PowerPoint presentation) was mailed to all of Maine's cranberry growers, as well as a survey for assessing the impact of the project.

Results: Only one of the seven study sites registered a tissue boron level in the "deficient" range throughout the entire study, and only during one of the four weeks: Week 4; boron level of 13.2 ppm; see Table 1 below. Weeks 1 and 2, however, at the same location, had boron levels that were "low," or *almost* deficient. The three values labeled as "low" still fall within the supposedly optimum range of 15 to 60 ppm, but, just barely, and they were conspicuously lower than all of the other values obtained in the study so they were shaded in the table in order to draw attention to them. Deficiency symptoms become evident when boron is at only 12 ppm or less, and all of the shaded boron levels in the table are not much higher than that.

Table 1. Cranberry leaf boron levels (ppm) from the six farms (seven sites) that participated in the study, beginning during the first week of July, 2014 (Week 1).

	Site 1	Site 2	Site 3	Site 4-a	Site 4-b	Site 5	Site 6
Week 1	23.3	46.8	63.9	36	30	63.9	19 **(low)**
Week 2	20.9	50.8	67	32.4	33.1	63.5	18.7 **(low)**
Week 4	16.7 **(low)**	57	57.9	28.2	27.1	60.7	**deficient 13.2**
Week 11	21.3	105	54.6	50.4	47	45	27.9

It should be noted, that since four of the seven sites used a foliar boron spray (Cal-Bor®) during the study, the subsequent tissue boron level at those particular sites would likely have registered higher than they otherwise might have. *However, through weeks 1 and 2, two of the four boron 'spray' sites had not yet applied the boron material*. The boron level for sites 2, 3, 4-b, 5, and 6, through week 2, had no additional boron applied as yet. Sites 3, 4-b and 6, had no foliar boron applied throughout the *entire* study, nor at any time in the history of those sites. Nevertheless, with the exception of Site 6, the majority of those boron levels were still within the "optimum" range for boron. **Therefore, on the whole, it seems that the answer to this study's foremost question of whether Maine cranberry plants might be experiencing a deficiency in boron during bloom, is—for the most part—"no."**

Boron Soil Test Results: Every Maine cranberry soil test analyzed by UMaine's Soil Testing Service prior to this study (prior to 2014 and from 15 sites in all) showed either a very low level of boron, or, in a few cases, barely a "medium" level, and averaging just 0.26 ppm when 0.5 to 1.2 ppm is the optimum for cranberries. The 2014 average from the study sites was 0.38 ppm, so slightly higher, perhaps, but still par for the course. The individual results (from 2014) were as follows: Site 1 (0.3 ppm), Site 2 (0.5 ppm), Site 3 (0.5 ppm), Site 4-a (0.3 ppm), Site 4-b (0.4 ppm), Site 5 (0.4 ppm), and Site 6 (0.3 ppm).

Where is most of the boron in a flowering cranberry upright located? [Site 4-b was utilized for answering this question, as the grower there was generous enough to sacrifice the additional flowers needed for this additional part of the overall project.] Answer: As shown in Figure 1, most of the boron (53%) was found to be located in the leaves. Even though this site received an application of Cal-Bor® eight days prior, at a rate of 2 quarts per acre, just 32% of the total boron in the uprights was found to be in the flowers themselves, where it is in such high demand during bloom (as previously said).

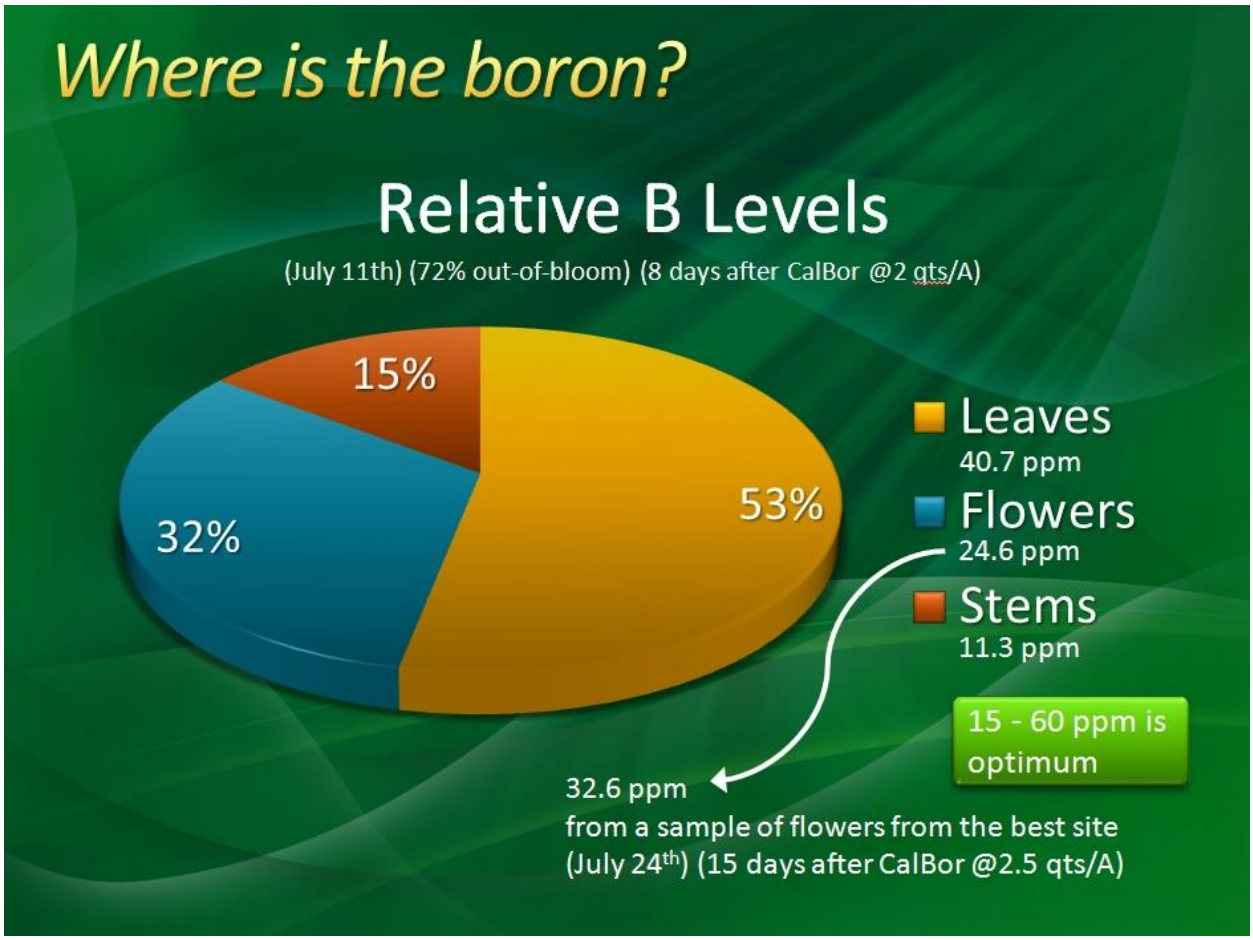

Figure 1. Relative boron levels of leaves, flowers and stems, from tissue samples taken from Site 4-b following an application of Cal-Bor® eight days prior.

Since most of the boron stored in flowering cranberry uprights appears to be contained in the leaves, this could be a finding that helps to justify the reason for using a boron foliar spray during bloom, when coupled with the knowledge that boron is relatively immobile inside plants, including cranberry plants. This means that since boron cannot move very well inside the plants, it may be that the plant cannot (or does not, for whatever reason) transport additional boron to the flowers during pollination and fertilization from the roots and/or from other areas in the plant (stems and/or leaves) soon enough, when it is needed the most. This is the prevailing theory as to why it might be that using a foliar boron spray during bloom can result in a higher yield, because in that situation the boron is reaching—and being absorbed by—the flowers, directly.

Additional Findings: Even though this study indicated an answer of "no" to the question of whether or not Maine flowering cranberry stems were experiencing a 'universal' deficiency in boron during bloom, was there nevertheless any improvements to be seen in any of the additional 'measures' that were looked at, between the four sites that used a foliar boron spray (Cal-Bor®) during the study, and the three sites that did not? The answer here appears to be "yes!" There were

two additional measures that were obtained from this study: fruit set, and berries per upright. It was discovered that, on average, compared to the sites that did not use Cal-Bor® and had never used a boron spray of any kind in the past, the sites that used Cal-Bor® during bloom had:

- 4.5% greater fruit set
- More berries per upright (1.5 versus 1.2)
- A slightly higher level of tissue boron (average of 45.7 ppm versus 38.3 ppm)

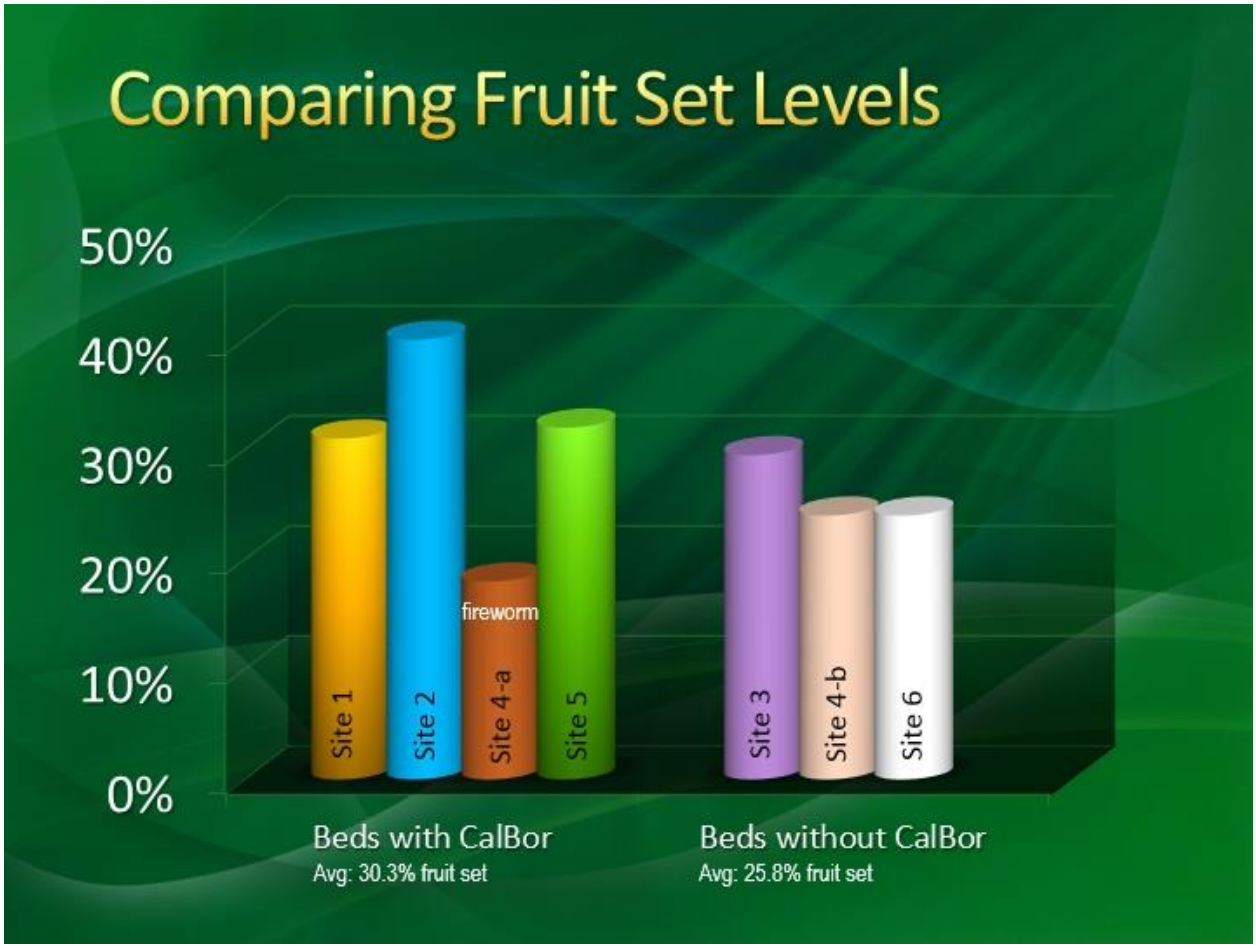

Figure 2. Comparing levels of fruit set between cranberry beds (plantings) that had Cal-Bor® applied during bloom, and beds that had no Cal-Bor® (or any other foliar boron material ever before). **Note:** "Site 4-a" experienced a high blackheaded fireworm population during the study.

Conclusions: The individual boron tissue levels were not statistically significant between the Cal-Bor® and 'no Cal-Bor®' sites, but, the difference was at least in the direction that makes sense. The differences in all three of the above measures may have been significantly larger, had the four growers who used Cal-Bor® used it in better accordance with the 'recommended recipe,' if you will. Two of the three Cal-Bor® growers, for example, only used a single application of the Cal-Bor® when the recommendation from Massachusetts is to use it twice: once at early bloom and again at mid-bloom, at a rate of 2 quarts per acre per application. The third grower used it twice, but

at a very low rate of only 0.8 quarts per acre each time, and the first application was put out about 10 days too soon, so may have had no benefit at all. The site that had the highest fruit set of anyone (site 2 at 40%) (Figure 2 above), used only a single application of it, but, the rate used was 2.5 qts/A rather than the recommended 2 qts/A, which could be part of the reason for getting a higher level of fruit set there compared to the others who used the 2 qts/A rate. Site 2 also finished the season with 1.8 berries per upright, compared to an average of just 1.2 berries per upright for the 'no Cal-Bor®' sites.

Finally, it is worth noting that sites #4-a and #4-b, which were two one-acre plantings that were side-by-side, had some problems with fireworm caterpillars during the study period (especially site 4-a), which likely affected the results obtained from that location, and which actually gave a fruit set result that was opposite of what was expected at that location; the fruit set on the bed that received the Cal-Bor® application was *lower than* on the bed that did not receive it (18% versus 23.8%, respectively). But in spite of the backwards result at that location, the Cal-Bor® sites, overall, still averaged 4.5% higher fruit set level than the 'no Cal-Bor®' sites. An increase of 4.5% in fruit set is consistent with the 5% increase in yield that the Massachusetts cranberry industry has seen, from using Cal-Bor® during bloom, so this experiment seems to reinforce what has been observed in Massachusetts.

Project Partners: The six Maine cranberry growers who took part in this project were monumental in their contribution to the project, by allowing the work to be conducted on their farms, and for providing the PI at UMaine Extension with pollinator, spray and fertilizer records, and for being willing to use a boron foliar product in the case of four of the six growers.

GOALS and OUTCOMES ACHIEVED:

Lab Results: One of the measurable outcomes of this project was simply the soil and plant tissue reports obtained from the UMaine Analytical Laboratory and Soil Testing Service lab. Each report was shared with the corresponding/source grower, and all of the other growers' reports were also shared with the participating growers, but with the grower names left off. But allowing each grower to view the results from the other grower's sites allowed the grower to see how his/her nutrient levels compared to everyone else's in the study. The tissue levels for boron that were obtained from all of the sites are given in Table 1. The soil boron levels that were obtained are listed in the text that follows Table 1.

Grower Survey Results: Another measureable outcome in the study is the percentage of Maine cranberry growers who—after learning of the results of the project—indicated whether they planned to start using a boron foliar spray. 67% of respondents said they plan to use a boron foliar spray (during bloom) in the future, with ¾ of those saying their decision to do so was based "partially" on what was learned from this study, and ¼ saying it was due "completely" to what was learned from this study. Those same individuals (67%) also checked "true" for each of the following two

statements: “I was already planning to use a boron foliar spray in the future (already convinced of its benefits and/or a firm believer that it helps),” and to this statement “*And*, this study makes me even more convinced of its benefits.” One respondent (17%) said “perhaps” to the question of using a boron foliar spray in the future (and “partially” due to what was learned from this study), and one other respondent said “no” to that question, and did not answer the second part of the question as to if the decision was “partially” or “completely” due to what was learned from this study. All but one (83%) of the respondents said “yes” when asked if they had learned anything new as a result of the boron study.

The final measureable outcome was a workshop that was held on May 8th, 2014, by the PI of the study, Charles Armstrong. Only two of Maine’s roughly 28 cranberry growers were in attendance, but one of those two is a manager for one of Maine’s larger cranberry farms and is very influential with many of the other Maine growers. Grower turnout was obviously disappointing, but, copies of the PowerPoint presentation were mailed to the other growers, along with a one-page summary of the findings. The state’s largest grower, making up over half of the state’s total cranberry acres, was unable to attend, but requested the study’s results by email that same day, and found the results to be compelling enough to advocate for the use of a boron foliar spray during bloom. Another Maine cranberry grower learned of the study’s results in person, by the project’s PI, during a cranberry meeting at the Maine Agricultural Trades Show in January of 2014, and upon learning of the results, expressed an interest in trying a foliar boron application during bloom on his 12-acre farm.

BENEFICIARIES:

Greater than 76% of Maine’s roughly 200 acres of cranberries are managed by growers who were keenly interested in and pleased with the results of this project. Two of those individuals also indicated that the results reinforced for them what they already believed, but which they previously had little to no concrete data to back up their gut feelings and field observations surrounding the benefits of using a material such as Cal-Bor®. They are very pleased to think that using a product like Cal-Bor® at the appropriate time(s) during bloom could bring an increase in fruit set and yield of around 5%, so plan on continuing its usage.

Financial Gain: Only two quarts per acre are needed for each foliar boron spray, at an incredibly inexpensive cost of only about $5/A per spray, or $10/A if both applications are made. The ‘typical’ Maine cranberry grower has yielded an average of 110 barrels (11,000 lbs.) per acre of cranberries averaged over the past decade. An increase of 4.5% would give the grower an additional 495 lbs./A which at last year’s (2014) price for water-harvested berries ($0.13/lb.), would have translated to an additional value of $64.35/A and a net gain, therefore, of $54.35/A. For a fresh-pick operation, which consistently gets a much higher berry return of anywhere from $0.75 to $1.50 per lb., the net gain would be an impressive $361.25/A to $732.50/A. Finally, a 4.5% increase to the entire Maine

cranberry crop, which in 2013 was nearly 3.6 million lbs. with a value of 1.4 million dollars, would have meant a total yield of 3.76 million lbs. worth a total of 1.5 million dollars; an increase of $100,000. The hope was that the 4.5% increase observed in fruit set here (in this study) would have been considerably larger than the 5% increase that was reported from Massachusetts cranberry farms, but, any gain is still a gain, and with prices for water-harvested cranberries being painfully low in recent years, anything that is a net gain, is helpful!

LESSONS LEARNED:

There were some clear lessons learned as a result of this project, which were very helpful! The most burning question, which was very basic in its scope, was answered quite definitively, and that was: **Is there a deficiency of boron occurring in commercial cranberry plants in Maine during the pollination and fruit set period?** The answer, with rare exception, appears to be "no." Having that question answered is very helpful, because there were some compelling reasons to suspect that perhaps it was the use of a foliar boron spray that was causing one of the Maine cranberry farms in particular to be getting such a higher level of fruit set than everyone else. It seems apparent now that although that may have been *part* of the reason for the high numbers there in the past, there must be another reason (or reasons) for explaining the mystery of the high-performing site. High leaf boron levels from that site was the one, single and unique 'measure' that really stood out, compared to other cranberry sites in the region. Finding an average increase in fruit set of only 4.5%, rather than 50%, illustrates the complexity of nature, and how most likely, there are a multitude of factors that led to that one particular site performing so well in its fruit set and number of berries per upright. But learning that giving cranberry plants some extra boron during bloom may give a grower a bump in fruit set (and be extension, yield), is definitely a valuable lesson that was learned here. It was particularly interesting, too, to find that even with just a single dose of the foliar boron spray during bloom, rather than the two applications that is recommended, there was a detectable increase in fruit set. This might make the Maine growers more willing to try a *second* application of the material, now that they are armed with some evidence that the material really does help with increasing fruit set.

It was also interesting to get to discover where, in the cranberry stems, the bulk of the boron is held. Figure 1 shows that it was clearly in the leaves where most of the boron is found. This was a little 'side study' that was done, as it required only three additional samples to be analyzed by the laboratory, and yet yielded a very helpful result because it suggested that although the plants might indicate an "optimum" level of boron, there is always the possibility that the leaves are selfish and/or require a lot of boron, or perhaps do not share it readily with the flowers, or, even if they do, that they may be unable to share it fast enough to satisfy the needs of the flowers. So finding out that most of the boron is contained in the leaves, was an important clue to what might be going on. Examining that question was an idea that the staff at UMaine's Analytical Lab put forth, in fact, and

was not even part of the project's original Work Plan, but which greatly added to the value of the project!

The biggest surprise with this project was what happened at farm #4 (i.e. site 4-a and 4-b), where—as discussed previously—the cranberry bed which received an application of Cal-Bor® (site 4-a) indicated about a 6% lower fruit set level (and about 25% fewer berries per upright) than the cranberry bed that bordered it which received no boron spray at all. Those differences are very small, however, so perhaps if the sample size and area (either one or both) had been greater, the results would have been more in line with what was hoped for. Blackheaded fireworm, also, was present in both of those beds and especially in the Cal-Bor® bed, which could easily have weakened the stems that were marked in the study and caused some of the pollinated flowers to have been aborted. Tracking a greater number of stems per site through the season, at all of the sites, would have helped the experiment, but there was only a single person carrying out that work. The amount of time spent monitoring the 20 to 30 stems at each site that were marked, was just about right, in terms of striking a practical balance in what could realistically be achieved in two days across seven sites and three separate visits per site, all within the bloom period of the cranberries, which only lasts one month.

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Project 5: Enhancing and Expanding the Disease Integrated Pest Management Program for Maine's 575 Wild Blueberry Growers

Final Report – Previously Submitted

Project summary: This project improved the Integrated Pest Management of two diseases, mummy berry blight and Botrytis blossom blight which seriously impact wild blueberry production in Maine. Mummy berry and Botrytis blight are of immediate economic concern to Maine wild blueberry growers because both diseases can result in substantial crop loss and revenue. A 2011 SCBG grant provided funds to purchase 10 weather stations connected to a cellular network which gave Annis the capability to report important disease events to growers in a timely way and growers had a better opportunity to control disease and reduce pesticide use. The weathers stations were first deployed in April 2012 in 10 wild blueberry fields. Unfortunately these stations did not cover all blueberry growing areas. This project built on an earlier project that expanded the network of weather stations that provide environmental data to develop fungi infection risk forecasts. We also extended the forecast to include information on Botrytis blossom blight. This project also began studies to look at the development of the fungus that causes mummy berry disease in order to further improve forecasting for this disease. We tested fungicides with different modes of action for their effectiveness in controlling mummy berry disease since the two prevalent fungicides used have the same mode of action increasing the risk of the development of resistance. The objectives of this project enhanced the IPM program for control of two of the most economically important diseases of wild blueberries.

Project Approach

Obj. 1: Expand the disease and pest forecasting system. Four new weather stations were purchased in March 2014 and in 2014, they were deployed in blueberry fields in Dresden Mills, West Rockport, Union and Belfast and the remaining 10 stations purchased previously with Northeastern IPM funds and Specialty Crop Block Grant funds were deployed in fields in Hancock and Washington counties. These stations were also deployed in April of 2015 at 13 locations. Data from the stations were used for the mummy berry forecasts starting in April and extending through May and then for Botrytis reports in May and June in both years. Growers reported on development of fungal structures from 10 fields with weather stations and plots containing mummy berries (the common name for pseudosclerotia which are the overwintering structures of the fungus). Throughout the disease risk season from early April to mid-May, we provided forecast reports on mummy berry disease, as well as, reporting the occurrence of frost and Botrytis infection for most of the blueberry growing areas. The forecast reports were delivered in three ways;

1. In email messages sent out to an email list,
2. Posted on the Wild Blueberry extension blog (http://umaine.edu/blueberries/blog/)
3. Recorded as answering machine messages.

Weather data was also collected through to the end of September 2014 to determine if some weather parameters can be used to predict leaf spot disease occurrence or severity and for use with pest emergence models. We rated the blueberry plants in fields with weather stations for occurrence and

severity of various diseases including mummy berry, Botrytis and leaf spots during the season and compared it to various weather conditions. We have not seen any clear pattern linking certain weather parameters to disease and will be repeating this analysis on data collected in 2015. The weather data also was sent to Dr. Frank Drummond, Entomologist at the University of Maine, to assess environmental impacts on the emergence of two important pests of wild blueberries, the Spotted Wing Drosophila and the Blueberry Maggot. These data are still being analyzed.
We contracted with Skybit to get virtual data for 10 locations where we also had real weather stations. These data were used to calculate forecasts based on the virtual data. The virtual and real data are being compared to see how well they correspond using the mummy berry, bloom and Botrytis blight forecast models. We found there were some problems in where the weather data is estimated spatially since the weather stations measure weather parameters at 4 inches off the ground in the blueberry canopy and the virtual data was estimated for 6 ft off the ground. Skybit is re-analyzing the data to provide us with a more accurate estimate of the weather in the blueberry canopy.

Obj. 2: Provide data to develop a biological model of *Monilinia vaccinii-corymbosi*, the fungus which causes mummy berry disease

We are using use soil moisture and temperature, and humidity, as well as, air temperature data from the weather stations to determine how these factors affect the development of the mummy berry fungus in the soil. We were unable to use the cameras to track fungal development since a suitable prototype was not available this field season.
We did set up a field experiment in fall of 2013 where pseudosclerotia from four blueberry fields were planted at one location on the University of Maine campus. The environmental conditions were monitored and the development of the fungus. We had low levels of germination, and did not see any differences between fields. We found there was an approximately normal distribution when cups were produced and a last flush of water at the end of the cups did not produce a new flush to germination. We also found from a separate experiment that from 50 to 60% of pseudosclerotia were lost from August to November when placed in the soil. A graduate student will be following up on this observation with an experiment to determine what is happening to these pseudosclerotia.

Obj. 3: Investigating additional control materials to build fungicide resistance management into the mummy berry IPM system.

We tested four fungicides for mummy berry control at two field sites with histories of mummy berry disease in 2014. The standard fungicide, propiconazole (Tilt), was compared to fungicides with different modes of action (amino-pyrazolinone, Protexio), and different chemistries (metaconazole; Quash, prothioconazole Proline) and one organically accepted biocontrol (*Bacillus subtilis*, Serenade). We timed application of the fungicides using the mummy berry forecasting system (MBFS) and applied fungicides accordingly. In 2014, we made one application on May 12 and rated for disease on May 30th. Yield was harvested on August 12th. We found in one field we had differences among fungicides with good control with Quash, Proline and our positive control, Tilt. There were no differences in yield among the fungicide treatments.

Goals and Outcomes

Objective 1 At the March 2014 blueberry grower schools, information on the IPM mummy berry and Botrytis blight forecasts and how to track plant and fungal development was presented. From surveys at these meetings, we found 66% of growers present at the meeting used the mummy berry forecasting system method. We found most growers were aware of Botrytis blossom blight but there was still confusion on how to control Botrytis and use the forecast. Due to change in grower meetings, we were unable to survey growers again in March 2015. At that meeting, more information was provided to growers about the mummy berry forecast and Botrytis forecast. We will be surveying growers again in January and March grower meetings in 2016.

Objective 2 . We have initial information that will lead to developing a model of the development of the mummy berry fungus. This will provide growers with better information on the timing of when the fungus causing mummy berry disease is present in their fields. We also learned the interesting fact that something is consuming or destroying pseudosclerotia in the fields.

Objective 3 . Fungicides that have been consistent in their results for two years will be recommended to the growers and others will be retested next year. These trials were successful in identifying a material with a different mode of action, Fontelis (penthiopyrad) and two fungicides with different chemistries Quash (metaconazole) and Proline (prothioconazole) for controlling mummy berry disease and worked well for two field seasons. Fontelis can be used in rotation with other fungicides to decrease the risk of fungicide resistance developing in the fungus that causes mummy berry disease. Results were presented at the Agricultural Trade show in January 2015 by David Yarborough and at a growers' meeting in March 2015 by S. Annis.

Beneficiaries

All blueberry growers who have mummy berry in their fields will benefit from this research as will blueberry consumers and the general public who live near blueberry fields. We send the mummy berry disease forecast to an email list of approximately 350 individuals and 66% of 100+ growers indicate that they use this valuable tool. The forecast improves control of mummy berry disease and has a positive impact for growers and grower groups. Identification of materials with different modes of action, and chemistries that may be used to control mummy berry will help growers decrease the chances of resistance developing by continual use of propiconazole.

Lesson Learned.

We found the surprising result that something is consuming or destroying significant numbers of pseudosclerotia in the wild blueberry fields. We also learned to double check that all weather stations are operational before deployment. Our unexpected problems with the weather stations after deployment caused some headaches and disruption of providing the initial forecast for those locations.

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Project 6: Management Of New Serious Invasive Insect Pests Of Fruit And Vegetables, Spotted Wing Drosophila, Winter Moth, And Assessment Of Brown Marmorated Stink Bug

Final Report

PROJECT SUMMARY

Currently, Maine is experiencing an unprecedented threat to small fruit production. Three new serious insect small fruit pests have been detected within our borders. Maine, for a long time, has enjoyed lower pest pressure than many of the small fruit producing regions to our south and west and our fruit production systems had efficient and sustainable pest management tactics in place that were recommended by the University of Maine Cooperative Extension and adopted by most growers. The three NEW invasive insects of focus are the Spotted Wing Drosophila, the Winter Moth, and the Brown Marmorated Stink Bug. These new pests upset the established pest management programs and resulted in levels of crop loss not accustomed to many of the Maine small fruit growers. As an example, about 25% of the Maine raspberry growers went out of business when the spotted wing drosophila entered the state. The Wild Blueberry Commission, Maine Vegetable and Small Fruit Growers Association, and Maine Organic Farmers and Gardeners Association propose to develop and implement an Invasive Pest "integrated pest management" program for Maine's more than 700 berry growers. This IPM program is conservatively estimated to prevent $ 75 million alone in berry grower losses from SWD and save over $160 million in Maine economic activity over 5 years. Additionally, through adoption of this program, growers can avoid losses.

PROJECT APPROACH

Four objectives were formulated by our research team.

Objective 1. Develop and test IPM tactics for spotted wing drosophila management.
Objective 2. Determine damage potential and least toxic management tactics for winter moth.
Objective 3. Determine the extent of the brown marmorated stinkbug and its potential as a pest of small fruits in Maine.
Objective 4. Educate growers on monitoring and management of these pests; evaluate adoption of, and impediments to management tactics.

Our approach was mostly based upon field experiments in both grower fields and University of Maine Experiment Station Farm fields. However, we also conducted some laboratory experiments at the University of Maine to determine the mechanisms of some of the responses observed in the field. This project was originally proposed as a one-year investigation, but because of the complexity of some of the new invasive insect pest problems and because the pest dynamics of the spotted wing drosophila changed as the invasion spread throughout the state, we worked on our objectives over a three-year time frame 2014-2016.

Activities Performed (AP)

Objective 1. Develop and test IPM tactics for spotted wing drosophila management.
This objective was our most involved one because of the serious crop loss potential of the spotted wing drosophila across most of Maine's small fruit production systems. We studied: 1) monitoring trap designs and bait formulations in raspberry, highbush and wild blueberry crops (2014-2015), 2) insecticide efficacy and residues on fruit at harvest (2014 & 2015), 3) alternative wild fruit hosts (2015 & 2016), 4) predation by natural enemies in the field (2014-2016), 5) action thresholds for timing of insecticide applications (2014-2016), 6) mass trap and kill tactics (2014 & 2015), and 7) exclusion netting (2014-2016). All of these studies were conducted in the field in Central, Mid-coast and Downeast, Maine.

Objective 2. Determine damage potential and least toxic management tactics for winter moth.
Replicated field pest management tactics were evaluated both in the field and in the laboratory. In the field, natural enemy (parasitoids and pathogens) incidence and effectiveness was evaluated in wild blueberry fields, apple, and deciduous forest edge habitats. In addition, the phenology of life history parameters such as the timing of adult moth flights and oviposition were measured in the epicenter of the winter moth outbreak in mid-coast Maine. Least toxic insecticide efficacy was evaluated by spraying wild blueberry foliage in the field. Stem cuttings were then transported to the laboratory on several sequential days after application. Winter moth caterpillars were then forced to feed on the sprayed foliage in Petri dishes. Time to death and the level of mortality was evaluated for the following insecticides: Dipel® DF (*Bacillus thurengiensis kurstaki, Bt-k* toxin), Intrepid® 2F, Azaguard® (neem oil) and Entrust® SC (spinosyn). In May and June 2016, a laboratory assay was conducted to follow up on the 2015 field trial and explore the susceptibility of winter moth larvae to the microbial insecticide, Dipel. Winter moth larvae were collected on different host plants including: oak, apple, and wild blueberry. Foliage was collected from each host plant and leaves were pinned to a styrofoam board and sprayed with Dipel or a control of water. Larvae were then fed on the treated or control foliage from their respective host plant.

Objective 3. Determine the extent of the brown marmorated stinkbug and its potential as a pest of small fruits in Maine.
An early detection surveillance program by direct observation and trapping was instituted for brown marmorated stinkbug across the state of Maine. This annual survey was conducted in all small fruit crops in Maine. In addition to our efforts, grower education was initiated in order to increase the number of observers.

Objective 4. Educate growers on monitoring and management of these pests; evaluate adoption of, and impediments to management tactics.
Our approach for this objective was to incorporate all the useful knowledge learned from objectives 1-3 AND from researchers in other states into: Oral presentations at grower conventions and fruit schools, 2) Grower Twilight meetings at grower's farms and at the University of Maine research farms where monitoring, control, and pest identification and damage could be demonstrated, 3) Factsheets and grower recommendations, 4) Newsletters and blogs, and 5) video tutorials.

GOALS AND OUTCOMES ACHIEVED

Objective 1. Develop and test IPM tactics for spotted wing drosophila management.

In the three years that this project began developing IPM tactics for managing spotted wing drosophila we have also had to conduct preliminary studies that form the basis of IPM. Development of monitoring tools were one of our first endeavors. An initial informal comparison of the yeast/vinegar baited traps and a new commercially available lure (Trece) was carried out at several of the sites. The yeast/vinegar bait caught flies earlier and in greater quantities, so the commercial lure was not adopted. Formal experiments in 2014 showed that a yeast/sugar bait in a red Solo® cup caught more flies in wild blueberry than other trap and bait combinations ($F_{(3,16)} = 46.90$), $P < 0.0001$); Fig. 1). Therefore, this is the monitoring tool that we adopted. Further study in Maine and elsewhere supported similar conclusions (Burrack et al. 2015). Figure 2 shows use of the monitoring tool in a high-tunnel raspberry operation in Maine.

Fig. 1. Bar graph showing mean SWD adults per treatment over each sample date. Lines are standard errors of the mean.

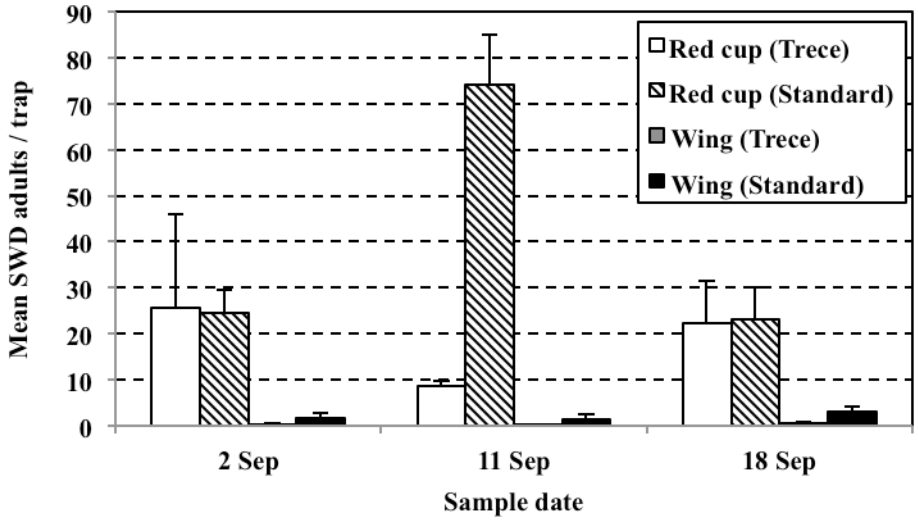
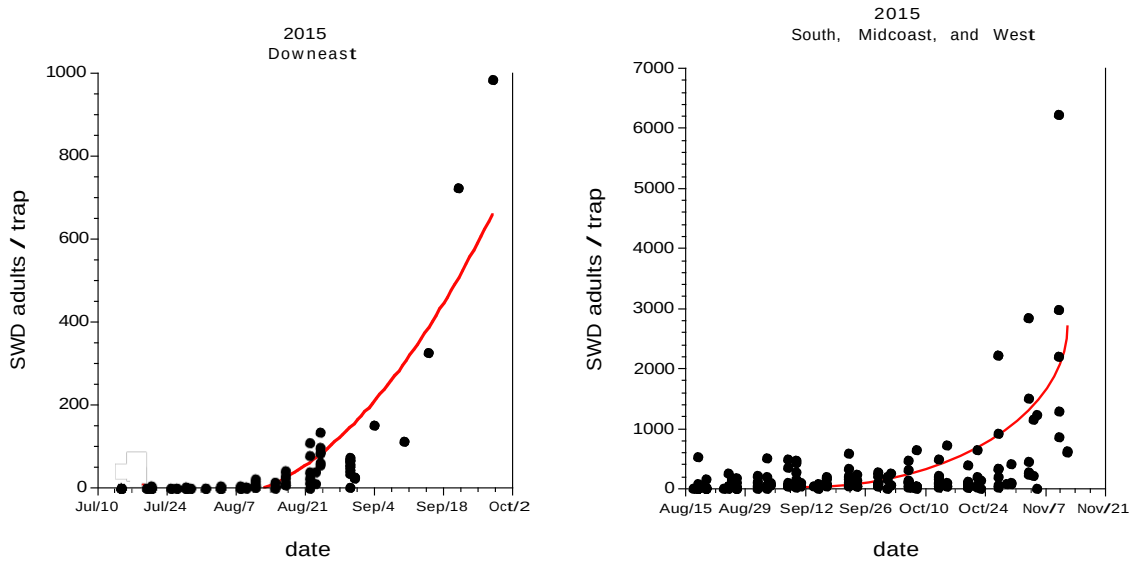


Fig. 2. Use of a Solo® red cup trap baited with yeast solution (Dr. Handley in photo).

With a monitoring tool that researchers and growers could use, relative abundance of population levels could be estimated across different crops and regions of the state (Fig. 3). We found that fairly consistently over the three years spotted wing drosophila was not detected until mid- August and then quickly increased in population buildup after that. Overall population patterns over the season in 2016 differed from the two previous years of monitoring (Figs. 3 and 4). The growth rate in the Downeast wild blueberry region was slower and did not reach the high abundance in 2016 as was observed in 2015. In the south, mid-coast and western regions, the rate of population increase, indicated by trap capture was higher in 2015 compared to 2016, but trap captures in 2016 appeared to vary more from week to week and location to location than we had seen in the previous year. This allowed growers in some locations to delay insecticide sprays and spray less frequently than in previous years. However, populations did reach damaging levels early enough to pose a significant threat to late ripening blueberries and fall-bearing raspberries (Fig. 4).

Fig. 3. Adult SWD captures for 2015 in 12 wild blueberry fields in Downeast, Maine and 21 highbush blueberry, wild blueberry, and raspberry in Southern, Mid-coast, and Western Maine.



Our insecticide trials in both the laboratory and field (2014-2016) identified efficacious insecticides for management of spotted wing drosophila and the frequency between applications that is necessary for protecting the crop (Table 1, Table 2). In addition, results of residue trials provides data that growers can use to make decisions about which insecticides will allow them to market their crop to various countries around the world (a few examples are shown in Fig. 5).

Fig. 4. Adult SWD captures for 2016 in 16 wild blueberry fields in Downeast, and 14 highbush blueberry, wild blueberry, and raspberry fields in Southern, Mid-coast, and Western Maine.

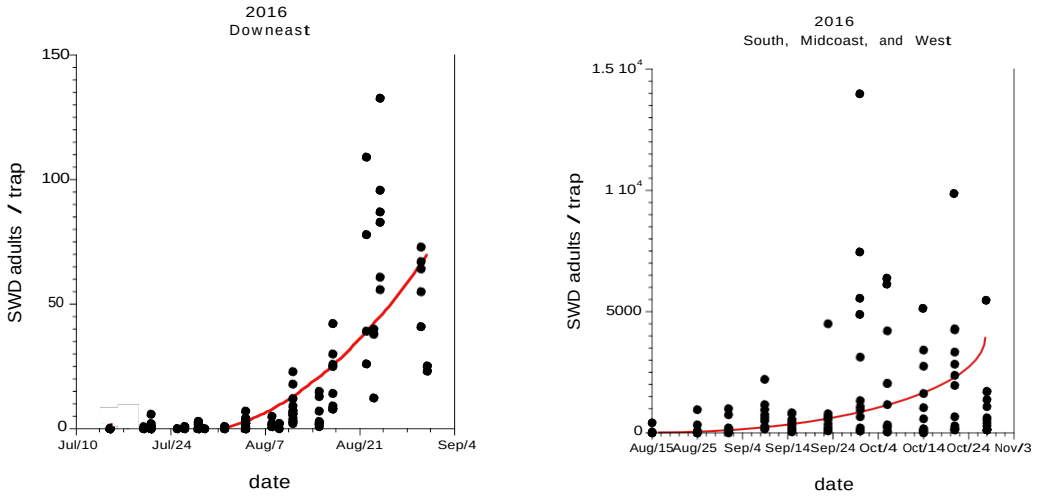


Table 1. Field control of SWD with insecticides (2014), summary (logistic regression used to assess treatment effects).

Material	Amt. form./ acre	Prespray 3 Sep	SWD larvae/sample (odds ratio*) 7 Sep (3)**	10 Sep (6)	23 Sep (4)	26 Sep (7)	4 Oct (15)
Delegate 25WG	6.0 oz	0.25	0.00 (0.02)	0.25 (ns)	0.25 (0.06)	0.25 (0.04)	0.25 (ns)
Success 480SC	6.0 oz	0.08	0.00 (0.02)	0.08 (ns)	0.33 (0.02)	0.00 (<0.001)	0.25 (ns)
Mustang Max	4.0 oz	0.08	0.08 (ns)	0.25 (ns)	0.00 (<0.001)	0.17 (<0.001)	0.00 (0.05)
Imidan 70WP	21.3 oz	0.00	0.00 (0.02)	0.00 (<0.001)	0.17 (0.01)	0.17 (<0.001)	0.17 (0.08)
AzaGuard	8.0 oz	0.50	0.17 (ns)	0.67 (ns)	1.17 (ns)	1.17 (ns)	0.25 (ns)
Non-treated check	-	0.33	0.33 (NA)	0.67 (NA)	1.42 (NA)	1.33 (NA)	0.67 (NA)
P =		0.098	0.054	0.013	<0.0001	<0.0001	0.103

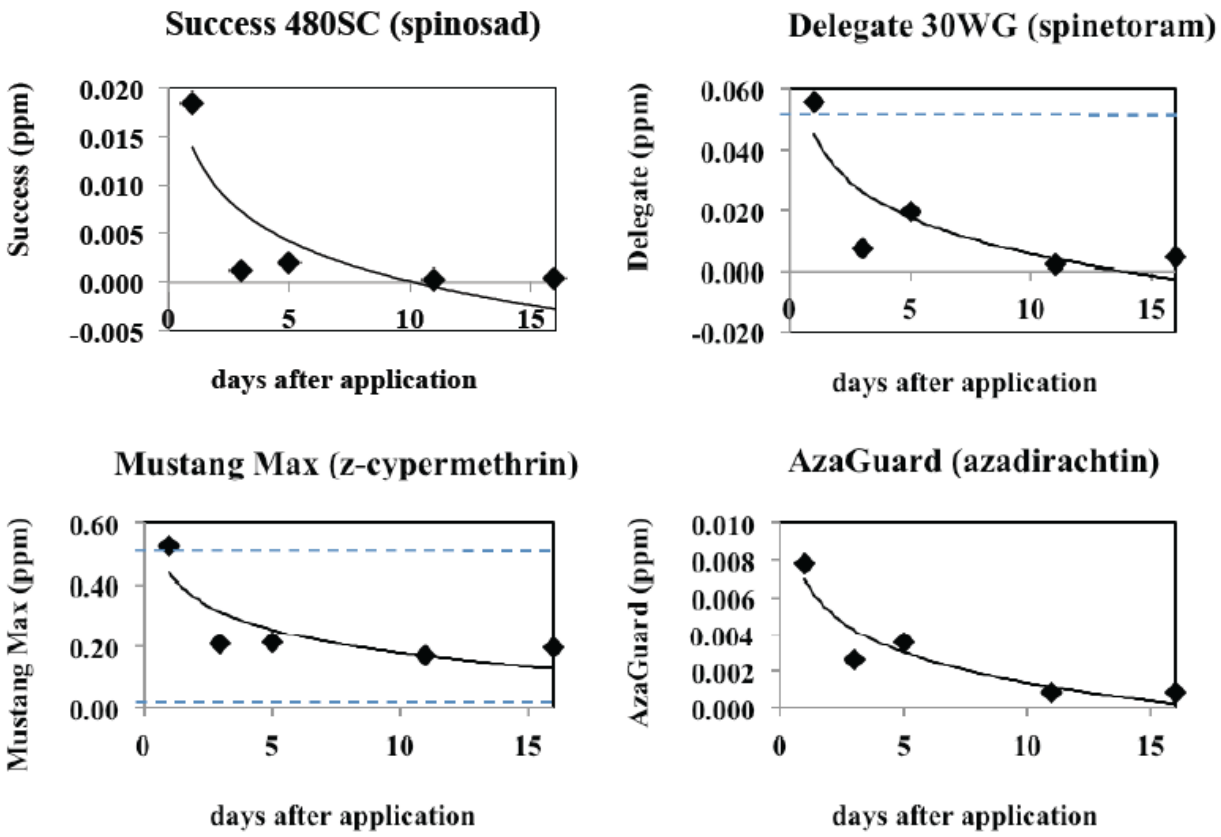
* odds ratio: likelihood that insecticide treatment has lower maggot infestation than check.
** numbers in parentheses: days after application for trial 1 (application = 4 Sep) and trial 2 (application = 19 Sep).

Table 2. Laboratory control of SWD with Assail, summary (2015).

Treatment	Rate oz/acre	Cumulative % mortality day 0*	day 1	day 2
Assail 30SG	5.3	30.0 a	100.0 a	100.0 a
Assail 30SG + Sugar	5.3 + 16.0	20.6 a	96.7 a	100.0 a
Assail 30SG	0.53	10.0 a	90.0 a	100.0 a
Assail 30SG + Sugar	0.53 + 16.0	20.0 a	96.7 a	100.0 a
Untreated check	-	13.3 a	26.7 b	33.0 b

* Observations made 4 hrs after adding spotted wing drosophila adults
Means within columns followed by the same letter are not significantly different (LSD, $P \leq 0.05$).
Data were transformed by sqrt prior to analysis.

Fig. 5. Residues of insecticides used against spotted wing drosophila (2015). Blue dashed line is the Japanese MRL (maximum residue level) and the gray dashed line is the European Union MRL)



Wild fruit along the edge of blueberry fields provides a resource for early population growth prior to wild blueberry fruit ripening (Fig. 6). In 2015 and 2016 spotted wing drosophila increase in wild fruits before flowing into blueberry fields (data for 2015 shown in Fig. 7).

Fig.6. Distribution of wild fruit collected along wild blueberry field edges.

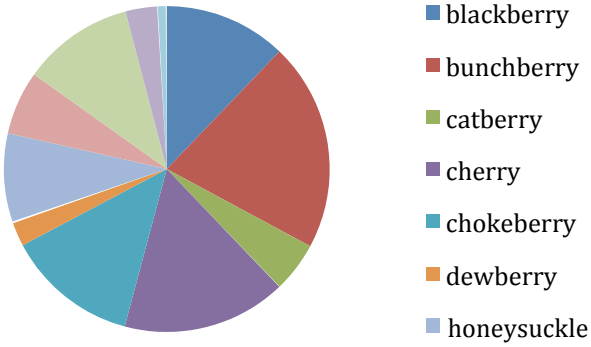
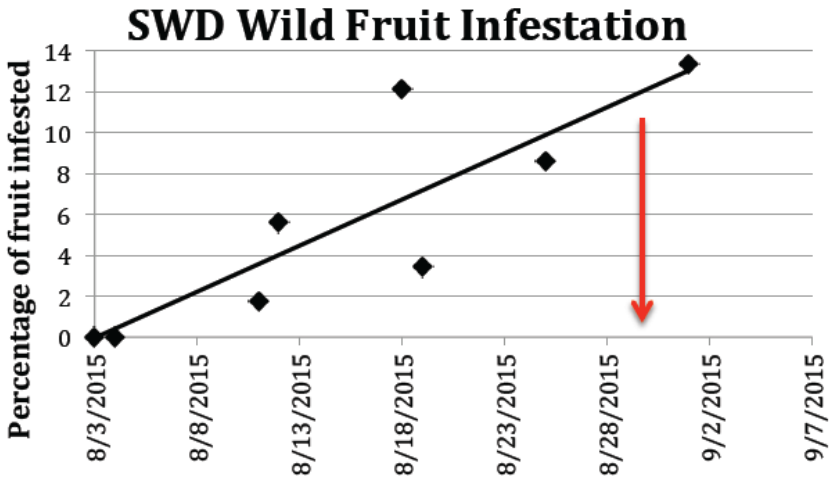


Fig. 7. Increase in SWD population denoted by % infested wild fruit along edge of wild blueberry fields. Red arrow is average date of initiation of blueberry infestation (2015).



In all three years of this project we found predation of spotted wing drosophila sentinel pupae in wild blueberry fields to be exceedingly high and in 2015 and 2016 it was 100% (Table 3). We identified the most likely predators using video cameras in the field and using pitfall traps to capture potential predators near the consumed pupae. Carabid beetles (ground beetles) of the species *Pterostichus melanarius* and *Bembidion quadrimaculatum* were voracious predators when tested in the laboratory, but the most important predator appears to be *Gryllus* spp. crickets. Crickets consume up to 80 spotted wing drosophila pupae per day.

Table 3. Predation rate of sentinel pupae over a three-week period in each of the three years (2014-2016).

Site	Year	% Predation
Jonesboro	2014	64.6
Sedgewick	2014	95.6
Jonesboro	2015	94.0
Stockton Springs	2015	100.0
Jonesboro	2016	100.0
Stockton Springs	2016	100.0

Use of action thresholds to guide growers in timing of insecticide applications do appear to be a viable IPM tactic for wild blueberry in Midcoast and Downeast Maine. During the period 2012-2015 thresholds were estimated by relating cumulative trap capture of male SWD over time with the first occurrence of detectable berry infestation in 34 fields (15 of the 34 fields had male captures but were harvested before damage appeared and so were not used in the calculations for threshold probabilities). Male SWD adults were used because it is a life stage that growers can identify easily with limited error from their trap monitoring. A range of thresholds were calculated in order to fit the various risk aversion profiles of growers (Fig. 8). Table 4 shows the action thresholds that have been presented to growers and validated during the 2016 field season. In 2016, a cooperative study was conducted with 6 growers involving 14 fields. Growers selected action thresholds that were suited to their farming operation. Three growers also decided to use our thresholds and monitor for SWD with the protocol that if no male SWD were captured prior to harvest then no insecticides would be applied and the fields would be harvested. In this early harvest tactic none of the four fields that were managed in this manner had fruit infestation. Four fields were managed by using an action threshold of 3 males per trap and none of these fields had any infestation by time of harvest. Five fields were managed using a threshold of 9 males per cup.

Fig. 8. The frequency distribution of 34 fields and the relationship between male SWD cumulative trap capture and the resulting following week of the field not being infested. Four of five fields managed in this manner did have infested fruit the following week after reaching the action threshold. However, the percent fruit infestation for these growers was for the most part acceptable and extremely low at 0.0, 0.13, 0.14, 0.2, and 0.8 %.

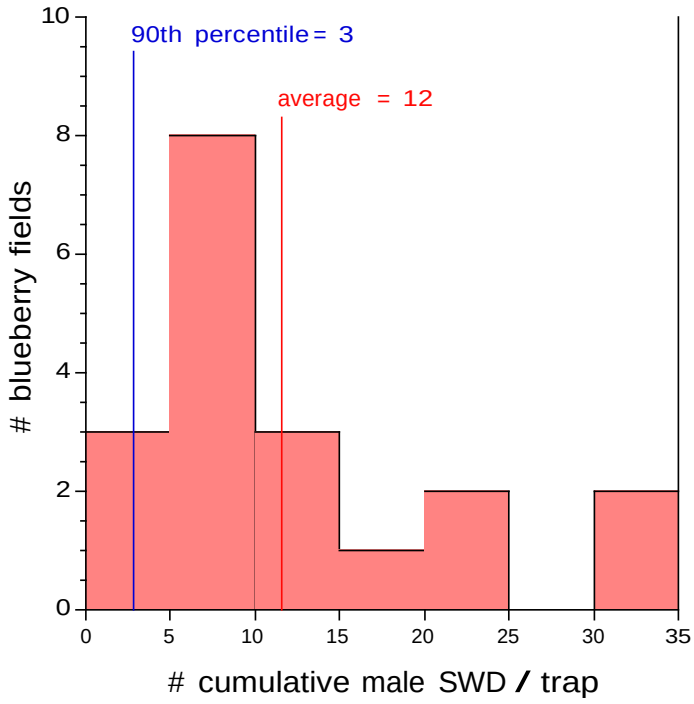


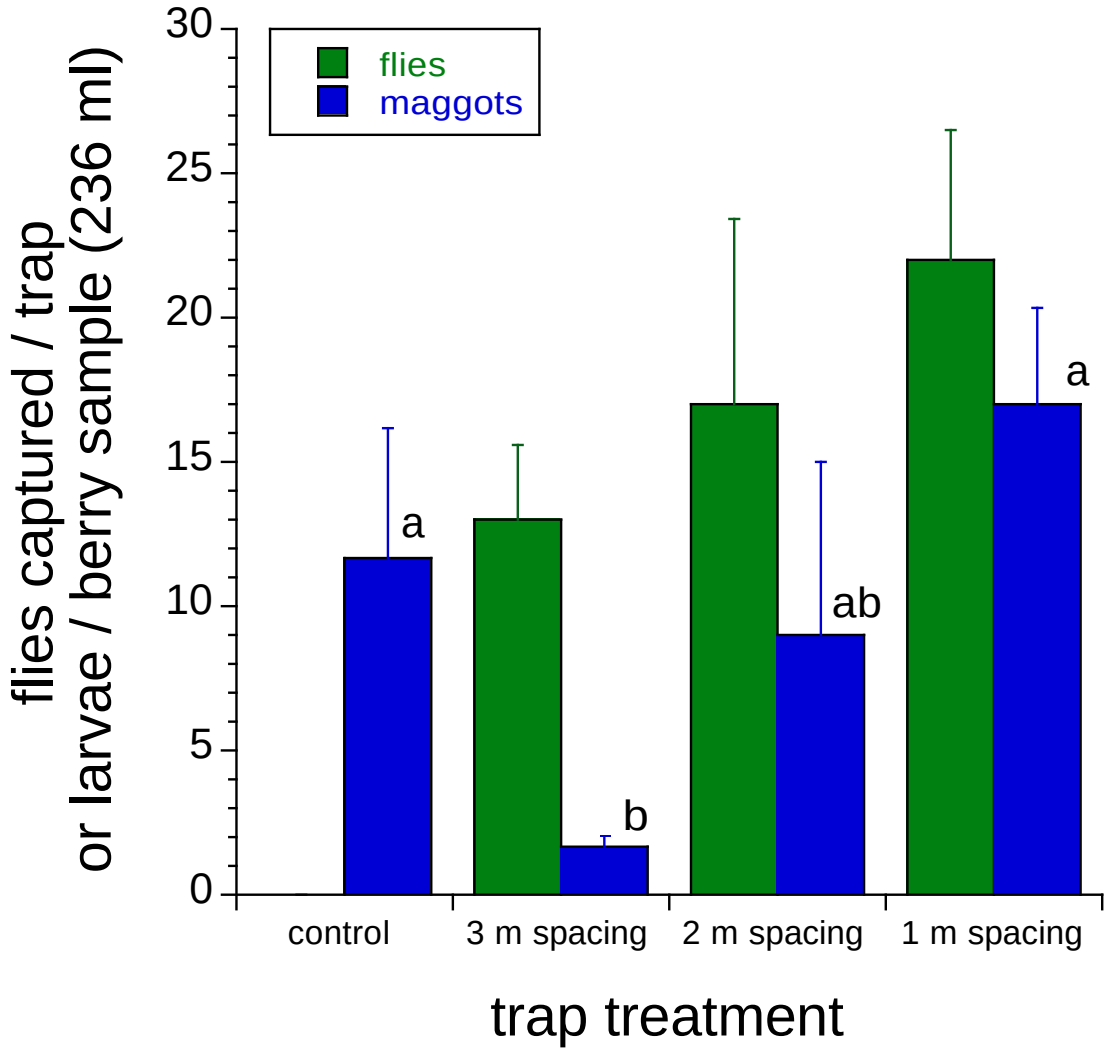
Table 4. Action thresholds for the spotted wing drosophila in Maine wild blueberry.

Cumulative Male SWD captured / cup (based upon three cups / field)	Probability of a non-infested field the week following attainment of the action threshold
0	0.1%
1	0.3%
3	9.7%
9	25.0%
12	49.0%

Mass trapping (trap and kill) was evaluated in 2014 and 2015. In an extensive replicated study in 2015 we found that a trap and kill tactic with the current baits used in traps coated on the exterior surface with the insecticide boric acid, did not reduce levels of maggot infestation. On the contrary, we found, as shown in Figure 9 that the more traps in a field plot, the more maggot infested fruit occurred. A trend in increasing SWD adults recruiting to the plots suggested that

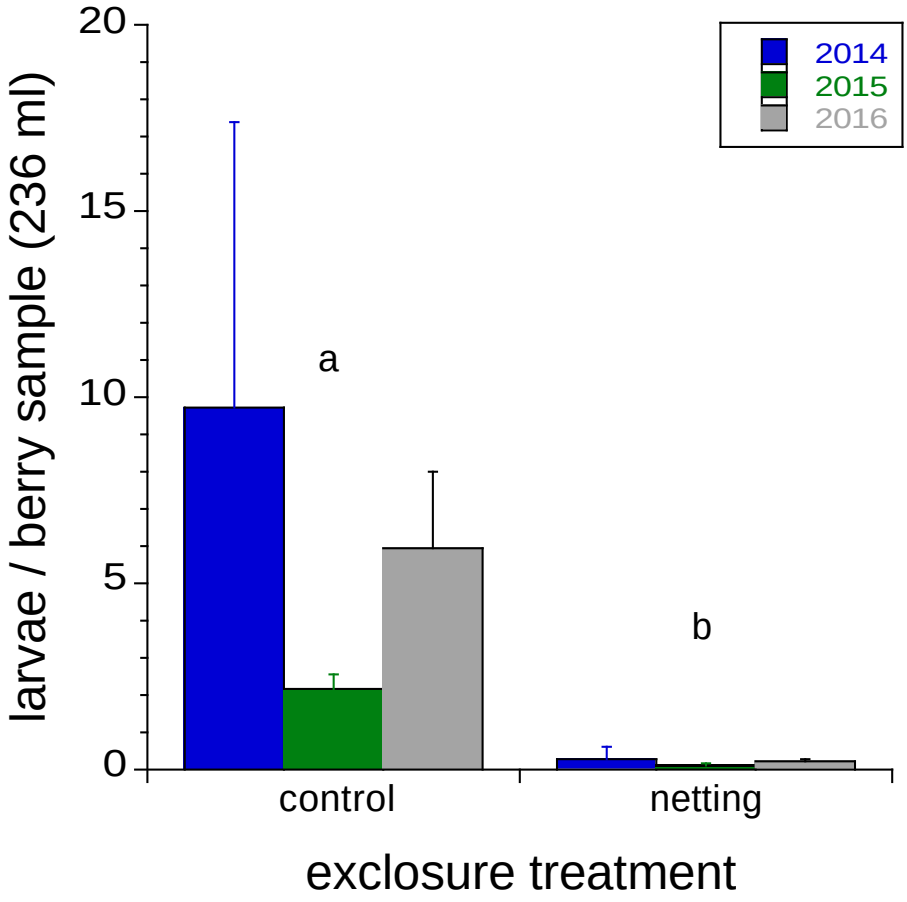
higher densities of traps resulted in a higher recruitment of flies and that the traps were overwhelmed in fly numbers and not able to trap or kill an increasing proportion of flies.

Fig. 9. Mean abundance of individual *D. suzukii* captured in control, low density (2.7 m), medium density (1.8 m) and high-density (0.9 m) experiment trapping grids. Each mean represents the average of three replicates over four weeks of trapping. Letters above larval abundance columns represent Tukey post-hoc results, with bars displaying dissimilar letters signifying statistical significance. Error bars are one standard error of the mean.



Excluding damage in wild blueberries by netting was found to be very successful in minimizing crop loss to SWD for all three years that experiments were performed. Figure 10. shows the results of this IPM tactic. However, currently the expense of netting is a likely obstacle to wide spread adoption of this control measure.

Fig. 10. Mean abundance of SWD larvae inhabiting five blueberry samples (adjusted to 236 ml each) from uncovered control plots or crop plots protected with exclusion netting. The measurements presented here represent the combined data from three consecutive trials conducted in 2014, 2015, and 2016. Error bars represent the standard error of the mean.

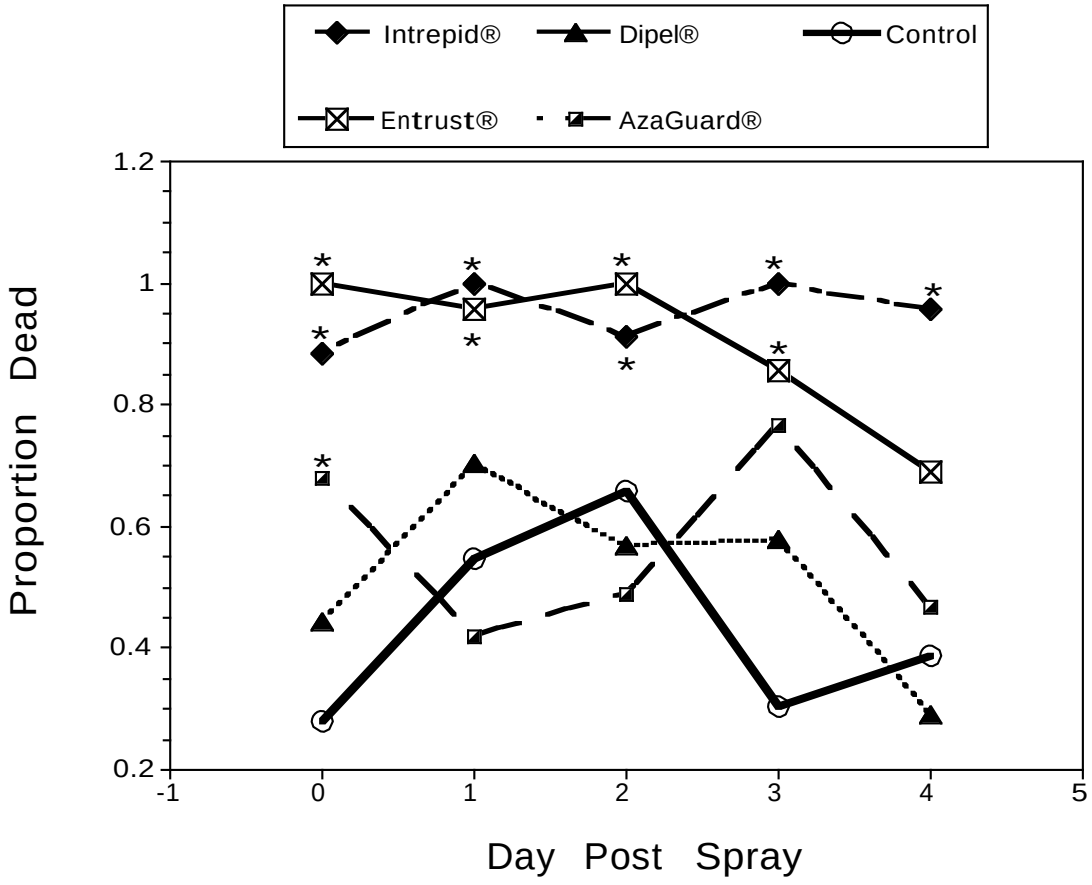


Objective 2. Determine damage potential and least toxic management tactics for winter moth.
In 2013-2015 winter moth was found in higher densities feeding on apple than on highbush and wild blueberry consistently throughout the entire feeding period. Densities on both highbush and wild blueberry were comparable. Winter moth density was highest on these plants in late May. In addition, winter moth larvae increased throughout the spring in Apple, but actually declined in wild and highbush blueberry due to high larval mortality. Laboratory studies and caged studies in the field on survival when confined to the different crop plants showed that highbush and wild blueberries are NOT optimal host plants for this new invasive plant. Winter moth only developed and survived at a high level on apple.

Winter moth larvae fed field sprayed foliage experienced significantly higher mortality on foliage treated with Entrust® and Intrepid® compared with the control. This significant mortality continued for four days post spray with Intrepid and three days post spray with Entrust.

Neither Dipel nor AzaGuard resulted in significantly higher mortality than the controls at any time post spray (Fig. 11). In 2016, we found that the susceptibility of winter moth to *Bt* was significantly lower in winter moth feeding on wild blueberry then those feeding on oak or apple. This supports the results of the 2015 field trial in which Dipel did not result in successful control of winter moth in wild blueberry, although *Bt* has been shown to be effective against this pest in apple (Hardman and Gaul 1990).

Fig. 11. Proportion of winter moth larvae dead after 5 days of exposure to foliage collected from field plots between 0 and 4 days after being sprayed with insecticides. * indicates treatments that are significantly different from the control of no treatment at alpha=0.05.



Objective 3. Determine the extent of the brown marmorated stinkbug and its potential as a pest of small fruits in Maine.

Stinkbug traps were set up at 6 locations in southern and coastal Maine in highbush blueberries, red raspberries and strawberries and 12 locations in Downeast Maine in wild blueberry fields. The traps were checked weekly during the growing season. In addition, 48 wild blueberry fields were visually inspected between 2014 and 2016 for brown marmorated stinkbug during harvest. Over the three years that we monitored brown marmorated stinkbug we did not find any evidence of a threat in Maine, despite it being detected in one location in northern Maine 2012.

Objective 4. Educate growers on monitoring and management of these pests; evaluate adoption of, and impediments to management tactics.

Most of our outreach and technology transfer in this project was focused on the spotted wing drosophila since this invasive insect has spread throughout Maine rapidly and has caused significant crop loss in wild blueberry, highbush blueberry, and especially fall raspberry. Spotted wing drosophila outreach resulted in eleven Factsheets, videos and blogs (see Additional Information, below). We plan on writing four more Factsheets this winter and spring on: 1) action thresholds, 2) use of netting to minimize fruit infestation, 3) alternative wild fruit use by spotted wing drosophila, and 4) natural predation of pupae. We also developed an spotted wing drosophila web page hosted by the University of Maine Cooperative Extension, which contains a blog, updated regularly with monitoring reports, photos and information on monitoring and control methods (see Additional Information). Updates to farmers regarding the SWD situation over the growing season were also provided through presentations at the Maine Vegetable and Fruit School (approximately 140 farmers), and the Maine Vegetable and Small Fruit Growers Annual Meeting (approximately 80 growers), and a vegetable and berry growers summer twilight meeting (approximately 40 growers). We also presented a poster on the Maine/Northeast SWD Program at the International IPM Symposium. Program surveys show that most growers have become aware of spotted wing drosophila and now have access to management information. Extension was cited as the primary source of spotted wing drosophila information. In addition, we submitted five manuscripts for publication (see Additional Information) and plan on writing submitting three more manuscripts to scientific journals (pupation ecology in maine wild blueberry, wild fruit use by spotted wing drosophila, and biological control potential based upon entomopathogens).

Thirteen winter moth oral presentations were given to growers at the 2014 and 2015 Agricultural Trade Shows; the 2014 Maine Wild Blueberry Schools in Waldoboro, Ellsworth, and Jonesboro; the 2015 Maine Wild Blueberry School in Bangor, and the 2014 and 2015 Annual Summer Blueberry Field Day. In addition, winter moth biology and control were discussed at the Waldoboro wild blueberry grower twilight meetings in May 2014, 2015, and 2016. A winter moth factsheet was written about biology and identification (see Additional Information) and recommendations for control were published on the wild blueberry website (see Additional Information). In addition two oral presentations were given to the scientific audience in 2014 at the University of Maine and at the Northeast Forest Pest Council in Quebec, Canada. One manuscript on the biology of winter moth in Maine has been submitted for publication in a scientific journal, with an additional manuscript planned for submission this winter.

Brown marmorated stinkbug was discussed at seven grower meetings from 2014-2016: the Maine Vegetable and Small Fruit Growers Annual Meeting, the Maine Vegetable and Small Fruit School, The Maine Wild Blueberry Schools in Waldoboro, Ellsworth, and Jonesboro, and the Maine Agricultural Trade Show. These presentations were designed to educate farmers on proper identification of this new pest species, the crops threatened, and management techniques presently being utilized in other locations.

BENIFICIARIES

Sound insect pest management is critical to the wild blueberry industry for three main reasons. Maine's greater than 700 small fruit growers will receive economic benefits from the results of

the research efforts to study to develop appropriate IPM strategies for invasive insect pests, especially the spotted wing drosophila. Without effective management, the five-year average annual yield loss due to lack of control of all insect pests is estimated to be a 30% crop loss, 10-20% due to blueberry fly and spotted wing drosophila alone. Second, poor insect pest management can result in contamination of the environment with insecticide residues. Third, inappropriate decisions and resulting control tactics regarding pest outbreaks can result in insecticide residues on fruit that may make them unacceptable in foreign markets. This IPM program is conservatively estimated to prevent $ 75 million alone in berry grower losses from spotted wing drosophila and save over $160 million in Maine economic activity over 5 years. The general public will also benefit from production practices that allow growers to produce wild blueberries at an affordable price and volume so that consumers will be able to afford to eat more healthy small fruits. The benefits of a healthier society are incalculable.

LESSONS LEARNED

During the conduct of this project we learned several important aspects of Maine's new invasive small fruit insect pests.

Regarding the spotted wing drosophila we learned that growers can use an inexpensive red cup trap with a yeast vinegar or sugar syrup bait to monitor adults and be effective in detecting when flies are first active in the field. The monitoring can be used to determine when flies are active and potential damage is likely or they can be used in wild blueberry to help make decisions about when to protect the crop with an insecticide. We need to collect more data on the relationship between cumulative male captures and percent infestation of fruit to have a robust action threshold. However, we believe that we have provided evidence and a validation that action thresholds will work for this pest in Maine wild blueberry. But thresholds or presence of flies are not the only criteria that growers need to incorporate in their decision making. Those growers that sell their crop abroad need to pay strict attention to MRLs (maximum residue levels). Our research has provided growers with a suite of efficacious insecticides, the average persistence of these insecticides, and the amount of time necessary before harvest that an application has to be made to avoid dangerous residue levels. We also learned that spotted wing drosophila pressure is much more intense in the Southern and Midcoast region of the state compared to the Downeast fruit growing region. Wild fruit along small fruit field edges appears to result in a fast buildup in fly pressure. Therefore growers should manage wild fruits whenever possible to reduce fly pressure. In addition, predation of spotted wing drosophila pupae is high due to naturally occurring ground beetles and crickets. This predation is obviously not enough to suppress fly populations, but growers should minimize insecticide exposure to these beneficial insects whenever possible. Trap and kill technology may have promise in the future, but it is not ready to implement with current trap and bait technology in Maine. Lastly, exclusion netting has great promise, from a technical fruit infestation mitigation perspective, but it might not be cost effective for most growers. Excluding labor requirements for seasonal installation and maintenance of netting, the deployment of the most inexpensive exclusion netting (Agribon®) on a single hectare would cost roughly US$ 4,600 according to product pricing by Gardeners Supply Company®. Therefore, relative to Anti-insect Netting® at US$6.09 / 13 ft^2 or US$49,680 per hectare, Agribon® appears to be a cost effective alternative. According to Chen et al. (2015), from 2010 to 2014 organic wild blueberry cultivation in Maine generated an annual net revenue of US $3,724 per hectare. In a single year, therefore, the financial inputs of purchasing netting units alone would exceed the total amount of generated revenue if the Agribon® netting was used.

However, more economically justifiable cost estimates are derived when considering the repeated use of netting. Assuming a degree of material durability and longevity spanning 2, 3, 4 and 5 years, the respective proportional cost decreases to roughly 62%, 41%, 31%, and 25% of total revenue generated from organically produced wild blueberry. However, our experience with the Agribon® material suggests only a one year use for a two month duration during the growing season. Given the high degree of infestation mitigation obtained with exclusion netting reported in this and other studies, it might be more feasible to deploy this management tactic if the yield damage caused by SWD exceeds the depreciated annual cost estimate of using a single netting unit repeatedly over time. Presumably, this disparity will increase over longer re-use time periods. Unfortunately, monetary losses due to SWD infestation have not yet been quantified in the wild blueberry crop system; although, some farms have experienced up to 25% crop loss due to SWD in some years (Drummond, pers. comm.). Therefore, this technique has great promise only if multiple-year use of netting is possible.

Clearly; the winter moth being a new threat to wild blueberry, apple, highbush blueberry and raspberry; needs management options. We have demonstrated that Azaguard and Bt do not fit the bill. Entrust and Intrepid appear to work quite well. Recommendations to growers in the near future will include these two insecticides. However, it is very interesting that the efficacy of Bt might be determined by the acidity of the soil environment that the crop grows in, and how the specific crop plant tissue pH is affected. This has never been shown before, but could have great implications in a state like Maine where the soils are highly acidic.

In discussions with our counterparts in New England over the season, we learned that brown marmorated stinkbug has been increasing to the south of Maine, and may soon become a significant pest of fruit and vegetable crops in Maine. Therefore, continued monitoring is important so that Maine growers do not experience unexpected crop loss.

CONTACT PERSONS

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ADDITIONAL INFORMATION

Extension Factsheets and Videos:

Spotted wing drosophila biology and management video is available for growers at:
https://www.youtube.com/watch?v=cbuqdP6Qhjs&feature=youtu.be
Spotted wing drosophila biology and IPM recommendations are available for growers at:
https://extension.umaine.edu/blueberries/factsheets/insects/210-spotted-wing-drosophila/
https://extension.umaine.edu/highmoor/spotted-wing-drosophila/
Spotted wing drosophila insecticide persistence and efficacy is available for growers at:
https://extension.umaine.edu/blueberries/factsheets/insects/spotted-wing-drosophila-update/
Spotted wing drosophila identification guide is available for growers at:
https://extension.umaine.edu/blueberries/factsheets/insects/spotted-wing-drosophila-identification-guide/

Spotted wing drosophila monitoring techniques are available for growers at:
https://extension.umaine.edu/blueberries/factsheets/insects/spotted-wing-drosophila-traps/
https://extension.umaine.edu/blueberries/factsheets/insects/solo-cup-and-lid-sources/
http://umaine.edu/highmoor/blog/tag/spotted-wing-drosophila/,
http://umaine.edu/blueberries/blog/ AND http://umaine.edu/highmoor/spotted-wing-drosophila/.
Winter moth biology factsheet is available at:
https://extension.umaine.edu/blueberries/factsheets/insects/207-winter-moth-a-new-spring-insect-defoliator-of-wild-blueberry-operophtera-brumata-linneaus/
Control recommendations for spotted wing drosophila and winter moth are available at:
https://extension.umaine.edu/blueberries/factsheets/insects/209-insect-control-guide-for-wild-blueberries/
Insecticide information sheets and non-target effects are available to growers at:
https://extension.umaine.edu/blueberries/wp-content/uploads/sites/56/2010/05/2016-Maine- Wild-Blueberry-Pesticide-Chart-Insecticides.pdf

Journal articles:

Burrack, H.J., Asplen, M., Bahder , L., Collins, J., Drummond, F.A., Guédot, C., Isaacs, R., Johnson, D., Blanton, A., Lee, J.C., Loeb, G., Rodriguez-Saona, C., Van Timmeren, S., Walsh, S. and D. R. McPhie. 2015. Multi-state comparison of attractants for monitoring *Drosophila suzukii* (Diptera: Drosophilidae) in blueberries and caneberries. Environ. Entomol. 1–9 (2015); DOI: 10.1093/ee/nvv022

Collins, J.A. and F. A. Drummond. 2016. *Spotted Wing Drosophila Control, 2014.* Arthropod Management Tests 2016 40 (1): C2doi: 10.1093/amt/tsv012

Collins, J.A. and F. A. Drummond. 2016. *Spotted Wing Drosophila Control in the Laboratory, 2014.* Arthropod Management Tests 2016 40 (1): L1doi: 10.1093/amt/tsv201

Alnajjar, G., J. Collins,and F.A. Drummond. *In Press.* Behavioral and preventative management of *Drosophila suzukii* Matsumura (Diptera: Drosophilidae) in Maine wild blueberry (*Vaccinium angustifolium* Aiton) through attract and kill trapping and insect exclusion-netting. Intl. J. Entomol. And Nematol.

Ballman, E. and F.A. Drummond. *submitted.* Natural predation of spotted wing drosophila in wild blueberry. Environ. Entomol.

O'Donnell, K., and E. Groden. *submitted.* Population Trends of Adult Winter Moth (*Operophtera brumata*) Over Two Years in Coastal Maine. Northeastern Naturalist.

Project 7: Roberts Farm CSA and Education

Final Report- Previously Submitted

Project Summary

The overall goal of the Roberts Farm CSA & Education program was to engage students in nutrition and science programs through the growing of specialty crops at Roberts Farm, the 2 acre farm of the Oxford Hills School District. Specialty crops grown, were distributed through a CSA for low-income residents, donation to the University of Maine Cooperative Extension – Maine Harvest for Hunger Program and USDA Summer Feeding Program.

Project Approach:

In 2013/14, the Oxford Hills School District continued this expansion of programming opportunities at Roberts Farm for students and community members. These integrated curriculums were delivered at the 2nd grade and 5th grade (ecosystems, biomes, nutrition education, 6th grade (living things and nutrition education) and middle school levels (chemistry, biology, living things, ecosystems, nutrition education, fitness plans) provided interwoven curriculum opportunities that paralleled the Next Generation Science Standards, Common Core and Maine Learning Results. This integrated learning continued to occur both in the school classroom and at Roberts Farm Preserve, which hosts the schools districts 2 acre farm, 6 greenhouses and 28 raised beds. We also partnered with 2 local farmers (Bisbee Orchard and Whitman Farms) to deliver the goals and objectives.

Goals and Outcomes Achieved:

Objective 1: Childhood obesity prevention through Specialty Crop Consumption and Education

Measurable Goal – 400 students will participate in Roberts Farm Educational programs including 100 that will participate in 6 hours of Farm-to-School nutrition education.

Achieved Outcome –

- Year 1: 468 students participated in Roberts Farm Education programs and 138 participated in 135 hours or more of programs. Thirty four of the 135 hours were Farm-to-School Nutrition Education.
- Year 2: 498 students participated in Roberts Farm Educational programs and 189 participated in 135 hours or more of these programs. Twenty eight hours were spent in Farm to School Nutrition Education

Over the course of the USDA Specialty Crop Grant, the following student data has been collected regarding educational programs for students:

- Year 1 - Seventy-seven 5th grade students from Oxford Elementary participated in 38 days of educational programming at Roberts Farm for a total of 228 hours per student.
- Year 2- 156 5th & 6th grade students from Oxford Elementary participated in 35 days of educational programming at Roberts Farm for a total of 208 hours per student.
- Year 1: Thirty-three 2nd grade students from Waterford/Harrison Elementary participated in 30 days of educational programming at Roberts Farm for a total of 180 hours per student.
- Year 2: Twenty-four 2nd grade students from Waterford/Harrison Elementary participated in 20 days of educational programming at Roberts Farm for a total of 120 hours per student

- Year 1 - Twenty-eight 7th and 8th grade students from Oxford Hills Middle School participated in 35 days of educational programming at Roberts Farm for a total of 165 hours per student.
- Year 2 – 22 7th and 8th grade students from Oxford Hills Middle School participated in 35 days of educational programming at Roberts Farm for a total of 165 hours per student.
- Year 1- Forty 5th and 6th grade students from Paris Elementary participated in 10 days of programming for a total of 80 hours per student.
- Year 2 – 121 5th and 6th grade students from Paris Elementary participated in 10 days of programming for a total of 80 hours per student.
- Year 1 - Forty five 8th grade students from Oxford Hills Middle School participated in 13 days of programming at Roberts Farm for a total of 98 hours per student.
- Year 2 – 42 8th grade students from Oxford Hills Middle School participated in 14 days of programming at Roberts Farm for a total of 101 hours per student.
- Year 1- One hundred and forty-five students, grades K-6 from Paris Elementary participated in 12 days of educational programs at Roberts Farm for a total of 48 hours per student.
- Year 2 – 133 students, grades K-6 from Paris Elementary participated in 12 days of educational programs at Roberts Farm for a total of 48 hours per student.
- Year 1 - Ninety-two students, graded K-6 participated in 8 hours of programming at Roberts Farm.
- Year 2 – Zero K-2 students participated in programming, as after Year 1, this age group participated in district programming related to the Oxford County Fair.

Objective 2: Nutrition and Nutrition Education through specialty crop production at Roberts Farm, partnerships with 2 local farmers and an adult education agriculture course.

In total, Roberts Farm partnered with 4 area farms over the project, 2 of which were contracted in Year 1 to help with the with the deliverable outcomes of the grant. Roberts Farm administer an Adult Education Course in both Year 1 and Year 2 of the project.

The first local farmer Roberts Farm partner was Scott Vlaun of Moose Pond Farm and Ecology in Otisfield, Maine. Moose Pond Farm provided both student agricultural programs and facilitated the Adult Education Course. Scott worked with three 5th grade classes over the course of Year 1 of the grant year providing 9 days of educational programming at Roberts Farm and three days at Moose Pond Farm. In addition he provided in-kind in year 2 by working with 16 Middle School students on a hydroponics project at Roberts Farm. The majority of his programming offered to students included specialty crop production of lettuce, spinach, squash and apples. Scott also facilitated all 8 Adult Education classes in Year 1 (16 hours total), which had a total of 22 adult students. In Year 2, Scott was a guest presenter at 2 of the adult education courses. Moose Pond Farm continued as a partner in year two.

The second local farmer was Thaine Eastman of Bisbee Apple Orchard & Farm in Sumner, Maine who donated his time and orchard for the project. In total, 12 middle school science classes made day-long visits to Bisbee Apple Orchard where the participated in an in-depth analysis of the orchard, its economic value and the nutritional value of apples. Bisbee Apple Orchard & Farm will continue as a partner in year two.

The third farmer was Dottie Bell, of Flying Hill Farms in Waterford, Maine. Dottie donated her time with 2nd grade classrooms at Harrison and Waterford Elementary schools as part of a 4 series curriculum unit. This program integrated nutrition, agriculture and visits to Flying Hill Farm. Flying Hill Farm did not continue as an in-kind contributor in year two.

The fourth farmer was Toby Whitman of Whitman Farms in West Paris, Maine. Toby both worked with students growing squash and working with students to make organic soil amendments. Whitman Farms will continue as an in-kind donor in Year 2.

Objective 3: Food Security through a C.S.A. for low income community members and donated produce for the Maine Harvest for Hunger program. (Goal – 10,000 pounds of donated produce. Actual 7,900 pounds of donated produce)

Roberts Farm CSA:

- Roberts Farm provided 10 CSA shares for low-income community members. The CSA distributed between 12 and 40 pounds of produce per week for a 12 week period of time. 3,900 total pounds of specialty crops were part of this effort.

Roberts Farm Harvest for Hunger

- In Year 1, Students at Roberts Farm grew and donated 4,000 pounds of produce to the University of Maine Cooperative Extension Harvest-for-Hunger program and 1,500 pounds of produce to the Oxford Food Bank. These donations were made each Thursday and became part of the network of Harvest for Hunger distributions in both South Paris and Oxford, Maine.
- In Year 2, students at Roberts Farm donated 4,400 pounds of produce to Harvest for Hunger and 1800 pounds to the Summer Feeding Program in Oxford Hills.

Potential Impact

Total Student Participation at Roberts Farm

Programming Option	Total student participants in Roberts Farm programs	48 hour plus student participation at Roberts Farm	165 hour plus student participation at Roberts Farm
Year 1 - # of students	468	368	138
Year 2 - # of students	498	498	178

Lessons Learned

MSAD 17 entered into this project under the impression that this was a 2 year project with 2 separate budget years. Going into Year 2, the Director of the USDA John Harker asked for the submission of the 2nd year budget. As it turns out, there was not a 2nd year awarded, in which MSAD 17 has absorbed $18,000 in deficit funds to cover the goals and objectives of year 2.

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