North Carolina Department and Agriculture & Consumer Services

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Final Report

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PROJECT TITLE: Apple Production for NC Craft Cider

PROJECT SUMMARY

The purpose of this project was to develop knowledge that would be useful to the hard cider industries in North Carolina, providing support and relevant data for apple growers and orchardists, established cider and wine producers, and those seeking entry into the orchard or cider production industries. As the hard cider industry expands in the state and across the US, apple growers struggle to evaluate the viability of establishing young trees that are valuable for cider production versus those that are well accepted on the market (eating, desert, juice apples etc.). Cider producers face a similar struggle of evaluating apple varieties that are well suited for high quality cider production; this includes both varieties planted at high densities (widely available) and those that are in more limited quantities but may possess exceptional attributes. At this same time there are dozens of heirloom apple varieties grown in limited quantities in NC and the southeastern US that have a place in our regional agricultural heritage, are the center of focus for many conservation orchards, and a number were traditionally used for cider production (sweet and hard ciders). The principal focus of this project was to perform a multi-year survey of apple varieties growing in western NC including in-depth analysis of apple juices, identification of varieties with exceptional cider potential for lab-scale trials, and analysis of finished cider including chemical and sensory parameters. A second objective was to provide information regarding apple varieties including in this survey to growers and provide input for successful integrated pest management (IPM) tactics. The goals for this project are intended to be useful for growers and cider producers and fill an existing knowledge gap.

This project was intended to fill a gap in knowledge that is useful and critical for both apple growers and cider producers to make well-informed decisions. The hard cider industry in the US began experiencing a rapid growth at the start of this project (2013 at ASU and 2015 with NCDA SCBG Funding), with approximately five commercial cider producers compared to over twenty currently (July 2017), including Bold Rock Hard Cider who expanded production from VA into Mills River NC to accommodate growth. During this same time frame numerous orchards have been established for cider production and larger producers have developed their interests in cider-specific varieties as the demand and potential revenues continues to increase nationwide. The timeliness of this project has been evident in the participation in workshops and events conducted over the past 2.5 years. The Enology Services Laboratory at Appalachian State University has also seen a tangential increase in submissions of apple juices and ciders from NC and across the US, as well as inquiries into apple juice data collected during this project. Project personnel intend to contribute the results of this project to the annual cider producer's conference (CiderCon) to expand the impact and scope of discussions. The process of identifying apples that are 1) valuable for cider producers and 2) viable for a commercial grower is seminal to assure financial success and stability of both parties. This process is not plausible for producers due to the associated time and costs and is often not data they would not necessarily share with competitors. Our objective was to perform this survey and provide information to industry members during their startup and expansion in hopes to help with their successes.

PROJECT APPROACH

Work on this grant included visitation with orchards and producers during the growing season, discussion on cultivation techniques and practices, coordination for harvest of apples, apple juice processing (grinding and juicing), sample transport to the analytical laboratory at Appalachian State University, bench-scale fermentation of select varieties, and analysis of juice and finished ciders. Mr. Hundley dedicated more than three hundred hours each year coordinating with apple growers, discussion of cultivation methods, collecting samples, and processing apple samples. He contributed to four outreach workshops/meetings conducted at ASU in relation to this project and has developed a strong network of apple growers (small and large), to which he disperses weekly and monthly updates and newsletters focused on disseminating timely information relevant to planting, caring for, and IPM approaches to growing apples. Mr. Hundley was instrumental in cultivating relationships with growers and providing valuable insight to many new growers regarding selection of apple varieties, pest management strategies and timing, and has been growing and grafting apple varieties included in this study for several years to supply growers. His contributions through his apple-grower newsletters will continue to be an incredibly valuable resource for coming years.

Laboratory analyses of juice and cider samples were conducted over four years (2013-2016), with over 140 unique apple varieties sampled and analyzed and several comparisons made within variety differing by orchard or origin. Juice analysis was conducted on 75, 124, 111, and 32 apple samples in 2013, 2014, 2015, and 2016 respectively. Ten apple varieties were chosen for cider production trials in 2015, which was expanded to 19 varieties in 2015. Analytical parameters included key metrics such as sugar and acid content, pH, amino- and ammonia-nitrogen contents, and analysis of phenolic content. Cider analysis included those listed above as well as alcohol, volatile acids content, and sorbitol content in 2016 following discussions with industry members in 2015. During the course of completing juice and cider analysis over a four-year period the service laboratory was also able to develop a comprehensive and rugged calibration for FTIR analysis juice and cider for the FOSS Winescan. This instrument is now used as a rapid and low cost option for analysis for many critical parameters; the analysis is offered to apple growers and cider producers through the service laboratory. Cider trials in 2015 and 2016 resulted in a compiled list of 19 apple varieties that have been well characterized for use in cider based on juice and cider analysis as well as sensory analysis provided by a panel of growers and cider makers in North Carolina. This list does not represent the only varieties suitable for high quality cider production but illustrates the connection between apple and juice characteristics (including analytical parameters) and hard cider character and quality. This data will provide the grower and cider maker the opportunity to align objectives and build a lexicon through which they can communicate. Growers will benefit from characterization of apples that may hold high cider potential and meet a fresh-market, eating-apple target while cidermakers will be able to understand the relevance of analytical parameters and cider production. The goal for this portion of the project is to help cider producers align with apple growers with the intent of helping the grower achieve prices for the fruit that is lucrative and stable. As many cider producers seek to process cider essentially year-round, and they are willing to pay much higher prices for high quality fruit than typical juicing facilities, we expect this comprehensive data set will help growers and cider makers identify lucrative relationships for both parties.

Dr. Cohen managed the project and coordinated efforts among team members. He worked with Mr. Hundely in orchard visits and observations, providing sample materials, tools, pruning

demonstrations, and feedback for growers. Dr. Cohen worked on laboratory analysis of juice and cider samples, production of cider trials, and packaging. He organized annual workshops and meetings at ASU for apple growers and cider producers (4 workshops/meetings, 3 sensory evaluations sessions, and 4 production demonstrations). He also attended and presented data at CiderCon annual conferences in Chicago IL and Portland OR and will lead the submission of a manuscript for peer-review in the fall of 2017.

Dr. Sommer assisted in orchard training activities, worked on laboratory analysis of juice and ciders, managed the development of a calibration for the FTIR analysis of juice and ciders, helped manage cider production trials, packaging, and sensory evaluations, and database management. Dr. Sommer will work with Dr. Cohen to prepare a final manuscript for peer-review.

Mr. Hundley developed a comprehensive network of apple growers across NC and neighboring states (TN and VA), develop a monthly apple grower newsletter focused on IPM and cultivation strategies, and has provided valuable support for apple growers including helping connect new orchardists with more established growers. Mr. Hundley identified over 100 heirloom apple trees, confirmed their cultivar identity, collected samples, and processed juice samples for analysis and cider trials. Mr Hundley continues to be highly engaged with apple growers in western NC and nearby states and has reached out to apple specialist in distal areas to provide input and support for growers in this region. Mr. Hundley has also collected scion wood from trees identified as highly valuable cider varieties in this trial and began grafting trees and providing them to local growers interested in cider apples and preservation of important apple varieties in the region.

Mr. Kuhfeld has served as the primary team member orchestrating sample intake and laboratory analysis. He has provided data to team members and industry collaborators and was instrumental in curating the project database. Mr. Kuhfeld helped managed cider production trials and packaging and help Dr. Sommer develop the FTIR calibration for apple juice and cider.

Mr. Bowen was not a listed project team member, however he was instrumental in providing support and apple samples from Horne Creek Farm from 2013-2015 before a staff shortage severely limited the time he could commit to this project. Mr. Bowen has been an incredible source of knowledge regarding apple cultivation and pest management alongside Mr. Hundley and has helped many growers with advice and by providing plant material through the farm. Mr. Bowen has also developed a keen sense for the relationship between apple composition and cider character and quality, which is inherently valuable for producers that contact him through the preservation orchard at Horne Creek.

GOALS AND OUTCOMES ACHIEVED

The first goal established in the project proposal was to identify top tier apple varieties for cider production and to add a minimum of 20 apple varieties to the to the database we began in 2013. Mr. Hundley and Dr. Cohen spent considerable time and efforts in 2014, 2015, and 2016 to identify apple varieties and growers to include in the survey surpassing the baseline goal of 20 additional apple

varieties for inclusion into the database. Mr. Bowen was able to provide apples for 2014 and 2015, also making additions of novel apples grown at slightly lower elevations than most others in the survey; he suffered staff reductions in 2016 and was not able to dedicate as much time and labor to this project in 2016 but plans to continue this work into 2017 with the project team. This first goal was met with considerable success; from a quantitative standpoint 156 apple varieties were added to the database after 2013, approximately 65 were represented in multiple years (providing vintage variability), and approximately 39 varieties were represented from multiple growing regions (providing geographic variability). A total of 29 bench trials were conducted for hard ciders, with 19 completed in 2016 using data from 2013 to 2015 to guide choices for cider trials. A comprehensive dataset has been collected for juice, cider, and sensory panel analysis from those 19 ciders. This work required concerted activities among project team members including 1) orchard observation and sampling by Hundley, Cohen, and Bowen 2) processing of a large number of juice samples by Hundley (>150) and Bowen with help from ASU faculty, staff, and student research assistants 3) laboratory analysis by Kuhfled, Cohen, and Sommer 4) data analysis and FTIR calibration by Cohen, Sommer, and Kuhfeld 5) cider production trials and packaging by Cohen, Sommer, and Kuhfeld and 6) sensory analysis managed by Cohen and Sommer with participation from all team members and more than 75 industry members over two years. The project team is very pleased with the amount of input from each team member and the scope the project was able to achieve. They are also very pleased with the level of industry participation in discussions, workshops, and evaluations.

The second goal of this project was to aggregate information regarding cultural practices for apple cultivation and provide input towards IPM strategies for growers; this was found to be especially important for smaller growers with limited access to equipment, labor, and applied knowledge regarding apple production. Mr. Hundley worked diligently over the project period to observe and assess approaches to managing apples for cider production and has developed a thorough and timely e-newsletter keeping growers updated with current information and seasonal considerations for pests and pest management strategies. While conventional programs in place at large commercial orchards allow for high-yields of apples with low cull rates due to issues with low apple grading, these management programs are often not feasible for smaller orchards and not necessary for the production of cider apples where aesthetics are not an important factor, only harvest of sound fruit. Mr. Hundley and Dr. Cohen have worked with several small growers to help them grasp traditional scouting techniques and acquire necessary tools for effective IPM. Mr. Hundley has provided much-needed follow up with growers over the past 4 years to assure they are able to keep up an efficient pest management strategy resulting in limited spray applications based on observation and proper orchard surveys. The project team is also very happy with the progression of this portion of the project and the opportunities to disseminate information via online newsletters, annual workshops and meetings, and one-on-one discussions with growers and cider producers. The evidence of this progress is shown in the numbers of apple and juice samples submitted by industry members associated with this project and submission of juice samples for their own knowledge and use (to the ASU Service Laboratory). Juice and cider sample submissions to the laboratory support the notion that industry members are becoming more aware and educated to the value of analytical monitoring for quality control and consistency in the orchard and cidery. Juice and cider submissions to the laboratory have increased from 3-4 cider producers annually in 2013 to more than 30 cider producers in 2017. Many of producers have submitted samples and inquire about how their juice samples compare to other

samples of the same variety we have stored in our database; in many instances these producers are now able to compare vintage variability within their own fruits and begin to track changes. This latter aspect has become a critical process for wine makers as it allows them to adjust processing tactics based on educated assessment of juice parameters (i.e. sugars, acids, pH, yeast assimilable nitrogen, total phenolics). The next stage for apple growers is to develop internal dataset to help them assess the impact of vintage and cultural practices (spray programs, orchard nutrition, pruning and training) on fruit composition. The project team is hopeful that this dataset will be useful for producers moving forward in this regard, from pest management to cider production techniques. Providing a cohesive lexicon among apple growers and cider producers is integral to this process.

Outcome measures for this project were not necessarily long-term, however it is the team objective that the data collected over the past four years will continue to be developed in years moving forward. A similar process was undertaken in the grape wine industry at ASU starting in 2010. Dr. Cohen and ASU faculty and staff began collecting grape and wine samples and curating a database of producer data generated through sample submissions to the service laboratory. Each year ASU has presented anonymous juice and wine data at the annual NC Wine Growers conference as a point of discussion for the prior season, overarching issues or concerns for growers and producers, and to help identify areas for research and extension education efforts in the state. The project team expects this same process can be followed for apple growers and cider producers now that a baseline of juice and cider data has been developed as a point of comparison and contrast.

Goals for this reporting period were to complete packaging, sensory analysis, and laboratory analysis of 2016 cider trials and to collate data and begin developing data sets for publication in a peer-review journal. The project team worked to complete all of these goals to date and are working to develop data and discussions into a cohesive manuscript for publication. The accomplishments in the last reporting period have fallen in-line with the team's goals for the period.

A summary data table is attached that illustrates many of the outcomes of this project and the depth of the project as a whole. The project team completed analysis of nearly 350 samples during the project period; this represents the time and effort to follow apples during the growing season, harvest samples in a timely manner, process juice in a consistent and timely manner, and conduct an array of chemical analyses. A calibration for a Foss Winescan Flex FTIR instrument was developed through this process by completing comprehensive chemical analysis on the bench in tangent with conducting FTIR scans of samples. Analytical data was imported into the calibration database and Fourier-Transformed to develop a robust algorithm that can now accurately and precisely quantify analyte values in apple juices and ciders in a rapid and cost-effective manner. This can now be applied and offered to juice and cider producers in the region at a much lower costs than conventional methods, helping to build a more comprehensive dataset in subsequent years. In addition to juice sample the project team prepared 29 cider trials based on apples that show a high level of interest for hard cider. The final trials and sensory evaluations in 2016 resulted in a list of 19 apple varieties that show very good to exceptional potential as cider apples and have good potential from a fruit management perspective. Mr. Hundley has developed a strong cohort of apple growers and provides a comprehensive monthly newsletter to keep readers abreast of time-relevant issues and considerations as well as introducing

new products, research, and developments in the apple cultivation community. The project team has spent considerable time and energy over the past 4 years, with SCBG funding for 2015 and 2016, and was able to develop a valuable tool for apple growers and cider makers in NC and the region that can be further developed in coming years through tracking industry submission data. This project was also conducted during a time when the cider apple and hard cider industry is just beginning to expand in NC and throughout the US, representing substantial economic potential for specialty crop producers and processors. Data associated with this project was not available in the southeastern US prior to this project and the team was very thankful to the NCDA for the support to develop this work.

- Curation of a comprehensive database for apple varieties and subsequent hard ciders.
    - Nearly 350 samples, over 150 apple varieties, ca. 65 varieties tracked over multiple vintages, and ca. 39 varieties comparable across geographic regions in western NC.
- Production of 29 cider trails with a final list of 19 varieties well described via analytical chemistry and in-depth sensory panel analysis that demonstrate exceptional use for commercial cider production.
- Development of apple and cider producer network in NC through a series of workshops, meetings, and sensory evaluations sessions.
- Development of grower network and e-newsletter specific to IPM and cultivation topics by calendar year.
    - Ability to provide growers access to varieties studied in this project for cultivation.
- Development an effective and efficient tool for apple juice and cider analysis in NC.
    - Established sound baseline of juice and cider data that can be provided to growers and producers each year to assess vintage variability and impact of cultivation practices.

BENEFICIARIES

Apple growers in NC, VA, TN, GA, and SC were in attendance at the events hosted during this project and data was shared with them on several occasions. Growers were very interested in developing their understanding of what attributes of apples are desirable for cider producers and identifying those that are good for cider and also desirable for the fresh market (premium and dessert). Growers concerns have traditionally been the cost and time associated with establishing new trees or varieties in orchards relative to the long-term guarantee of their sales potential. Many varieties of focus in this study have high culinary value outside of cider markets and possess a regional historic value, which is also found to be desirable in the artisan culinary market.

Cider producers benefit from developing their understanding of apple juice composition and resulting ciders as well as gaining firsthand knowledge of hard ciders produced from such apples without the investment of preparing trials in a production environment, which is often infeasible. Cider producers and apple growers can use data produced in this project to come to some common understanding of a comprehensive array of apple varieties and options they may have to work together for a common good (financial/economic benefit and stability) with reduced risk in working with the “unknown”. As more cider producers enter the commercial market their biggest question to faculty and staff at ASU is to help them develop an understanding for cider apple varieties, tools for

assessing cider apple varieties, and to identify growers working with such varieties or willing to work with cider producers to deliver fruit they can work with; this often means an apple grower can reduce the number of inputs into their orchard to produce acceptable fruit for the cider maker but requires the cider maker commit to purchasing the fruits at acceptable prices to the grower.

The numbers of beneficiaries from this project can be best described through attendance of workshops, meetings, and evaluations hosted during this project. A workshop in 2015 was attended by more the 80 industry members split between growers and cider makers and featured guest speakers from industry in NC, VA, and VT and included an apple variety tasting and a cider trial tasting. A follow up meeting with local industry members in Spring of 2016 was attended by approximately 25 industry members in NC and a second cider trial tasting was attended by 12 industry members engaged in this project. During the Fall of 2015 and 2016, Dr. Cohen, Dr. Sommer, and Mr. Kuhfeld hosted more than 12 new cider makers for production and lab analysis demonstrations. Following the packaging of cider trials from 2016, 14 industry members took part in a final sensory evaluation of hard ciders; a comprehensive review of those ciders is included with this report. Mr. Hundley reaches an expansive audience of growers and cider producers with his newsletter. Our hope is that publication of this data will help expand the audience it reaches and spur greater discussion beyond our immediate region. Presentation at the annual CiderCon meeting will also help disseminate information to a captive audience and provide some discussions to compare and contrast observations made across the US.

LESSONS LEARNED

Through this project team members quickly appreciated the amount of time it would actually require to meet our goals and targets; the process of tracking fruits across the western portion of the state, coordinating harvest and transportation of samples, process juice samples, and performing analysis became daunting. We were fortunate that team members were able to work well together in a timely manner and each person involved was highly engaged in the outcome of this project. After the first year we realized that providing bench-top grinders and presses to Mr. Hundley and Mr. Bowen to use was critical given the time constraints and numbers of samples were targeted for processing. This allowed team members to process samples quickly, stabilize with sulfur dioxide to prevent fermentation, and cold-pack up to and during transport to the lab. The team also realized that participation of industry members was critical, however, we did have to build an understanding that both apple growers and cider producers must work around their production schedules and most often this meant participation rates of 50% were quite good. It is a challenge for many of these people to break away from a busy schedule for even one-half of a day; however, their participation was much appreciated and contributed to the success of the project. In the end, the workload associated with this project was on the higher end of our expectations but was very rewarding to complete and the team worked very well together for a common set of goals. Had any team member not been able to contribute as they did the project would have struggled.

With careful reflection the only tangible unexpected outcome from this project was the number of distinct samples the team was able to process and the number of contributing orchards that provided

unique samples in 2015 and 2016; these contributions were definitively the result of attendance to workshops and meeting by industry members who realized the value in such a process and felt compelled and interested to participate. This process lead to a great number of samples submitted than the team projected at onset. An indirect outcome of this project was the submission and funding of a second grant submitted by Dr. Cohen and Dr. Sommer to the US Association of Cider Makers to study the source of reduced sulfur aromas in hard ciders. The NCDA-funded project provided indications into possible sources for these aroma compounds and provided us with a bank highly diverse and well-preserved apple juice samples with a broad range of amino nitrogen contents and profiles.

The one goal we aimed to achieve that was a challenge was the quantitation of tannins in apple juice and cider samples. An otherwise robust and simple analytical approach to wine grapes proved to be challenging in apples; after multiple trials and modifications to this procedure the team was not able to produce results with reproducibility greater than 92%, which was not acceptable. We found that the inherent variability among apples and the composition and content of phenolics, tannins, and the very high content of pectins made this specific analysis very challenging in the laboratory. The nature of this challenge was shared by several other researchers and is actually the focus of a project funded by the US Association of Cider Makers for 2016: A comparison of methods for tannin quantification in apples. The team was able to account for total phenolics and apple juices and ciders, however, which provides a value that reflects tannin contents along with non-tannin phenolics.

Positive lessons learned, or more accurately, progress from this project is the outcome of developing a rapid and robust method for juice and cider analysis via FTIR; this tool greatly increases sample throughput in the lab with a significant cost reduction. A challenge remains in apple juice processing for lab analysis as well as cider trials. It is critical to assure one has a representative sample (multiple fruits) for lab analysis and cider production while avoiding cross-contamination. This process required considerable time for setup, processing, and cleaning between samples.

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ADDITIONAL INFORMATION

Please see attached tables for 1) 2013-2016 Juice Data 2) 2015 and 2016 Cider Data and 3) 2016 Sensory Evaluation Data. Also attached are sample emails from Mr Hundley's apple grower communications.

Apple Juice Data: 2013 to 2016

Date Received	Sample Name ID	Apple Origin	pH	TA (g/L)	° BRIX	Amino (mg/L)	NH_4 (mg/L)	Total YAN (mg/L)	Total Phenol (mg/L)
09/23/2013	Butter Milk	Western NC	3.95	2.88	12.8	49	2	51	
09/23/2013	Crenshaw Stump	Western NC	3.66	5.63	14.9	39	2	41	
09/23/2013	Early Harvest	Western NC	3.89	2.68	12.8	52	3	55	
09/23/2013	Grimes Gold	Western NC	3.34	7.04	12.6	64	1	65	
09/23/2013	Hawkeye Delicius	Western NC	3.48	7.17	13.3	50	3	53	
09/23/2013	Improved Transparnt	Western NC	3.19	10.52	11.7	84	4	88	
09/23/2013	Maiden Blush	Western NC	3.23	8.64	12.3	32	4	36	
09/23/2013	Mc Intosh	Western NC	3.31	8.44	13.5	16	1	17	
09/23/2013	Ozark Pippin	Western NC	4.04	3.08	12.9	31	1	32	
09/23/2013	Rambo	Western NC	3.18	8.17	12	12	1.2	13.2	
09/23/2013	Ray Apple	Western NC	3.34	8.58	14.9	106	2	108	
09/23/2013	Red Astrachan	Western NC	3.33	8.17	11.9	21	2	23	
09/23/2013	Summer Rambo	Western NC	3.32	5.83	11.1	28	3	31	
10/01/2013	Fall Premium	Western NC	3.23	5.7	12.4	37	0.7	37.7	
10/01/2013	Hawkeye Delicious (Repeat)	Western NC	3.38	4.49	14.1	4	0.4	4.4	
10/01/2013	Old 194	Western NC	3.19	10.59	17	69	0.4	69.4	
10/01/2013	Rambo (Repeat)	Western NC	3.29	5.9	12.4	4	0.4	4.4	
10/16/13	194 Orange	Western NC	3.04	18.34	19.5	58	1.3	59.3	
10/16/13	194 Red	Western NC	3.63	5.83	13.8	34	4.7	38.7	
10/16/13	194 Strawberry	Western NC	3.33	5.49	13.5	17	0.8	17.8	
10/16/13	Arkansas Sweet	Southern Heritage Orchard	3.73	3.48	13.4	50	1.4	51.4	
10/16/13	Balls Choice (Horne)	Horne Creek State Park	3.4	7.84	14.8	66	0.9	66.9	
10/16/13	Black Amish (Horne)	Horne Creek State Park	3.27	5.63	11.2	34	0.5	34.5	
10/16/13	Doctor Matthews (Horne)	Horne Creek State Park	3.45	4.42	12.9	38	1.4	39.4	
10/16/13	Dula (Horne)	Horne Creek State Park	3.43	5.09	12	26	1.8	27.8	
10/16/13	Fall Pound Mildred Glenn (Horne)	Horne Creek State Park	3.27	6.57	12	27	0.5	27.5	
10/16/13	Fall Premium (Repeat)	Southern Heritage Orchard	3.45	4.02	12.1	37	1.1	38.1	
10/16/13	Flat Fall Cheese (Horne)	Horne Creek State Park	3.41	5.23	12.4	29	0.7	29.7	
10/16/13	Green River	Southern Heritage Orchard	3.46	3.75	10.6	35	0.9	35.9	
10/16/13	Grimes Golden	Southern Heritage Orchard	3.24	8.17	14.1	13	0.6	13.6	
10/16/13	Guyandotte Pippin (Horne)	Horne Creek State Park	3.75	2.95	11.4	104	0.8	104.8	
10/16/13	Hawkeye Delicious (Repeat)	Southern Heritage Orchard	3.52	3.62	13.9	22	0.4	22.4	
10/16/13	Huffman Red (Horne)	Horne Creek State Park	3.94	2.68	10.1	88	2.8	90.8	
10/16/13	Holly (Horne)	Horne Creek State Park	3.86	2.68	12.2	83	0.6	83.6	
10/16/13	Hoover (Horne)	Horne Creek State Park	3.28	6.84	11.5	28	0.7	28.7	
10/16/13	Improved Milan (Horne)	Horne Creek State Park	3.49	4.69	11.6	110	0.9	110.9	
10/16/13	Kinnards Choice (Horne)	Horne Creek State Park	3.71	3.19	15.1	28	1	29	
10/16/13	Marshals Rocky Limbertwig (Horne)	Horne Creek State Park	3.62	3.25	10.9	31	1	32	
10/16/13	Moore Strawberry	Western NC	3.31	7.78	13.3	37	0.8	37.8	
10/16/13	Nunez Smokehouse	Western NC	3.21	9.38	11.1	27	1.1	28.1	
10/16/13	Oliver (Horne)	Horne Creek State Park	3.44	5.56	10	44	0.7	44.7	
10/16/13	Pineapple (Horne)	Horne Creek State Park	3.39	4.89	11.4	52	0.7	52.7	
10/16/13	Red Detroit (Horne)	Horne Creek State Park	3.25	5.63	11	45	1.3	46.3	
10/16/13	Rocky River Limbertwig (Horne)	Horne Creek State Park	4.5	1.34	13	38	0.8	38.8	
10/16/13	Roxbury Russet	Western NC	3.83	3.89	16.4	100	1.4	101.4	
10/16/13	Russet Sheepnose (Horne)	Horne Creek State Park	3.85	3.35	13.6	134	2	136	
10/16/13	Short Core (Horne)	Horne Creek State Park	3.42	6.57	10	94	0.9	94.9	
10/16/13	Snuff (Horne)	Horne Creek State Park	3.32	6.77	9.9	18	0.5	18.5	
10/16/13	Spotted Pippin (Horne)	Horne Creek State Park	3.52	3.87	12.1	45	2.4	47.4	
10/24/13	Fallawater	Western NC	3.08	7.84	12.1	43	1.2	44.2	
10/24/13	Flat Fallawater	Western NC	3.35	5.88	14.2	18	0.8	18.8	
10/24/13	Golden Pippin	Western NC	3.45	6.13	12.8	12	2.2	14.2	
10/24/13	Hunters Orange	Western NC	3.2	7.69	16.2	34	1.6	35.6	
10/24/13	Jonathan	Western NC	3.36	5.36	10.8	98	3.9	101.9	
10/24/13	Orange 194 (Repeat)	Western NC	3.44	10.12	16.2	91	3	94	
10/24/13	Sheepnose Avery	Western NC	3.65	4.74	15.9	47	1	48	
10/24/13	Summer Banana	Western NC	3.33	6.93	17.3	19	0.6	19.6	
10/24/13	Turbyfill Notley P.	Western NC	3.09	9	14.3	13	0.9	13.9	

10/24/13	Virginia Beauty Orchard	Western NC	3.54	3.01	13.1	12	3.1	15.1	
10/24/13	Virginia Beauty Wild	Western NC	3.69	5.47	16.4	16	2.3	18.3	
10/24/13	Winter Banana Orchard	Western NC	3.35	3.72	11.4	30	4.5	34.5	
10/24/13	Winter Banana Wild	Western NC	3.66	3.89	13.2	29	6.3	35.3	
10/31/13	American Golden Russet	Western NC	3.32	4.78	16.2	25	0.3	25.3	
10/31/13	Dulla's Beauty	Western NC	3.31	5.85	13.6	32	0.4	32.4	
10/31/13	Hunters Orange Repeat	Western NC	3.35	7.57	15.3	68	1.3	69.3	
10/31/13	Keener Seedling	Western NC	4.12	1.89	16.5	73	2	75	
10/31/13	Old Fashion Limbertwig	Western NC	3.46	4.7	12.6	19	1.9	20.9	
10/31/13	Old Fashion Red Rome Beauty	Western NC	3.24	8.23	13.3	50	0.9	50.9	
10/31/13	Old Fashion Stripped Rome Beauty	Western NC	3.45	3.76	12	13	0.2	13.2	
10/31/13	Ralls Janet	Western NC	3.47	6.78	14	106	3.9	109.9	
10/31/13	Rhode Island Greening	Western NC	3.16	10.15	18.1	33	1	34	
10/31/13	Royal Limbertwig	Western NC	3.4	6.01	13.6	55	1	56	
10/31/13	The Beezer	Western NC	3.49	7.05	16.3	37	0.7	37.7	
11/07/2013	Magnum Bonum? Valle Crucis	Valley Crucis	3.57	4.71	17.7				
11/07/2013	Winesap, Stayman? Valle Crucis	Valley Crucis	3.31	6.54	17.1				
Date Received	**Sample Name ID**	**Apple Origin**	**pH**	**TA (g/L)**	**° BRIX**	**Amino (mg/L)**	**NH_4 (mg/L)**	**Total YAN (mg/L)**	**Total Phenol (mg/L)**
08/27/2014	July Delicious	Western NC	3.36	4.72	15.3	96	8.1	104.1	
08/27/2014	Bodenheimer	Western NC	3.91	2.66	15	151	2.9	153.9	
08/27/2014	Gravenstein	Western NC	2.92	13.5	10.2	9	1.2	10.2	
08/27/2014	William's Favorite	Western NC	3.02	5.32	11.8	0	1.0	1	
08/27/2014	Summer Rambo	Western NC	3.09	6.4	9.8	40	0.8	40.8	
09/04/2014	McIntosh	Western NC	3.06	8.15	12.6	24	2.6	26.6	
09/04/2014	Horse Apple	Western NC	3.03	7.94	12	13	0.5	13.5	
09/04/2014	Horse Hundley Orchard	Western NC	3.1	7.84	11.3	57	1.0	58	
09/04/2014	Maiden Blush	Western NC	2.8	13.77	11.1	0	0.6	0.6	
09/04/2014	Liveland Raspberry	Western NC	3	7.01	9.9	21	1.0	22	
09/04/2014	Golden Sweet (Foscoe)	Western NC	3.93	1.37	11.6	48	2.0	50	
09/04/2014	Summer Rambo	Western NC	3	9.56	10.6	47	2.3	49.3	
09/17/2014	Motherbud (Crossnore)	Western NC	3.6	5.48	14.4	66	2.5	68.5	
09/24/2014	Rusty Coat	Western NC	4.35	1.3	16	108	1.2	109.2	
09/17/2014	Motherbud	Western NC	3.4	3.68	15.7	58	2.4	60.4	
09/17/2014	Magnum Bonum	Western NC	3.34	8.85	15.8	35	1.7	36.7	
09/17/2014	Jenny Beauty	Western NC	3.27	6.26	14.7	45	2.5	47.5	
09/17/2014	American Beauty	Western NC	3.41	4.47	15.8	68	1.8	69.8	
09/17/2014	Bud Wolf	Western NC	3.22	6.11	14.7	52	1.7	53.7	
09/17/2014	Ophir	Western NC	3.1	8.53		53	2.1	55.1	
09/17/2014	Hayes Green	Western NC	3.12	9.22	13.2	117	2.8	119.8	
09/17/2014	Fall Pippin	Western NC	3.06	6.03	14.6	48	1.8	49.8	
09/17/2014	Shannon	Western NC	3.14	7.3	13.7	50	2.8	52.8	
09/17/2014	Cauley	Western NC	3.13	5.8	13.7	43	1.6	44.6	
09/17/2014	Pumpkin Sweet (Horne Creek)	Western NC	4.34	1.94	17.7	80	1.8	81.8	
09/17/2014	Paw	Western NC	3.72	3.64	16.9	73	1.9	74.9	
09/17/2014	Turley Winesap	Western NC	4.02	1.67	14.7	80	1.2	81.2	
09/17/2014	Yellow Bellflower	Western NC	3.24	6.89	16.7	4	1.2	5.2	
09/17/2014	J-A-G-N-F (July August Go No Further)	Western NC	3.31	4.41	14.8	53	1.2	54.2	
09/17/2014	Smokehouse	Western NC	3.26	6.97	16	169	2.9	171.9	
09/17/2014	Hunge	Western NC	3.18	8.68	13.8	95	1.6	96.6	
09/17/2014	Russet Shapnose	Western NC	3.69	3.42	14.3	131	2.3	133.3	
09/24/2014	Gloria Mundi	Western NC	3.34	5.42	11.1	57	4.9	61.9	
09/24/2014	Senshu sweet (Moretz)	Western NC	3.41	5.13	11.7	21	2.4	23.4	
09/24/2014	Buff	Western NC	3.06	9.74	12.9	50	1.5	51.5	
09/24/2014	Rusty Coat (Horne Creek)	Western NC	3.76	2.4	11.1	23	0.7	23.7	
09/24/2014	5 on a mac (Moretz)	Western NC	3.42	3.62	8.6	44	4.7	48.7	
09/24/2014	King solomon	Western NC	3.2	6.24	9.8	50	1.9	51.9	
10/02/2014	Jonathan	Western NC	3.3	10.21	14.8	9	5.3	14.3	
10/02/2014	Ray Apple	Western NC	3.01	11.66	15.9	121	2.9	123.9	
10/02/2014	SW Corner	Western NC	3.35	3.98	13	23	2.6	25.6	

10/02/2014	Sweet 16 (Moretz)	Western NC	3.48	3.65	9.5	71	8.7	79.7	
10/02/2014	Grimes Golden (Moretz)	Western NC	3.3	5.89	13.5	44	2.7	46.7	
10/02/2014	Grimes Golden (Linville)	Western NC	3.42	2.74	14.2	32	3.0	35	
10/02/2014	Hunters Orange	Western NC	3.18	8.61	12.7	72	1.9	73.9	
10/02/2014	Ethans Orange	Western NC	2.89	18.84	16.8	12	1.1	13.1	
10/06/2014	Matt Daniels	Western NC	3.26	4.38	16.4	25	1.0	26	
10/06/2014	Magnum Bonum (Altapass)	Western NC	3.28	5.34	12.2	25	0.6	25.6	
10/06/2014	Summer Banana	Western NC	3.53	4.86	14	33	0.7	33.7	
10/06/2014	Va. Beauty (Altapass)	Western NC	3.84	2.77	11.9	111	4.5	115.5	
10/06/2014	194 Orange	Western NC	3.08	10.94	15.2	105	1.8	106.8	
10/06/2014	Sheepnose	Western NC	3.59	4.43	15.1	73	4.1	77.1	
10/06/2014	Old Fashioned Striped Rome	Western NC	3.34	4.82	12.5	0	0.6	0.6	
10/06/2014	Rusty Coat	Western NC	4.33	1.63	15.5	71	0.8	71.8	
10/06/2014	Last Cameron	Western NC	3.34	4.23	11.3	47	1.0	48	
10/06/2014	Grimes Golden (Altapass)	Western NC	3.36	4.81	13.2	58	1.2	59.2	
10/06/2014	Yates (Altapass)	Western NC	3.15	7.13	10.7	27	0.5	27.5	
10/06/2014	Mountain Boomer	Western NC	3.14	5.73	13	29	0.5	29.5	
10/06/2014	gloria mundi	Western NC	3.34	12.97	14.3	85	1.0	86	
10/14/2014	Magnum Bonum (Valle Crucis)		3.75	4.22	12.9	11	0.5	11.5	
10/14/2014	Myer's Royal Limbertwig (Valle Crucis)		3.13	6.93	12	25	0.5	25.5	
10/14/2014	Myer's Royal Limbertwig (Newland, Dr. Clark)		3.24	7.82	13.2	32	0.5	32.5	
10/14/2014	Roxbury Russet		4.3	1.57	15.2	50	0.7	50.7	
10/14/2014	Golden Pippin		3.44	3.93	14.5	59	1.0	60	
10/14/2014	Gragg		3.2	4.58	10.8	15	0.5	15.5	
10/14/2014	Fall Premium (Baird)		3.09	6.46	12.6	39	0.6	39.6	
10/14/2014	Rhode Island Greening (Foscoe)		2.93	10.47	15.8	48	0.9	48.9	
10/30/2014	Arkansas Black		3.28	6.63	14.5	37	1.6	38.6	
10/30/2014	Coffee Seedling		3.44	7.61	15.3	82	1.1	83.1	
10/30/2014	Johnson Keeper		3.33	5.69	14.4	59	1.0	60	
10/30/2014	Hammond		3.26	7.14	15.6	67	1.5	68.5	
10/30/2014	Seedling Keener		3.18	9.4	16.7	48	1.1	49.1	
10/30/2014	Sam Hunt		3.27	3.99	12.5	38	1.6	39.6	
10/30/2014	Hillside		3.21	5.94	16.9	42	2.1	44.1	
10/30/2014	Balsam		3.16	10.23	15.6	83	1.1	84.1	
10/30/2014	Pinky		3.19	6.22	13.9	80	2.3	82.3	
10/30/2014	Dula Beauty		3.14	6.97	15.2	13	1.0	14	
10/30/2014	Blacktwig		3.25	6.36	15.2	28	1.0	29	
10/30/2014	Jonalicious		3.45	3.35	12.9	26	0.8	26.8	
10/30/2014	Sparger		3.45	7.27	14.7	13	0.6	13.6	
10/30/2014	Yates		3.39	6.55	13.8	9	1.9	10.9	
10/30/2014	Terry Winter		3.28	8.78	13.8	55	2.0	57	
10/30/2014	Morgan's X-mas		3.39	4.2	13.7	45	0.8	45.8	
10/30/2014	Edward's Winter		3.23	9.2	16.8	94	1.1	95.1	
10/30/2014	Crack Apple		3.54	3.22	11	26	0.6	26.6	
10/30/2014	Abram		3.27	9.92	15.8	63	1.7	64.7	
10/30/2014	Winter Jon		3.01	17.17	21.2	71		71	
10/30/2014	Myer's Royal Limbertwig (Horne Creek)		3.27	6.14	15.2	23	0.7	23.7	
11/04/2014	Gilmores Special Winesap		3.41	7.54	15.4	27	0.6	27.6	
11/04/2014	Sawmill		3.41	5.09	11.9	51	0.6	51.6	
11/04/2014	Dr. Mathews		3.54	2.4	10.5	21	1.6	22.6	
11/04/2014	Rocky River Limbertwig		4.48	0.96	10.7	44	2.1	46.1	
11/04/2014	Swiss Limbertwig		3.55	5.39	16.5	88	1.5	89.5	
11/04/2014	McClean		3.61	3.31	10.6	18	0.5	18.5	
11/04/2014	Mountain Beauty		3.2	9.16	14.5	56	1.6	57.6	
11/04/2014	Slabside		3.66	3.33	11.6	42	3.4	45.4	
11/04/2014	Junaluska		3.51	6.92	15.3	90	1.7	91.7	
11/04/2014	Springdale		3.54	4.8	14.9	118	4.7	122.7	
11/04/2014	Notley P Turbyfil		3.14	7.97	14.9	26	0.5	26.5	
11/04/2014	American Golden Russet		3.55	5.19	17	130	1.1	131.1	
11/04/2014	Keener Seedling		4.08	2.11	14.5	27	0.8	27.8	

11/04/2014	Mutzu		3.58	4.65	15.6	103	2.2	105.2	
11/04/2014	Gragg (Eswine)		3.37	4.85	11.5	25	2.1	27.1	
11/04/2014	Flat Fallawater	3 Oaks	3.69	3.44	14.5	27	1.0	28	
11/04/2014	Pink October		3.52	3.05	12.9	34	2.5	36.5	
11/04/2014	Beezer		3.7	6.8	17.9	6	1.3	7.3	
11/10/2014	Grimes Golden	Altapass	3.64	3.64	13.9	19	0.5	19.5	
11/10/2014	Dan's Sweetie		3.94	3.09	13	100	2.0	102	
11/10/2014	King Luscious	Altapass	3.57	2.22	11.5	29	0.6	29.6	
11/10/2014	Winesap	Altapass	3.33	5.97	15.4	10	0.2	10.2	
11/10/2014	York	Altapass	3.39	7.34	14	51	0.7	51.7	
11/10/2014	Kinnard's Choice	Altapass	3.46	5.37	12.5	70	1.2	71.2	
11/10/2014	#14 Ray Apple		3.45	5.57	15.3	73	0.5	73.5	
11/10/2014	Stayman		3.31	5.89	12.4	15	0.3	15.3	
11/10/2014	Rails Janet		3.38	5.62	13	29	1.0	30	
11/10/2014	Striped Rome Beauty		3.38	5.21	12	12	0.2	12.2	
11/10/2014	Daddy		3.45	6.34	15.7	48	1.0	49	
11/10/2014	Gloria Mundi		3.58	4.33	12.1	72	1.7	73.7	
11/10/2014	Tim Miller		3.34	7.55	13.3	12	2.4	14.4	
11/10/2014	Jimbo		3.29	7.55	13.3	25	0.6	25.6	
11/10/2014	Frank Mast South		3.33	5.69	13.6	10	0.2	10.2	
11/10/2014	Fallawater		3.45	4.13	13.9	27	0.5	27.5	
11/10/2014	Swiss Limbertwig (Marshal)		3.3	7.9	16.9	53	0.5	53.5	
Date Received	**Sample Name ID**	**Apple Origin**	**pH**	**TA (g/L)**	**° BRIX**	**Amino (mg/L)**	**NH_4 (mg/L)**	**Total YAN (mg/L)**	**Total Phenol (mg/L)**
8/6/15	Bud Wolf	Horne Creek	3.46	4.8	12.2	38		38	689
8/6/15	July Delicious	Horne Creek	3.61	3.3	11	87		87	652
8/6/15	Alexander's Ice Cream	Horne Creek	4.23	1.28	13.2	46		46	380
8/6/15	Bevins Favorite	Avery /Hundley	3.38	6.9	13.3	33		33	1,000
8/6/15	Holly	Horne Creek	4.01	2.3	13.4	89		89	657
8/6/15	Red June	Avery / Hundley	3.22	7.4	12.8	30		30	831
8/6/15	Accordian	Horne Creek	3.43	4.6	13	71		71	608
8/6/15	Hackworth	Horne Creek	3.56	4.4	13.8	43		43	646
8/7/15	Branch	Horne Creek	3.72	5.2	15.4	104		104	394
8/7/15	Hayes Green	Horne Creek	3.19	8.9	12.3	139		139	608
8/7/15	Melangton Gold	Horne Creek	4.22	1.12	12	220		220	326
8/7/15	Rebel	Horne Creek	3.64	3.9	14.7	76		76	237
8/7/15	Mayflower	Horne Creek	3.44	5	13.9	148		148	380
8/7/15	Holland	Horne Creek	3.54	3.8	12.6	104		104	221
8/7/15	Mason Beauty	Horne Creek	3.45	5.4	14.3	206		206	227
8/7/15	Blairmont	Horne Creek	3.37	5.8	12.4	172		172	627
8/7/15	Ladyskin	Horne Creek	3.32	3.6	12.1	33		33	960
8/7/15	American Golden Russet	Horne Creek	3.54	4.4	13.4	140		140	782
8/7/15	Bumncombe of TN	Horne Creek	3.16	8.4	13.2	135		135	340
8/7/15	Jakis Seedling	Horne Creek	3.16	8.6	13.1	183		183	571
8/7/15	Dixie Red Delight	Horne Creek	3.57	3.4	11.5	84		84	331
8/7/15	Yellow Bellflower	Horne Creek	3.38	5.4	13.7	54		54	226
8/7/15	St. Clair	Horne Creek	3.44	4.5	10.1	103		103	175
8/7/15	Anderson Sweet	Horne Creek	4.3	1.6	15.1	89		89	189
8/7/15	Hewis Crab	Horne Creek	3.37	8.4	16.9	127		127	557
8/28/15	Summer Rambo	hundley/crossnore	3.31	7.2	11.2	11	0	11	921
8/28/15	Marry Reid	Avery/crosby	3.37	6.7	12.9	47	0	47	796
8/28/15	Hewes Crab	Avery/crosby	3.32	9.4	17.1	99	0	99	1,741
8/28/15	Harris	Avery/crosby	3.32	7.2	13	160	2	162	1,096
8/28/15	Sour Rusticoat	Horne Creek	3.37	6.6	13.4	64	0	64	1,192
8/28/15	Buckingham	Horne Creek	3.45	5.1	12.4	121	3	124	529
8/28/15	Shannon	Horne Creek	3.42	5.7	12.9	12	1	13	526
8/28/15	Slope	Horne Creek	3.47	4.8	12.5	10	1	11	716
8/28/15	Flat Fall Cheese	Horne Creek	3.27	5.8	13.4	40	1	41	732
8/28/15	Summer Queen	Horne Creek	3.57	4.8	11.9	65	1	66	646
8/28/15	Magnum Bonum	Horne Creek	3.78	3.5	12.2	42	2	44	549
8/28/15	Hunge	Horne Creek	3.44	5.5	12.4	84	3	87	480

8/28/15	Slabside	Horne Creek	3.82	3.5	11.9	200	3	203	273
8/28/15	Shennandoah	Horne Creek	3.37	5.8	11	75	2	77	337
8/28/15	Wolf River	Horne Creek	3.19	8.2	13.7	162	3	165	474
8/28/15	Mayflower	Horne Creek	3.55	4.2	12.6	81	1	82	580
8/28/15	American Beauty	Horne Creek	3.57	2.9	14.1	55	1	56	471
8/28/15	Yellow Bellflower	Horne Creek	3.65	5	12.3	103	2	105	420
8/28/15	King David	Horne Creek	3.41	6.9	10.2	39	0	39	116
8/28/15	Durham	Horne Creek	3.48	10.4	14.5	258	2	260	1,078
8/28/15	Black Beauty	Horne Creek	3.99	1.8	10.6	92	1	93	488
8/28/15	Chimney	Horne Creek	3.53	8	14.2	48	1	49	895
8/28/15	Schuler	Horne Creek	3.64	5.6	13.6	35	0	35	337
8/28/15	Pumpkin Sweet	Horne Creek	4.76	2.3	15	199	3	202	476
8/28/15	Blue Ridge King	Horne Creek	3.56	3.9	10.5	29	2	31	787
8/28/15	Beckham's Seedling	Horne Creek	3.77	3.5	13.6	154	2	156	146
8/28/15	Lugar Red	Horne Creek	3.72	3.5	13	87	2	89	851
8/28/15	Watercore	Horne Creek	3.44	8.5	12.9	351	5	356	851
8/28/15	Mother	Horne Creek	3.51	6.3	15.2	134	1	135	315
8/28/15	Black Amish	Horne Creek	3.35	7.7	11.7	98	1	99	645
8/28/15	Jason's Favorite	Horne Creek	3.47	5.8	13.4	41	1	42	645
8/28/15	Harris	Horne Creek	3.61	3.9	11.6	48	2	50	472
8/28/15	King Solomon	Horne Creek	3.26	8.2	11.3	12	0	12	658
8/28/15	Cothren	Horne Creek	3.75	3.3	10.9	60	2	62	
8/28/15	Russet Sheepnose	Horne Creek	4.05	3.2	14.5	124	2	126	
8/28/15	Mix #2		3.63	4.5	12.6	118	2	120	
8/31/15	Geneva Crab	hundley orchard	3.26	7.1	9.6	66	2	68	
2015	194 Orange	Avery/ hwy 194	3.39	12.1	15	38	2	40	
2015	Virginia Greening		3.55	5.2	12.5	213	3	216	269
2015	Potomac		3.48	5.5	13.8	140	1	141	474
2015	Dan McDaniel		3.95	1.6	11.1	107	2	109	336
2015	Means Seedling		3.44	4.7	10.8	52	0	52	206
2015	Sulser Red		3.56	3.7	11.8	74	1	75	359
2015	Jenny Beauty		3.43	5.2	13.4	88	2	90	359
2015	Oliver		3.48	4.9	10.8	48	2	50	473
2015	Ophir		3.6	4.7	13.7	73	4	77	774
2015	Queen		3.42	4	12.4	50	1	51	469
2015	Jagnf		3.69	3.4	12.3	163	2	165	394
2015	Rambo	Avery/Wilson	3.48	4.2	11.2	18	1	19	810
2015	Taliffero	hundley/crosby	3.21	9.2	10.7	67	3	70	570
2015	McIntosh	Avery/hundley	3.3	6.4	13.1	9	2	11	551
2015	Ginard	Avery/Ginard	3.25	6.6	10.6	24	0	24	449
2015	Rhode Is Greening	Avery/Foscoe	2.97	12.6	13.3	65	0	65	887
2015	Hyeala	Avery/hundley Hy Gala	3.56	3.3	12.3	27	1	28	925
2015	Vernon Crab	Avery/David Vernon	3.56	9.6	18	211	5	216	566
9/25/15	magnum bonum		3.79	3.3	12.5		2.9	2.9	203
2015	Grape	Avery/hundley pinkgrape	2.09	7.96	12.9	84	43	127	
2015	White Winter Pearmain		3.64	3	11.5	60	0	60	485
2015	Smith's Seedling		3.64	3.3	10.5	56	0	56	617
2015	Lacy		3.79	1.4	9.8	37	1	38	482
2015	Reasor Green		3.36	8.3	12.4	100	1	101	582
2015	Aunt Sally		3.58	4	13.6	142	2	144	520
2015	Gilpin		3.97	2.1	12.7	53	0	53	1506
2015	Fair Grove		3.31	4.1	13.9	0	0	0	670
2015	Rockingham Red		3.37	8.1	13.7	62	1	63	287
2015	Juicy Fruit		3.76	3.5	13.2	124	2	126	550
2015	Cullasaga		3.88	3.1	13.9	73	3	76	502
2015	Ben Davis		3.5	5.1	12.7	70	1	71	538
2015	Old Fashioned Winesap		3.56	5.3	13.8	78	1	79	747
2015	Tanyard Seedling		3.74	3.6	11.5	42	1	43	791
2015	Buckeye Beauty		3.62	5.7	14.9	24	0	24	628
2015	Golden Harvest		3.69	1.6	10	4	0	4	365
2015	Black Jack		3.4	4.4	13.9	29	1	30	543
2015	Smith's Cider		3.79	4.4	12.6	183	4	187	417
2015	Red Rebel		3.38	4.1	12.9	18	1	19	633

2015	Granny Mack		3.92	1.5	13.9	31	0	31	759
2015	Bank's Gravenstein		3.58	3.6	10.7	68	2	70	484
2015	Roxbury Russet	Avery Watuaga	3.11	9.4	15.5	84	0	84	834
2015	Rhode Island Greening	Avery Foscoe	3.21	10.2	15.9	17	1	18	635
2015	Spitzemburg	Avery Watuaga	3.35	7.8	18	30	0	30	567
2015	Pound Pippin	Avery Hoilman	3.54	5.1	12.3	0	1	1	708
2015	Zion Baptist	Avery watauga	3.24	10.7	15.1	0	0	0	925
2015	TED Red		3.48	6.1	13.4	35	0	35	
2015	TED 50		3.36	7.9	14.5	27	1	28	
Date Received	**Sample Name ID**	**Apple Origin**	**pH**	**TA (g/L)**	**° BRIX**	**Amino (mg/L)**	**NH_4 (mg/L)**	**Total YAN (mg/L)**	**Total Phenol (mg/L)**
8/23/16	Geneva Crab	hundley orchard	3.20	6.48	8.4	73	0	73	1612
8/23/16	Harris	.Old Crosby Orch.	3.22	8.74	11	85	0	85	800
8/23/16	Summer Rambo	Crossnore	3.19	8.04	12.1	54	0	54	219
8/23/16	Almeda	Jimmy Savely	3.26	6.74	10.4	46	1	47	839
8/23/16	Rush Branch	Old Crosby Orch.	4.14	1.98	11.5	51	1	52	936
9/8/16	Horse	Old Crosby Orch.	3.36	6.2	13.1	36	2	38	1057
9/8/16	Hewes Crab	Old Crosby Orch.	3.36	7.44	16.8	92	2	94	1744
9/8/16	Mary Reid	Old Crosby Orch.	3.33	4.68	10.2	130	2	132	713
9/21/16	Grimes Golden	hundley orchard	3.37	5.34	11.8	39	0	39	758
9/21/16	Srawberry Roan	Eswine Orchard	3.22	7.41	11.9	26	0	26	381
9/21/16	south side	Green Valley	3.28	8.95	15.9	41	0	41	844
10/11/16	yellow bellflower	Woodring orchard	3.26	6.55	12.9	36	0	36	679
10/11/16	American Beauty	Woodring orchard	3.35	7.80	13.9	28	0	28	636
10/11/16	Bill Close Mystery	Bill Close Orchard	3.36	3.90	12.3	33	0	33	762
10/11/16	Meg Bonnum	Old Crosby Orch.	3.86	3.00	12.6	16	0	16	306
10/11/16	Blacktwig	unknown	3.4	6.00	12.7	61	0	61	577
10/11/16	Spitzenberg	Old Crosby Orch.	3.38	7.2	16.4	78	0	78	748
10/25/16	Newton Pippin	Old Crosby Orchard	3.39	6.6	14.6	74	0	74	588
10/25/16	Royal Limbertwig	Jeff Gragg	3.41	5.4	11.1	86	0	86	601
10/25/16	Notlry P	Clay Hartley	3.16	7.8	10.9	20	0	20	264
10/25/16	Green Cheese	Old Crosby Orchard	3.72	3.5	14.1	95	0	95	716
10/25/16	Golden Russet	Old Crosby Orchard	3.58	5.2	16.4	116	0	116	597
10/25/16	Fugi	hundley orchard	3.76	3.6	14.1	65	0	65	511
11/3/16	Red Delicious	Nancy Moretz	3.62	2.6	12.1	14	0	14	392
11/3/16	Golden Delicious	Nancy Moretz	3.93	1.9	12.3	16	1	17	527
11/3/16	Black Oxford	Bill Moretz	3.72	3.0	14	118	3	121	317
11/3/16	sour apple	unknown	3.28	8.4	12.5	52	0	52	561
11/3/16	black winesap	Old Crosby Orch.	3.50	5.6	15.5	52	0	52	720
11/3/16	chestnut crab	Mark Forbes	3.71	6.2	16	63	0	63	1002
11/3/16	summer banana	hundley orchard	3.66	4.0	14.3	18	0	18	539
11/3/16	roxyburry russet	Bill Moretz	3.73	2.7	12.2	43	0	43	763
11/3/16	old fassion limber twig	Jeff Gragg	3.73	3.7	12.3	73	0	73	444

Cider Trials: Juice and Cider data Comparison in 2016. Cider analytical data only in 2015.

	Sample Name	Brix: Juice (%)	Alcohol: Cider (%)	Density: Cider	Sorbitol: Cider (g/100mL)	pH: Juice	pH: Cider	Total Acidity: Juice (g/L)	Total Acidity: Cider (g/L)	Total Phenols: Cider (mg/L)	Total Phenols: Juice mg/L)	Volatile Acids (g/100ml)
2016	Geneva Crab	8.4	3.75	1.009	0.01	3.2	3.22	6.48	7.24	1181	1612	0.330
	Summer Rambo	12.1	5.87	1.000	0.21	3.19	3.25	8.04	8.38	282	219	0.445
	Horse	13.1	5.9	1.004	0.05	3.36	3.34	6.2	7.88	965	1057	0.295
	Hewes Crab	16.8	7.87	1.003	0.8	3.36	3.42	7.44	8.82	1645	1744	0.740
	Meg Bonnum	12.6	6.55	0.997	0.13	3.86	3.65	3	3.79	289	306	0.240
	Blacktwig	12.7	6.62	0.997	0.14	3.4	3.44	6	6.42	403	577	0.410
	Spitzenberg	16.4	8.55	0.998	0.67	3.38	3.49	7.2	7.67	616	748	0.690
	Newton Pippin	14.6	6.94	1.005	0.69	3.39	3.42	6.6	7.75	380	588	0.565
	Royal Limbertwig	11.1	5.46	1.000	0.06	3.41	3.42	5.4	6.61	461	601	0.300
	Notley P	10.9	4.91	1.003	0.09	3.16	3.13	7.8	9.15	295	264	0.470
	Golden Russet	16.4	8.03	1.000	0.84	3.58	3.60	5.2	6.73	597	597	0.530
	Fuji	14.1	7.18	0.998	0.4	3.76	3.81	3.6	4.46	510	511	0.315
	Red Delicious	12.1	6.36	0.998	0.09	3.62	3.56	2.6	3.78	285	392	0.275
	Golden Delicious	12.3	6.79	0.995	0.11	3.93	3.40	1.9	3.34	401	527	0.190
	Black winesap	15.5	7.68	1.003	0.6	3.5	3.56	5.6	6.31	649	720	0.655
	Chestnut crab	16	8.16	1.001	0.85	3.71	3.75	6.2	6.91	759	1002	0.725
	Summer banana	14.3	7.52	0.998	0.18	3.66	3.52	4	5.39	500	539	0.285
	Roxyburry russet	12.2	6.45	0.997	0.15	3.73	3.40	2.7	3.65	508	763	0.205
	Gragg		5.49	0.998	0.01		3.44		4.33	532		0.21

	Sample Name	Alcohol: Cider (%)	pH: Cider	Total Acidity: Cider (g/L)	Total Phenols: Cider (mg/L)	Volatile Acids (g/100ml)
2015	Grimes	7.04	3.57	5.25	334	0.19
	Magnum B. Dark	6.18	3.33	7.13	495	0.15
	VA Beauty	6.11	3.66	4.17	271	0.16
	Breezer	7.73	3.68	6.19	662	0.07
	Greenings	8.38	3.38	8.67	554	0.37
	Magnum B Lite	7.08	3.86	3.6	329	0.24
	194 Orange	7.68	3.26	9.18	546	0.19
	Yates	7.36	3.71	5.18	419	0.18
	Wild Yates	5.65	3.7	3.92	497	0.22

2016 Hard Cider Trials: Collated Sensory Panel Evaluation

Variety	Color	Aroma	Acidity	Flavor	Mouthfeel	Astringency	Finish	Overall	Potential
Geneva Crab	red/orange, slt oxidation	caramel and butter: low intensity	moderate to high	tart strawberry, green tea leaves, green apple/fruit	high astringency, dry to very dry	finish dry, aggressive	chalky/dry finish	lots of tannin, moderate character, color	***Blending for phenolics, color and structur; good base for cider***
Summer Rambo	Light yellow, straw	green apple, slight VA and H2S in nose	good acid, tart, slight malic aggressive	Green apple, lower H2S than nose, VA in back	more acid-driven, thin/sour	dry but sour, not driven by tannin	dry/tart finish dominates	tart, green apples, more acid than flavor	***Blening for acid (early season apple), standalone potential***
Horse	Dark Caramel, slight orange	slight butter, caramel, plastic, mineral, pencil shaving	high/moderate	orange, waxy-crayon, mineral/dusty: pineapple, rose hips	good, full, rich structure	good tannin, full and soft, mouthcoating	generally good, soft tannins. Citrus/lemon finish	Good overall; different flavor profile, not high on fruit, good structure/phenolics	***Good blending for complexity and structure (phenolic)***
Hewes Crab	Deep golden, orange	Fresh apple, apple concentrate, mineral, paste	moderate/moderate high, back of throat	orange peels and spice, leather, apple concentrate, musk melon:jolly rancher sour apple	full, dry, chalky/creamy	high	creamy, orange lingers, grapefuit/peels	higher tannin/astringenchy, oranges and peel of citrus, slight paper/cardboard	***Bledning for complexity and phenolic structure, lower % has large impact***
Spitzenberg	moderate/high golden	Fresh green apple, some aldehydes/dried apple	Good acid, moderate/high	Fresh apple, mineral and spice, dried fruit, orange peel, black tea/hibiscus	Moderate tannin, acidity thins out MF, overall good	Good tannin/structure, sharp but not overwhelming	Dry-tannins, rich, black tea, orange peel, spice	Good, good acid, good tannin, good character of aroma.	***Good potential, base: Standalone***
Meg Bonum (*some relative of Magnum bonum)*	Light yellow, platinum	slight S-reduction	Soft/Low	Slight Butter/MLF	Low structure	Low	Soft and quick finish, light	Soft MF and texture, low varietal character, low acid	***Blending, vintage variability, prior vintage high potential***
Blacktwig (AK Mammoth Blacktwig)	Moderate depth; golden hue	green apple + aldehydes, some acetic notes	moderate/high acid	green apple/aldehyde	dry and tart	dry- moderate aggressive, not too high	dry, acid finish, OK	Fresh apple/green apple character, good MF overall	***Good base and blending, structure w acid***
Fuji	Drak caramel, golden, deeper orange	mineral, earthy, sassafrass	low/moderate low	mineral and earthy	full, rich, mode/high body/texture	moderate tannin, moderate dry	low acid, mineral to bitter in finish, quick off palate	lower acid, mineral and earthy notes, slight cooked apples (ald), moderate tannin w good structure in general, some spice in finish (cinnamon)	***standalone potential, belnd in high %***
Royal Limbertwig	Dark orange	musty/musty fruit: low intensity	good acid :high	butter, caramel, cooked sugars	good tannin, full-body, good texture	full/good	good acid and phenolic profile: long lasting, notes of citrus finish	butterscotch flavor profile, moderate	***Good blending for character and tannin/texture***

Notley P	Light platinum	Soft green apple	very high	green apple, soft/low	tart, sour	soft, mild	tart finish, acid dominates	green fresh apple, very tart/sour	***Blending for acid, fresh apple***
Golden Russet	Deep golden, honey colored	dried orange, caramel, honey	good acid, RS, rich balance	caramel, coooked sugars, nutty	good acid, balance w RS, provides structure, balance w tannin	moderate to high	full, rich, creamy, dried sweet fruits/nuts/sugar/orange	good flavor, good acid, good phenolic structure	***Standalone/base***
Newton Pippin	Deep golden/bronze	pear, pineapple, melon	good acid, still RS noticeable	good orange, dried fruit, apricot: honey/sweet	good tannin structure, full	good tannin, balanced w acid/sweet	good dried fruit character, rich, good balance	good structure and balance, intense flavor profile.	***Standalone/base***
Red Delicious	Golden/straw	Slight acetic, soft on the nose	low, slight RS in mouth	flat acid, dried apples, "apple tea"	thin/watery	slt dry finish, not high but evident in finish, transient	soft but dry finish	moderate aroma/flavor intensity, dry apple, slight sweet provide some fullness	***Base/bulk***
Golden Delicious	Straw/Golden, light	Fresh green apple, slight acetic	OK- moderate to low	green apple skins	soft, watery, low but ok	low, low-moderate	soft, slight acid, not long finish on palate	tart/light, ok acid, ok flavor but light overall	***Blending, base/bulk***
Black Oxford	*NA- cider not tasted; spoilage issue.*								
Chestnut Crab (Beezer)	Deep orange, brown hues	Slight acetic, sweet flavors, dried oranges and orange peel	good acid, not oevrly acidic, moderate balance	dried orange, dried apple or concentrate, some spice and earthy character	full, round/creamy	moderate to moderate-high, supple	some bitter and dry finish	spice, dried fruit, apricots and figs	***Good base, high % blending***
Black Winesap	Light golden/orange	cooked apple juice	good, moderate and balanced	cooked sugars and caramel	full body, some RS fills body	OK- softer, supple, full but not aggressive tannin	full, good balance overall, good fruit character (ripe/sugars)	Good character and depth, good phenolic profile, moderate acid	***Standalone/base***
Roxbury Russet	Deep golden orange	Almost plastic/vinyl, green apple (some aldehydes), dried apple and orange peel.	low, moderate-low	Dry fruit, plastic, orange	some tannin, dry, low acid/sour	moderate	dry but transient	OK, better aroma than finish	***Good blending for character/aroma, moderate standalone potential (vintage)***
Gragg (Winter Queen)	Deep hue; golden/orange	Mineral, nutty (dried), earthy, musk, vanilla	low, very soft	Tea leaves (light), ok tart-apple flavor	moderate tannin, slt astringency	soft, does not linger on palate	OK- soft, low acid, mod/low astringent	Ok flavor, tea leaf character, slt green apple, tannin but low acid	***Blending, no major character for base or filling holes.***
Summer Banana	Yellow/Golden	Sharp and floral aromas: fresh apple	good acid, not too aggressive, some RS	fresh apple, floral	slight drying, oxidation, good MF	soft, good/pleasing	dry but good, slt RS, dried fruit and fresh apple notes	overall good	***good base/blenind in high %***

Sample communications from Mr Hundley to his apple grower cohort (June and August 2017)

August 2017

How about them apples this summer! In my last newsletter I told you that just below us, (in elevation), fire blight was wreaking havoc but I had not seem any in Jonas Ridge. That has remained true for me and I hope for you. Both community orchards located in Crossnore and above Newland, are clean this year too. Over the years I have been monitoring apples in Avery County this remains a striking example of how fortunate we are to have such good apple growing conditions.

If you haven't been by the Crossnore Heritage Orchard this summer, you should go and see it. It is loaded with fruit. Two weeks ago I had to shake several bushels of fruit off the Summer Banana and Grimes Golden to keep the apples from breaking the limbs of these two trees. The Grimes should be ripening very soon and the Summer Bananas by mid September. It has been encouraging for me to see the Fall Premiums, Winesaps, and Newtown Pippins finally bearing more fruit. These trees are 9 years old now. It has been great to have the opportunity to see the “slow to bear” varieties reveal their natural timing in the Crossnore Heritage Orchard. It's been a location with ideal growing conditions for apples.

Honestly, the orchard will need the help of you, the apple lovers; take a fair share of the fruit to keep

the place looking clean. Visit, learn and enjoy the Crossnore Heritage Orchard! ***The Crossnore School makes this possible for our community of apple lovers. Give your thanks to Crossnore School director, Brett Loftis!***

You know that keeping these heirloom apple varieties alive and well in our area is a noble local cause of ours. However this is nothing new. Plant preservationists have been working to maintain the diversity of plants for centuries, beginning with the medieval monasteries of Europe. Over the last 100 years science has confirmed that, to adapt to changing conditions and diseases, it is important to keep historic plant varieties alive or in storage. You may know of the great seed banks around the world. Since 1989 Cornell University has been sending expeditions to Kazakhstan, the origin of all apples. They have been bringing back to their orchards those apples that provided all the genetic history of today's modern apples. A one page story of Cornell's work and a condensed history of "Apples in America" is attached below.

Recently a member of the Avery Apple Program sent me a couple of articles on the history of and updates on the work of the seed banks today. Attached below is a "Ted Talks" presentation by Cary Fowler, a leader in the project, on "global seed banks". Cary Fowler has an heirloom apple orchard and talks about the lost apples during our time. Lastly, I received a story about a battle that was fought to save a seed bank in Russia during World War II. Botanists gave their lives to save it, literally. I thought some of you might want to read more about this. Thanks for sharing this with us Jimmy Savely! You will find all together three attachments below.

There is not a lot to do in our orchards this time of year, except maybe clean out your apple cellar. (-: It is officially the wrong time to be pruning your apples trees. August thru October is not good. It might promote new growth which may be damaged by winter weather. Besides, picking and storing apples is a lot more fun.

The varieties, starting to ripen in about a month, are the beginning of the varieties that will store well. You may have read the stories of our success storing Virginia Beauty, Sheepnose, Rusty Coats, Winesaps, Newtown Pippins, and Limbertwigs well into March this spring. Meg and I don't have an apple cellar. So we use a large refrigerator set at 35 degrees. We have had our best results when we handpick the apples, then put them in 2 -5 gal. plastic buckets with snap on lids. This keeps the apples fresh and stops them from drying out (shriveling). We can also check on them periodically to throw out any that begin to rot. To better utilize space we've also used heavy plastic bags well closed; again, to prevent drying of the apples. In summary, 35 degrees, air tight package, and careful handling should give you good apples well past the Holiday Season. Note: The best apples are picked when fully ripe and before seriously cold temps. (usually before November 1st.) If hanging on the tree, temperatures below 30 degrees can damage the apples.

Hope you are finding apples to harvest on your own trees this fall. If you are still waiting on your own trees to bear fruit and want a source for heirloom apple varieties grown locally, here is a list.

Heritage orchards open to the public include:

- "Orchard at Altapass", on the Blue Ridge Parkway in Mitchell County
- "Shady Lane Farm" on Arbuckle Rd. in Yancey County
- "Bill Moretz Mountain Orchard" and "Coffey Orchard" in Watauga County
- "Big Horse Creek Farm" in Ashe County. You can usually find these heirloom apples at the Watauga and Ashe County Farmers' Markets.
- "Jarrett Orchard" and "Roan Highlands Farm" in Burbank, near the Roan Mt. State Park.

(Cross the Tennessee State line in Elk Park going toward Roan Mtn. Tenn.)

Most these orchards and directions to them can be found online.

If you are new to our Avery Apple Program you might want to attend one of the following events:

Banner Elk, NC, the Banner Elk Book Exchange will present a lecture on October 18th 4:00pm.

"*Heritage Apples of Avery County" by yours truly,*

For details see the calendar for Banner Elk Book Exchange at: HTTP://www.bannerelkbookexchange.com/calendar

Boone, NC, Watauga County Ag. Center, an Heirloom Apple Tasting is being planned For details and date contact: Blue Ridge Women in Agriculture 828-386-1537 info@brwia.org .

Hope all of you can harvest your own or find some delicious heirloom apples to enjoy and put away for the winter this fall. If you have some old apple trees and are not sure what kind they are you can drop a few off at the Avery Extension Center and we will take a look for you. Bring them by when they are fully ripe and bring at least a half dozen of each kind. Now, there is no guarantee of a successful ID! (-:

If you have any trouble opening the attachments below or have questions concerning anything in the newsletter, please reply via email.

Look forward to hearing from you.

Sincerely,

Doug

June 2017

Good Day Apple Grower!

What a great spring we have had, a little too wet perhaps, but true springlike temperatures!

Over recent weeks I have had some orchard experiences that I want to share with you.

In my last newsletter I suggested, strongly, that you make your "Borer Prevention spray" and watch for Fire Blight. I have been very happy to see very little Fire Blight at my orchard nor in the Community Orchards. Both orchards, Crossnore Heritage and the Nunez Orchard are loaded with fruit! I hope you have found the same. I understand that Fire Blight has occurred at lower elevations in Hendersonville, Morganton, and even Spruce Pine. I suppose it's just been our good fortune in the weather pattern. If you have had incidences of Fire Blight please let me know when and where. I'f like to know and perhaps I can give you some additional information.

My big story for this newsletter is going to be something new on **"BORERS"** . As you know, the deadline or date to start your borer prevention measures was June 1st. I made mine by then, and always

have. No worries right? Unfortunately I have recently been stunned to find borer damage in the Nunez community orchard on Hickory Nut Gap.

I was checking on the apple trees there about June 15th and found the telltale sign of “frass” at the base of several trees. Frass is the deposit of orange chewed wood that young borers exude from the new tunnels as they burrow into the base of trees. I also noticed that I had trees showing a deterioration of growth; trees with stunted growth and poor leaf color. What threw me was the fact the I had sprayed the trees with Lorsban as I always do in May. I spray my own apple orchard, in Jonas Ridge, every year at the same time, with the same insecticide, and have never had a single problem with borer damage here.

A friend of mine, Bill Church and I began investigating the trees closer. We found the source of the “frass” by cutting away the bark to find a tunnel. We then used a piece of wire and ran it into the tunnel to destroy the borer. Then we looked at the trees that had showed deterioration (these were different trees) and noticed, what I later learned were, the “exit holes” of the “Roundheaded Apple Tree Borer” (RHATB). These are recognizable, as they are circular and about the size of a pencil. While these trees are still alive, I am concerned whether they will survive. Interestingly, we didn't notice any new tunneling by the RHATB on these trees. To make it real, it hurts when I lose an 8 year old Wolf River and and American Golden Russet.

The reasons for these observations are clearly explained by reading two articles I have found and attached below on this email. While the article from Cornell U. covers many possible apple borers, it is accepted by many, for good reason, that our prominent borer problem comes from the Round Headed Apple Tree Borer. In these articles you will see the same advice I have been telling you about prevention. What I've been learning this month is how, in June, we all have a chance to spot a problem if, perhaps our prevention methods are less than 100% effective, and that we have a window to try and stop the damage.

Now, in hind site, I am trying to figure out why my treatments appear to have failed here, at the Nunez Orchard, and nowhere else. Here is what I am thinking for now. At my home orchard I haven't had much deer pressure and I have not had to build deer fencing of any kind. At the Nunez orchard we had to build individual deer cages, with no doors, six feet across, with stiff construction wire. For years these cages can allow a build up of leaves, dead grass and weeds to collect. When I come in May to spray I often find 2-4 inches of this kind of “trash” around the base of the tree. Because I could not conveniently remove this trash I've been forced to spray the trunk above this trash. Then I would hold the spray nozzle on the trunk, above the trash, and let the spray run down behind the trash hoping I was covering the bark well. Perhaps I was

not.
At my home orchard I had the freedom of brushing leaves and dead grass back with my boot before I sprayed. I'd soak the bottom of the trunk, where, apparently, the RHATB lays her eggs.
A friend and member of the apple grower grower community, Greg Bovino has an orchard where the pressure of deer and the absence of people and dogs make the risk of deer damage high. He has built similar cages around his apple trees and has also had very significant borer damage. Greg has used both white latex paint and Lorsban annually!
What I want to tell you is go and look at the base of your young apple trees and see if you have any evidence of an orange sawdust looking deposit. If so, you still have a chance to stop the young borers before they do permanent damage. Do this especially if you have deer-caged trees or even wire rabbit cages that might collect leaves and trash. Call me if you have similar problems to report. Help me and all of us to learn more about this risk. The attached articles are really interesting with good detail.
A couple more ideas :
Fertilizing... If it's been over a month since you last applied any fertilizer to you fruits trees or small fruit and you'd like to apply more, (a fine idea if your plants are young and need to grow wood). You'll want to make the last application in the next couple of weeks. Applying nitrogen containing fertilizer after July 1st is not recommended. Now is the time, not later.
Black Raspberries... If you are a black raspberry grower. June is the month to “top” your new current year canes. By topping them at about 3 feet tall, they will grow laterals for the next 2-3 months, instead of tangled tops. Next March you can cut those laterals back to about a foot long. This will result in self supporting, erect canes that will stand on their own. These laterals will produce shoots that bloom next June and load up with ripe fruit July 1st. next year. This style of erect black raspberry production does not require trellising and prevents your raspberries from becoming out of control briar patches. The laterals you cut off next March will give you many new plants to enlarge your raspberry patch in neat rows.
Apple Pie... Oh, I almost forgot to tell you; The refrigerated apples I've been telling you about over the winter, making pies, is over. However believe it or not, Meg made the last pie from the “Frig”, just last week! That's right mid-June! The Am. Golden Russet won, lasting the longest. Don't believe me? Ask me and I'll tell you the details of how I had them stored. (-:
Do keep an eye out for Fire Blight. It can show up at anytime. Hey, I see Early Transparent apples nearly full size on my tree and my Carolina

Red June apples are beginning to turn red. Hang on, it's almost apple eating time again. It may never happen again but we ate and baked fresh apples for 11 months this last year!
Take care of your apple trees and yourself,
Sincerely,
Doug

PROJECT TITLE: Local Produce Safety Initiative III

PROJECT SUMMARY

The complex and expensive food safety protocols that have evolved to address public health challenges principally attributable to national and international food supply chains are a threat to the participation of small and mid-sized farms in local supply chains. Small farms consistently face barriers in implementing GAPs and achieving USDA GAP certification including: 1) limited staff capacity, which makes GAP record-keeping more burdensome on the farm operators; 2) reliance on proven, low-cost fertility sources such as compost and manure, which are not permitted in some private GAP audit regimes and subject to extreme controls in others; 3) limited capacity to make capital investments, which are assumed as a cost of doing business in larger farming operations; and 4) reliance on multiple crops, including livestock, to diversify income streams and mitigate risk.

Thanks to funding from the NCDA&CS Specialty Crops Block grant program, CFSA launched the Local Produce Safety Initiative (LPSI) in 2011 to address these barriers. Since then, CFSA has provided training to empower individual farmers to utilize tools and strategies that match the specific labor, climate, water supply, soil quality, economic and cultural conditions of their farming operations. We have found that a farm-specific approach is the most effective means of protecting the consuming public from pathogen outbreaks while preserving the ability of small specialty crop farms to thrive, and to provide numerous other benefits to the public including fresher, more nutritious fruits and vegetables, preservation of farmlands and open space, and rural economic development.

Through this iteration of LPSI, CFSA sought to expand LPSI to establish a model approach for community-based, sustainable farmer-friendly food safety quality management systems (QMS) that would increase specialty crop farmers' access to markets by developing a food safety consultation and support program by implementing GroupGAP programs at three food hubs in the Carolinas. This model would allow those entities to maintain food safety QMS and pursue USDA GroupGAP certification by sharing the costs among them in a pay for service arrangement. The objectives of LPSI III were to: 1) establish and maintain processes and record-keeping protocols for documenting training, policies, and procedures for three food hubs implementing GroupGAP standards that conform to USDA standards, 2) develop food safety plans for three food hubs and their participating farmers, and 3) advise food hubs in the evaluation and use of software or web-based services for food safety QMS record management.

This project is timely because demand for local produce is influencing purchasing decisions of wholesale and institutional buyers. A 2012 USDA report found sales through intermediated channels are a growing segment of the local food market; buyers in those supply chains often require farms to be GAP certified. By providing direct assistance to farmers wanting to become GAPs certified, we will enable them to improve access to the local produce market, which we estimate to be at $180 million in current annual demand state wide. We estimate that obtaining a USDA GAPs certificate will increase the volume and/or value of products produced by $10,000 - $32,000 per participating farm. Furthermore, we estimate that total sales through food hubs will increase by $190,000 in the first year with the potential to increase by $400K to $1.2M by the end of the project.

During this project period, the USDA was seeking a solution to offer cooperative, food hubs and other marketing organizations a way to work collectively in obtaining GAP certification, ultimately sharing in the cost of certification and resources. By removing these marketing barriers, the USDA launched the GroupGAP Standard in April 2016 with a mission of offering solutions for small growers to sustain their businesses through their Agriculture Marketing Services (AMS) division. USDA AMS designed the program to provide a Standard that would effectively enhance market opportunities for small producers, while providing them cost savings in order to compete in the produce industry.

The GroupGAP pilot program required participants to develop and implement their own quality management system (QMS), based on the principles of ISO 9001, and food safety policies and procedures that included internal inspections and audits of their members and verification by USDA licensed auditors. The USDA recruited seven groups across the country to participate in the pilot program, CFSA being one of the recruits.

CFSA was one of two entities in the pilot program that developed a 3rd Party Administrator model that would allow food hubs to offer GroupGAP to their members while being supported by outsourced technical assistance. Technical assistance included help writing and implementing QMS and food safety plans, staff training, conducting internal audits and general technical support meeting the GroupGAP standard. The participants recognized the value in this model because it allowed them to maintain relationships with growers without having to act as an auditor, eliminated the need to retain on staff a qualified individual to conduct internal audits, provided access to qualified food safety experts and a liaison to communicate with buyers on food safety efforts.

LPSI III builds on the FY 10 and FY 12 Specialty Crops Block Grant from NCDA to CFSA for LPSI I and LPSI II and has not been submitted to any other federal or state funding programs. However, we have been awarded funding from the Wallace Foundation to support the work they are doing with the USDA Agricultural Marketing Service Center (AMS) to develop a GroupGAP certification program. AMS recently piloted a successful GroupGAP approach with Good Natured Family Farms, a food hub in Kansas City, MO. However, additional pilot efforts are needed to provide information to AMS to further develop a national GroupGAP program.

PROJECT APPROACH

There are a significant number of food hubs at various stages of development in the Carolinas, which are seeking to capitalize on the very strong public demand for local foods. Farmers and food entrepreneurs in this region have been early adopters of cooperative, community-based strategies to increase the availability of locally-grown specialty crops through wholesale and institutional channels, and these businesses are now grappling with the issues of GAP and QMS. These hubs include Feast Down East in Burgaw, NC; New River Growers in Fleetwood, NC; and TRACTOR in Burnsville, NC. GroupGAP models offer significant potential for these firms to improve farmers' access to markets, and all three have supplied letters of commitment for this proposal indicating the potential importance of GroupGAP approaches to their future growth and their desire to attain food safety certification for their farms and facilities. The objectives of LPSI III were to:

- Establish and maintain processes and record-keeping protocols for documenting training, policies, and procedures for three food hubs implementing Group GAP standards that conform to USDA standards.
- Develop food safety plans for three food hubs and their participating farmers.
- Advise food hubs in the evaluation and use of software or web-based services for food safety QMS record management.

CFSA elected to utilize the Fresh Produce Harmonized GAP Standard for USDA GroupGAP within the state of North Carolina. Harmonized GAP was chosen over the USDA GAP/GHP standard since it is vastly becoming a preferred food safety standard, developed by industry professionals, to reduce the duplication of supplier audits. The Harmonized GAP standard allows for multiple third-party certifying bodies to audit under this scheme, reducing potential competition among other individual benchmarked schemes.

The goal for the development of the Harmonized GAP Standard was to offer one audit, by any creditable third party, acceptable to all buyers. The standard covers both, pre and postharvest operations, providing small growers the opportunity to reduce audit fatigue and allow operations to focus their food safety resources on achieving food safety, rather than passing audits. The Harmonized GAP standard is not the typically scored audit, and instead focuses on risk mitigation and is a pass/fail audit program. This standard in combination with the USDA GroupGAP requirement of implementing an ISO 9001:2008/ISO 22006 PRP based QMS was a good fit providing a robust food safety program for small growers.

Project partners include the food hub managers at Feast Down East and New Appalachia, and partners at the USDA. Food hub managers have contributed to the project by identifying growers to participate, providing on-going support for growers in identifying benefits of supporting the project, and speaking with potential buyers to gain their support for the USDA GroupGAP Standard. USDA project partners have contributed by reviewing and benchmarking the food hubs QMS.

GOALS AND OUTCOMES ACHIEVED

GOAL 1: Establish and maintain processes and record-keeping protocols for documenting training, policies, and procedures for three food hubs implementing GroupGAP standards that conform to USDA standards (Table 1).

Promoted the GroupGAP program through direct communication with over 40 growers, at a growers meeting at CFSA's Organic Commodities and Livestock Conference in Rocky Mount on March, 2015 (6 attendees) and through an article in our electronic newsletter, *New Appalachia Foods Becomes NC's First GroupGAP Certified Food Hub* (114 unique views). Promoted GroupGAP to eight state and national buyers and potential food hub customers in order to evaluate the acceptance of the program.

Completed Quality Management Plans (QMS) for Feast Down East and New Appalachia Foods, formerly New River Organic Growers. QMS plans include sections on Quality Management Systems,

Management Responsibility, Resource Management, Product Realization, and Measurement, Analysis, and Improvement. The QMS plans were reviewed by the USDA, revised based on their comments, and benchmarked to the USDA GroupGAP standard. Conducted a GoToMeeting for hub managers on implementing their QMS, conducted site visits to provide employee training and additional technical assistance to food hub managers.

Created thirteen Standard Operating Procedures (SOP) for Feast Down East and New Appalachia Foods, including Adding and Removing Growers, Customer Satisfaction, Training Awareness and Competency, Internal Audit, Internal Inspections and Audit (Farm Level), Control of Non-Conforming Product, Third Party Administrator, Corrective Action Procedures, Water Systems Description Management, Calibration of Refrigeration Equipment, Postharvest Handling, Document and Record Control, and a Recall Program. Recordkeeping protocols were defined and maintained for both hubs, in preparation for the External Systems Audit, conducted by the USDA in October 2015.

Conducted two internal QMS audits and two internal facility audits at Feast Down East and New Appalachia Foods prior to the external audit being conducted by the USDA. Corrective actions and additional risk mitigation strategies were put into place following the internal audits, including revisions to the QMS plan based on ongoing changes to the USDA requirements as the GroupGAP program was being developed. Trained staff on newly implemented policies and procedures based on the internal audit results.

Conducted four internal farm audits for Feast Down East, of which three farms met the requirements of GroupGAP. Conducted five internal farm audits for New Appalachia Foods, of which 4 farms met the requirements of GroupGAP. Provided corrective action technical assistance to the two farms who did not pass the internal audit. Due to diversity in their operations, including livestock on small land parcels, and financial constraints, the farms were unable to correct all non-conformances needed to pass the audit and therefore were not able to participate in the Group.

Provided initial internal auditor training to six staff members of the food hubs. Additional trainings were conducted throughout 2015 and 2016 as the food hubs had turnover in the staff (four trainings). Although CFSA was conducting the internal audits supporting the model, the food hubs recognized the benefit of continuous training for the employees and managers who had direct food safety responsibilities at the food hub and farm levels in order to provide additional technical assistance and to conduct internal inspections, where consulting was allowed during the farm visit.

CFSA hosted an additional internal auditor training that was conducted in partnership with the USDA for 75 food safety professionals, food hub managers and NCDA auditors. Due to high demand, a 2-day add-on was conducted on the Harmonized GAP Standard. As this training was being coordinated, CFSA and the USDA realized that there was a nationwide demand for those pursuing GroupGAP. This training was televised in two satellite locations, Wisconsin and Pennsylvania, with USDA representatives

available on-site to answer questions.

Provided site-specific Harmonized GAP training to five staff members of the food hubs and ten farmers with an emphasis on conducting risk assessments as required by the Harmonized GAP Standard. Provided additional Harmonized GAP training for five new employees due to turnover throughout 2015-2016.

Provided technical support to seven farmers participating in the GroupGAP project while undergoing their external audits conducted by the USDA to learn how to communicate with the auditor on a technical level, as well as ensure that the growers understand the 'real-time' opportunity to make immediate corrective actions. Harmonized GAP is a pass/fail audit requiring in some cases that corrective actions be submitted to the USDA, then undergoing a long review process, potentially delaying certification. By growers learning to communicate with the auditors and understanding their boundaries during the audit, growers can eliminate this process.

Provided technical support to food hubs during the QMS External Audits. The USDA requested feedback from Group participants, as well as technical service providers on the 'process' of conducting the external audit. The outcome of this provided the USDA with an understanding that food hub managers are able to understand the concept of the implementation of a Quality Management System, including very positive feedback that implementing a 'system' has assisted in the improvement of overall operations. While designing the program, CFSA realized that the food hubs would need to see additional benefits, not just food safety, in order to maintain the QMS with having very little staff capacity to do so. Therefore, in the development of the QMS plans, CFSA incorporated the key components of success: 1) Food Safety in order to meet buyer requirements; 2) Product quality and specifications in order to meet quality and shelf-life requirements in the market; and 3) Customer Service, requiring the food hubs to acknowledge and record all customer communications, especially complaints and corrective actions taken. All three included a continual improvement component.

Participated in twenty-four monthly GroupGAP Community of Practice calls hosted by the Wallace Center. These calls included national GroupGAP Pilot Program participants, Wallace Center and USDA staff. It provided an opportunity for those working on implementing GroupGAP to share experiences and learn from others.

In 2016, the USDA established a GroupGAP Expert Advisory Panel to assist them in evaluating the GroupGAP pilot program and develop a GroupGAP user manual. Trish Tripp was one of five experts asked to participate in this panel and participated in twelve monthly calls. Ms. Tripp attended the pre-launch GroupGAP Meeting with USDA in Fredericksburg, VA, to finalize the GroupGAP Standard, including finding solutions to implementation challenges, discussing buyer acceptance, and needed training materials. During this meeting, the barriers and benefits identified through the implementation of GroupGAP in NC were shared among the group.

Conducted sixteen monthly calls for NC GroupGAP participants in order to encourage them to share their experiences, identify ways to overcome challenges, discuss QMS development and implementation, transitioning to year-two, as well as implementation of other requirements of the USDA GroupGAP Standard.

Table 1: Activities performed to help food hubs and their growers implement GroupGAP standards that conform to USDA standards.

ACTIVITY	TRACTOR	FDE	NAF
Conducted Initial Site Visit	Feb, 2015	Feb, 2015	Mar, 2015
Recruit Group Members	Mar, 2015	Mar, 2015	May, 2015
Conducted Management Team Meetings	April, 2015	NA	NA
Conducted On-Farm Risk Assessments	NA	April, 2015	April, 2015
Conducted Facility Risk Assessments	March 2015	April 2015	April 2015
Developed QMS Plans	NA	July, 2015	Aug, 2015
Assisted Growers in developing SOPs and recordkeeping documents based on the Harmonized GAP Standard	NA	Sept, 2015	Sept, 2015
Implemented QMS Programs	NA	Aug, 2015	Aug, 2015
Conducted Grower Meeting for GroupGAP	March 7, 2015		
Conducted QMS Training	May 25, 2015		
Conducted Harmonized GAP and Internal Food Hub Audit Training	March 3-5, 2015		
Conducted Internal Food Hub Audits	NA	Oct, 2015	Oct, 2015
Conducted 7 Internal Farm Audits	NA	Sept, 2015	Oct, 2015
Provided Support to Food Hubs during QMS External Audits	NA	Oct, 2015	Oct, 2015
Provided Support to Grower Members during External USDA Audits	NA	Oct, 2015	Oct, 2015
Assisted with developing the *USDA's Group GAP & GHP Certification Program User's Guide*	Released by the USDA in March, 2016		
Attended the pre-launch GroupGAP Meeting with USDA	November 16-17, 2015		
Conducted unannounced internal audits on four farms.	May 2016		
Conducted unannounced internal audit at one food hub.	May 2016		
Planned, wrote and implemented Food Defense Plan at one food hub. Trained food hub staff on content and compliance.	March 2016 - April 2016		

Conducted site visit at one food hub to provide technical assistance on additional risk mitigation recordkeeping requirements.	November 14, 2016
Conducted Harmonized GAP training to one food hub via GoToMeeting.	November 2, 2016
Participated on 24 Monthly GroupGAP Community of Practice Calls.	January 1, 2015 – December 31, 2016
Conducted 16 Monthly Calls for NC Group GAP Participants	March 29, 2015 – June 26, 2016
Participated in 12 monthly GroupGAP Expert Advisory Panel calls with USDA.	January 20, 2016 – December 14, 2016

GOAL 2: Develop food safety plans for forty farmers selling through participating food hubs.

Promoted the direct consulting program on CFSA's website (794 views), at conferences and workshops, through ads our monthly electronic newsletter, and in an expert tip, Farm Food Safety Begins with Worker Health and Personal Hygiene (35 unique views).

Completed one-on-one consultations with 42 farmers/facilities. Of those 25 have obtained GAP Certification (Table 2). We anticipate an additional six will get certified this spring/summer as CFSA only began working with them quarter three and four of 2016. Those who did not get certified identified the certification cost and lack of demand or the fact that the product of the buyers interest was not being grown in 2017, therefore certification was delayed for 2017, as the reasons they did not certify. However, 41% of program participants who became GAP certified reported an increase in the volume of sales since becoming certified and 11% have been able to hire additional staff because of the increased volume of sales. Additionally, 23.8% reported that they have scaled up production to meet market demand since receiving GAP certification.

Table 2: Program participants who received one-on-one consultations and their certification status.

FARM	COUNTY	GAP Certified
Balsam Gardens	Buncombe	X
Black River Organic Farm	Sampson	X
Brent Riggs Farm	Mecklenburg	X
Britt Farms	Wayne	X
Cedar Grove Blueberry	Orange	
Charlene's Garden	Polk	X
Cottle Organics	Duplin	X
Crouch's Gourmet Specialty	Carteret	X
Down 2 Earth Farms	Durham	

Eastern Carolina Organics	Durham	X
Eden Song Wheatgrass	Wake	X
Endless Sun Produce	Wake	
Fishel Organics	Ashe	X
Fox Farm & Forage	Wake	
Friendship Gardens	Mecklenburg	X
Funny Girl Farm	Orange	
G&S Trees	Avery	
JW Merrel Farm	Carteret	
Living Roots Farm	Caldwell	
Long Family Farms	Cherokee	
MG3 Farms	Robeson	X
Microgreen King	Forsyth	X
Miller Farms	Cherokee	
Morris Blueberry Farm	Craven	X
New Ground Farm	Robeson	X
Otter Branch Organics	Duplin	X
Piedmont Bio Farm	Chatham	
Raven Rock Farm	Watauga	X
Rebecca Knolls Farm	Forsyth	
River Bluff Farms	Forsyth	
Rocking S Farm	Alleghany	X
Rouse Brothers/Uncle Henry Organics	Duplin	X
Sonny Rowe Farms	Pender	X
Springhouse Farms	Watauga	X
Sunburst Tomato Farm	Nash	X
Sunset Market Garden	Rockingham	
The Brodie Farm	Henderson	X
The Crews Farm	Henderson	X
Triangle Premium Micro Greens	Wake	
Wiebe Farming	Yancey	
Woods Strawberries	Nash	X
Yadkin Valley Farms	Wilkes	

Goal 3: Advise food hubs in the evaluation and use of software or web-based services for food safety QMS record management that documents the hubs' and farmers' performance in adhering to their safety plans.

Evaluated 13 software options (Table 3) that could be utilized individually, or in combination with one another as an alternative to current QMS recordkeeping and traceability software's food hubs are using, primarily including QuickBooks and Excel worksheets. It is believed that the utilization of software can reduce human error in recordkeeping for QMS programs, including traceability, as well as provide efficiencies for food hubs.

Most of these options are cloud-based software's designed to keep the cost down for growers. The costs range from $300/year to $12,000/year, but are constantly changing due to market demand. It is recommended that pricing be evaluated when the need for the food hub and/or grower are identified to ensure updated pricing structure.

At this time, no software has been identified specifically for QMS management within a food hub, although the identified software can assist, at a minimum in maintaining customer service, traceability, inventory and sales records. Improvements would need to be made to ensure that the software can track performance in adhering to their food safety plans, other than the features mentioned above.

E-commerce, social networking, networks of farmers and food hubs, networked inventory including on-the-farm crops, lot traceability, supply and demand planning, allow for producers or network to set prices, recipes and work order management for food processing, delivery cycle and route management, would provide other efficiencies to food hubs.

There is potential for any of these software companies to collaborate on their efforts to combine their knowledge to create a robust software at an affordable price. Currently, neither food hub is using commercially available software at this time because they are cost prohibitive and there are time constraints in implementing a new system, although efficiencies have been identified.

Table 3: Description of software programs reviewed for improving efficiencies for food hubs.

SOFTWARE	DESCRIPTION
Enkidu	From Spain, maintains and maps delivery routes.
FarmLogix	Utilizes proprietary technology to connect local farms with schools, hotels, restaurants and institutions.
Food Hub Pro	User-friendly food hub management software that assist with planning, aggregation, distribution and accountability for locally produced foods. With its ability to integrate with QuickBooks, this software provides easy integration into the food hubs current practices. The software supports Purchase Orders via Electronic Data Interchange from major grocers, like Whole Foods. An availability list can easily be compiled and sent to buyers via EDI or email. This software provides full traceability features.

Food Network Software	Comprehensive operational and administrative software for a single food aggregation and distribution network, designed by food networks, and currently only used by two. Includes supply and demand planning and income forecasts, on-the-farm crop inventory, lot traceability, and light food processing. Prices for the software are set on a per-network bases.
Local Economic Development	Regional economic resource mapping and analysis. Could be useful at the early stages of organizing food networks or groups.
Local Food Marketplace	A comprehensive and integrated platform that is designed to support and maximize the sales and distribution of local food. Provides an infrastructure to include inventory management, ordering, customer service, sales and marketing, with the ability to make it possible to scale up as the business grows. The service includes a custom-branded website and ordering system, distribution and route support, a producer interface, sales tools and reporting functions. A mobile app is available providing a user-friendly means for farmers to upload availability of product from the field, prior to harvest.
Local Orbit	A cloud-based software solution that allows farms and/or food hubs to sell in multiple marketplaces from one account. It supports local food businesses with a built-in suite of back0end tools for marketing products, tracking customers, updating and monitoring inventory and organizing delivery.
Nova	Producers maintain availability and set prices, within limits set by the network. The newer version provides a lot more farmer oriented and social features to the system.
Network Resource Planning	Operational and administrative software for one or many economic networks of any kind, not just food. ERP for networks. Includes complete recipes and work order management for food processing.
Open ERP	We understand that some hubs are looking at this to support internal operations. During the evaluation it was determined that the software provides a variety of tools that would benefit food hubs, however this was one of the more expensive options.

Open Food Network	Provides a comprehensive e-commerce and social networking platform for farmers and food hubs. The software originated from Australia and is now being marketed in the US and Canada. The benefit of this software is that it can be used to network multiple farmers, as well as multiple food hubs. Sellers set up their own payment methods, including direct bank deposit, PayPal, and credit card. All payment are made directly, so no money passes through the Open Food Network, providing growers and food hubs with the necessary trace forward recordkeeping.
Open Food Source	Originally built for Oklahoma Food Hub, used by several US food hubs for overall business operations.
Stroudco	From a food hub in the UK, has been downloaded by 90 groups and provides support for overall business operations.

BENEFICIARIES

Direct beneficiaries of this project were specialty crop producers who received technical information about GAP Certification through CFSA staff or Food Hub staff who received training by CFSA (Table 4).

Table 4: Beneficiaries of the Local Produce Safety Initiative from 2015-2016.

TYPE of INFORMATION	NUMBER OF BENEFICIARIES
Viewed CFSA's GAP Manual and Training Video	2,574
Received One-on-One Consultation	42
Obtained GAP Certified	25

LESSONS LEARNED

Three food hubs expressed interest in implementing GroupGAP prior to the start of the project period, TRACTOR, New Appalachia Foods, and Feast Down East. Unfortunately, early in the project period, TRACTOR recognized they lacked the capacity to implement GroupGAP and opted out of the project. The remaining food hubs, Feast Down East and New Appalachia Foods continued with the project and participated in monthly meetings, trainings and successfully implemented their QMS and standard operating procedures with only one, New Appalachia Foods, LLC, becoming certified in USDA GroupGAP.

What We Learned About Food Safety Culture

Educating the growers and food hubs on food safety, as well as quality management systems, proved to be invaluable. The USDA GroupGAP Standard is considered a validated ongoing, effective management system the acts as a continuing process of keeping food safe. Through management, monitoring, validation, verification, and documentation processes and procedures, USDA GroupGAP is believed to provide efficiency improvements in all management areas. The food hub managers embraced the culture of food safety, as well as the implementation of the QMS, recognizing the value in managing risks at all levels for the success of their business.

Implementing ISO 9001:2008; ISO 22006 PRP

The objective of the ISO 9001:2008 standard is a systematic pursuit of process development in order to achieve continual improvement and gain knowledge needed to enhance quality and performance. The USDA recognized the need to provide participants with a ready framework for ordering and structuring an organization's knowledge. Reducing overall risks of a successful business exceeds food safety alone. The implementation of a quality management system requires the right activities, in the right order and with the right resource involvement throughout the entire organization.

Although implementation involved a huge learning curve, the food hubs found that executing a quality management system was beneficial not only due to the potential external advantages, such as increased marketability and improved customer service. They found that implementation resulted mostly in an increase of internal benefits such as improvements of the clarity of responsibilities and obligations of employees, decrease of non-conformities, better communication among the employees, increased product quality and overall operational efficiency. Identifying these benefits helped to keep the food hub managers engaged in the process.

FSMA Compliance

The need for growers to understand the difference in a voluntary GAP program and FSMA, the law, was evident throughout the project, especially differentiating USDA's role in the development of GroupGAP. The USDA anticipates that the GroupGAP Standard will be FSMA compliant by April 2018. It is anticipated that the Harmonized GAP standard will be FSMA compliant by December 2017. It was recommended to all program participants that moving forward with GAP certification will ensure FSMA compliance over the next 12-18 months, based on these facts.

Buyer Engagement

Several buyers, including US Foods, Sysco, FreshPoint, Whole Foods, Lowes Foods and Foster-Caviness were informed that CFSA actively engaged two food hubs to participate in the Group GAP project. The buyers were provided information on USDA GroupGAP as it was developed, the benefits of implementing a quality management system and the Fresh Produce Harmonized GAP standard. Feedback from the buyers was provided to the USDA as the Standard was developed to assist in

determining buyers' acceptance. The most attractive component of the USDA GroupGap Standard to all entities was the fact that the program is a risk-based, continual improvement process with a multi-tiered verification process in place to ensure food safety compliance.

Cost of Implementation

The cost of implementing GroupGAP on the hub level for FDE and New Appalachia was $17,713 and $21,625 respectively. The average cost to farmers participating ranged from about $3,000 to $4,000 (Table 5). The cost of GroupGAP exceeds individual GAP certification because of additional components not required with individual GAP certification. Specifically, writing, implementing, and documenting improvements to a QMS Manual, internal auditor training and consulting fees, and ISO 9001:2008 training. The cost of implementation is one of the factors that resulted in the food hubs involved in this project not pursuing or maintaining GroupGAP certification. However, implementing GroupGAP could provide cost savings and efficiencies for groups consisting of 25 or more members. This is because the larger the group, the higher the cost savings, due to the fact that the square root +1 of the number of growers is randomly selected for an external audit. However, the internal costs will significantly rise for larger groups, increasing the number of internal audits that need to be conducted. Therefore, the competency of the individuals managing the program, especially conducting internal audits, is crucial. The food hub will need to be highly dependent on the skills of a qualified Internal Auditor to ensure that members are complying with the food safety standards.

Table 5: Cost of Implementing USDA GroupGAP

ENTITY	TRAINING	3rd PARTY CONSULTING	AUDITING FEES	IMPLEMENTATION & MAINTENANCE	QMS DEVELPOMENT	TOTAL
FDE	**$450**	**$9,200**	**$1,663**	**$3,400**	**$3,000**	**$17,713**
FARMER 1	$1,200	$1,200	$1,016	$560	$200	$4,176
FARMER 2	$1,200	$1,500	N/A	$125	$200	$3,025
FARMER 3	$1,200	$1,500	TBD	$380	$200	$3,280
NAF	**$1,675**	**$11,200**	**$2,350**	**$3,400**	**$3,000**	**$21,625**
FARMER 1	$1,200	$1,200	$924	$560	$200	$4,084
FARMER 2	$1,200	$1,500	$1,108	$125	$200	$4,133
FARMER 3	$1,200	$1,500	NA	$380	$200	$3,280

Though this project, we were able to identify a number of barriers to implementing GroupGAP including: 1) cost, 2) availability of resources to assist with implementation, including training materials training opportunities, 3) acceptability from all buyers due to the lack of knowledge of the program, and 4) qualified Internal QMS and Harmonized GAP Auditor's skilled in identifying potential food safety

risks. However, we were also able to determine a number of resource and tools that would help remove some of those barriers by developing:

1. QMS Development and Implementation training and resources for trainers.
2. A Glossary of Terms to be included with the USDA's Group GAP User's Guide
3. Training and resources on *How to Conduct an External Group GAP Audit*, including FV-651 and invoicing guidance.
4. Guidance on conducting an Internal QMS Audit, if process is managed in-house by a qualified individual
5. Internal Auditor Training Curriculum
6. A Nationwide Internal Audit Network

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ADDITIONAL INFORMATION

New Appalachia Foods Becomes NC's First GroupGAP Certified Food Hub

Farm Food Safety Begins with Worker Health and Personal Hygiene

USDA Group GAP & GHP Certification Program User's Guide

PROJECT TITLE: Organic Farming Conservation Outreach Project

PROJECT SUMMARY

According to the Organic Trade Association's 2016 Organic Industry Survey, the organic industry increased in sales by 11% in 2015, resulting in the largest annual gain of organic sales in over two decades. Reaching a new high, US organic sales reached $43.3 billion dollars, with organic fruits and vegetables maintaining its position as the largest category in regards to sales at $14.4 billion dollars, up 10.5% from 2014. The organic industry in NC has also seen an increase in total certified farms, acreage and sales during the funding period compared to previous years (Table 1), highlighting the growing importance of organic agriculture in the state.

Table 1: Increase in organic specialty crop production in North Carolina.

Production Metric	2014	2015	2016
Certified Organic Operations[1]	170	286	359
Total Certified Acreage in Specialty Crop Production[2]	2806	4042	NA
Total Sales from Specialty Crop Operations[2]	$13,678,633	$21,338,735	NA

[1]USDA AMS Organic Integrity Database, retrieved from <https://organic.ams.usda.gov/integrity/> on 2/21/2017.
[2]USDA Census of Agriculture 2014 and 2015 Organic Surveys, retrieved from <https://www.agcensus.usda.gov /Publications/2012/Online_Resources/Organics/> and <http://usda.mannlib.cornell.edu/usda/current/ OrganicProduction/OrganicProduction-09-15-2016.pdf>, verified 2/21/17.

However, North Carolina's farmers continue to face technical challenges in seizing a greater share of our state's organic market and overcoming barriers to organic certification. In a recent survey, conducted by Carolina Farm Stewardship Association (CFSA), of specialty crop producers, farmers continue to identify certification cost, interpreting the National Organic Program regulations, producing an Organic System Plan, time spent record keeping, and sourcing organic seed as barriers to certification.

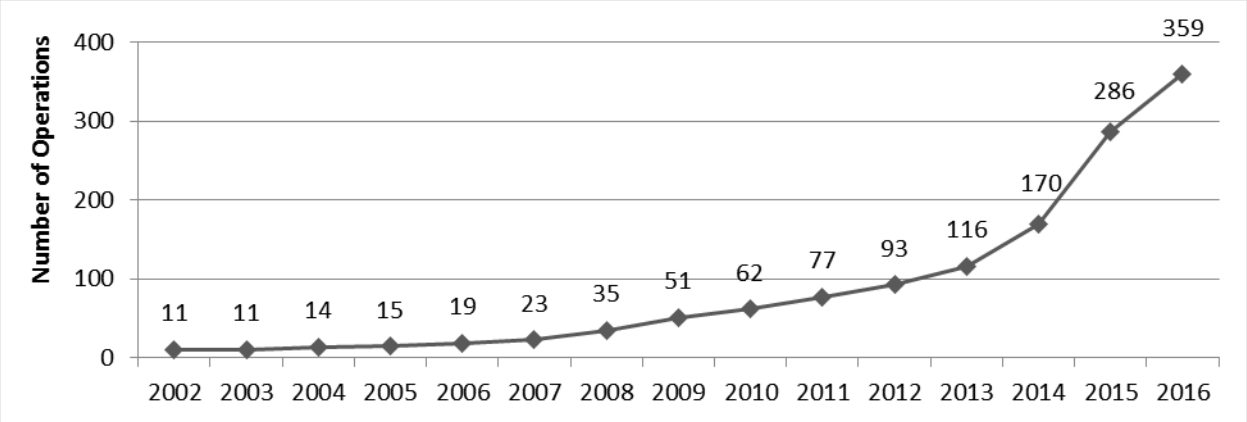
In the spring of 2011, CFSA initiated an Organic Produce Market Survey (OPMS), funded by the NCDA Specialty Crops Block program, for the purpose of helping enhance the competitiveness of North Carolina (NC) specialty-crop producers entering the expanding market for organic fruits and vegetables. The results of this survey show that there is a considerable gap in NC between the demand for organic products and what the state's growers are currently supplying. The estimated value of that gap is over seven million dollars a year. Providing direct assistance to specialty crop growers seeking organic certification provides them with the opportunity to meet the demand for organic produce, both regionally and nationally.

Federal cost share programs for adopting organic farming practices, such as the Natural Resources Conservation Service Environmental Quality Incentive Program Organic Initiative, (NRCS EQIP-OI) also

provide opportunities for NC specialty crop producers to increase their competitiveness in the organic food market. However, NC farmers are not taking full advantage of this program.

In 2010, CFSA launched the Organic Carolinas Initiative (OCI), a comprehensive, long-term strategy to build the organic agriculture community in the Carolinas. The goal of this initiative is to build on regional assets and successes to establish a world-class organics industry in the Carolinas, and double the size of the organics sector in the region by 2020. We exceeded that goal in 2014; by 2016, the number of certified organic operations in NC increased 480% from 2010, when OCI was launched (Figure 1).

Figure 1: Number of certified operations in North Carolina, 2002 to 2016[1].



[1]USDA AMS Organic Integrity Database, retrieved from <https://organic.ams.usda.gov/integrity/> on 2/21/2017

In 2011, we launched Organic Farming Conservation Outreach Project (OFCOP) in South Carolina with funding from the SCDA Specialty Crops Block Grant Program (SCBGP), as part of OCI. Through that project we hosted fourteen workshops providing information on organic production, organic transition, and resource conservation to over 300 SC growers and Natural Resources Conservation Service (NRCS) employees and provided direct consulting services to over 50 producers. We published the *Organic Production Handbook* (1,438 views) and the *Carolina Organic Transition Handbook for Produce Farmers* (1,130 views). We reviewed 20 NRCS EQIP-OI job scenarios and payment schedules and provided outreach and education to over 250 farmers about the NRCS EQIP-OI program, resulting in a 513% increase in funds allocated by the SC NRCS through the EQIP-OI program in 2011. Our work has resulted in at least thirteen specialty crop growers beginning the transition to certified organic production. Thanks to ongoing support from the SC SCBGP we will be able to run the Organic Farming Conservation Outreach Project in SC through 2017.

We also received funding from the NCDA&CS SCBGP in 2013 in order to offer OFCOP services to NC specialty crop growers. Through that program we provided eight workshops to 325 specialty crop producers and NRCS employees and provided information on the EQIP-OI program to 814 specialty crop producers; 18 of which began transitioning to certified organic production. This iteration of

NCDA&CS SCBGP funding (G20100305815MKT) enabled us to relaunch OFCOP in NC so we could build on the work we did in 2013 and offer the same services to NC growers that we have offered to SC growers since 2011.

PROJECT APPROACH

In order to improve the competitiveness of NC specialty crop producers seeking to take advantage of the high-value market for organic produce we provided farmers with the tools they needed to transition to certified organic production by retaining on staff a certified technical service provider to write Conservation Activity Plans Supporting Organic Transition (CAP 138) for specialty crop producers, provide direct consulting services to specialty crop producers seeking USDA Organic Certification, and provide workshops on organic production and certification. Specifically we:

- Wrote 16 CAP 138;
- Provided direct consulting services to 24 specialty crop producers;
- Conducted 11 workshops on organic production practices;
- Wrote 8 expert tip articles on organic production

The success of this project relied on significant contributions from project partners who helped host workshops and promote both workshops and our direct consulting services. Significant project partners included: 1) Southern Appalachian Family Farms; 2) Southern Organic Female Farmers Association; 3) The Organic Growers School, 4) Feast Down East; 5) NC Cooperative Extension; and 6) Living Web Farms. All six of these partners hosted a workshop. These partners, along with many extension agents, NRCS staff, and other partner organizations helped promote our workshops and consulting services.

GOALS AND OUTCOMES ACHIEVED

Goal 1: Increase the number of NC producers transitioning to organic production in order to take advantage of new markets for organic specialty crops. As a result of this program, thirty producers will begin transitioning to certified organic production, ten will become certified, and 150 will attend workshops.

Promoted our direct assistance to producers seeking USDA organic certification on our website (715 unique views), through eight Expert Tip articles in our monthly electronic newsletter (Table 2), and at conferences and workshops. This resulted in 23 specialty crop farmers taking advantage of our direct consulting program (Table 3). Five of which have been certified, seventeen have started transitioning.

Table 2: Expert tip articles in CFSA's electronic newsletter from Jan. 1, 2015 to Jan. 31, 2016.

Expert Tip	Unique Views
Estimating Nitrogen Production from Cover Crops	156

Considerations for a Fall Cover Crop	128
Managing Annual Weeds & the Weed Seedbank in Organic Fields	185
Reduce Tillage and Increase Cover Crops for Soil Conservation on Your Farm	169
How to Use Organic Enterprise Budgets to Make Your Farm Profitable	98
Avoid Common Mistakes with Organic Inputs	305
Organic Pest Management	57
Growing Good Organic Transplants	148

Table 3: Program participants receiving organic certification consulting services.

Farm Name	County	Certification Status
Brodie Farm	Vance	Transitioning
Brothers on Farms	Clay	Transitioning
Carolina Farmhouse Dairy	Durham	Transitioning
Cedar Grove Blueberry Farm	Orange	Certified
Crews Farm	Vance	Certified
David Moody	Wake	Transitioning
Delmar Farm	Halifax	Transitioning
Down 2 Earth Farm	Wake	Certified
Green Heart Gardens	Buncombe	Certified
Heritage Harvest	Forsyth	Transitioning
Judson Farm	Cherokee	Sold Farm
Morning Star Farm	Davidson	Transitioning
Mt. Olive University Student Organic Farm	Wayne	Transitioning
New Ground Farm	Robeson	Transitioning
Oda al la Cebolla Farm	Currituck	Transitioning
Poplin Farms	Stanly	Transitioning
Red Scout Farm	Buncombe	Transitioning
Doe, Feather & Fork	Yadkin	Transitioning
Sarah Jean Acres	Pitt	Transitioning
Sweet Retreat Orchard	Orange	Transitioning
Kepley Grange	Chatham	Transitioning
Thirteen Moons Farm	Buncombe	Certified
Wawag Farm	Pender	Transitioning

Provided 11 workshops on organic transition and production practices to 349 participants.

- Collaborated with Southern Appalachian Family Farms to conduct a full day organic transition workshop on April 23, 2015 in Andrews for 18 attendees. Topics include an Introduction to Organic Production, Organic Pest Management, NCDA Organic Certification Cost Share Program, and Success for the Field (Jon Miller, Miller Farm).
- Collaborated with Southern Organic Female Farmers Association to conduct a full day workshop titled *Organic Crop Certification for Agricultural Small Businesses* on March 19, 2015 for 35 attendees. Topics included and Introduction to Organic Production, Organic Soil Fertility

Management, Organic Pest Management, Allowable and Prohibited Inputs, and Success from the Field (Jane Saier, RambilRill Farm).

- Hosted a full day, pre-conference Organic Certification workshop at CFSA's Sustainable Agriculture Conference Nov. 6, 2015 for 17 attendees. Topics included: Trends in Organic Production and Demand, Introduction to Certified Organic Production, Completing an Organic System Plan, How to Meet the NOP Soil Management Standards, Pest Management Planning for your Organic System Plan, Allowable and Prohibited Inputs, Preparing for an Inspection, Successes from the Field, and a Certifier Q & A Panel with representatives from California Certified Organic Farms, International Certification Services, Quality Certification Services, and Clemson.
- Conducted a 90-minute Organic Certification workshop at CFSA's Sustainable Agriculture Conference Nov. 7, 2015 for 16 attendees. Topics included Trends in Organic Production, and Overview of NOP Regulations, and Basic Organic Pest Management.
- Participated in a half day workshop on organic certification for organic herb growers focusing on wild crop & hydroponic production on Jan. 29, 2016 in Mills River for 28 attendees.
- Conducted a 90 minute workshop for specialty crop growers titled *Organic Certification* CFSA's Organic Commodities & Livestock Conference in Mt Olive on March 7, 2016 for 37 attendees.
- Presented two 90 minute workshops titled *Soils 101 and Organic Soil Management* at the Organic Growers' School Spring Conference March 12 and 13, 2016 in Asheville for approximately 70 attendees between both days.
- Collaborated with Feast Down East & Quality Certification Services to conduct a full day workshop titled *Introduction to Organic Certification & Production* in Clinton on April 22, 2016 for ten attendees. Topics included: Organic Certification, Organic Nutrient & Pest Management, Good Agricultural Practices (GAP) certification, as well as an on-farm mock organic inspection at Black River Organic Farm.
- Collaborated with NC Cooperative Extension, Southeast Agriseeds & local farmers to conduct a full day workshop titled *Organic Cover Crop Management* in Concord on October 17, 2016 for 26 attendees. Topics included: Cover crop management, nutrient & pest management, variety selection, grower experiences, and a farm tour (Elma C. Lomax Farm).
- Hosted a full day, pre-conference Organic Certification workshop at CFSA's Sustainable Agriculture Conference Nov. 4, 2016 for 12 attendees. Topics included Trends in Organic Production and Demand, Introduction to Certified Organic Production, Recordkeeping, How to Meet the NOP Soil Management Standards, Pest Management Planning for your Organic System Plan, Allowable and Prohibited Inputs, Preparing for an Inspection, Successes from the Field, and a Certifier Q & A Panel with representatives from California Certified Organic Farms, Quality Certification Services, and Clemson.
- Conducted a 90 minute workshop in collaboration with Patryk Battle (Living Web Farms) titled *Organic No-till for Soil Health* at CFSA's Sustainable Agriculture Conference Nov. 5, 2016 for 50 attendees. Topics included Soil Health, Cover Crop Management, and Nutrient & Pest Management.

Goal 2: Increase access and utilization by organic/transitioning producers of NRCS EQIP-OI cost share programs by offering NRCS-certified Technical Services to producers. Ten producers will receive

NRCS-certified Technical Service to develop Conservation Activity Plans; six will receive Supporting Organic Transition Plans, (CAP 138), two we receive Nutrient Management Plans (CAP 114), and two will receive Pollinator Habitat Plans (CAP 146).

While the data for the number of CAP 138s written on a national level is not available yet, CFSA was responsible for writing 22% of all CAP 138s contracted nationwide in 2014, and 18% in 2015. Not only does this speak to CFSA's reputation, but also our ability to effectively promote this program, on our website (783 unique views during the project period), through our monthly electronic newsletters, and at workshops and conferences. We also published a sample CAP 138 on our website to provide specialty crop producers with more information regarding what a CAP 138 contains (597 unique views during the project period). This resulted in the completion of 16 CAP 138s for NC specialty crop producers during the project period (Table 4). Of the sixteen program participants, two have become certified and fourteen have started transitioning. Of the 16 program participants who received CAP 138s, six were awarded new contracts for a total of $47,282. Additionally, our promotion of EQIP-OI and our Technical Service Provider work during the project period contributed to increase in EQIP-OI contracts increased from 2014 to 2016, as well as contracted acreage and dollars (Table 5).

Table 4: Program participants who received CAP 138s.

Farm Name	County	Certification Status
Back to Earth Farms	Randolph	Transitioning
Blueberries of Cameron	Moore	Transitioning
CaroKen Farm	Moore	Transitioning
River Sun Farms	Iredell	Certified
Herndon Hills Farm	Durham	Transitioning
Running Rabbit	Moore	Transitioning
Faith Family Farm	Moore	Transitioning
Mighty Greens	Cherokee	Transitioning
Karefree Produce	Moore	Transitioning
Crews Farm	Vance	Certified
Brodie Farm	Vance	Transitioning
Marrow Farm	Vance	Transitioning
Dinner Bell Farm	Alamance	Transitioning
Flow Farm	Moore	Transitioning
Sarah Jean Acres	Pitt	Transitioning
New Ground Farm	Robeson	Transitioning

Table 5: Total EQIP-OI contracts, contracted dollars and acreage in North Carolina, 2014-2016.

Contract Metric	2014	2015	2016
Number of contracts	18	29	28
Contracted dollars	$94,751	$57,583	$127,115
Contracted acreage	316	646	710

BENEFICIARIES

Direct beneficiaries of this project were specialty crop producers who received technical information about organic transition and production through one-on-one consulting and a CAP 138 Supporting Organic Transition (Table 6).

Table 6: Organic Farming Conservation Outreach Project beneficiaries.

TYPE of INFORMATION	NUMBER of BENEFICIARIES
Viewed one of CFSA's Expert Tips	1246
Received One-on-One Consultation	35
Received CAP 138s	16
Attended a workshop	349
Started transitioning to Certified Organic	31
Became Certified Organic	6

LESSONS LEARNED

The process of certifying as a Technical Service Provider (TSP) to write CAP 138s is arduous and challenging. To be successful, a TSP has to be very familiar with NRCS's EQIP program and have an intimate understanding the intricacies of NRCS operations and conservation planning. The process is also very time-intensive and was delayed; it took CFSA five months to certify when it should have only taken 1-2 months. This is largely due to NRCS staff turnover, as well as the lack of clear instruction on the TSP certification process. The delays limited our ability to write more CAP 138s, and therefore limited our ability to provide guidance to more growers during the funding period. However, supporting farmers as they transition to certified organic production has led to positive management changes that has also improved conservation outcomes across many NC farms.

Another interesting realization that emerged from this work is that it's difficult to track information on organic sales and acreage because this information is self-reported to the USDA and several organizations, and therefore information is variable and almost certainly under-reported. Thus, it has been difficult to provide accurate information on the impact of our work across NC.

While we met our goal of having at least 30 growers begin the transition to certification, we were not able to meet our second goal of having ten of those growers become certified USDA organic. This is because transitioning from conventional to certified organic production is a three year process, whereas transitioning organically-managed or unmanaged land is much quicker. Thus, of the 35 growers who began transitioning, only six were in the position to certify in less than 3 years, and the

remaining 28 growers will be able to certify in 2017 and 2018 (note that the number of transitioning growers presented here is 28 instead of 29, as Judson Farm was sold).

During the funding period we retained a TSP certified to write CAP 138s, but not to write CAP 104s (Nutrient Management) and CAP 146s (Pollinator Habitat). The reason for this is two-fold: first, there is currently little interest in CAP 104s and 146s from growers; second, due to the time required to become certified to write CAPs in general – especially CAP 104s & 146s, which would require training – we focused only on CAP 138s to meet the high demand for these CAPs among NC growers. As we continue to grow the technical services we provide we plan to eventually have at least one staff member certified to write CAP 104s, and possibly CAP 146s, depending on demand for these services.

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ADDITIONAL INFORMATION

- Organic Certification Consulting landing page provides information about the consulting program.
- Conservation Activity Plan (CAP) Consulting landing page provides information about CAP 138s.
- Sample CAP 138 Plan gives specialty crop producers an idea of what a CAP 138 contains.
- Eight articles on organic production practices in our electronic newsletter:
  - Estimating Nitrogen Production from Cover Crops
  - Considerations for a Fall Cover Crop
  - Managing Annual Weeds & the Weed Seedbank in Organic Fields
  - Reduce Tillage and Increase Cover Crops for Soil Conservation on Your Farm
  - How to Use Organic Enterprise Budgets to Make Your Farm Profitable
  - Avoid Common Mistakes with Organic Inputs
  - Organic Pest Management
  - Growing Good Organic Transplants

PROJECT TITLE: POP Market **(Final Report Previously Accepted)**

PROJECT SUMMARY

The POP Market is a non-profit wholesaler that brokers sales between North Carolina fruit and vegetable farmers and hunger relief agencies. The purpose of this project is to increase demand and sales exclusively for NC fruit and vegetable specialty crops. Small and mid-scale fruit and vegetable farmers benefit from sales to a new and otherwise unavailable market. Food insecure community members that access hunger relief agencies, like food pantries, community kitchens, and low cost produce box programs, benefit from access to fresh local food. It is clear from our work that North Carolina's food insecure population wants and needs access to fresh produce, and they can provide a viable market to specialty crop farmers seeking new secondary markets. The purpose of this project was to address the issues of food and farm insecurity in NC.

This project was important for the development of specialty crop growers and hunger relief agencies in NC. The project focused on building capacity for both of these stakeholders through website branding and redesign to increase sales and improve efficiency. The NCDA funding came at the perfect time to leverage the existing operational infrastructure. The updated website simplified our ordering process and allowed us to spend more time marketing and creating demand for specialty crops. Additionally, the educational component allowed Farmer Foodshare to increase demand by giving us the face-to-face exposure with low-income individuals who were new to using fresh local produce.

PROJECT APPROACH

During the grant period the POP Market has surpassed its goals and outcomes, almost doubling sales from our benchmark (+$40k over our goal) and reaching an additional 34 new buyers, including many new hunger relief agencies. This success was thanks to activities outlined in our work plan, namely continuing to identify new buyers, developing a business plan, supporting the unique demands of hunger relief partners by expanding educational opportunities for low-resource consumers to work with specialty crops, and improving the ordering system for shoppers. Funds were used solely to benefit specialty crops and increase competitiveness in the market. Project partners included:

Sheri Castle: Created the Food Ambassadors training manual and trained volunteers to become advocates for using and cooking fresh, local vegetables and fruits in simple, budget conscious, and culturally appropriate ways.
The Change: Consulted with the POP Market team on website development and messaging.
Food Mint: Consulted with the POP Market team to perform essential market research and develop the financial viability model for reaching sustainability.
Gigi Graphics: Designed the POP Market homepage to be aesthetically appealing and user friendly.
Eggleston Multimedia: Consulted with the POP Market team to help develop website usability and improve user experience.

GOALS AND OUTCOMES ACHIEVED

Activities and Results

• **Identify new hunger relief agencies to participate**. Through outreach efforts and the business plan marketing research, over 25 new hunger relief agencies have been identified as potential participants in the POP Market. During this grant period we have identified over 300 potential customers in target segments (food pantries, child care, catering, schools, churches, mobile markets). To date, we have worked with a total of 52 agencies and expanded the program to reach 50+ individual consumers.

• **Business plan development**. Working with the Food Mint, we have successfully developed the essential components of a business plan including a market assessment and financial viability model. These tools will help us continue to grow the POP Market program and increase demand for NC specialty crops.

• **Production planning**. The POP Market planned and executed approximately $20,000 worth of produce sales with 3 growers for the 2015 season. In 2016 we purchased the accompanying software for our online platform that streamlines the production planning process. Our approach in 2016 has been to use historical data to determine what specialty crops are best suited for different growers. During the project period we have learned that there are unexpected circumstances that can lead to reduced ability to bring specialty crops to market. Specifically, bad weather and poor germination issues caused farmers to not have the full supply that was planned so it forced us to adjust the crops on the plan.

• **Assess opportunities for bridging educational gaps**. We have taken steps within this activity that involve meeting with partner organizations on a regular basis and determining what their needs are around education. Through these conversations we have revamped our Food Ambassadors program to incorporate more in person food and cooking demonstrations. We have recruited and trained over a dozen volunteers to be advocates for specialty crops in the community. To date, we have hosted 20 food demonstrations that provide basic cooking and storage info for vegetables and fruits.

• **Upgrade POP Market website and implement new software for ordering and tracking sales**. Upgrading the POP Market website and implementing new sales software was completed earlier than expected. This allowed us to focused on improving the new software functionality and integrating improved sales methods. The new POP Market website has increased operational efficiencies and provides a visually appealing platform for buyers to see the specialty products farmers have to offer.

• **Sales records and analysis**. With the new software, maintaining sales records has also become easier because the software allows us to run several different kinds of reports. These reports can be analyzed for identifying trends in types of products sold, which customers purchase the most, and how regularly we are buying from target farmers.

The outcomes described in the grant were short term. However the long term goal of the POP Market is to continue increasing supply and demand of specialty vegetable and fruit crops. We will continue to pursue the outcomes with updated goals based on the progress of the market with the tools we have developed during this grant period (business plan, website, Food Ambassador training materials).

OUTCOME 1:

- Goal: Increase sales of fruits and vegetables from North Carolina farmers by selling through the POP Market into hunger relief and health-oriented agencies.
- Target: Increase sales of fruits and vegetables to $110,000, a 40% increase from 2013 sales.
- Accomplishments: Sales of specialty vegetables and fruits reached $152,000 in 2015. We will close out the year around $250,000.

OUTCOME 2:

- Goal: Expand the market for North Carolina fruits and vegetables into hunger relief organizations.
- Target: increase the number of hunger relief and health oriented organizations purchasing North Carolina fruits and vegetables from 15 to 18, a 20% increase in buyers from 2013.
- Accomplishment: During the grant period we reached 52 organizations and 50+ individuals, creating new market opportunities for farmers.

BENEFICIARIES

Hunger Relief Agencies and Community Organizations: This project allowed Farmer Foodshare to expand our outreach to hunger relief agencies and community organizations in the Triangle. We provided Food Ambassador demonstrations at no cost so that the clients served could be exposed to fresh local food. Through other grant funding sources, we provided some items for the families to take home and try the vegetables and fruits with a simple recipe. This helped build demand among partners (Take and Eat Food Pantry, PORCH, TABLE, IFC, Reality Ministries, Student U, Club Nova, American Heart Assn., CORA and more).

Durham Public Schools: During this project we were able to begin working with Durham Public Schools to purchase high quality greens and broccoli for their 30,000 students. We worked closely with Working Landscapes in Warren County to add value to the specialty crops by processing them into chopped and bagged greens.

Consumers: The Food Share subscription program was piloted in October 2015 and continues to grow. Over 50 individuals have subscribed to purchase fresh specialty crops on a regular basis through our new online platform. We have gathered some initial feedback from clients who say, “I’m going to be totally honest and say that I was sort of surprised at how much better your veggies are

than ones from the store! I made some awesome salads and cooked the kale, which was great! You were right about getting to try new things with the different types of veggies you all offer!"

NC Specialty Crop Growers: Throughout the grant period we've supported over 40 specialty crop growers in NC. In March 2016 we hosted our first Annual Farmers Gathering where 30 farmers attended for an update on our progress with POP Market, future outlook, and a discussion about the specific needs regarding business and marketing. Farmers were happy to be heard and eager to meet each other.

Of the $152,000 in POP Market sales in 2015, approximately $120,000 went directly to NC specialty crop growers.

LESSONS LEARNED

One lesson learned is that working within the specialty crop value chain, farmers' needs and buyers' needs do not always align. Farmers are looking for the price that meets their bottom line and allows them to continue farming as a lifestyle. Buyers with limited budgets, specifically hunger relief agencies, may not always be able to pay the premium price associated with specialty crops. We learned that there is a lot of communication and capacity building required to match the right size farmer with agencies based on available resources. One reason we began the direct to consumer retail market was to provide our smaller, limited resource farmers with higher prices an outlet for their specialty products.

Another lesson learned is that it is important to recognize that recruiting new buyers takes time. It was important for us to establish the online platform and business plan so that we can strategically direct our marketing efforts to the target buyer segments. Building relationships and trust is time-consuming but valuable work that allows more people to participate in the specialty crop supply chain.

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PROJECT TITLE: Optimizing Fraser Fir Christmas Tree Promotions

PROJECT SUMMARY

This project sought to increase demand for real NC Christmas trees by focusing promotional efforts on the North Carolina Christmas Tree Association's (NCCTA) established brand: "North Carolina Fraser Fir, The Perfect Christmas Tree." With supporting values and images, this provides a positive message that resonates with today's consumer. Nearly all NC Fraser fir Christmas tree growers have seen a decrease in wholesale tree prices in excess of 15% in the past few years due to regional oversupply, increased national competition, and the economic recession. For those with limited market access or those who sold exclusively to other growers, prices dropped by 75% or more. This project used targeted promotional activities to focus buyer and consumer attention on NC Fraser Fir: The Perfect Christmas Tree, and to further develop a media strategy to drive brand awareness. This project also took the association's current strategic planning and promotional development to a higher level by accessing professional marketing/business planning resources. Promotion of NC Fraser fir is an effective and proactive approach to creating additional demand for farm-raised Christmas trees and returning tree prices to a sustainable level.

The North Carolina Christmas Tree Industry was hit hard by the recession, oversupply, competition and shifting consumer behaviors (e.g. toward artificial trees). Nearly all NC Fraser fir Christmas tree growers suffered a decrease in wholesale tree prices in excess of 15% in the past few years due to regional oversupply, increased national competition, and the economic recession. For those with limited market access or those who sold exclusively to other growers, prices dropped by 75% or more.

Nearly all NC Christmas tree growers (1,000 plus) struggled through the recession and oversupply of Christmas trees. Most lost money on trees they sold as prices dropped below the cost of production. Even growers who sold more trees in 2012 and 2013 made less money because of eroded tree prices. USDA Agricultural Statistics reported a decline in Christmas tree income in North Carolina from $101 Million dollars in 2007 to $75 million in 2011.

This project utilized the concept of employing point-of-sale materials and promotions developed with previous grant funds. These ideas were refined to complement and enhance new materials and promotions.

PROJECT APPROACH

Objective 1: Develop a detailed promotion plan that covers exact target market identification, slogan and messaging enhancements, media choices, performance monitoring, and a long-term plan.
Objective 2: Create membership value and increase revenue for members – tailor organizational needs of all size grower members.
Objective 3: Introduce Fraser fir to new markets

January – May, 2015, NCCTA partnered with the Student Teams Achieving Results (STAR) team at the UNC Kenan-Flagler School of Business and conducted an internal study to determine "How can the NCCTA best create value and increase revenue for its members?"
To effectively answer the key question and deliver upon the goals of the project, the Star team:

- Conducted a detailed customer analysis in both wholesale and retail markets
    - Grower Members (wholesale)
        - What are the sizes of grower operations?
        - What are the details of trees being grown (i.e. size, type, number, etc.)?
    - End Users (consumers)
        - What are the key demographics, preferences, and buying behaviors related to Christmas tree purchases by the end consumer?
        - Sales data surround purchases (i.e. price, type, location, style, etc.)
- Conducted a detailed industry analysis
    - Benchmark best practices for industry associations with similar missions
    - What is happening in the industry?
    - Who is the competition?
    - NCCTA
        - What is the value in having a NCCTA membership?
        - How will the check-off program impact the NCCTA?
- Investigated Christmas tree markets
    - Traditional
    - Non-traditional
- Delivered a strategic action plan
    - Detailing recommendations to address key question

Recommendations from STAR Team Project were devised to tackle three major issues facing NCCTA:
1. Declining Membership
2. Weak value perception
3. National Checkoff Program

Short-term recommendations (internal):

a) Quantify benefits growers receive by being a member of NCCTA and collect anecdotes to share with growers. Show monetary value of benefits. Anecdotes will provide a tangible demonstration of benefits. Determine best way to share these values with growers. – NCCTA has completed a detailed spreadsheet that quantifies membership values.

BENEFIT	DETERMINATION	VALUE PER GROWER
NCCTA Research Funded Projects	Perceived value to industry/cost to do your own	$469.00
Listing on Website	Annual cost of maintenance and hosting plus design cost averaged over 3 years	$180.29
Advocacy & Monitoring of Legislative Issues	Contracted lobbyist annual salary of $25,000	$110.00
Annual Listing in Buy Sell Guide	All production, promotional & distribution costs	$129.31
Choose and Cut	All production, promotional & distribution costs	$369.57
Advertising	Actual annual cost of all NCCTA advertising	$407.08
Promotional Materials	Production costs	$115.00
Allied Business Partners Insurance Discounts	First Pioneer, LifeStore, First Benefits workers' compensation	$500.00
Limbs and Needles	Cost of annual subscription to Limb & Needles	$45.00
Trade Shows	Actual cost of all trade shows attended	$318.67
Reduced Semi-Annual Meeting Registration Rates	2 meetings annually at $30 = $60	$60
ADDITIONAL BENEFITS	DETERMINATION	TOTAL VALUE
Other Marketing Activities	Business value of educational information, logo use, promotioinal displays, promotional & legislative trees, media contact, tree inventory, classifieds, updates, retail lot opportunities, retail lot listings, cooperative shipping	Undetermined
Partnership Collaboration & Networking Among NC Agencies	NCSU, NCSU Cooperative Extension, NCDA&CS, etc.	Undetermined
Agricultural and Trade Association Memberships	Annual cost of individual memberships	$1,430.00
Grants	Since 2010 NCCTA has leveraged your dues and assessments into grant funds	$421,007.00
Long-Range Planning Through NCSU STAR (Included in Grant $$)	Total cost included in grants total	$40,000.00
Access to Professional Video & Photography (Included in Grant $$)	Total cost included in grants total	$18,000.00

b) A record of detailed calculations can be viewed in the attachment. (See attachment)

Member Benefit Dollar Values for Allied Businesses:

BENEFIT	DETERMINATION	VALUE PER ALLIED BUSINESS MEMBER
Limbs and Needles Magazine	Cost of annual subscription to Limbs & Needles	$45.00
Listing on Website	Annual cost of maintenance and hosting plus design cost averaged over 3 years	$149.00
Annual Listing in Buy Sell Guide	Value comparable to in-state classified listing	$230.00
Reduced Semi-Annual Meeting Registration Rates	2 meetings annually $115 X 2	$230.00
Roster	Value comparable to in-state classified listing OR production costs	$26.09
TOTAL MEMBERSHIP VALUE PER ALLIED BUSINESS		$450.89
Other Marketing Activities	Logo use, direct networking with growers, "members doing business with members", updates	Undetermined
Professional and Trade Association Memberships	Annual cost if individual joined	$1,430.00

A record of detailed calculations can be viewed in the attachment. (See attachment)
This information is accessible through NCCTA publications and newsletters, and is also available for viewing at http://www.ncchristmastrees.com/members/member-benefits

c) Modify meeting structure by offering concurrent sessions to give flexibility. Base a set of breakout sessions by topic rather than size. Collect meeting topics from growers and assess the most appropriate way to adjust the meeting structure. Goal is to actively engage more members and elevate participation level. – NCCTA has incorporated round table discussions into our meetings. This provides growers a chance to express industry and association thoughts, opinions and ideas. The round table discussions have proven to be successful and the attendee feedback has been very positive. This is something we plan to continue moving forward.
d) Leverage relationships with other Christmas tree associations by reaching out to them. Some have been successful with quantifying benefits and promoting them to their membership. There may be other areas that we can assess to generate ideas. – NCCTA reached out to other state Christmas tree associations to understand their methods for quantifying membership benefits. NCCTA used some of these methods when quantifying benefits.
e) Embrace the Checkoff Program. Track updates to understand impact on the industry. – NCCTA regularly shares Christmas Tree Promotion Board facts and updates with membership.

Long-term recommendations: consumer-oriented marketing plan – Increase Conversion

a) Educate consumers about Christmas trees and their impact – promoting environmental hazards prove more effective than environmental benefits.
b) Leverage the retailers' direct consumer engagement to convert new real tree consumers – Opportunity to educate about qualities of North Carolina Fraser Fir. Partner with retailers in advertising. Engage in grassroots marketing; Mass distribute NCCTA promotional items.
c) Continue monitoring Checkoff Program updates and industry impacts.
d) Tailor the consumer buying and disposal process to increase convenience. NCCTA should focus on what is within our control and develop a web page on the NCCTA website that has recycling and disposal information. Give recommendations for recycling and disposal, and possibly link to a source that will assist the consumer in finding disposal options near them.

All long-term recommendations are being discussed among the NCCTA long range planning committee and will be incorporated into future marketing and promotion.

January – May 2016, NCCTA once again partnered with the STAR team to develop a 3-year promotional plan for the NCCTA. They leveraged the work of the previous STAR team surrounding consumer and retailer behavior and preferences to identify an appropriate marketing mix for the organization. The goal was to prioritize advertising and promotional materials into an actionable three-year timeline. The project focused on the following primary objectives:

- Design 3-year promotional plan for the NCCTA
    - Utilize the 2015 STAR Christmas tree consumer survey as well as other data to identify further promotional opportunities
    - Identify priority target market segments for consumer education to increase conversion to real tree purchases
    - Detail proper mix between "pull" activities that draw customers to seek NC Fraser Firs and "push" endeavors that incentivize retailers to purchase and promote these Christmas trees focusing on proportion of the following activities:
        - Sales promotions
        - Publicity
        - Advertising
    - Generate implementation timeline for promotional plan
    - Benchmark best practices in brand promotion for industries with similar regional assets
    - Utilize integrated marketing communications to evaluate the message conveyed through NCCTA for consistency in promotions, publicity, and advertising

- Measurement of marketing efforts
    - Explore comparing relative increase in sales for NC growers compared to national Christmas tree sales in coming years
    - Conduct survey of retailers on usefulness and usage of new point-of-sale materials
    - Assess familiarity of key demographic target groups (families with kids and middle-aged consumers) with NC Fraser Fir trees

The items that are in-scope and out-of-scope for this engagement are as follows:

- The following are considered "in-scope":
    - Analysis of end consumers
    - Research of comparative regional brands
    - Analysis of check-off program
    - Creation of promotional timeline
    - Recommendations for measuring impact of marketing efforts
    - Recommendation of balance between sales promotions, publicity, and advertising tactics for NCCTA efforts
    - Mockups of communication and promotion materials

- The following items are considered "out-of-scope"
    - Strategy to increase NCCTA membership
    - Recommendations for price stability of Christmas Trees
    - Methods to increase supply of Fraser Firs
    - Addressing membership cost structure
    - Final copies of marketing materials

To achieve a feasible 3-year promotion plan, the STAR team considered the real versus artificial debate, the NCCTA budget and current marketing strategies. In response, three key recommendations were proposed.

RECOMMENDATION 1: Target - clearly identify target markets to more effectively reach potential customers in addition to existing customers.

a) Target middle class customers between the ages of 25 and 39 – particularly those with children
b) Utilize a pull strategy to facilitate demand growth from the customer side

RECOMMENDATION 2: Message - evaluate and refine marketing message to increase specificity and consistency of message.

a) Focus all of its marketing efforts on promoting the NC Fraser Fir and let the Check-off program to define the real versus artificial Christmas Tree debate
b) Implement "Integrated Marketing Communications" to ensure the consistency of marketing message

RECOMMENDATION 3: Implement - evaluate channels of communication and adapt to promote word-of-mouth exposure and publicity.

a) Use low-cost, publicity-heavy marketing and publicity partnerships to target customers
b) Market through channels that have a large influence on the end customer
c) Better utilize and market through online interfaces

These recommendations will enhance the visibility of the Fraser Fir Christmas Tree by keeping marketing specific and consistent, while maximizing resource efficiency by targeting specific groups.

All long-term recommendations are currently being implemented into NCCTA's marketing and promotion. We have secured a Specialty Crop Block Grant that will focus on "Targeting Millennials with Fraser Fir Promotions." The focus of this project will be to target 25-39 year-olds, particularly those with children, with marketing efforts focused primarily on promotion of North Carolina Fraser Fir. This project will put a heavy emphasis on online advertising and social media marketing.

NCCTA conducted annual grower surveys in January 2015, January 2016, & January 2017.
In an effort to increase brand awareness, bring Fraser fir to new markets, excite prospective and returning customers, NCCTA attended the following trade and consumer-oriented shows:

- North Carolina Mountain State Fair, Fletcher, NC in September 2015 & 2016
- Cleveland County Fair, Shelby, NC in September 2016 & 2016

- North Carolina State Fair, Raleigh, NC in October 2015 & 2016
- *Produce Marketing Association Fresh Summit (PMA), Atlanta, Ga in October 2015 - **The PMA Fresh Summit** engages more than 20,000 participants. Thirty-six percent are management personnel: President, CEO, Owner, Partner, Vice President, Director, and General Manager. Seventy-six percent are directly involved in purchasing decisions. Contacts were made with two large national companies and two international companies.

Note: It was originally planned for the NCCTA to attend the Cultivate trade show in Columbus, Ohio. After reassessing the attendee base, NCCTA decided it would be more beneficial to attend the Produce Marketing Association Fresh Summit in Atlanta, GA.

- Southern Christmas Show, Charlotte, NC in November 2015 & 2016
- NCNLA Green & Growin', Greensboro, NC in January 2015, 2016 & 2017
- *National Grocers Association (NGA), Las Vegas, February 2016 & 2017 - **The NGA Show** brings together independent retailers and wholesalers, food retail industry executives, food/CPG manufacturers and service providers for opportunities to learn, engage, share, network, and innovate. Buyers were very responsive to our display of North Carolina Fraser fir. Direct contacts were made with 17 different buyers. These individuals ranged from direct store owners to directors of sales & operations for entire districts.

**These shows were attended for the first time by NCCTA*

These shows provide the opportunity to get high-value "face time" with consumers and potential consumers to promote North Carolina Fraser fir, educate them about farm-grown North Carolina Christmas trees and their environmental benefits, and provide information on tree availability, tree care and merchandising. Wholesale buyer's guides were distributed at buyer shows and choose & cut directories were distributed at consumer shows & fairs. Tree care information was distributed for buyers and consumers. Educational kits were provided for retailers consisting of retail and buying information. Care tips for retailers and the kit included a DVD featuring three short videos: "Tree Care", "NC Fraser Fir Attributes", and "Tips for a Successful Retail Lot".

Print ads highlighting North Carolina Fraser Fir, Fraser fir attributes, and the Family Tradition message were purchased. Wholesale ads were designed to drive buyers and potential buyers to NCchristmastrees.com where they can locate wholesale suppliers, tree care information, retail lot start-up information and retail lot equipment suppliers. Consumer ads were designed to drive consumers and potential consumers to NCchristmastrees.com, where they can locate farms and retail lots, and find tree care and selection tips as well as environmental information on real Christmas trees. NCCTA purchased advertising through web, E-Newsletter, magazine & newspaper ads. Larger ads to enhance exposure were purchased. Advertising efforts included:

- Our State Magazine – Nov. 2015, 2016
- Smoky Mountain Living Magazine – Nov. 2015, 2016
- Facebook Ads – Nov., Dec. 2015 and July, August, Oct., Nov., Dec. 2016
- High Country Radio – Nov. 1 – Dec. 13, 2015 & 2016 - In 2015 NCCTA ran a radio promotion giving away three North Carolina Fraser fir Christmas trees at a NCCTA choose & cut farm of

their choice. This giveaway was designed to promote the choose & cut experience. The radio station reported almost 900 entries from call-ins and Facebook entries, which was the second highest amount of entries for a contest they ever promoted. In 2016 NCCTA ran the same promotion but gave away six trees. Entries totaled over 1,300.

- WSOCTV.com – Nov. 12th – Dec 15th 2015 & 2016
- WXII.com – Nov. 12-Dec. 12 2015 & 2016 - Over 907,000 impressions were delivered with 1,892 click thrus. This is a .21% delivery rate which is higher than the industry standard of .03-.06%
- NGA Show Program Ad – Feb. 2016, 2017
- Plant & Supply Locator - Two ads in Locator Catalog for 12 months. 2015, 2016, 2017
- American Nurseryman - (1) Home Page Banner on their website for July, August, Sept.; (2) Full page ad and advertorial in the Green Industry Guide (printed publication); (3) Digital magazine sponsorship (online publication) for July, Aug., Sep. 2015, 2016
- IGC Magazine - Full page ad in show preview edition. 2016
- Boy Scouts of America - Scouting Magazine Sept./Oct. 2015, 2016

In May 2016, an updated wholesale direct mail list was purchased containing 7,000+ names. Search criteria included all privately held retail grocers and garden centers in Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, West Virginia and Eastern Texas. From this list, 4,500 promotional postcards and 1,800 promotional emails were sent highlighting NC Fraser fir and the NCCTA wholesale directory. Of the 1,800 emails sent, there was a 16% open rate and a 9% click rate. A total of 73 Buy-Sell Guides were distributed as a result of the postcards and email.

NCCTA ran Facebook ads in 2015 and 2016. In 2015, we ran a total of seven Facebook ad campaigns, including one boosted post from 11/24/2015 to 12/26/15. Two of the campaigns encouraged Facebook users to visit the NCCTA website. Five of the campaigns encouraged Facebook users to like the NCCTA Facebook page. The theory behind this is that if we keep users engaged on the Facebook page they will repetitively see us in their news feed in the future, as where they might visit the website once and never go back.

Funds were split between ads that targeted consumers in major eastern market areas (TN, SC, VA, WV, D.C., GA, AL, FL) and ads that targeted consumers in North Carolina. The ads that targeted consumers in major markets were intended to spread the message that real trees were environmentally-friendly and grown by American farmers. Other ads instilled the message of “NC Fraser Fir – The Perfect Christmas Tree”. Ads that targeted North Carolina consumers were intended to drive people to choose & cut farms and local retail lots to purchase a real, North Carolina Christmas tree.

Ad sets included: TN, NC, SC, VA, WV, D.C., GA, AL, FL. Total Spent: $3,523.26.

Results: (including boosted post)

- Total Reach: 154,945 Facebook users
    - 16,236 engagement (people talking about)
    - 55 website clicks

- 8,492 page likes
- 6,601 post likes
- 201 comments
- 1,138 shares

In July 2016, an ad campaign consisting of two different ads targeted potential wholesale buyers. Both ads targeted potential buyers in Alabama, Arkansas, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Massachusetts, Michigan, Mississippi, Missouri, New Hampshire, New York, New Jersey, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, West Virginia and Eastern Texas. The first ad ran for fourteen days (July 28 – August 11) and highlighted North Carolina Fraser Fir and its attributes. The ad encouraged potential buyers to click on a link to "Get Offer" for a free wholesale directory. The ad reached 12,464 people, received 417 "Likes" and was shared 79 times. 63 users actively engaged the offer and requested a wholesale directory. Total cost of this ad was $100. The second ad ran July 28 – August 3. This was the same type of ad but with a different photo. The ad reached 86,016 people, received 375 "Likes" and was shared 65 times. 1,215 users clicked on the link to "Get Offer" and 82 users actively engaged the offer and requested a wholesale directory.

In November 2016, an ad campaign consisting of two different ads targeted potential choose & cut customers. The first ad targeted potential customers in North Carolina, Florida, Georgia, Tennessee, West Virginia, Virginia, Pennsylvania, New York, Mississippi, New Jersey, Kentucky, South Carolina and highlighted North Carolina Fraser Fir and its attributes while showcasing the 2016 Choose & Cut Memories directory cover. Users were given a link to click on to request a FREE Choose & Cut directory. The link directed users to the choose & cut directory request form on the NCCTA website. Total cost of this ad was $75. Total ad reach was 10,362 with 44 users who actively engaged the offer. The second ad titled "Start A Family Tradition" highlighted NC Fraser Fir and its attributes and encouraged potential buyers to click on a link to "Get Offer" for a free Choose & Cut Memories directory. Total ad cost was $350. Total ad reach was 19,824 with 404 users who actively engaged the offer.

Two ads were run that promoted the NCCTA video "Fraser Fir Country in the Fall" which was created from a previous Specialty Crop Block Grant. This educational video highlights the process of harvesting Christmas trees and the work that goes into getting a Christmas tree into the home. This video was primarily promoted to the Southeast with a small focus on the entire US. Total ad cost was $325. Total ad reach was 84,800. Actual engagement (people who watched the video) was 2,011 and 583 people shared the video with their friends.

Ten additional ad campaigns were run during the 2016 season featuring various images of families picking a tree in the field, children riding a sled pulled by a horse in a tree field, and multiple images of Fraser fir trees. All ads focused on the "Family Tradition" message and targeted audiences in the Southeastern region of the United States.

<u>Total results</u>:

- Total Reach: 377,249 Facebook users
    - 30,472 engagement (people talking about)
    - 4,573 link clicks

- 12,482 page likes
- 8,740 post likes
- 306 comments
- 1,964 shares

Promotional materials were produced and distributed to NC Christmas tree growers and retailers for the 2015 and 2016 seasons. Items produced include: 36 x 55" outdoor Fraser fir banners, 12"x18" corrugated plastic "NC Fraser Fir, The Perfect Christmas Tree" signs, tree care pads that outline tree care and safety, and "Real Trees Make Scents" brochures. These materials enhance brand identity of North Carolina Fraser Fir as the "Perfect Christmas Tree" and educate consumers about positive attributes of Farm Grown Christmas Trees, proper tree care and fire safety.

NCCTA staff used email, promotions in association publications, mailings and the NCchristmastrees.com website to promote availability and distribution from the NCCTA office. Materials were also made available at association meetings.

Production and distribution of 100,000 rack cards promoting NC choose & cut. Rack cards are distributed through professional distribution services to over 570 locations along I-85, I-40, I-95, the NC High Country and TN Tri-City Regional area during the months of September thru December. Rack cards are also distributed at trade and consumer shows and to Chambers of Commerce and Visitor Centers throughout North Carolina.

All NCCTA promotional activities drive consumers and buyers to the NCCTA website: www.NCchristmastrees.com. Contractual funds were used to add additional information to the website including retail lot start-up information, fundraising buying and selling tips, fire safety and general educational information about real farm-grown Christmas trees.

A budget revision was requested and approved in May 2016. The STAR project came in under budget and it was requested that those funds be used for additional travel to trade and consumer shows, printing of additional North Carolina Fraser Fir banners, educational brochures, and Fraser fir care pads, and purchasing additional print and online advertising.

This project took the association's current strategic planning and promotional development to a higher level by accessing professional marketing/business planning resources through the Student Teams Achieving Results (STAR) team at the UNC Kenan-Flagler School of Business.
Advisors to the NCCTA Board of Directors from the NCDA&CS Marketing Division and NC State University, assisted in the completion of project tasks. Partnerships with NCSU and NCDA&CS will continue to be fostered as they provide assistance in implementing promotional activities, conducting research, and advising association leadership and members.

GOALS AND OUTCOMES ACHIEVED

Goal 1: Increase farm income by increasing the number of trees sold and the average price of Fraser fir Christmas trees.

Performance Measure: Provide the number of trees identified through the Christmas Tree Research & Promotion Order assessments and NCCTA grower surveys.
Benchmark: Derived from pre-project grower surveys.
Target: Increase tree prices by at least 10% above 2013 levels

Results from our grower surveys indicate that in the current seller's market, prices have been rising and respondent attitudes reflect that optimism. When growers reported on their pricing for the 2014 season, sixty-eight percent increased their prices. Among those increasing price, thirty-six percent raised their prices less than five percent; fifty-five percent raised their prices from five to ten percent; and eight percent raised their prices between eleven and twenty percent.

When the pricing question shifted to anticipate pricing for 2015, confidence was even greater. Seventy-nine percent planned to increase prices. At least half of the respondents who planned to increase prices in 2015 did so for the second year in a row.

Ninety percent of responding wholesalers increased their prices in 2016 and 95% expected to increase their prices this year 2017. In 2016, 43% of wholesalers increased prices 1-5% and 38% increased prices 5-10%. For 2017, nearly half plan to increase prices an additional 5-10% and another 36% plan to increase prices by an additional 1-5%. So, more wholesalers will raise prices to a greater degree this season than they reported for 2016.

Retailers, both on the lot and farm, share in the optimism regarding tree prices. In 2016, 69% of retailers and 76% of choose & cut growers raised their prices. Fifteen percent of choose & cutters raised their prices between 11-20%. More retailers expected to raise prices in 2017 but by 1-5% rather than larger amounts. More choose & cut growers expect to hold prices to the same level in 2017 than they did in 2016.

According to the Christmas Tree Research & Promotion Order, North Carolina assessments collected in 2016 for the 2015 season indicate that NC growers paid assessments that equal 2,662,671 trees. In 2017, NC growers paid assessments for the 2016 season that equal 2,870,885. This indicates a 7.8% increase in the number of trees sold from 2015 to 2016.

*Numbers are based on assessments received by the Christmas Tree Promotion Board. They may or may not reflect actual harvest quantities in NC, but are based on what is reported from NC.

PERFORMANCE MONITORING: Member surveys help to identify grower decisions regarding tree planting, pricing, and sellers markets.

Goal 2: Increase demand and awareness for North Carolina Fraser Fir.
Performance Measure: Promotional materials distributed, point-of-sale materials distributed to retailers and the number of people that visit our consumer and wholesale oriented pages in our website.
Benchmark: Website traffic data and point-of-sale inventories.
Target: Increase website use and point of sale distribution above 2013 levels.

NCCTA was able to increase and improve their presence at local, regional and national "Green Industry", consumer, and other trade show events. Wholesale buyer's guides are distributed at nursery oriented trade shows along with educational information for buyers. Wholesale buyer's guides were

distributed at buyer shows and choose & cut directories were distributed at consumer shows & fairs. Tree care information was distributed for buyers and consumers. Educational kits were provided for retailers consisting of retail and buying information. Care tips for retailers and the kit included a DVD featuring three short videos: “Tree Care”, “NC Fraser Fir Attributes”, and “Tips for a Successful Retail Lot”.

Promotional materials were produced and distributed to NC Christmas tree growers and retailers for the 2015 and 2016 seasons. Items produced include: 36 x 55” outdoor Fraser fir banners, 12”x18” corrugated plastic “NC Fraser Fir, The Perfect Christmas Tree” signs, tree care pads that outline tree care and safety, and “Real Trees Make Scents” brochures. These materials enhance brand identity of North Carolina Fraser Fir as the “Perfect Christmas Tree” and educate consumers about positive attributes of Farm Grown Christmas Trees, proper tree care and fire safety.

NCCTA staff used email, promotions in association publications, mailings and the NCchristmastrees.com website to promote availability and distribution from the NCCTA office. Materials were also made available at association meetings.

The NCCTA Buy-Sell Guide is distributed at trade-oriented shows as well as environmental choice flyers and information on tree availability, tree care and merchandising. The number of directories distributed in 2015 increased 10% from the number distributed in 2014. The number of Guides distributed in 2016 increased by 18% from the number distributed in 2015. Total increase in distribution over the life of this project is 30%.

During August – December of 2015 and May – December of 2016, point-of-sale materials such as banners, Fraser fir signage, Real Trees Make Scents brochures and Fraser fir care pads were distributed to NCCTA members and retailers in North Carolina, South Carolina, Virginia, Georgia, Michigan Texas, Alabama and Florida. Of all materials printed over the life of this project, less than 15% remain in inventory. The increased value of these point-of-sale materials to NCCTA members was supported by their elevated ranking in the grower survey.

Throughout the course of the project, the NCCTA developed and marketed print and digital advertising to drive all potential buyers (wholesale, retail, choose & cut) to the NCCTA website www.NCchristmastrees.com. Where buyers and consumers can find tree availability, tree care, positive attributes of real trees, fire safety tips, locate wholesale suppliers, choose & cut farms, mail order suppliers and retail lot locations. Over the life of this project, total website sessions increased 11.9% from 2014, while increasing website traffic 67% above 2013 levels. There has also been an increase in visitor engagement on the website. In 2016 visitors viewed a total of 317,457 pages on the NCCTA website, increasing engagement levels by 23.7% over 2013.

A noticeable increase in website visits was seen during the months that promotions were active. During the months of July, August & September, wholesale promotions were most active and the site received a significant increase in visitors. The wholesale visitors during these months increased 35.6% over the same time frame in 2015. The site receives the highest traffic in the months of October, November & December. During these months, wholesale promotions as well as choose & cut and consumer promotions are active. During these months activity increased 13.1% from 2015 during the

same months. The online edition of the Buy- Sell Guide was downloaded a total of 2,305 times on the website - almost three times the amount of downloads in 2015, which was 777.

PERFORMANCE MONITORING: Members were surveyed to measure perceptions of NCCTA promotional activities as a way to prioritize future efforts. Advertising efforts continue with annual website data analyzation.

STAR Project – Year 1: Internal focus/Long Range Planning of NCCTA: Final Recommendations

Recommendations from STAR Team Project were devised to tackle three major issues facing NCCTA:

1. **Declining Membership**
2. **Weak value perception**
3. **National Checkoff Program**

Short-term recommendations (internal):

a) **Quantify benefits** growers receive by being a member of NCCTA and collect anecdotes to share with growers. Show monetary value of benefits. Anecdotes will provide a tangible demonstration of benefits. Determine best way to share these values with growers.
b) **Modify meeting structure** by offering concurrent sessions to give flexibility. Base a set of breakout sessions by topic rather than size. Collect meeting topics from growers and assess the most appropriate way to adjust the meeting structure. Goal is to actively engage more members and elevate participation level.
c) **Leverage relationships with other Christmas tree associations** by reaching out to them. Some have been successful with quantifying benefits and promoting them to their membership. There may be other areas that we can assess to generate ideas.
d) **Embrace the Checkoff Program**. Track updates to understand impact on the industry.

Long-term recommendations: consumer-oriented marketing plan – Increase Conversion

a) **Educate consumers about Christmas trees and their impact** – promoting environmental hazards prove more effective than environmental benefits.
b) **Leverage the retailers' direct consumer engagement to convert new real tree consumers** – Opportunity to educate about qualities of North Carolina Fraser Fir. Partner with retailers in advertising. Engage in grassroots marketing; Mass distribute NCCTA promotional items.
c) **Continue monitoring Checkoff Program updates and industry impacts**.
d) **Tailor the consumer buying and disposal process to increase convenience**. NCCTA should focus on what is within our control and develop a web page on the NCCTA website that has recycling and disposal information. Give recommendations for recycling and disposal, and possibly link to a source that will assist the consumer in finding disposal options near them.

STAR Project – Year 2: Final Recommendations

Key question - How can NCCTA develop a 3-year promotional strategy for North Carolina Fraser Firs to build member value through increased tree sales and drive long term association sustainability?

To achieve a feasible 3-year promotion plan, the STAR team considered the real versus artificial debate, the NCCTA budget and current marketing strategies. In response, three key recommendations were proposed.

RECOMMENDATION 1: **Target** - clearly identify target markets to more effectively reach potential customers in addition to existing customers.

Actions:

a) Target middle class customers between the ages of 25 and 39 – particularly those with children
b) Utilize a pull strategy to facilitate demand growth from the customer side

RECOMMENDATION 2: **Message** - evaluate and refine marketing message to increase specificity and consistency of message.

Actions:

a) Focus all of its marketing efforts on promoting the NC Fraser Fir and let the Check-off program to define the real versus artificial Christmas Tree debate
b) Implement "Integrated Marketing Communications" to ensure the consistency of marketing message

RECOMMENDATION 3: **Implement** - evaluate channels of communication and adapt to promote word-of-mouth exposure and publicity.

Actions:

a) Use low-cost, publicity-heavy marketing and publicity partnerships to target customers
b) Market through channels that have a large influence on the end customer
c) Better utilize and market through online interfaces

These recommendations will enhance the visibility of the Fraser Fir Christmas Tree by keeping marketing specific and consistent, while maximizing resource efficiency by targeting specific groups.

An annual grower survey was created and distributed to NCCTA members to evaluate association marketing efforts and pricing and planting trends. Results of the 2017 NCCTA grower survey have important implications for our industry's future as it touches on grower ambitions, seedling and tree supply, regional markets, and NCCTA promotional efforts.

Measurable Outcome: Increase Farm Income

The main **goal** of this project was to increase farm income. Grant funded activities will increase demand, the numbers of trees sold and the average price of Fraser fir Christmas trees. The **performance measures** will include the number of trees identified through the Christmas Tree Research & Promotion Order assessments and NCCTA grower surveys. Our **target** is to increase tree prices by at least 10% above 2013 levels. **Benchmark data** will be derived from pre-project grower surveys.

Results from our grower survey indicate that in the current seller's market, prices have been rising and respondent attitudes reflect that optimism. Ninety percent of responding wholesalers increased their prices in 2016 and 95% expected to increase their prices this year. In 2016, 43% of wholesalers increased prices 1-5% and 38% increased prices 5-10%. For 2017, nearly half plan to increase prices an

additional 5-10% and another 36% plan to increase prices by an additional 1-5%. So, more wholesalers will raise prices to a greater degree this season than they reported for 2016.

Retailers, both on the lot and farm, share in the optimism regarding tree prices. In 2016, 69% of retailers and 76% of choose & cut growers raised their prices. Fifteen percent of choose & cutters raised their prices between 11-20%. More retailers expect to raise prices in 2017 but by 1-5% rather than larger amounts. More choose & cut growers expect to hold prices to the same level in 2017 than they did in 2016.

Measurable Outcome: Increase demand for and awareness of NC Fraser Fir
Our **goal** was to increase demand for NC Fraser fir. The **performance measures** will be the amount of promotional material distributed, point-of-sale materials distributed to retailers and the number of people that visit our consumer and wholesale oriented pages in our website. Our **target** was to increase website use and point of sale distribution above 2013 levels. Website traffic data and point-of-sale inventories will be used as the **benchmark.**

The NCCTA Buy-Sell Guide is distributed at trade-oriented shows as well as environmental choice flyers and information on tree availability, tree care and merchandising. The number of directories distributed in 2015 increased 10% from the number distributed in 2014. The number of Guides distributed in 2016 increased by 18% from the number distributed in 2015. Total increase in distribution over the life of this project is 30%.

Point-of-sale materials such as banners, Fraser fir signage, Real Trees Make Scents brochures and Fraser fir care pads were distributed to NCCTA members and retailers in North Carolina, South Carolina, Virginia, Georgia, Michigan Texas, Alabama and Florida. Of all materials printed over the life of this project, less than 15% remain in inventory. The increased value of these point-of-sale materials to NCCTA members was supported by their elevated ranking in the grower survey.

The project expanded on NCCTA efforts to use advertising to drive all potential buyers (wholesale, retail, choose & cut) to the NCCTA website www.NCchristmastrees.com. Where buyers and consumers can find tree availability, tree care, positive attributes of real trees, fire safety tips, locate wholesale suppliers, choose & cut farms, mail order suppliers and retail lot locations. Over the life of this project, total website sessions increased 11.9% from 2014, while increasing website traffic 67% above 2013 levels. There has also been an increase in visitor engagement on the website. In 2016 visitors viewed a total of 317,457 pages on the NCCTA website, increasing engagement levels by 23.7% over 2013.

A noticeable increase in website visits was seen during the months that promotions were active. During the months of July, August & September, wholesale promotions were most active and the site received a significant increase in visitors. The wholesale visitors during these months increased 35.6% over the same time frame in 2015. The site receives the highest traffic in the months of October, November & December. During these months, wholesale promotions as well as choose & cut and consumer promotions are active. During these months activity increased 13.1% from 2015 during the same months. The online edition of the Buy- Sell Guide was downloaded a total of 2,305 times on the website - almost three times the amount of downloads in 2015, which was 777.

Based on recommendations from the two-part STAR Team project, NCCTA has worked to:

1. Promote and improve membership benefits by quantifying membership benefits in dollar value.
2. Modify membership meeting structure to be more accommodating to membership needs and concerns by including multiple topics that interest various groups of growers.
3. Continue to promote to and educate members about the national Christmas tree checkoff promotion order through communication with the Promotion Board and email and newsletters.
4. Identify our target audience (millennials – ages 25-39) in an effort to more effectively reach potential customers in addition to existing customers.
5. Evaluate and refine our marketing message to increase specificity and consistency of the message by focusing on Fraser fir attributes and the "Family Tradition" message.

The 2017 grower survey measured perceptions of NCCTA promotional activities as a way to prioritize future efforts. The NCCTA website received the widest approval with 86% of respondents agreeing that it was effective. The buy-sell and choose & cut directories both achieved second tier popularity among respondents (71-75%). Both online versions were slightly more popular than print versions. Two thirds of respondents believed the NCCTA Facebook page to be an effective promotional tool, but only half considered other social media outlets such as Twitter or Instagram to be as effective. A number of point-of-sale promotional items and consumer-directed activities all received support (50 - 65% of respondents). Except for maintaining a business website, the use of NCCTA promotional tools was generally more widespread among respondents than other marketing activities employed in their own businesses. When asked how NCCTA promotional activities have impacted their business over the last three years, 44% were "significantly impacted" and 42% were "somewhat impacted". Only 13% of respondents felt there had been little or no impact. Clearly, these promotional services are widely used and important to NCCTA membership.

BENEFICIARIES

Direct beneficiaries include the 1,000+ Christmas tree growers in North Carolina and contiguous counties in Virginia and Tennessee. All of these growers are not claimed as members of the North Carolina Christmas Tree Association, but the vast majority of tree production in these areas is from Association members. Furthermore, any promotion that stabilizes or increases demand for North Carolina Christmas trees will benefit all of these growers over time, regardless of association affiliation.

When comparing 2014 membership numbers and income totals to 2016, the following was concluded:

- Actual number of members has decreased by -9.6%
- Membership dues income has increased by 12.7% (base membership dues were increased in 2015)
- Fraser fir assessment has increased by 3.4% (standard voluntary assessment of $.05 per tree sold the previous year)
- Total annual income has increased by 10.8%

LESSONS LEARNED

While not all members agree with all promotional activities, the popularity of different activities shouldn't be used to eliminate investment in any promotional strategy outright, but it does provide another means of prioritizing limited promotional dollars.

- Investments made by the NCCTA over the last two and a half years have expanded our promotional impact and website usage has continued to increase. Not only does the association provide a higher quality presence on-line, but the total promotional effort driving potential buyers and consumers to the website has improved.
- Through research from the STAR project, it was recommended we focus on targeting middle-class 25-39 year olds with children using low-cost, publicity-heavy marketing tactics to make the most impact with our limited promotional funds.
- We learned through research from STAR that some of our current marketing messages and slogans didn't resonate effectively with consumers. We learned which messages were ineffective and which messages had the most impact with our target audience.
- NCCTA had inconsistent messaging in marketing and advertisements. Through recommendations from STAR, we learned how to incorporate the most effective messages using integrated marketing techniques, thus providing us with a unified, consistent and repetitive message.
- We learned that we were primarily using a "push" marketing strategy, working to bring the product to the customer. With limited funds available, STAR recommended that we utilize a "pull" strategy, increasing contact with potential customers and drive demand that benefits everyone i.e. - advertising and mass media, sales promotions.

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ADDITIONAL INFORMATION

Member Value Calculations:

Listing on NCCTA website	$16,000 design cost / 3 years = $5,333 5 domains @ $12 each = $60 annual maintenance = $800 hosting $15 month x 12 months = $180 Labor $17.50 per hour x 800 hours = $14,000 Total - $20,373 / 113 growers listed on website = $180.29
Legislative	$25,000 annual salary of contract lobbyist $25,000 / 228 members = $109.65

Research	$107,000 / 228 members = $469.30 *From Jeff Owen - In 2015, NCCTA spent $7,000 on research grants to NC State University faculty. This leveraged $100,000 in labor and expenses from university personnel dedicated to Christmas trees.
Annual Buy-Sell Listing	$5,000 production costs (print, design) postage @ $1.78 each x 1,000 = $1,780 5,000 postcards = $150 printing, $1,375 postage $1,385 purchase of distribution list labor @ $20 per hour x 175 hours = $3,500 $13,190 / 102 farms listed in book = $129.31
Annual Choose & Cut Listing	$7,000 production costs (print, design) Rack card printing (80,000) $2,500 Rack card distribution $4,000 Shipping $1,000 Labor @ 125 hours x $20 per hour = $2,500 $17,000 / 46 growers listed in book = $369.57
Advertising	$230,000 / 5 years = $46,000 annually $46,000/ 113 members paying FF Asses. = $407.08
Promotional Materials	$43,050 / 5 years = $8,610 $8,610/ 75 people utilizing = $114.80 per person
Membership in professional and trade oriented associations	$25 NC Farm Bureau $180 High Country Host $300 NCTA $500 Ag Alliance $250 NC Agribusiness Council $175 NCNLA Total = $1,430

SHOW	Cost	Description	Work
Southern Christmas Show	$6,000.00	Booth	
	$500.00	rentals	

	$740.30	hotel	$67.30 x 11 nights
	$208.44	mileage	386 miles x .54/mile
	$416.90	meals	$37.90 x 11 days
	$2,550.00	Labor	102 hours x $25/HR
Southern Christmas Show	**$10,415.64**		
PMA	$3,500.00	Booth	
	$360.00	hotel	$120 x 3 nights
	$318.60	mileage	590 miles x .54/mile
	$113.70	meals	$37.90 x 3 days
	$400.00	Labor	16 hours x $25/HR
PMA	**$4,692.30**		
NGA	$5,000.00	Booth	
	$1,600.00	rentals	
	$1,200.00	Shipping	
	$880.00	hotel	$220 x 4 nights
	$500.00	Flight	
	$96.12	mileage	178 miles x .54/mile
	$162.00	meals	$40.50 x 4 days
	$350.00	Labor	14 hours x $25/HR
NGA	**$9,788.12**		
NC State Fair	$1,280.00	Booth	
	$740.30	hotel	$67.30 x 11 nights

	$208.44	mileage	386 miles x .54/mile
	$379.00	meals	$37.90 x 10 days
	$3,575.00	Labor	143 hours x $25/HR
NC State Fair	**$6,182.74**		
Mountain State Fair	$0.00	Booth	
	$740.30	hotel	$67.30 x 11 nights
	$121.50	mileage	225 miles x .54/mile
	$379.00	meals	$37.90 x 11 days
	$3,325.00	Labor	133 hours x $25/HR
Mountain State Fair	**$4,565.80**		
Green & Growin'	$25.00	Booth	
	$100.00	rentals	
	$240.00	hotel	$120 x 2 nights
	$162.00	mileage	300 miles x .54/mile
	$113.70	meals	$37.90 x 3 days
	$400.00	Labor	16 hours x $25/HR
Green & Growin'	**$365.00**		
TOTAL	**$36,009.60**		
		$36,009.60/113 growers =	**$318.67**

Quantified NCCTA Research Impacts

Prepared by Jeff Owen

In 2015, NCCTA spent $7,000 on research grants to NC State University faculty. This leveraged $100,000 in labor and expenses from university personnel dedicated to Christmas trees. These positions represent in excess of $300,000 in personnel expenses but only a portion of their time is specifically dedicated to NCCTA projects .By providing these funds, the NCCTA has insured university personnel are focused on growers' research priorities. Results include:

- Pesticide trials for elongate hemlock scale and balsam wooly adelgid provide new treatments and recommended rates for pest control. The value of elongate hemlock control products being applied correctly is in excess of $300,000 a year.
- By monitoring populations of beneficial insects such as honey bees and parasitic wasps, we have a greater understanding of the effects of pesticides in Christmas trees. Monitoring data has already been used to successfully defend a grower in a lawsuit.
- By a developing a spray treatment to control stress-related cones on Fraser fir, growers have the potential to save thousands of dollars a year spent manually pulling cones from trees. If 100 growers could avoid paying 5 workers $400 per week for 2 weeks of cone pulling, together they would save $400,000. While this research is ongoing, a recommendation appears close.
- NCCTA has funded research into the control of Roundup-resistant weeds. In 2015, four growers saved $60,000 in labor associated with manually spraying problem weeds in Christmas tree fields. Instead they applied these new herbicides in tractor-mounted sprayers.
- By monitoring temperatures of Christmas tree pallets, a practice initiated in NCCTA-funded research, 10 growers saved an average of 20 pallets of trees from overheating damage for an estimated savings of $140,000

Allied Business Value Calculations:

Listing on NCCTA website	$16,000 design cost / 3 years = $5,333 5 domains @ $12 each = $60 annual maintenance = $800 hosting $15 month x 12 months = $180 Labor $17.50 per hour x 800 hours = $14,000 Total - $20,373 / 136 business listings on site = $149.80
Annual Buy-Sell Listing	
Membership in professional and trade oriented associations	$25 NC Farm Bureau $180 High Country Host $300 NCTA $500 Ag Alliance $250 NC Agribusiness Council $175 NCNLA Total = $1,430

Roster Listing	Labor @ $20 per hour x 30 hours = $600

$600 / 23 AB listings = $26.09

PROJECT TITLE: Promoting North Carolina Horticulture Certifications

PROJECT SUMMARY

The purpose of this project is to increase awareness of professional certifications and enhance the knowledge, skill and experience of the North Carolina nursery and landscape industry. Promoting professionalism through certifications will increase industry participation and increase awareness not only to the green industry, but to the end consumer.

During the recent economic recession, income and profits for the nursery and landscape industry declined. Buying plants and landscaping one's yard was a luxury not necessity. Now that the economy is improving, homeowners have the resources to spend on plant material and landscaping. Professional certifications enhance nursery and landscape businesses' ability to satisfy this new consumer demand. Whether at your local garden center or hiring a landscaper, consulting with certified industry professionals helps safeguard one's investment and environment.

This project builds on our previous Specialty Crop Block Grant project "Improving Nursery Employees Plant Marketing Knowledge". That project ended December 31, 2014. That project is focused on revising nursery and landscape study materials used to prepare for the Certified Plant Professional CPP exam. We are currently revising the Certified Plant Professional study manual and plant identification CD. We are also improving five CPP plant collections across the state to assist in preparation for the Plant Identification exam. Funding received in this award was used to promote the CPP and other industry certifications to encourage participation by the industry and to educate consumers on the importance of nursery and landscape professional certifications.

PROJECT APPROACH

Task: Create a Web Page on Tarheel Gardening to Promote NC Professional Certifications to Consumers.

The North Carolina Nursery and Landscape Association (NCNLA), Raleigh, NC hired MMI Public Relations & Horticulture expert, Bryce Lane to develop content and messaging for the website and advertising campaigns. These campaigns have been launched and have reached over 8,271,000 impressions from April 4, 2017 thru June 30, 2017. This new site is named NCGreenPrints.com. This website hosts "Greenprints" designed as blueprints to help homeowners develop horticulture projects for their home. This website also has its own web page that promotes industry certifications and encourages professional involvement when doing their projects.

Campaign	Impressions
Custom Audience Modeling & RTG	6,174,477
Facebook News Feed	1,435,618
YouTube TruView	660,991
Grand Total	**8,271,086**

Task: Develop marketing materials for the CPP Programs to promote to consumers.

Task: Distribute marketing materials for the CPP Programs to Garden Centers for promotion to consumers.

Task: Develop & Distribute marketing materials for the CPP Programs for the NC nursery and landscape industry

With approval from the NCDA, we allocated funds from print material and distribution to marketing through increased advertising on the established digital platforms. The money spent on digital advertising reached more potential consumers than if direct marketing was done.

Task: Compile data on the enrollment rate of the four certification exams given. Collect website visits to track consumer use of certification website information and the impact of advertising.

The two exams given before the end of the project date gained 46 applicants with 3 tests remaining in 2017. Website data for the certification information page of the NCNLA website for 2015 was 162 visitors, 2016 – 158, and 2017 – 213.

The NCGreenprints website was launched in 2016 and has reached over seven thousand unique visitors and over 8 million impressions with the digital advertising campaign.

The North Carolina Nursery & Landscape Association was the only contributor to this grant project. NCNLA performed the tasks to complete the project such as meetings, content development, and education to learn the new platforms in order to effectively promote them to the end user.
In addition, NCNLA increased promotion/marketing of the Certifications to promote professionalism and participation within the industry and to the end consumer.

GOALS AND OUTCOMES ACHIEVED

1. Measurable Outcome: Increase in number of Applicants Certified
Goal: Increase participation of the Certified Plant Professional exam.
Performance Measure: increase in the number of participants taking the certification exams.
Target: Have participation increase by 55% by 2016 to 300 people compared to the 2013 benchmark
Benchmark: 2013: Participation of 190 taking the CPP, ESL, and LIC exams
Progress Achieved: NCNLA has successfully registered 263 applicants in 2016 and 201 to-date in 2017 with three test remaining for the year.

2. Measurable Outcome: Consumer Awareness of Certification Programs
Goal: Improve customer awareness of certifications.
Performance Measure: Number of consumers that visit our website for information on certification programs.
Target: Increase visits 25% by 2016 compared to 2015
Benchmark: Currently we don't have a consumer website for certification programs so we don't have

benchmark data for this.
Progress Achieved: Reached over seven thousand unique visitors.

3. Measurable Outcome: Number of students participating in the new CYPP program.
Goal: Increase awareness and participation in the new CYPP program to young horticulture professionals.
Performance Measure: The number of students that participate in the CYPP exam**.**
Target: The target is to have 200 students participate in 2015 and 250 by Dec. 31, 2016.
Benchmark: This is a new program so we currently do not have benchmark data.
Progress Achieved: In 2015, NCNLA tested 41 students. In 2016, NCNLA has tested 45 students and in 2017, NCNLA tested 58 students.

BENEFICIARIES

The beneficiaries of the project were the nurseries, garden centers, landscapers, and their employees across North Carolina that participate in the CPP, LIC, CYPP, and ESL certification programs. In addition, NC consumers and wholesale buyers will benefit from the improved customer service and information they receive about NC plants and the landscapes.

The NCNLA certification programs are offered annually to more than 3,500+ horticulture industry businesses throughout North Carolina. Over 2,300 industry professionals are currently certified and will benefit from promoting certifications to consumers. An additional 300 people representing 200 nursery and landscape businesses will participate in taking the certification exams and benefit from the information and certifications that they receive.

NCNLA introduced the Certified Young Plant Professional (CYPP), a new high school level certification, in the 2014/2015 school year. This program is designed to fit the current North Carolina Department of Public Instruction's Career and Technical Education Credentialing. It is estimated that 200 students representing over 100 North Carolina High Schools will potentially benefit from the new knowledge that they would receive. In addition, 500,000 consumers will benefit from the plant and landscape information and services they receive from certified employees and NCNLA certification website.

LESSONS LEARNED

The project was delayed because the signed contract from NCDA was delayed 6 months. NCNLA did not spend any funds on this project through 9/30/2015 due to lack of the marketing opportunities. All plans were implemented from January 1, 2016 – June 30, 2017. There were no changes in the measurables and outcomes as of this report.

In addition, there was an executive change within the organization which created a shift in the project idea. Although it did not change the scope of the project, it did create challenges with the different ideas and opinions towards the project and how it was going to be implemented.

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PROJECT TITLE: Development of a Muscadine Clean Plant Program

PROJECT SUMMARY

Muscadine grapes are native to the southeastern United States and are grown in both commercial and home vineyards. Muscadines are the primary commercial wine grape in North Carolina, and are also grown for fresh market commercial sales. Additionally, muscadines are marketed direct to the consumer by growers who sell pick-your-own or ready-picked fruit. Acreage is expanding, including organic acreage. However, the lack of clean, disease-free, true-to-type nursery stock is a barrier to success. Using existing infrastructure and expertise at the Micropropagation and Repository Unit (MPRU) at NCSU, our proposed goal was to identify, collect, virus-test and propagate old and new cultivars, to provide growers with a reliable source of true-to-type, productive and healthy plants.

Muscadine grapes are the primary species grown in most of North Carolina and the southeastern US. Plant material currently available has not been tested for pathogens and is sometimes not true-to-type, due to mix-ups and mis-identification of clones.

PROJECT APPROACH

We have established a repository of micropropagated, disease-free, true-to-type muscadines by identifying source plants of key cultivars, collecting meristematic tissue, growing plantlets in sterile culture, and transferring sterile plantlets to pots to produce field-ready plants that are growing in protected culture in a screenhouse. Fungal and bacterial pathogens have been excluded, and virus testing is pending. We can now provide growers with the opportunity to *"start clean and stay clean"* by utilizing this source of superior muscadine plants.

Current Inventory of Plant Material:

1. In Tissue Culture:

Muscadine Cultivars	Number of Plants in Tissue Culture
Summit	10
Triump	12
NC 1005	16
Supreme	12
Noble	10
Carlos	10
Fry	10
Nesbitt	6
Grand Total	86

2. In Pots:

Muscadine Cultivars	Number of Pots
Summit	7
Triump	7
NC 1005	15
Supreme	6
Noble	7
Carlos	7
Fry	7
Nesbitt	2
Grand Total	58

- Identify, propagate and virus-test key muscadine grape clones (Cline, Almeyda)
- Field test resultant plants for vigor, trueness-to-type, and disease symptoms (Cline, Bloodworth).
- Maintain plants in tissue culture and in the field as a resource for growers and nurseries (Almeyda and staff at MPRU; Cline and Bloodworth at Castle Hayne).

GOALS AND OUTCOMES ACHIEVED

SUCCESSES AND ACTIVITIES COMPLETED:

1. We identified vines to use as mother plants, and verified their trueness-to-type by examining leaves, shoots and fruit at harvest. Mother Plants were tagged and mapped.
2. We collected emerging shoots for tissue culture.
3. Shoots were micro-propagated to produce plantlets.
4. Plantlets were transferred to pots in the greenhouse and screenhouse.
5. Foundation stocks have been retained in both lab and greenhouse -- both as tissue culture plantlets in the lab, and as potted plants in greenhouse and screenhouses.

- We identified candidate vines and verified trueness-to-type by examining fruit at harvest; vines were tagged, mapped and plotted using GPS; Shoots were collected for tissue culture and for testing for viruses and other pathogens; we achieved micropropagation followed by transfer of plantlets to pots in the greenhouse, and establishment of foundation stock for distribution to nurseries.
- Virus testing is under way but has not been completed. This is an ongoing process.
- Large potted plants have been produced and will be planted in the field in Spring 2018 at the NCSU Hort Crops Research Station in Castle Hayne.

Potted muscadine plants from tissue culture in the MPRU screenhouse

BENEFICIARIES

Beneficiaries are all nurseries, growers, researchers, state, regional and international clean plant centers that are seeking disease-free, true-to-type muscadine vines. It is not possible at this time to quantify the impact this project will have on the industry. However, muscadines were one of the few vegetatively propagated small fruit crops not available in tissue culture. As with blueberry, strawberry, caneberries and other small fruits, we anticipate future demand for TC plants to outstrip the demand for conventionally propagated plants.

Mucadine nurseries (3-4), muscadine growers in the southeast (50-100), and plant breeders of muscadine grape (2-3) are all potential beneficiaries of this project. This is a long-term project (micropropagation of woody perennial plants) and benefits will not accrue until long after the grant period has ended.

LESSONS LEARNED

ACTIVITIES NOT COMPLETED/LESSONS LEARNED:

1. Micropropagation of woody perennials takes a long time. Although we achieved most of our goals, the two-year scope of this project is only the beginning.
2. Virus testing is still pending. We have the necessary supplies but protocols are still implementing. Virus testing will be completed as part of our ongoing support for this crop.

3. Field planting and evaluation of cultivars for trueness-to-type is still pending. We have large, healthy potted plants in 3-gallon pots from our tissue-culture throughput that are ready to be planted in the field this fall. After that, it usually takes three years for muscadines to develop fruit-bearing wood and to produce fruit in the vineyard.

We have not published our certification protocols, primarily because plant material has not yet been distributed to cooperators. Upon reflection, we felt that it would be irresponsible to distribute planting stock without first growing out the new vines in the field to verify that they are true-to-type. This grow-out and verification period was not included in the original proposal, but should have been.

CONTACT PERSON

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PROJECT TITLE: Improving North Carolina Black Truffle Production

PROJECT SUMMARY

There is an established Black Périgord truffle (*Tuber melanosporum* [Tmel]) industry in North Carolina. Truffles are fungi that grow underground in close association with the roots of certain tree species. Black Périgord truffles are valuable, often bringing prices as high as $800 per pound. The North Carolina truffle industry has grown and developed with little assistance from any governmental agencies or universities. There are now growers scattered across the state with a national growers' (non-profit registered in NC) association, the North American Truffle Growers Association that meets here twice a year to share experiences and discuss the future of the industry. The growers have reached the conclusion that they need to refine their production practices and address a few key problems. Of primary concern is identifying practical and cost-effective methods to ensure inoculated seedlings are inoculated with the proper fungus and to measure the extent of colonization of the Tmel fungus in the orchard soil.

A large number of truffle orchards were established in North Carolina over the past fifteen years, but only a few of them have actually produced truffles. Truffle orchards can take nine or more years from planting to produce truffles, but there is currently no proven method for growers to determine if their orchards have any chance of ever producing. Some consultants examine the roots of the trees with a microscope and say they can tell if the trees are colonized with the Tmel mycorrhizae and can predict if they will eventually fruit. But there were many questions about that method. DNA analysis can be used, but not knowing how to collect samples or where to send them to, and the high cost have prevented most growers from even trying it. We initiated this project because many growers in the North American Truffle Growers Association wanted to know what was happening in their orchards so they could make informed decisions about whether to keep pruning, liming, spraying, and mowing their non-productive orchards or whether to remove them altogether.

PROJECT APPROACH

- **Project Personnel:** J. Davis, K. Gaskill, and L. Stefanile, Department of Horticultural Science, North Carolina State University; I.M. Meadows, Department of Entomology & Plant Pathology, North Carolina State University; Mountain Horticultural Crops Research & Extension Center, Mills River, North Carolina, 28759 USA.

- **Six growers were recruited to cooperate on the project.** This was the first opportunity we had to work closely with new and long-term truffle growers in North Carolina. In addition to providing sampling sites for this study, we were able to gather information on the experiences of truffle growers from across the state, adding to our general knowledge base about the production of this new crop. More growers were surveyed about their current colonization detection and measurement methods, if they used any. There was a total of eight orchards used in the study. Six were with cooperating farmers and two were the research and demonstration orchards at the Mountain Research Station in Waynesville. For the purposes of this study, the two research station

orchards were treated as one. Several of the orchards used had produced truffles, several were expected to produce them soon (those included the research station orchards), and several were newly established orchards.

- **Relationships were developed with truffle experts across the world.** Through the course of this study we developed strong relationships with Dr. Greg Bonito, Michigan State University; Dr. Jim Trappe, emeritus professor, Oregon State University; Dr. Rytas Vilgalys, Duke University; and Dr. Marcos Morcillo, Micolgia Forestral and Aplicada, Barcelona, Spain. We are discussing cooperating on a grant proposal with several of these individuals.

- **What we did:** In each orchard, 10 to 18 trees were arbitrarily chosen to capture representative trees spread throughout the orchard, depending on the size of the orchard. Four soil and root cores were collected from 2 to 3 feet from the base of each tree. For each tree sampled, roots were sorted using a dissecting scope based on color and shape of the mycorrhizal association and the pattern of emanating hyphae in an attempt to identify root tips as matching the description of Tmel. Root tips of each type of mycorrhiza were collected and analyzed using quantitative polymerase chain reaction (qPCR) to detect Tmel DNA. Approximately 10-30 mg of mycorrhizal root tips were placed in a 2.0 ml microcentrifuge tube with a 3 mm glass bead. Tubes were kept frozen at -20°C until processed. DNA was extracted using Omega Biotek Plant DNA DS Kit and DNA was stored at 20°C until processed. Quantitative polymerase chain reaction (qPCR) was used to detect Tmel DNA on roots (Parlade et al., 2012). Root tips from which Tmel was not detected were analyzed further by sequencing a portion of the internal transcribed spacer region (ITS)—a DNA region that is routinely used for fungal identification. A subset of root tips from which Tmel was detected was also sequenced. The partial ITS region was amplified using primers ITS1 and ITS4 (White et al., 1990). Resulting sequences were compared to reliable accessions in the GenBank database.

  Duplicate root and soil samples were also sent to two commercial testing laboratories to compare results and evaluate options for growers to use. We quickly learned that there are few commercial options available to growers. There is only one commercial lab that we could find in the United States experienced at testing for Tmel. It is located in Greensboro, NC. The other lab we used is one with an excellent international reputation in Spain.

  The laboratory in Spain uses Real-Time PCR which is a more sensitive and quantitative than the conventional PCR we used in our lab. It is also much more costly to use and probably not necessary to use in most routine testing situations. We did experiment with Real-Time PCR and can offer it as a service if growers request it.

- **Results and discussion**: Tmel was detected in all 7 orchards sampled. All trees sampled in 6 of the 7 orchards tested positive for Tmel; there was one orchard where only 1 of 15 trees sampled tested positive for Tmel (Table 1). Of the 6 orchards where Tmel was detected in all trees, 75-100% of root tips sampled tested positive for Tmel, suggesting a high level of Tmel colonization still present in these orchards. This also confirms that the inoculated trees purchased were colonized by Tmel as this fungus is not native to North America.

Microscopic examination of the roots revealed that identifying root tips of Tmel is very difficult, if not impossible, to achieve. In our attempt to sort roots based on morphology, Tmel was detected in many of the samples where we did not suspect Tmel presence. This confirms other mycologists' statements that identification of Tmel based on root tip morphology alone is unreliable (personal communications). Therefore, we did not provide training to growers on microscopic examination of roots tips.

Other ectomycorrhiza also were detected. *Tuber lyonii* was detected in 3 orchards on downy oak and filbert. It is a native truffle with a wide host range in eastern North America. It is commonly associated with pecan orchards, but has been detected in natural areas on a variety of hosts (Trappe et al., 1996). *Tuber canaliculatum* was detected on three trees in one orchard. This truffle is mostly known from sandy soils in Michigan, but has been found elsewhere in the eastern US (O. Taylor, personal communication). A Tuber species that we were not able to identify also was detected, and is likely to be a species that has not yet been formally described. *Scleroderma bovista* is known to form ectomycorrhizal associations with poplar and is not uncommon in forest soils of the eastern US. Other Orders or Families of fungi detected are also known to contain a number of ectomycorrhizal fungi and their presence is not surprising.

The detection of other Tuber species and other ectomycorrhizal fungi is significant because it is most likely that these fungi colonized the root tip sometime after the tree was planted. We do not know the level of colonization of Tmel on the trees before they were planted in the field, but we do know that the root tip and the fungus must re-form the association each growing season. This presents an opportunity for other ectomycorrhizal fungi to colonize the root tip and this is the most likely scenario. However, the relationship between Tmel and other fungi and if or when the association with Tmel was replaced by these other fungi are unknown. Clearly more research needs to be conducted to optimize growing conditions for Tmel in North Carolina and the eastern US.

Our lab results compared favorably with those from the lab in Spain and they were very helpful in comparing methods and providing advice on how to make our own methods more efficient and reliable. The results from the lab in North Carolina were incomplete and not very meaningful for our purposes.

- **New truffle testing lab created:** During the course of this project it became clear that there weren't reliable commercial labs in the United States that growers could submit their samples to for testing. The lab in Spain is the best, but sending samples overseas is expensive and complicated. So, Dr. Inga Meadows discussed this with her department and the college and got permission to offer the testing as a service. This is now an affordable and practical solution for North Carolina growers to use. The website for this service is: https://meadows.wordpress.ncsu.edu/truffles/ .

- **New studies initiated as a result of this project:** This project resulted in new collaborations with truffle businesses and other research teams. It also helped us identify other important issues

affecting growers.

1. **Light study:** Dr. Marcos Morcillo from Spain visited us and several of the truffle growers in the state. He questioned the spacing of trees in orchards in the state, including our own research and demonstration orchards in Waynesville. He explained to us that new research indicates that truffle orchards need more light on the orchard floor than our current spacing gives. He suggested that we remove half the trees from our orchard to see if that triggered production (our orchards were established in 2010 and 2013, and although they are well colonized, have not yet produced truffles). Asking a grower to remove trees that cost about $25 a piece and have been lovingly tended for five or more years without proof of concept, is a tough sell. So we agreed to perform the test on our orchards. In spring of 2017 we cut out every other row in both orchards and will monitor the results and report back to the growers at the North American Truffle Growers Association conference.
2. **Wood ash study:** Tmel needs a very high soil pH in order to fruit. Our test orchards have been heavily limed but the soil pH has only reached about 7.5 to 7.6. One of the state agronomists tested our soil again and showed us that all the cation sites on the soil particles were saturated with calcium and that adding more lime would not increase the pH any further. He suggested we try applying wood ash to drive the pH higher. Under his direction, we added wood ash to half of each of our orchards. We will monitor the soil pH and response of the Tmel mycorrhizae in response to it.
3. **Reinoculation study:** Dr. Marcos Morcillo has been experimenting with reinoculation of orchards to bring non-productive orchards into production. A local nurseryman, Brian Upchurch, has started his own truffle business called Carolina Truffles. He entered into a partnership with Dr. Morcillo to offer that reinoculation service here in in the Southeastern US. Before we can recommend such a practice, we need to know if it works here. So in collaboration with Dr. Morcillo and Mr. Upchurch, we reinoculated a number of trees in both of our test orchards.

- **Advice to truffle growers:** As a result of this study, we have new recommendations for Black Périgord truffle growers in North Carolina. We recommend that they when they purchase trees to plant, they should have a random sample of them DNA tested for the presence of Tmel (or whichever truffle they want to grow) and adequate colonization. Every few years they should test their soil/roots, choosing different trees each time. Careful records should be kept. We do not recommend microscopic examination as a method of determining if their trees are colonized with Tmel, although once Tmel has been confirmed to be the major Tuber species on their roots, they can use that method to monitor the extent of colonization in their orchard.

Figure 1. Microscopic pictures of roots colonized by ectomycorrhizal fungi: *Tuber melanosporum* (A); *T. canaliculatum* (B); *T. lyonii* (C); *Tuber* sp. (D); Basidiomycete (E); *Scleroderma bovista* (F).

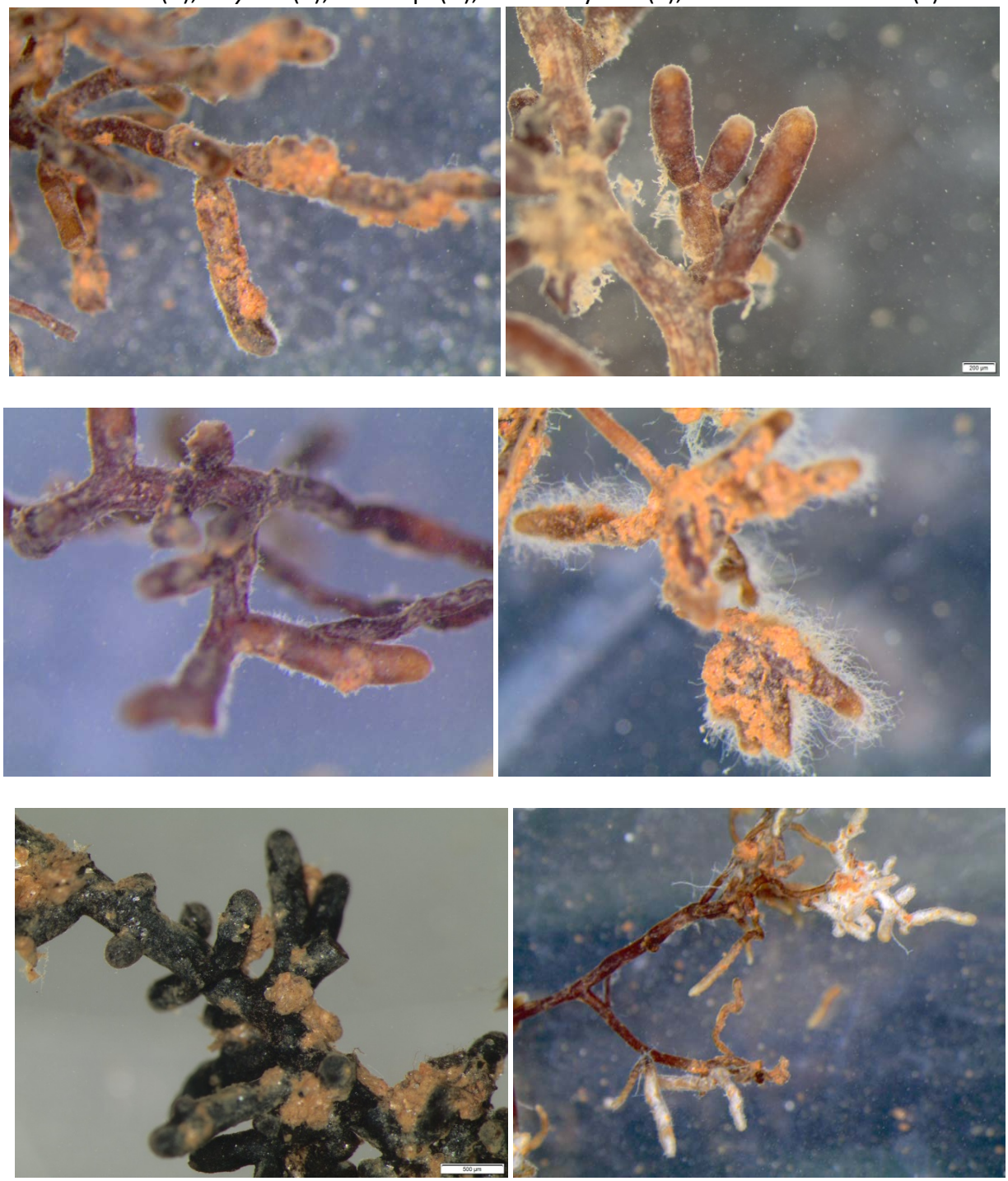

Table 1. Number of orchards, tree species, and roots sampled for the presence of *Tuber melanosporum* and other ectomycorrhizal fungi in truffle orchards in North Carolina in 2016.

Orchard	Tree species	Age (yr)	Produced?	No. trees sampled	No. root samples tested	% Root samples with Tmel	Other mycorrhiza detected[1]
1	English oak	x	Y/N	8	16	81%	*Tuber* sp. Pezizales
	Filbert			6	12	75%	*Tuber* sp., *Scleroderma* sp.
	Downy oak			1	2	100%	*Tuber lyonii*, *Scleroderma* sp.
2	Filbert	x		10	12	100%	*Tuber lyonii*
3	Filbert	x		12	16	100%	*Scleroderma bovista*
4	Turkish oak	x		1	1	100%	-
	Holly oak			1	1	100%	-
	Filbert			3	3	100%	-
	Unknown			4	3	75%	-
5	Scrub oak	x		2	2	100%	-
	English oak			4	5	100%	-
	Filbert			10	13	100%	-
6	English oak	x		2	1	50%	Pezizaceae
	Filbert			13	15	7%	*Tuber lyonii*
7	Filbert	x		16	18	100%	*T. canaliculatum*, *Tuber* sp., Pezizaceae
	Holly oak			1	1	100%	
	English oak			1	1	100%	

[1]Other species, genera, families, or orders of fungi known to form ectomycorrhizal associations with trees.

- **Extension and Outreach Activities:** A webpage was built and populated on the NC Alternative Crops and Organics blog. In the summer of 2017, the three program websites and blog were combined into a program portal which can be accessed at http://ncherb.org. The project URL is: https://newcropsorganics.ces.ncsu.edu/specialty-crops/black-truffle-project/about-black-truffle-research/. This report will be posted there also. Progress reports on the project have been presented to the truffle growers at four of the North American Truffle Grower Association events; two winter conferences and two summer meetings.

The two research and demonstration orchards at the Mountain Research Station were included in numerous events over the course of this project to educate growers, extension agents, state agronomists, industry consultants, students, home gardeners, and the general public about truffle growing, research, and this project. Over 600 people were educated at this site over the course of the project.

A display explaining the project was set-up at several conferences including the NC Herb Association summer conference (three times), the Sustainable Agriculture Conference in Durham, the South Atlantic Hops Conference (twice), and several natural products events.

Extension agent training on truffle production was provided at the Annual Extension Conference in Durham in November 2016.

- **Literature Cited**

Gilkey, H. 1920. Two new truffles. Mycologia 12:99-101.

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Trappe, J.M. Jumpponen A.M., Cá zares E. 1996. NATS truffle and truffle-like fungi: *Tuber lyonii* (= *T. texense*), with a key to the spiny-spored Tuber species groups. Mycotaxon 60:365–372.

White TJ, Bruns T, Lee S, Taylor J (1990) Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: PCR Protocols: a guide to methods and applications. (Innis MA, Gelfand DH, Sninsky JJ, White TJ, eds). Academic Press, New York, USA: 315–322.

This project was focused only on Black Périgord truffle production and only benefited people interested in producing it, consuming it, or just learning more about it.

When this project was proposed, the expert consultant was going to be Dr. Greg Bonito. But now that he is located at Michigan State University, he was not able to give the project the time required to do what we intended. He continued to be very helpful and available to us, but we still needed someone local that could do the DNA testing. We were fortunate that the new plant pathologist here in our building, Dr. Inga Meadows, not only had the equipment and experience to do the DNA work but also had previous experience with truffles in New Zealand and an interest in working with us. So she was brought on as a key researcher in this project. Dr. Marco Morcillo from Spain also became an important partner advising us on this project.

The growers in the North American Truffle Growers Association, who spearheaded this proposal idea, continued to be very supportive and cooperative throughout this project.

GOALS AND OUTCOMES ACHIEVED

- Cooperating orchards were recruited.
- Studies were designed and methods developed and identified to test the orchards.
- Tests were initiated.
- Data were collected over multiple growing seasons.
- A webpage was created and maintained.
- Results were presented multiple times at the North American Truffle Growers Association meetings and attendees were questioned about the potential project impact. Information from the project was also presented at other conferences, field days, and tours. Extension agents were trained on truffle production, incorporating the latest information from this project.

Expected Measurable Outcomes (from the approved project proposal)
To find an effective and reliable method for determining if a truffle orchard soil is colonized with the truffle mycelium (GOAL), we will test a minimum of three methods on eight orchards and a control site. The methods will be tested on producing orchards known to be colonized and on young orchards that have not been colonized and a control site (BENCHMARK). The ease of use and reliability of test results will be compared (PERFORMANCE MEASURE). If a test is correct 90% of the time, it will be considered useful for growers (TARGET).

Actual Outcomes:
Goal: We identified DNA testing as the most effective and reliable method for determining if a truffle orchard is colonized with the truffle mycelium.
Benchmark: We compared young, new colonized orchards with orchards we knew to be colonized with Tmel. All but one orchard was colonized with Tmel.
Performance Measure: We determined that differences between Tuber species cannot be reliable determined with the microscopic method, especially when done by a non-expert (even the experts say they can't rely on the method). Conventional PCR is the most reliable and cost-effective method for growers to use. Real-time PCR is another option, but it is expensive.
Target: We recommend that growers send samples to a lab experienced with truffles for DNA testing using the PCR method.

1. **Recruit cooperating orchards for the truffle colonization tests. Begin communication with several truffle/mycology experts who have worked with the association, some of its members, and Dr. Davis:** Six growers agreed to let us include their orchards in the project and we communicated with truffle experts Dr. Bonito, Dr. Trappe, Dr. Vilgalys, and Dr. Morcillo.
2. **Design studies and create data collection tools. Survey growers about their knowledge of truffle colonization detection tests:** Studies were designed and methods were tested. Growers were questioned at their orchards and at the North American Truffle Growers Association conference about what they knew about truffle detection tests.
3. **Establish tests and initiate colonization detection tests**: Tests were established and completed.
4. **Collect data**: Data were collected across multiple years.
5. **Create webpage**: A webpage was created and kept updated. https://newcropsorganics.ces.ncsu.edu/specialty-crops/black-truffle-project/about-black-truffle-research/

6. **Present results at the NATGA meetings in summer and winter both years**. **Survey attendees at the meetings about project impact:** Results were presented and feedback obtained to two winter conferences and two summer meetings.

Goal: We identified DNA testing as the most effective and reliable method for determining if a truffle orchard is colonized with the truffle mycelium.

Benchmark: We compared young, new colonized orchards with orchards we knew to be colonized with Tmel. All orchards were colonized with Tmel, but one had very low colonization.

Performance Measure: We determined that differences between Tuber species cannot be reliable determined with the microscopic method, especially when done by a non-expert (even the experts say they can't rely on the method). Conventional PCR is the most reliable and cost-effective method for growers to use. Real-time PCR is another option, but it is expensive.

Target: We recommend that growers send samples to a lab experienced with truffles for DNA testing using the PCR method.

This is a difficult project to quantify outcomes for, but the most important outcome is, that 80% or more of the truffle growers we spoke with were under the impression that a simple microscopic examination of their tree roots reveal whether their trees were colonized with Black Périgord truffles or not. This project shows that is not true. A DNA analysis by a reputable lab experienced with truffles is necessary to know if the trees are colonized and with what. We expect that most, if not all growers will use the DNA testing in the future.

Our goal was to find a reliable, practical, cost-effective method for growers to determine if their truffle orchards were colonized with the T. melanosporum (Tmel) truffle mycelium.

Our benchmark was that we would test at least three methods on eight orchards and a control site. We worked with six private orchards and two of our own orchards at the Mountain Research Station. The methods tested included 1) microscopic analysis of the root tips, 2) Conventional PCR of the root tips, 3) Real-Time PCR of the soil from around the roots, and 4) Real-Time PCR of the root tips.

Microscopic analysis: For the initial round of studies, 10 to 18 trees were arbitrarily chosen in each orchard. Four soil and root cores were collected from 2 to 3 feet from the base of each tree. For each tree sampled, roots were sorted using a dissecting scope based on color and shape of the mycorrhizal association and the pattern of emanating hyphae in an attempt to identify root tips as matching the description of Tmel. Hundreds of roots were studied, identification attempted, and photos taken. We have over 150 photos in our files. Examples were included in the report. After the Real-Time PCR analysis was conducted (which is definitive), the identification based on microscopic analysis was conducted and found to not be accurate enough to be reliable when trying to determine if Tmel is present or not. Once it is known if Tmel is present, the microscopic method could be used to monitor the growth.

PCR analysis: The same samples described above were used for the initial conventional PCR analysis. A data sheet from the first round of this analysis is included on the accompanying spreadsheet. This cost

effective method gave positive identification but not quantification. When we compared our lab results with those of the commercial lab that used Real-Time PCR, we found it was even more sensitive and did provide quantitative data. The commercial lab in Spain analyzes only soil from around the root tips. We examined root tips and soil. Several more sets of soil and root samples were collected and analyzed by the Spanish lab and our lab and were also examined under the microscope. The PCR analysis is correct at least 90% of the time. The limitation on this is in the collection technique used by the grower to prevent cross-contamination. We developed a protocol that is shared with growers (included)

Although microscopic analysis was the least expensive and easiest method to use, it was not reliable enough for a grower to determine if Tmel was present. The most reliable, cost-effective, and practical method was for growers to collect samples and send them to a lab for PCR analysis (performance measure). The only lab that offers this service commercially is in Spain. So we set up a service lab at NC State to do this for growers at a very reasonable fee. https://meadows.wordpress.ncsu.edu/truffles/.

BENEFICIARIES

The beneficiaries of this project are North Carolina truffle growers, people who are considering growing truffles, all the members of the North American Truffle Growers Association (NC based), truffle tree nurseries, extension agents, state agronomists, and people who might want to offer the appropriate laboratory services.

As was stated in the approved proposal, Black Périgord truffles are a high-value specialty crop that has gained the attention of many farmers, potential farmers, and landowners across North Carolina. Truffles require intensive management, similar to that required for orchards and vineyards. As such, truffles are only of interest to growers willing to produce intensive, horticultural type crops. Truffles are not a crop of interest to wheat, corn, or cotton producers! The beneficiaries of this project are existing truffle growers and new truffle growers (BENEFICIARIES). More people will be willing to grow truffles if there are answers to some of the basic truffle production questions this project seeks to answer. Many of these growers are members of the North American Truffle Growers Association, a non-profit organization initiated in North Carolina and from which a very high percentage of the membership and leadership reside. The information from this project also benefits truffle growers in other parts of the Southeastern U.S. Presently there are hundreds of established truffiéres in the U.S. with hundreds of people each year attending seminars and considering investing in an orchard (HOW MANY BENEFICIARIES). If just 100 growers in North Carolina each produced one acre of truffles with a conservative yield of 50 lbs. and received an average price of only $500 per lb. that would result in an economic impact in North Carolina of $2.5 million per year. In recent years, the prices have been $800 to $1,100 per pound which would translate into $4 million to $5.5 million per year (POTENTIAL ECONOMIC IMPACT). The North American Truffle Growers Association officers estimate that solving the problems tackled in this project would increase profits by 60% for all growers (HOW BENEFICIARIES WILL BE IMPACTED).

LESSONS LEARNED

When we started this project, we were hopeful that the microscopic method would be sufficient for identifying Tmel and determining if tree roots were sufficiently colonized to eventually result in fruit, and consequently, income for the growers. If that proved to be true, we planned to develop a brochure with the method and offer classes on how to do it. Unfortunately, we quickly learned from internationally recognized truffle experts and from our own experiences that it is not possible to distinguish Tmel from other similar truffle species using just a microscope.

(Also described above) During the course of this project it became clear that there weren't reliable commercial labs in the United States that growers could submit their samples to for testing. The lab in Spain is the best, but sending samples overseas is expensive and complicated. So, Dr. Inga Meadows discussed this with her department and the college and got permission to offer the testing as a service. This is now an affordable and practical solution for North Carolina growers to use. The website for this service is: https://meadows.wordpress.ncsu.edu/truffles/.

This was a very collaborative project with the growers. They felt ownership in the project and the members of the North American Truffle Growers Association spoke of it as their project. This made this project a delight to work on. We were welcomed to the farms and the growers took every opportunity to visit our orchards and attend presentations about the project.

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ADDITIONAL INFORMATION

Real-Time PCR ANALYSIS RESULTS

SAMPLE CODE	PCR CYCLES until detection	mg *Tuber melanosporum* mycelium/gram of soil
MRS Filberts R2 T7	35,3990	2,83444E-05
MRS R3 T11	17,2950	7,923498271
MRS R4 T8	18,855	2,689074832
MRS R5 T9	22,54	0,209410665

The concentration of black truffle mycelium from soil samples was calculated using Real Time PCR. The concentration of *T. melanosporum* mycelium easily varies for young trees from 0.1-0.03 mg mycelium/g soil. Concentrations above 0.03mg/g means a good level of infection. The results of these four samples show really good levels of infection, especially on samples R3 T11 and R4 T8. The Filbert R2 T7 has no truffle on it.

MYCORRHIZAL ANALYSIS

SAMPLE CODE	*Tuber melanosporum*	*CONTAMINANTS*
MRS Filberts R2 T7	non detected	Tuber aestivum
MRS R3 T11	low	high contamination with Basidiomicet
MRS R4 T8	high	non detected
MRS R5 T9	high	low

There was contamination with other fungi in some of the samples. How these may affect *T. melanosporum* development is unknown in this situation.

Growers visiting the research and demonstration truffle orchards at the Mountain Research Station in February 2015.

A truffle dog searching for truffles by scent in the truffle orchards at the Mountain Research Station in Waynesville.

Collecting soil and root samples from a cooperating orchard in North Carolina.

Examining truffle tree roots under the microscope in the lab at the Mountain Horticultural Crops Research and Extension Center in Mills River.

One of the orchards included in this study at the Mountain Research Station produced truffles for the first time in the 2017-2018 growing season.

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Root Sampling Instructions – Testing for *Tuber* melanosporum

Supplies:

- Hand trowel
- Tape measure
- Plastic baggies
- Ethanol
- Scrub brush
- Permanent marker
- Gloves (if you don't want to get your hands dirty)

Figure 1. Supplies needed for root sampling

Instructions:

1. Divide orchard into meaningful sections you want to sample that capture variation (e.g. different planting dates, age of trees, slope variation, etc.) within the orchard. For example, if trees were planted in different years, be sure to sample trees from both years.

2. In each section, choose a healthy tree that is representative of the section, then collect 1-2 scoops from each of four spots on each side of the tree (e.g. four cardinal points). Sample the edge of the brulee or burn; if there is no brulee, sample from within drip line (Fig. 2). Be sure the soil sample contains plenty of roots.

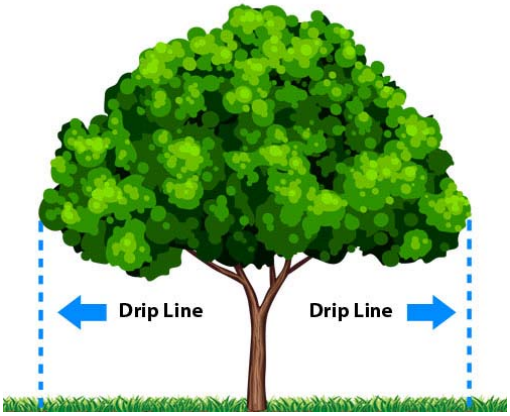

Figure 2. Drip line of a

3. Place all soil from each tree in one labeled bag; you should have one bag per tree.

4. Clean hand trowel with scrub brush between samples to remove soil, then spray with ethanol. Allow ethanol to air dry before sampling again.

Suggestions:

- Consider sampling 2-10% of trees, depending on the size of the orchard.
- Avoid sampling diseased or unhealthy trees as this may give you a misrepresentation of your orchard.
- Establish a clear labeling system that works for your orchard. For example, label sampled trees with flagging tape and use a consistent numbering system so you can sample from the same trees in the future.
- Keep a map of your orchard and note which trees have been sampled each year.

Tree Species	Lab Sample Number	Sample #	No. of roots	Color (of root tip/tuber)	Emanating hyphae pattern	Other notes	DNA Extraction Date	T. mel result (ITSML/LNG)	Tmel from qPCR	Notes (sequencing?, redo?, etc)	sequences				
											ITS1	ITS4	RESULT	% pairwise id	Qc
English Oak	1	1A	30+	red-brown, dark at tip	all over root, dense, long		2/8/2016	-	-		bad	bad	Tuber sp.	81.9	
		1B	3	dark brown	minimal, just behind tip		2/8/2016	-	+		ok	ok	hazelnut DNA	93.5	
		1C	2	dark brown and white	long, not dense,loose all over		2/8/2016	-	-		good	ok	Scleroderma areolatum (mycorrhizal)	99.3	
Filbert	2	2A	6	dark red brown	sparse behind root tip		2/9/2016	-	-	weak					
		2B	10	orange brown	abundant, all over root tip		2/9/2016	-	+		ok	good	Sordariales (fungal family-some mycorrhizal)	90.6	79.76
English Oak	3	3A	50	yellow brown	very sparse on root tip sides		2/9/2016	+	+						
		3B	10	dark brown, lighter root tips	very spase, long and short on root tip		2/9/2016	+	+		ok	ok	Verticillium dahliae (fungal pathogen; probably in vasc tissue)	99.1	
Filbert	4	4A	30	yellow brown	few scattered		2/9/2016	-	+		bad	bad	plant DNA	79.8	
		4B	50	dark orange brown, black	some very long		2/9/2016	-	+				no results		
		4C	1	yellow brown	many, long/short, all over root tip		2/16/2016	-	+	weak			no results		
Filbert	5	5A	50	dark red brown	many, long/ short, sporatic		2/16/2016	-	-	weak					
		5B	75	red brown	many, long/ short, sporatic		2/16/2016	-	+	weak			no results		
English Oak	6	6	100	light orange		tuber not visible	2/16/2016	-	+	weak					
English Oak	7	7A	5	white roots, light orange tips	scattered, long/ short	not seeing tuber or swollen tips	3/2/2016	+	+		bad	good	Pezizales (probably mycorrhizal)	98.2	64.94
		7B	30	light orange	mininmal/ none	not seeing tuber or swollen tips	3/2/2016	-	-						
Filbert	8	8A	5	dark brown, black	short, not visible		3/2/2016	-	+		bad	bad	fungal DNA	90	
		8B	40	Light- medium orange	short, abundant, long and scattered	a few dark nodes	3/2/2016	+	+	weak					
English Oak	9	9A	50	light orange	short scattered	not seeing tuber	3/2/2016	+	+	weak					
		9B	50	medium red/ orange	short, long, scattered	tubers swollen dark brown on orange roots	7/12/2016	-	+						
		9C	10	dark brown orange	abundant, longish	tubers dark on dark roots	7/15/2016	+	+						
English Oak	10	10	50	light brown	scattered, minimal		7/15/2016	+	+		good	good	Tuber melanosporum	99.8	56.14
English Oak	11	11A	3	medium brown	minimal, short, all over RT		7/15/2016	+	+	weak	bad	bad	no results		
		11B	25	light orange		tuber not visible	7/15/2016	+	+	weak			no results		
Filbert	12	12A	10	light orange, brown	short, scattered	no picture taken									
		12B	6	medium dark brown, orange	short, all ovar		7/15/2016	+	+	weak	ok	ok	Tuber sp. (can't confirm species)	92.4	70.13
Filbert	13	13	12	dark brown, orange	short, abundant, on RT	slight orange non colonized roots also visible	7/15/2016	-	+	ITSML smear	bad	ok	Peziza sp. (probably mycorrhizal)	85.3	61.69
Downy Oak	14	14A	4	light orange	long and short, abundant on RT	RT rough/ fuzzy texture	7/15/2016	-	+		bad	good	Scleroderma sp. (fungus)	96.5	
		14B	15	dark brown, red	few short, long, scattered on RT		7/15/2016	-	+		bad	good	Tuber lyonii	94	68.04
English Oak	15	15A	2	red/ brown	short, long scattered		7/15/2016	+	+		good	good	Tuber melanosporum	99.8	
		15B	20	orange/brown			7/15/2016	+	+						
European Filbert	16	16A	15	dark brown, black	scattered short or very long	rough/ fuzzy/ sandy like clusters	7/15/2016	+			good	good	Thelephorales (mycorrhizal)	94.9	
European Filbert	17	17	15	orange to dark red/ brown	few		7/15/2016	+		weak	bad	good	Tuber lyonii	93.3	40.33
European Filbert	18	18	8	orange to dark red	few or many, very long and web-like		7/18/2016	+		weak					
European Filbert	19	19A	1	pale and dark brown tips	many scattered, long	one root with dark and light tuber	7/18/2016	+							
		19B	2	light brown RT	many, long	rough/ fuzzy/ sandy like clusters	7/18/2016	+		ITSML 2 bands	good	good	Tarzetta catinus (fungus)	99.6	
European Filbert	20	20A	10	light orange		tuber not visible									
		20B	2	light orange/ dark brown	very few, short	rough/ fuzzy/ sandy like clusters	7/18/2016	+							
European Filbert	21	21	1	light brown	short, few on RT		7/18/2016	+							
European Filbert	22	22A	5	dark brown with some whiteish	long, abundant, crazy		7/18/2016	+			bad	bad	hazelnut DNA	84.4	
		22B	10	orange, dark red/ brown	long and shot and scattered		7/19/2016	+		weak					
European Filbert	23	23	10	light orange, orange- brown, dark br	long/short, scattered	rough/ fuzzy/ sandy like clusters	7/19/2016	+		weak	bad	bad	hazelnut DNA	82.9	
European Filbert	24	24	1	orange, dark brown	none or abundant, long and crazy		7/19/2016	-	+		ok	good	hazelnut DNA	93.3	40.33
European Filbert	25	25	10	light- dark, white- brown	long, short, scattered, abundant		7/19/2016	+			bad	bad	Tuber melanosporum		
European Filbert	26	26	3	white, brown, dark red	short abundant, long scattered		7/19/2016	+		weak					
European Filbert	27	27A	4	dark red- black	short and few		7/19/2016	+		weak					
		27B	4	dark	many all over, long										
European Filbert	28	28	7	dark red- blackish	both short and all over and scattered and long		7/19/2016	+		weak	ok	good	hazelnut DNA	91.6	67.1
European Filbert	29	29	10	dark brown/red	long, abundant, fuzzy		7/19/2016	+		weak					
European Filbert	30	30A	8	light brown/ orange	none/few/scattered		7/19/2016	+		weak	bad	bad	Pezizaceae (probably mycorrhizal)	94.1	
		30B	few	light- medium brown	short- medium, sporatic tufts										
European Filbert	31	31	many	dark brown/ red	short. Semi long, scattered and few	rough/ fuzzy/ sandy like clusters	7/19/2016	+							
European Filbert	32	32A	many	white with some light brown	few scattered, long and short		7/19/2016	+		weak	bad	bad	Scleroderma bovista (maybe mycorrhizal)	89	
		32B	many	light-dark brown	scattered		7/19/2016	+		weak	bad	bad	hazelnut DNA	86.7	
European Filbert	33	33	10	medium- dark, brown red	scattered, longish	rough/ fuzzy/ sandy like clusters	7/20/2016	+							
European Filbert	34	34A	5	very light brown	none or tiny small		7/20/2016	-	+		bad	bad	plant DNA	94.4	
		34B	5	dark brown	scattered longish tufts		7/20/2016	+		weak					
		34C	1	light- dark brown	very long, very abundant		7/20/2016	+		weak	bad	ok	hazelnut DNA	80.1	81.47
European Filbert	35	35	8	light- dark brown	very long, very abundant	also Rt with no hyphae	7/20/2016	+			good	good	hazelnut DNA	99.6	
European Filbert	36	36	8	light brown- orange- dark brown	none or many very long and abunda	rough/ fuzzy/ sandy like clusters	7/20/2016	+			bad	bad	hazelnut DNA	93.9	
European Filbert	37	37A	1	light -dark brown- orange	short, abundant all over RT		7/20/2016	+		weak	bad	bad	Tuber melanosporum	95.4	
		37B	8	light brown- orange- dark brown	none and long and abundant on same root		7/20/2016	+		very weak	bad	bad	Meliniomyces sp.	98.6	
8-yr-old- short- Turki	38	38A	25	dark brown- black	long and short and abundant	fuzzy clusters	7/20/2016	+		weak	bad	ok	hazelnut DNA	98.4	
Oak (#4)	39	39A	1	dark brown- black	long and short and abundant	fuzzy clusters	7/20/2016	+			bad	bad	Phomopsis sp. (hardwood fungal pathogen)	95.7	
		39B	5	light orange, whitish	medium, scattered										
Holly Oak	40	40	8	dark brown- black	long and short and abundant		7/21/2016	-	+				no results		
Filbert #2	41	41	10	dark brown- black	long and short and abundant		7/21/2016	+		weak	bad	bad	plant DNA	98.7	
C. Le Fevre	42	42A	1	brown/orange	medium, concetrated		7/21/2016	-	+		ok	ok	fungal DNA	91.4	6.64
		42B	2	blackish brown	mostly short and abundant, some long		7/21/2016	-	-		bad	ok	plant DNA	85.9	9.62
?	43	43	10	dark brown- black	long and short and abundant	fuzzy clusters	7/21/2016	-	+		ok	good	hazelnut DNA	98.4	
(Last) Filbert	44	44	6	light to dark brown			7/21/2016	-	+		bad	bad	hazelnut DNA	97	
(new) Holly Oak	45	45	0			no roots									
?	46	46	5	dark brown	long and short and scattered	fuzzy clusters	7/21/2016	-	+		good	good	hazelnut DNA	99.7	
Filbert	47	47	8	orange/brown- dark brown	sporatic, many, long		7/21/2016	+			bad	bad	hazelnut DNA	99.6	
Scrub Oak	48	48	2	black	very few, long	stubby	7/21/2016	-	+						
Filbert	49	49	5	light-brown- black	long and short	both on same roots, fuzzy clusters	7/21/2016	-	+				no results		
			2	black	very few, long	both on same roots, fuzzy clusters									
English Oak	50	50A	10	orangish white, light brown	many, long, covered		7/21/2016	-	+				no results		

		50B	2	medium to dark brown	long, sporatic		7/21/2016	-	+				no results		
Filbert	51	51A	5	light- dark brown	long, scattered, few		7/21/2016	+							
		51B	2	black	few, long	jumbled clusters	7/21/2016	+							
Filbert sp?	52	52	6	light-dark brown	long and short, scattered and abundant		7/27/2016	+							
Filbert	53	53	3	light-dark brown	long, abundant, web like		7/27/2016	-	+				no results		
Scrub Oak	53	54	6	light-dark brown, blackish	short and long, few		7/27/2016	+							
Filbert sp?	55	55	6	light brown-black	long and short		7/27/2016	+							
English Oak loya	56	56	10	light brown - very dark brown	scattered long and short		7/27/2016	-	+				no results		
English Oak	57	57	8	light-dark brown	scattered long and short		7/27/2016	-	+				no results		
Filbert	58	58A	2	medium redish brown	long, few		7/27/2016	+							
		58B	4	black	long, scattered, few	lots of roots in sample bag	7/27/2016	+							
Filbert sp?	59	59	4	light orange- brown-black	long, abundant, web like	not many roots in this sample	7/27/2016	-	+		bad	bad	fungal DNA	90.2	5.59
Filbert sp?	60	60	2	light orange- brown-black	long, abundant, web like	not many roots in this sample, also seeing black tub	7/27/2016	+							
Filbert sp?	61	61	10	dark brown, redish, black	long, abundant, web like		7/27/2016	+							
English Oak	62	62	15	light- dark brown, redish, black	long, short, scattered, abundant, w	also seeing black tuber with and without cystidia	7/27/2016	-	+				no results		
Filbert sp?	63	63	8	black	some long and scattered, some web like		7/27/2016	-	+		bad	bad	silene cisplatensis	89.9	9.61
		63A	2	dark brown	none or long		7/27/2016	-	+		bad	ok	fungal DNA	100	3.79
English Oak	64	64	10	light- dark brown	few- none or abundant long patche	basidiomycete	7/27/2016	-	+				no results		
European filbert	65	65	10	light -dark brown- reddish	none- a few long		7/27/2016	-	+	Streak			no results		
European filbert	66	66	10	light- dark brown	many, sporatic, long	basidiomycete	7/27/2016	-	-	Streak			no results		
European filbert	67	67	20	light- dark brown	few, long, scattered		7/27/2016	-	-	Streak			no results		
European filbert	68	68	12	light- dark brown, greyish	medium, sporatic		7/27/2016	-	-	Streak	bad	ok	plant DNA	100	5.19
European filbert	69	69	8	light- dark brown	mostly long, scattered		7/27/2016	-	-		good	good	Tuber lyonii	99.7	82.83
European filbert	70	70	15	light - medium brown	short- medium, scattered		7/27/2016	-	-		good	good	hazelnut DNA	99.8	66.53
European filbert	71	71	8	light-dark brown	few, sporatic, medium long	basidiomycete	7/27/2016	-	-				no results		
European filbert	72	72A	5	light- dark brown	long, many		7/27/2016	-	-				no results		
		72B	5	light whitish -blackish	long, scattered, some short		7/27/2016	-	-				no results		
European filbert	73	73	5	black	long, many		7/27/2016	-	-				no results		
European filbert	74	74	10	light-dark brown-black	mostly long, abundant	basidiomycete	7/27/2016	-	-		bad	good	animal DNA	81.4	16.3
European filbert	75	75	10	whitish- light-ark brown (all on same	long, few, scattered	basidiomycete	8/9/2016	-	-						
European filbert	76	76A	1	ligth -medium brown (slender, less c	long, sporatic	basidiomycete	8/10/2016	-	-		good	good	fungal DNA	75.3	17.18
		76B	6	light- dark brown, black	long, many, some fuzzy	basidiomycete	8/10/2016	-	-		bad	good	Thelephoraceae (mycorrhizal family)	96.2	42.31
European filbert	77	77	10	light- dark brown, black	long, many scattered		8/10/2016	-	-		ok	ok	plant DNA	99.6	12.99
English Oak	78	78A	8	light- medium brown	some short, few very long		8/10/2016	-	-		bad	good	Pezizaceae (probably mycorrhizal)	94.3	60.33
		78B	1	dark brown	lots, longish, abundant, sacttered		8/10/2016	-	-						
European filbert	79	79	15	light- medium brown, black	brown- short, few, sometimes long.	Black- long and scattered	8/10/2016	+	+		bad	good	Pezizaceae (probably mycorrhizal)	86.8	37.58
European filbert	80	80	12	light- medium brown, black	long, may, scattered		8/10/2016	+	+						
European filbert	81	81	10	light- medium brown, few black	mostly long, sporatic or abundant	some fuzzy	8/10/2016	+	+						
European filbert	82	82	10	white-brown-black	scattered, long, many		8/10/2016	+	+						
European filbert	83	83A	8	light-dark brown, black	long, scattered		8/10/2016	+	+				Tuber canaliculatum		
		83B	1	light-medium brown	long, abundant, fuzzy clusters	didn't sample for DNA	8/10/2016	+	+						
European filbert	84	84	8	light-medium brown, some dark bro	long, sporatic	fuzzy clusters	8/10/2016	+	+						
European filbert	85	85	10	light- dark brown, black	long, abundant, scattered		8/10/2016	+	+				Pezizaceae		
European filbert	86	86	8	white-brown-black	long, abundant, scattered		8/10/2016	+	+						
European filbert	87	87	8	light brown- dark brown	long, abundant, scattered	fuzzy clusters	8/10/2016	+	+						
European filbert	88	88	8	light- med- dark brown	short, scattered, few		8/10/2016	+	+						
Holly Oak	89	89	3	light-medium brown	very few, short, scattered	very few roots in sample	8/10/2016	+	+						
European filbert	90	90	10	light-medium brown	short- medium, few	some dark brown with long cystidia	8/10/2016	+	+				Tuber canaliculatum		
English Oak	91	91	8	medium- dark brown	some short, many long		8/10/2016	+	+						
European filbert	92	92	10	white-black- browns	very long, abundant, fuzzy		8/10/2016	+	+						
European filbert	93	93	8	light-dark brown- black	long, many, web like, or none on brown Rts		8/10/2016	+	+						
European filbert	94	94A	6	medium brown	few, medium		8/10/2016	+	+				Tuber sp.		
		94B	2	light-dark brown- black	long, many, web like, or none on br	no sample taken	8/10/2016	+	+						
European filbert	95	95	10	light-dark brown- black	many, long, fuzzy, scattered		8/10/2016	+	+						
European filbert	96	96	5	light-dark brown	long, few, scattered		8/10/2016	+	+				Tuber canaliculatum		
Filbert	97	R2T7					8/10/2016	+							
Filbert	98	R3T11					8/10/2016	+					Tomentella sp.		
Filbert	99	R4T8					8/10/2016	+					Tuber melanosporum		
Filbert	100	R5T9					8/10/2016	+					Tomentella sp.		

PROJECT TITLE: Increasing Winter Squash Markets for North Carolina

PROJECT SUMMARY

Winter squash is a specialty crop that has generally been neglected when it comes to financial support, yet it comprises a valuable group of vegetables. Butternut specifically, is a squash with a long storage life, easily cut rind, nutritionally rich, and offers flexibility in multiple markets such as fresh market as either whole or fresh cut, and for processing. Minimal research has been conducted on the adaptation of cultivars in North Carolina, and more specifically various regions of the state, which includes the mountains, piedmont and coastal plain. Cultivars or advanced lines were obtained from a number of seed companies to determine key horticulture considerations; yield, earliness, shape, size and how harvest date affects fruit storage life. In addition, a budget for this crop is needed so that producers know what potential profits and expenses there are in producing butternut squash so they have the chance to best achieve economic returns should they include this crop in their business operation. Lastly, the effects of cultivar, time of harvest, and postharvest handling on nutritional content was evaluated so that growers could provide consumers the most nutritional, high quality product.

Agricultural producers are constantly evaluating different crops that may add profitability to their business operation. Butternut is a specialty crop that is the most sold vegetable of the winter squash vegetable group (spaghetti, kabocha, hubbard, acorn, etc.). Providing information which helps to determine best cultivars and production management practices for a given climatic region in NC will better enable growers to transition to growing butternut most profitably and ultimately be able to more easily incorporate into their business.

The “Increasing Winter Squash Markets for North Carolina” Specialty Crop Block Grant Proposal (SCBGP) was not funded by a previously funded SCBGP. However, we received some limited funding prior to this grant from the North Carolina Vegetable Growers Association to initially screen and grow some butternut cultivars and advanced lines. This preliminary work allowed us the opportunity to see what butternut cultivars were available and to have an initial grow out of the crop so that we could improve our production practices in future work. The “Increasing Winter Squash Markets for North Carolina” project that was funded provided the resources to conduct the majority of the work and produce the deliverables for this project.

PROJECT APPROACH

<u>Study 1 - Butternut advanced line and cultivar evaluations</u>

1. **Nine butternut genotypes were found to be well adapted to North Carolina production zones**. Twenty-six butternut genotypes from 8 seed companies were evaluated in 2015 at three research stations (Lower Coastal Plain Tobacco Research Station, Kinston NC; Piedmont Research Station, Salisbury, NC; and the Upper Mountain Research Station, Laurel Springs, NC) representing research stations with warm and cool production zones. Nine of the highest yielding and highest quality entries from across locations were selected for evaluation in 2016 at the Piedmont (warm climate) and Upper Mountain Research Stations (cool climate). The

most productive and best quality processing types were Frisco, Maxim and Ultra; (50,000 to 76,000 lb/acre). Of these three cultivars, Frisco appears better suited for use as a puree, while Maxim is likely better suited for the fresh cut industry due to its symmetry and shape. 'Ultra' will work well either as a puree or for fresh cut, but tends to have more curvature in the neck (less ideal shape) than 'Maxim'. Among fresh market types, using 'Waltham' as the standard cultivar for comparison; 'Polaris', 'Avalon', 'Betternut 900', 'Butterfly' and 'Butterscotch' were highly productive. Smaller sized fruits are better suited for fresh market sales by the piece and cultivars that generally yielded well included 'Betternut 900', 'Butterfly' and 'Butterscotch' (yields ranged from 17,000 to 23,000 fruit per acre). These cultivars generally yielded more fruit per acre than the standard cultivar 'Waltham' (12,000 to 18,000 fruit per acre), regardless of growing location. Fresh market cultivars more suited for sale by weight and that yielded more tonnage per acre than 'Waltham' (32,000 to 42,000 lb/acre) were 'Polaris' (55,000 to 63,000 lb/acre) and 'Avalon' (43,000 to 53,000 lb/acre).

1A. Economic enterprise budget shows that net return from butternut can be substantial, from $3,000 to $8,000 per acre (See Addendum 1). Inputs required for butternut production were carefully recorded; a breakdown of costs indicates that labor input is about 50% of inputs. Yields at sites and relative gross prices used to calculate an enterprise budget assuming yields of 300 to 450 bushels/acre and a conservative price per bushel at farm of $22 to $25.00.

1B. Production location effects. Butternut squash has a much faster production time from seed than expected under warm growing conditions. The time from seeding to squash maturity varied greatly among locations, with as little as 70 days at Kinston (warm) to more than 90 days at Laurel Springs (cool site). While squash took longer to reach maturity in our cooler location, fruit size and yield were much greater than at the higher temperature locations. For example, Quantum yielded very large fruit in the cool production zone but takes slightly longer to mature than other cultivars. The vines at Laurel Springs never senesced and continued to grow whereas the vines lost vigor and senesced at the warmer growing locations in Salisbury and Kinston. Large differences in vine vigor was an unexpected result and could be of use for seed companies developing new cultivars and expanding production into warm climates.

Study 2 - Storage temperature response

Butternut squash should be marketed between 1 and 5 weeks from harvest for best quality. Minimal changes occurred in butternut squash held at 55 F vs 60 F, 60% relative humidity, indicating squash can be stored at either temperature. Vitamin A content (retinol) was greatly enhanced by storage, increasing 50-120% between 1 and 9 weeks of storage. Butternut squash cultivars Waltham, Butterfly, Betternut 900, Avalon, Quantum, and Butterscotch held at 60 F had 1-2% more weight loss than those stored at 55 F while changes in rind firmness, soluble solids content and vitamin A were similar at both storage temperatures. Over 0-9 weeks storage time, squash color increased to a dark orange color and soluble solids increased 2-3%. The high weight loss (4-6% at 5 weeks and 8-10% at 9 weeks) and loss of solids (conversion of starch to sugars) indicates that squash should be marketed between weeks 1 and 5 for best internal quality.

Study 3 - Curing response

Curing of butternut had minimal effects on weight loss and composition. 'Butterscotch' and 'Betternut 900' were harvested from the same locations (Kinston, Laurel Springs, Piedmont) as above, and held at 75° F and 75% relative humidity for one week, then placed at 55° or 60° F. Weight loss and color were slightly higher after 5 or 9 weeks storage for cured squash from all locations. When comparing storage temperature to curing, storage temperature appears to have more effect on butternut squash for weight loss and color development.

Study 4 - Fruit set timing on fruit maturation and quality

Butternut squash reached full size and full vitamin A content at 21 days from flower set for warm growing areas and 29 days in the cool growing areas. 'Butterfly' squash were tagged at fruit set at weekly intervals at Laurel Springs and Piedmont. In order to have fruit to tag at a uniform stage, female flowers were removed regularly prior to tagging at prescribed times to induce uniform fruit set. These squash were then harvested at weekly intervals to determine how uniform fruit set affects fruit maturation and quality. Weight loss was not different in stored squash after 21 days (Piedmont) and 29 days (Laurel Springs) while internal fruit color continued to turn from yellow to orange between 8 and 54 days after bloom. Total carotenoids at 28 days post bloom was 40 mcg/100 g of pro-vitamin A Laurel Springs and 1200 mcg/100g pro-Vitamin A in Piedmont squash and total carotenoids in Laurel Springs squash (40 days) reached 60% of the Piedmont squash (42 days), indicating strong differences in development of vitamin A with production location.

Observations were that fruit were much more uniform in size and shape when fruits were only allowed to set at the prescribed time interval after flower removal. Determination of a method to induce concentrated fruit set on a commercial scale for uniformity of fruit size, shape and quality could provide advantages to the producer and consumer.

Unofficial partners in this project have included seed companies and the NC State University and NCDA&CS research stations. Eight seed companies contributed seed and some company representatives traveled to sites to evaluate the squash vigor, fruit size, and shape. They also provided sponsorship of grower workshops. NC State University and NCDA&CS have provided us with support for the field studies at research stations across NC.

GOALS AND OUTCOMES ACHIEVED

Poster and powerpoint presentations made at regional (3)(See addendum 2) and national meetings (2) of the American Society for Horticultural Science and the National Association of County Agricultural Agents (poster presentation, state winner). A presentation made at the 2016 NC Tomato and Vegetable Growers Conference and at the Southeast Fruit and Vegetable Conference (Myrtle Beach) on squash varieties stimulated interest by growers who successfully grew and marketed butternut squash in their operations. Field and commodity specific grower meetings allowed growers to see squash for themselves and learn about variety selection, market trends, and production management of butternut squash. A total of 118 growers attended workshops with information conveyed directly from this project. In evaluation surveys, 87% of participants indicated an increase in knowledge in areas of variety selection, harvest timing, and storage to maximize internal nutrient content. 72% of

participants indicated that as a result of these workshops, they were considering or intended to plant butternut squash.

Nine butternut varieties were identified that have best possibility for use across NC production areas and 5 of these were used successfully by growers in 2016.

34 NC Cooperative Extension Agents and NCDA&CS staff participated in an in-service agent training on cucurbits/winter squash production, postharvest considerations, and nutrition of butternut in 2016. These agents work in a combined 71 counties of North Carolina. Through pre and post workshop evaluations, 91% of agents gained knowledge in butternut squash production. Evaluations also indicated that 86% of agents intended to share knowledge gained with growers in their respective counties. Follow up evaluations conducted at the end of the grant period showed 73% of participants had used information from in service agent training in presentations given to growers.

Consumer awareness of nutrition of butternut was done via presentations to grower groups.

In 2015, the amount of winter squash grown in North Carolina, excluding pumpkins and ornamental types, was estimated at 1,000 acres. In 2018, contracted production of 300 additional acres of butternut squash are scheduled as a direct result of information provided from this project. This is an estimated net value of $900,000 - $2,400,000 (based on developed enterprise budget) for NC farmers through crop diversification.

Cutting edge information with respect to cultivar recommendations for specific markets has been determined as eight cultivars superior to the control cultivar have been identified. Time to harvest and postharvest practices and their influence on quality has been determined, especially from an internal quality perspective (soluble soilds, color, vitamin A).

Agents have become more competent and knowledgeable with regards to butternut squash production as well as cucurbit production in general. An agent in-service training was conducted in 2016 and about 30 agents attended. Approximately 80% of agents either gained in their knowledge of butternut squash in terms of using improved cultivars, production practices, postharvest handling, and other factors that affect quality. Agents also conveyed this information to their clientele which provided them with a new specialty crop production opportunity of growing butternut squash to improve their business.

We were able to determine nutritional benefits that given cultivars had in comparison with others and how the fruits were handled after harvest. To date, we have not printed current nutritional values for retail outlets; however, this information will become more readily available as additional publications are obtained through these studies. The various nutritional benefits have been shared at agent in-service training, state and regional grower meetings, and at field days.

Successful outcomes:

- Adaptation of research to produce butternut by growers and make a profit. See information above regarding 300 additional acres of planting valued at $0.9 to 2.4 million.
- An enterprise budget was created to reflect current costs and potential values allowing potential growers to incorporate accurate cost benefit analysis into production business plan.
- Others:
    - It was demonstrated that nutritional quality of butternut was improved with storage up to 5 weeks without loss of other quality components.

BENEFICIARIES

Growers, consumers, extension agents, grocery stores/marketing chains.
34 agents in extension training; 118 growers in industry conference presentations and extension meetings; 200 scientists and extension agents in conference presentations at regional and national meetings. Economic impact identifies a considerable value in growing butternut squash in NC (from $3,000-8,000 per acre net return).

LESSONS LEARNED

Communication is always key in projects and especially this one where research and extension arms must be coordinated. Here, research supported selection of better varieties through analysis of yield and quality and extension efforts quickly moved these results into direct application by growers and into an economic enterprise budget that also showed a net return per acre higher than expected.

An unexpected but highly gratifying outcome was the immediate and successful adoption by growers of the information on best squash cultivars for production and their success in selling their crops to local grocery stores (Aldi, Ingles, MDI, Food Lion). Use of near infrared spectrometry was successfully applied to determine dry weight and carotenoid content of squash, which can replace highly laborious, slow, and expensive methods currently used in laboratories and can be adapted for researchers and seed companies screening high volumes of butternut squash for composition. It also became clear that butternut squash can reach mature weight (not mature in terms of internal quality) in 14 days from flowering, indicating a short period that may demand supplemental watering to ensure fruit uniformity, depending on climactic conditions.

Goals were achieved in this project.

While we were able to carry out this project successfully, we found that we probably were overly ambitious in the number of goals we set forth in the project, especially in regards to the labor involved in harvesting and compositional assays. Fortunately we were able to utilize an Extension Master Gardner program to help with harvesting and with two high school interns to help with laboratory tasks.

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ADDITIONAL INFORMATION

Abstracts: 3 in HortScience, 1 in National Association of County Agriculture Agents

Addendum 1
Butternut squash enterprise budget

Crop

Winter Squash-1 Acre

Insert Your Farm Info

Table 1: Description of Operations

Operation	Machinery Involved & Other Comments		Machine Hours/Acre	Labor Hours/Acre
LAND PREPARATION:				
Soil Test	Minimal			0.25
Lime	Custom Application			
Plowing	50 HP Diesel Tractor	3-16" Moldboard	1.00	1.00
Pre-Emerg. Herbicide	50 HP Diesel Tractor	21' Boom Sprayer	0.50	0.50
Planting (seed)	50 HP Diesel Tractor 2 Row Planter (1 row)		1.00	1.00
GROWING SEASON:				
Cultivation (3X)	50 HP Diesel Tractor	Cultivator	3.00	3.00
Cultivation/Sidedress (1X)	50 HP Diesel Tractor	Cultivator	1.25	1.25
Fungicide Application (8X)	50 HP Diesel Tractor	21' Boom Sprayer	2.00	2.00
Insecticide Applications (8X)	50 HP Diesel Tractor	21' Boom Sprayer	2.00	2.00
Hoeing/Thinning		Hoes		8.00
HARVEST:				
Harvest	Picking Labor	Crates		32.00
Harvest (hauling)	50 HP Diesel Tractor	Wagons	12.00	12.00
Total Hours			22.75	63.00

Table 2: Labor Summary

Operation	Labor Hours/Acre	Skilled or Unskille	Labor Cost/Hour	Labor Cost/Acre
Soil Sample	0.25	Skilled	$ 11.27	$ 2.82
Plowing	2.00	Skilled	$ 11.27	$ 22.54
Pre-Merg. Herbicide	1.00	Skilled	$ 11.27	$ 11.27
Planting	3.00	Skilled	$ 11.27	$ 33.81
Cultivations	3.00	Skilled	$ 11.27	$ 33.81
Cultivation/Sidedress	3.00	Skilled	$ 11.27	$ 33.81
Fertilizer Application	4.00	Skilled	$ 11.27	$ 45.08
Fungicide Application	4.00	Skilled	$ 11.27	$ 45.08
Insecticide Application	4.00	Skilled	$ 11.27	$ 45.08
Hoeing/Thinning	8.00	Unskilled	$ 11.27	$ 90.16
Harvest-Picking	40.00	Unskilled	$ 11.27	$ 450.80
Harvest-Hauling	17.00	Skilled	$ 11.27	$ 191.59
Total Skilled labor	41.25		$ 11.27	$ 464.89
Total Unskilled labor	48.00		$ 11.27	$ 540.96
Total Labor Cost				########

Table 3: Cash Expenses Per Acre (other than labor)

Expense Item	Units	Quantity	Price/Unit	Total Cost of Item
Soil Test		1.00	$ 25.00	$ 25.00
Land		1.00	$ 75.00	$ 75.00
Lime (custom)	tons	0.75	$ 36.00	$ 27.00
Seed	pounds	2.00	$ 13.50	$ 27.00
Fertilizer (will vary with soil test recommendations)				
10/10/2010	Tons	0.50	$ 750.00	$ 375.00
Herbicides:				
Curbit 3EC	Pint	2.00	$ 9.50	$ 19.00
Gramoxone Max	Pint	1.00	$ 10.00	$ 10.00
Roundup Weathermax	Quart	1.00	$ 15.00	$ 15.00
Command 4EC	Pint	1.00	$ 14.00	$ 14.00
Select 2EC	Pint	0.50	$ 24.00	$ 12.00
Fungicides 8 Total Applications	Application	8.00	$ 14.50	$ 116.00
Insecticides 8 Total Applications	Application	8.00	$ 20.50	$ 164.00
Crates	Bushel crates	400.00	$ 0.70	$ 280.00
Total				########

Table 4: Machine Costs

Machine (Name and Size)	Hours Used Per Acre	Operating Cost Per Hour	Operating Cost Per Acre	Ownership Cost Per Hour	Ownership Cost Per Acre
50 HP Diesel Tractor	22.8	$ 4.50	$ 102.38	$ 12.00	$ 273.00
Plow 3-16"	1.0	$ 2.00	$ 2.00	$ 8.00	$ 8.00
Boom Sprayer 21'	4.5	$ 1.50	$ 6.75	$ 5.25	$ 23.63
Cultivators	4.3	$ 1.00	$ 4.25	$ 1.25	$ 5.31
Planter	1.0	$ 1.50	$ 1.50	$ 30.00	$ 30.00
Wagon(s)/Trailers	12.0	$ 0.25	$ 3.00	$ 1.00	$ 12.00
Total			$ 119.88		$ 351.94
Total Operating and Ownership Cost Per Acre					$ 471.81

Table 5: Summary of Process Budget Costs

Winter Squash-1 Acre	Labor Rate Per Hour	Total Hours	Per Acre
Labor: Skilled	$ 11.27	41.25	$ 464.89
Unskilled	$ 11.27	48.00	$ 540.96
Cash Expenses:			########
Machinery: Operating Costs			$ 119.88
Ownership Costs			$ 351.94
Total Production Costs			########

Table 6: Gross Revenues

Yield (bushels)	Price Per Bushel at Farm $22.00	$23.00	$24.00	$25.00
300	6,600	6,900	##### ##	##### ##
350	7,700	8,050	8,400	8,750
400	8,800	9,200	9,600	10,000
450	9,900	10,350	10,800	11,250

Table 7: Net Revenues

Yield bushels	Price Per Bushel at Farm $22.00	$23.00	$24.00	$25.00
300	3,963	4,263	4,563	4,863
350	5,063	5,413	5,763	6,113
400	6,163	6,563	6,963	7,363
450	7,263	7,713	8,163	8,613

Addendum 2
Poster presented at ASHS meeting, abstract published in HortScience

NC STATE UNIVERSITY

Yield and Quality Response of Butternut Cultigens in NC

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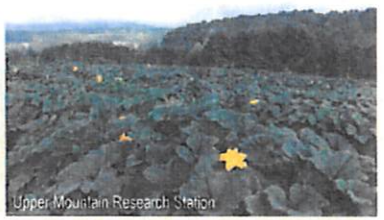
INTRODUCTION

Butternut squash, *Cucurbita moschata*, is commonly grown and sold across the United States. Butternut, a squash with a long storage life and easily cut rind, comes in small (individual serving), fresh market, and large processing varieties, offering flexibility for multiple markets. It is prized for its sweet orange flesh that is nutritionally rich and a valuable source of Vitamin A (Sudhaker et al, 2003). However, it has received relatively limited study on variety yield and response to growing conditions in the southeastern United States. With increasingly more varieties of Butternut available, it is difficult to determine proper selections due to limited butternut variety trials. Decreases in fruit yields and fruit size for *Cucurbita* have been associated with high temperatures (Wein et al, 2002) and water stress (Fandika et al 2011).

North Carolina has one of the most varied climates of any eastern state with its range in elevation from mountains, through the piedmont and to the coastal plain. In mid July, the mountains of NC have daily high temperatures reaching 80 F, while the Piedmont regularly experiences afternoon highs in excess of 92 F. Morning temperatures average about 20 degrees lower than those in the afternoon.



OBJECTIVES

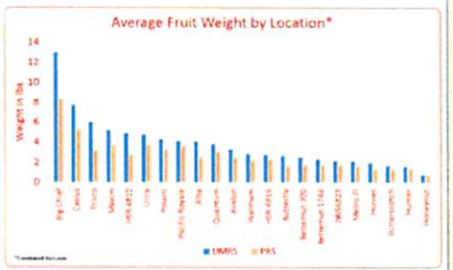
1. Survey the butternut cultigens for yields at different climatic locations in North Carolina, Piedmont and Mountains.
2. Sample internal nutrient composition, soluble solid content and total carotenoids, over time as potential variety selection tool.

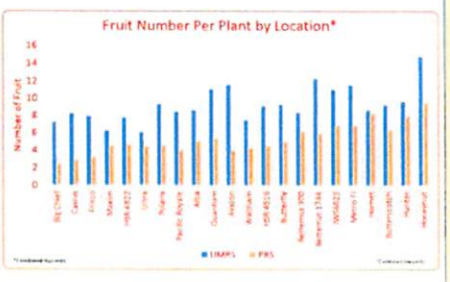
MATERIALS AND METHODS

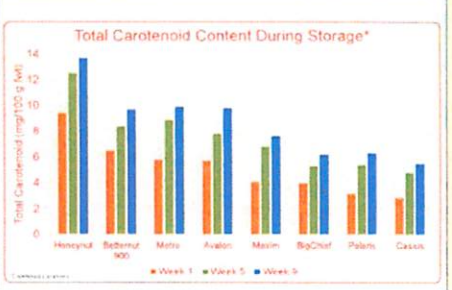
On black plastic mulch with drip irrigation, 22 Cultigens were direct seeded on May 22nd at UMRS and row centers were 8ft (space was limited by perimeter deer fence) with an in-row spacing of 2ft. Plots were 16ft long and contained 8 plants. The study was arranged as a randomized complete block design with three replications. Cultigens were direct seeded on May 27th at PRS and row centers were 10ft with an in-row spacing of 2ft. Plots were 16ft long and contained 8 plants. The study was arranged as a randomized complete block design with four replications. There were two harvests at both locations; UMRS 27 August 97 days after planting (DAP), 18 September (119 DAP): PRS 7 August (72 DAP) and 21 August (86 DAP). Each ripe fruit was harvested and weighed; from that, the weight and number per plant, and average fruit weight were determined. Three to five fruit per selected cultigen were transported from the research station to the Plants for Human Health Institute in Kannapolis, NC. There, percentage soluble solids content was determined by placing 0.5 ml puree onto a digital refractometer (Atago Model P1000). Carotenoid profile was determined on extracts by high performance liquid chromatography (Hitachi Elite La Chrome, Tokyo, Japan).

RESULTS

- UMRS, from planting to 1st harvest had an average daily high temperature of 76.7 F and a total rainfall of 39.6 inches.
- UMRS harvest was prolonged due to a cool, rainy August with 25.4 inches of rain coming during this month.
- PRS, planting to 1st harvest, had an average daily high temperature of 91.3 F and a total rainfall of 3.62 inches.
- PRS rainfall in July was only .5 inches.
- UMRS had larger fruit size than PRS with the largest percentage of difference amongst processing types and least difference amongst personal size.
- UMRS has significantly more fruit number per plant than PRS, with the exception of Hornet
- For selected cultigens, total carotenoid content increased 31% (Honeynut) to 49% (Polaris) from week 1 to week 9 storage at 55 F.
- For selected cultigens, soluble solid content (ssc) increased 25% (Honeynut) to 6% (Big Chief) from week 1 to week 9.
- Total carotenoid content and SSC vary significantly among butternut cultigens.







SUMMARY

- A wide selection of butternut varieties exist.
- Butternut squash respond to high temperatures and water stress by decreasing in fruit weight and decreasing in number of fruit per plant.
- The decreases are most significant in processing type butternuts.
- Opportunities exist to combine yield data and internal quality data to make more informed variety selections that maximize production, consumer taste preferences, and internal nutrient content for increased marketability of butternut squash.
- More work will be conducted in 2016 at the same locations with top performing butternut cultigens with more in depth internal nutrient content analysis.

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ACKNOWLEDGEMENTS

This work was supported in part by a grant from the NCDA&CS Specialty Crops Block Grant Program.

PROJECT TITLE: New Blueberry Production Guide and Budget

PROJECT SUMMARY

Blueberry production in North Carolina exceeds $71M in value and includes both large wholesale and small retail producers. Demand for blueberries remains high, but expansion is limited by a lack of suitable sites, high start-up costs, and delayed return on investment. New cultivars and improved production practices are available, but this knowledge needed to be compiled into a single resource document. Growers lack up-to-date production and budget information -- the state blueberry production guide is out of date and no longer in print, while the blueberry budget was last updated in 2005. This project brings together growers, production specialists and economists to revise and update the blueberry production guide, and to produce updated budgets for both large farms that sell wholesale berries through a marketer and small farms that market directly to consumers.

- The project was motivated by the lack of a blueberry production guide for North Carolina. Importance is indicated by the value of the state's blueberry crop (over $71M), and the presence of both large commercial farms, and small farms producing pick-your-own or locally-marketed fruit. Interest in the healthful benefits of blueberry consumption has increased interest in blueberry production as a farm enterprise making this a timely project for development of both production and budget information.
- The project is new and not based on any previous Specialty Crops Block Grant.

PROJECT APPROACH

BUDGETS: Our budget approach has been to build on previous budgets, while reflecting the changes that have occurred in the past 12 years since budgets were updated. We have been in regular contact with blueberry growers to verify the cost and utility of highly specialized equipment (blueberry harvesters, packing lines, pruning equipment and tractors) to make sure the budget reflects current trends and needs. We also contacted suppliers of fertilizers, pesticides and other expendable items for current pricing. Labor costs were based on current (2017) figures from growers, using H2A labor rates as a baseline.

Fruit prices were based on what we considered to be the best available numbers, a seven-year average (2008-2014) that we compiled using actual weekly reported grower returns as compiled by the NCDA&CS Marketing Division.

PRODUCTION GUIDE: The production guide began as a revision and has evolved into a full-blown re-write. Changes in the blueberry industry since the guide was last updated have been significant, including a near-complete change of the cultivars we grow, totally new packing systems, and much more intensive production. We have relied on our knowledge of the production systems currently in use, and in some cases (such as when writing about site selection) have done extensive research into the acreage and soil types where blueberries are currently grown in NC.

- Project partners Bill Cline and Benny Bloodworth met with growers and county agents to discuss needs and to review items to be included in the budget. Budget tables (1-15) from the last iteration (2005) have been completely updated with new figures (2017) that will be used for budget projections. The blueberry production guide has been updated but not yet published; our goal is to publish the guide in the coming year. For extensive comments on our efforts, see the final project report attached.
- Project partner Jonathan Baros will contribute budget analysis and projections in 2018.

GOALS AND OUTCOMES ACHIEVED

BUDGETS: Our budget work to date has produced revisions or re-writes of all fifteen (15) key tables that break out each component of production, both in terms of start-up costs and annual production costs. Table 1 is now a customizable spreadsheet that lists acres and pounds harvested, by cultivar, by week of the season, with weekly prices adjusted for typical declining fresh berry prices as the season progresses, based on 2008-2014 weekly averages. Tables 2-15, respectively, include:

- Capital Investment by Year
- Cost basis for individual equipment items
- Irrigation installation and operating costs for a 100 acre blueberry farm
- Establishment cost per 100 acres, excluding irrigation and maintenance
- Annual blueberry pruning costs
- Annual cost of blueberry fertilizer use in NC
- Annual cost of blueberry weed control in NC
- Disease and Insect control costs for blueberry in NC
- Blueberry harvest, sorting and packaging costs for fresh market sales
- Blueberry harvest costs for processing sales
- Miscellaneous costs in blueberry production
- Summary of gross receipts to grower from Table 1
- Summary of production costs and receipts per acre

We feel that this budget revision, especially the customizable spreadsheet in Table 1, creates a powerful tool for growers and investors. Our final budget step, not yet achieved, will be to project a 20-yr return-on-investment using various yield scenarios, and to compare that analysis to previous budget projections.

PRODUCTION GUIDE: Production guide achievements during the grant period began with assessment of sites used to grow blueberries. An accurate estimate of commercial blueberry acreage and blueberry farm soil type in North Carolina was achieved through the use of web-based tools that overlay existing soil maps onto user-defined areas of interest. We first mapped familiar blueberry sites, then searched for other sites using publicly-available imagery. A total of 102 fields, farm units or contiguous blocks were mapped in the Fall of 2015. Unplanted areas within farm boundaries (roads, ditches, headlands) averaged 17.2% of the total mapped acres, and these areas were excluded from the planted acreage estimate of 9,756 acres (3,948 hectares) in southeastern NC. Predominant soils (those representing five hundred acres or more of the total) were Leon fine sand (40%), Lynn Haven fine sand (19%), Murville fine sand and Murville muck (7%), and other muck soils (12%). Acres (or hectares) recorded by county

included Bladen 5,859 (2,371), Pender 2,092 (847), Sampson 1,012 (410), Duplin 501 (203), Columbus 165 (67) and Craven 127 (51).

Production Guide Contents

1. Introduction
    a. Types of blueberries
    b. Cultivated species grown in NC
    c. Characteristics of the best cultivars
2. Cultivars for NC
    a. Coastal Plain
    b. Piedmont
    c. Mountains
3. Site Selection and Preparation
    a. Non-amended sites
    b. Sites requiring soil amendment
    c. Drainage and row orientation
    d. Fertility and pH
4. Planting and Establishment
    a. Planting spacing
    b. Plant sources and types
    c. Pruning newly planted bushes
    d. Fertilizing young plants
    e. Irrigation during establishment
5. Irrigation and Water Management
    a. System types
    b. Overhead irrigation for freeze protection
    c. Water management
6. Culture and Management
    a. Blueberry growth stages
    b. Pollination
    c. Fertility and pH
    d. Effects of Climate on growth and productivity
    e. Diseases, Insects and Weeds
    f. Considerations for organic production
7. Pruning
    a. Pruning young plants
    b. Pruning mature bushes
    c. Rejuvenating old plants
    d. Summer pruning

8. Harvesting and Handling
    a. Harvest timing
    b. Hand harvest
    c. Machine harvest
9. Postharvest Handling
    a. Cooling, sorting and packing
    b. Forced-air cooling
    c. Color and soft sorting
    d. Food safety considerations

Appendix 1. Ripening times of blueberry cultivars in Southeastern NC

Appendix 2. Commercial blueberry acreage and soil type, by county

Appendix 3. Notes on individual cultivars

Appendix 4. Blueberry Propagation

Appendix 5. Diseases, Insects and Weeds

Appendix 6. Timing of Disease, Insect and Weed control measures

References

Acknowledgements

This is the current layout of the guide as written/outlined, but will change slightly as we finalize the document. Some sections are written, others are incomplete.

Note also that we appended a number of working documents that are outside the main text of the guide, but will be useful to growers. These include ripening times, the acreage and soil type survey, acres and harvest timing for cultivars, expanded descriptions of cultivars, propagation, and diseases, insects and weeds.

- Budget table revisions were completed in 2017. Production guide updates are ongoing. We anticipate publication in the coming year.

- Both budget and production guides are on track for publication but are approximately two (2) years behind schedule, based on the original proposal.

BENEFICIARIES

All blueberry growers in NC will benefit from completion of the production guide and budget. There are an estimated 160 full-time blueberry farmers (80+ separate farms) with nearly 10,000 acres under

cultivation. Budget documents and production information are also critical for banks and other farm lenders, and for crop insurance adjusters.

LESSONS LEARNED

LESSONS LEARNED/OUTCOMES NOT ACHIEVED

1. Unexpected, unavoidable delays occurred. The project will be completed regardless.
2. Publication of the budget and production guide is still pending. Publication will occur even though the grant period has ended.
3. Funds for publication were still unspent at the end of our 6 month no-cost extension. Therefore, we will secure other funds for publication.
4. Funding for personnel was critical to this project and was expended in a timely fashion.
5. Funds for travel and mileage were anticipated but not much needed; this expense was absorbed by other travel/mileage funding sources.

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ADDITIONAL INFORMATION

Cline, W.O. and Bloodworth, B.K. 2017. Determination of blueberry acreage and soil type in North Carolina using web-based resources. Proceedings, XI International Vaccinium Symposium, Orlando FL. 10-14 April, 2016. Acta Hort (in review).

PROJECT TITLE: NC GAP Cost Share Project **(Final Report Previously Accepted)**

PROJECT SUMMARY

The changing landscape of food safety and the increasing requirements of new legislation has wreaked havoc on the expense accounts of many growers in the US. Particularly, here in North Carolina there are many small and medium sized growers affected by the increased requirements of produce buyers to become GAP certified before they are eligible to sell.

The purpose of this grant is to assist growers in the cost of certification. The assistance enables them to have a stronger bottom line and consequently maintain GAP certification. The desire to advertise "support for local foods" is there from the retail and foodservice companies but they will not purchase from those growers who are not certified. This project enabled new growers and existing growers to seek GAP certification at a reduced expense and thereby maintain their marketability.

This grant was in addition to previously funded grants for GAP certification and has built on the number of assisted growers every year. Furthermore, the grant has been altered in scope from previous applications. The limitation has been placed on the number of times a grower can seek reimbursement. A grower can be reimbursed only for the 1st year and second year of certification. All certifications afterwards will not be eligible for payment.

PROJECT APPROACH

Throughout the course of this project the marketing specialists and Cooperative Grading representatives would explain the process of becoming GAP certified and how to apply for reimbursement at any speaking event available. In the duration of this project growers were contacted and educated on how to become reimbursed and assisted with the required paperwork. Once the inspection was complete, the request for funds was issued by the grower to the NCDA&CS and if all documentation was correct they were issued the approved amount.

No growers were denied full funding except in the event of a lack of funding or if certification had failed.

The funds were used to reimburse only North Carolina growers who had specialty crops certified by GAP standards through a 3rd party audit. Funds were not used for any other commodity as the individual crops being certified had to be listed before they were accepted.

GOALS AND OUTCOMES ACHIEVED

The goal of this project was to assist at least 60 growers per year for a 2 year period. The total number of growers supported from this project was 149. Therefore, the project has far exceeded its target by over 24%. The completed project has enhanced the GAP certification programs and has kept NC competitive in produce marketing by ensuring the availability of produce grown using Good Agricultural Practices which is sought out by buyers across the country.

BENEFICIARIES

The beneficiaries of this project are the Specialty crop producers who have become GAP certified. Furthermore, as more growers become certified more markets are opening in North Carolina. Publix, Wegmans and Lidl have officially planned to place stores or expand their stores in NC. They have also declared too openly support the purchase of local foods and thus are working or in talks with local growers to source products. Indirectly, by increasing a pool of local growers with the required certifications more markets are opening and thereby increasing more competition for NC consumers.

LESSONS LEARNED

The main lesson learned in this project was that an increased demand for GAP certification has outpaced the available funds and even though reducing the available number of growers still did not reduce the demand significantly. We had more growers ask for reimbursement than before and most of the growers were new to GAP Certification.

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PROJECT TITLE: Sweetpotato Weevil Eradication in the North Carolina Quarantine Zone (Phase 1)

PROJECT SUMMARY

The aim of this project was to collect the biological information necessary to establish a baseline for developing and implementing an integrated pest management program for future eradication of sweetpotato weevil (*Cylas formicarius*; SPW) populations in North Carolina (NC). The proximity of the sweetpotato weevil quarantined areas (NC-SPWQ; portions of Brunswick and New Hanover Counties) to sweet potato production areas makes SPWs a significant risk to the NC sweet potato industry, which produces more than fifty percent of all sweet potatoes in the United States and is currently ranked number one in the nation. The relatively small size and isolated conditions of the quarantined areas provided a unique opportunity for NC to study and test the feasibility of an eradication program, with the potential to extend this program to other sweet potato-producing states. We expect that successful eradication will benefit sweet potato growers by: 1) expanding the range of production areas; 2) facilitating the movement and export of sweet potatoes from previously regulated areas; and 3) reducing sweet potato production costs to farmers and consumers.

The main objectives of this project were: 1) to determine the temporal and spatial distribution of sweetpotato weevils and their host populations in the North Carolina quarantined areas; 2) to establish the basis for a collaborative work using sterile male weevil releases with agencies in Florida; and 3) to raise awareness of the importance of eradicating SPW from NC through outreach in the NC-SPWQ areas. The data collected from Phase One of this project will be used to initiate the eradication phase of the project beginning in 2018.

PROJECT APPROACH

Our approach to achieving the objectives outlined above are as follows:

To determine the temporal and spatial distribution of sweetpotato weevils we set detection traps utilizing a hexagonal grid system in the sweetpotato weevil quarantine areas. Based on a full year of trap check data from the detection grid, we re-set traps using an intensive delimiting grid system to gain a more precise understanding of weevil populations both temporally and spatially. Weevil hosts (e.g. morning glory; *Ipomoea* spp.) were surveyed visually and both species and general density were noted.

To establish the basis for a collaborative work using sterile male weevil releases the project leader reached out to the United States Department of Agriculture and the University of Florida to find collaborators and agencies willing to assist with mass rearing and sterilization of male weevils. As explained further in the 'Goals and Outcomes Achieved', efforts proved unsuccessful.

To raise awareness of the importance of eradicating sweetpotato weevils from North Carolina through outreach in the NC-SPWQ areas we developed outreach materials, published an NCDA&CS press release, interacted weekly with the Carolina/Kure & Caswell Beach communities, presented at

an international entomology conference, communicated with community leaders, and had a project write-up in a local newspaper.

Project developments and delays:

Mid-way through the duration of this project (June 2016), the original project leader, Alonso Suazo, resigned from NCDA&CS to pursue a new career opportunity. I (Whitney Swink) took over leadership of the project in July 2016. Due to this unexpected change, we requested a 6-month extension for the project to complete the work outlined in our objectives, which we received. With this extension, we were able to map the presence/absence of host species to the population clusters of the weevil over time—information which will be critical for eradication of this pest. Despite the leadership change mid-project, we were successful in meeting all outlined objectives, save one (which is explained in detail below in the 'Goals and Outcomes Achieved').

In October 2016, Hurricane Matthew swept through eastern North Carolina. Prior to its arrival on the coast, we pulled some of our traps to ensure they did not get washed away by the winds and water. The traps were replaced post-hurricane. The hurricane did not appear to have any effect on the weevil populations.

The original scope of work for this project included a plan to utilize a Masters student from North Carolina State University, supervised by a professor in the Department of Entomology, to assist with data collection, host species identification, sample collection for future DNA analysis, and outreach activities. The plan included having the student be funded via a fellowship rather than SCBGP funds and unfortunately this did not come to fruition. The original project leader left in the middle of this project and collaboration with a Masters student was not pursued further.

GOALS AND OUTCOMES ACHIEVED

(Please note: All figures and tables are located at the end of this document under 'Additional Information'.)

We began this project in February 2015 when the Project Leader (State Regulatory Entomologist) along with six North Carolina Department of Agriculture & Consumer Services - Plant Industry Division - Plant Protection Section (NCDA&CS-PID-PPS) personnel and one temporary employee set up a detection grid consisting of 405 universal moth traps (buckets traps; Figure 1) in a hexagonal grid pattern in the NC-SPWQ areas to obtain a baseline determination of the spatial and temporal distribution of SPW populations (Figures 2&3). The quarantined areas in North Carolina consist of portions of Carolina Beach and Kure Beach (New Hanover County) and Caswell Beach (Brunswick County). The traps were set at an average distance of 150 yards apart and a hexagonal grid pattern was utilized to allow for maximum pheromone lure coverage. Traps were baited with a rubber septa lure containing 10µg of a female-specific SPW sex pheromone and a Vaportape™ insecticidal kill strip and checked for weevils every two weeks. Lures were replaced once per month and kill strips were replaced every three months. Data was collected using a mobile GIS application called Avenza® Maps on iPad devices. The traps remained in place for the entirety of 2015.

Based on the number of weevils caught per trap over time a total of 11 population clusters were identified in New Hanover County and five in Brunswick County (Figures 4 & 5). These are well-

defined areas where SPWs are found in significant numbers and define the spatial distribution of SPW populations in the NC-SPWQ areas. Two types of population clusters were found: low-density clusters (LDC) represented by a few weevil detections throughout the year (n≤5) and high-density clusters (HDC) represented by high numbers of weevils collected over the entire survey season (n≥6). Of the 11 population clusters detected in New Hanover County, three were HDCs (Figure 4: clusters 6, 9, and 10) and eight were LDCs (Figure 4: clusters 1-5, 7-8, and 11). In Brunswick County, the high-density clusters represented a significantly higher number of weevils than those in New Hanover County (Figure 5).

Although adult weevils were expected to become active in May and June, traps in the Carolina Beach area first caught weevils as early as March 2015 (Table 1; Figure 6). The weevil count steadily increased through the spring and summer months, peaking in September with 134 weevils caught for the month (nine in New Hanover County and 125 in Brunswick County). A combined 418 weevils were caught in both counties in 2015 with 83% collected in Brunswick County and only 17% from New Hanover County. The temporal distribution of SPW populations is consistent across both New Hanover and Brunswick Counties with low numbers seen in February through April and peaks during the months of September and October.

The results obtained from the detection survey completed in 2015 were used to layout the sites where traps were set for the delimiting surveys in 2016 (Figures 7 & 8). Traps were set in and around the areas where population clusters were detected. A total of 336 traps were set in January 2016 at an average distance of 50-yards between traps. The number of traps in each delimiting grid cluster was determined based on the cumulative number of weevils found throughout the 2015 season in that cluster. LDCs received fewer traps than HDCs.

The information collected from the delimiting grids was used to determine with high precision the spatial distribution of SPW populations and provided a more detailed representation of the SPW spatial and temporal distribution. In addition to the traps set in the delimiting grid, two to three traps from the detection grid remained set to serve as a control. The delimiting traps were checked on a weekly basis with lures (increased to 100µg concentration in 2016) replaced every other week to maximize pheromone efficiency and thus improve detection sensitivity.

The temporal and spatial distribution of sweetpotato weevils utilizing the delimiting grid was consistent with the results of the detection grid—SPW began to slowly become active in the spring, with a population explosion in August that peaked in October (Table 1; Figure 9). A total of 3,834 weevils were caught in 2016 with 97% (n=3,715) of the weevils collected in Brunswick County and the remaining 3% (n=119) collected in New Hanover County. Of the 339 traps set in the delimiting grid, only 93 traps caught weevils. Five traps (all in Brunswick County) were responsible for 33% of the total weevils captured in 2016. Those five traps correspond with the largest population clusters in Brunswick County (Figures 5 & 8) and with the largest concentration of host material in the area (discussed further below).

The delimiting grid traps corresponding to New Hanover LDCs 2, 3, 5, 7, & 8 and Brunswick LDCs 4 & 5 were all negative for the entire duration of 2016 suggesting that those clusters were a result of drift via wind rather than established populations. Results of trap checks during the first half of 2017 remained consistent with the previous year's temporal and spatial distribution results (Figure 10). Notably, 2017 was the first year we were able to collect data in January and trap catch results showed the weevils experienced a brief spike in population. Since this was the only year of the project we have been able to collect data for the month of January, we are not certain if this was an unusual

population spike or something that happens annually. Despite this phase of the project ending, we will continue to monitor the weevil populations as we move forward with our plans for eradication.

Density, abundance, and presence of host species, specifically morning glory, (*Ipomoea* spp. L.; Convulvulaceae), were determined through visual surveys in the SPWQ. There are 11 species of morning glory known to occur in Brunswick and New Hanover counties and of those 11, three species were found in abundance in the SPWQ, *Ipomoea cordatotriloba*, *I. imperati*, and *I. sagittata* (Figure 11). Of those species, *I. imperati* is the most noteworthy as it is strongly associated with the large SPW population clusters detected in Caswell Beach. *I. imperati* is a rare, typically evergreen species of morning glory and is only found in small pockets along the coast of North Carolina, including along the dunes of Caswell Beach (Figure 12). While conducting visual surveys of the host material, all but one life stage of the weevil were recovered directly from *I. imperati* along Caswell Beach (larva, pupa, and adult; Figure 13). We monitored the growth of *I. imperati* over time and found that in the summer and fall when the morning glory is at its most dense, the weevil population explodes and during the winter and spring months when the morning glory has died back, the weevil populations drop off (Figure 14). In the New Hanover portion of the SPWQ the morning glory species are deciduous which might explain why the weevil populations are significantly smaller than in Brunswick County. The information gathered from these surveys will be critical in implementing an integrated pest management and eradication plan for SPW.

A secondary objective for this project was to establish the basis for collaborative work with agencies in Florida to conduct sterile male weevil releases based on a successful eradication program in Japan. The concept was to sterilize huge numbers of male weevils using sterile insect technique (e.g. irradiation of high numbers of male weevils) and then release them into the wild populations. The sterilized males would mate with females who would then lay nonfertilized eggs. Over time this would lead to population decline and eventually total eradication. Unfortunately, this work turned out to come with exorbitantly high production costs and unrealistic time requirements and the objective had to be abandoned. However, an alternative method for eradication has been proposed and is the impetus for Phase 2 of this project (the eradication phase) which we plan to initiate in 2018.

Lastly, community outreach and education were considered critical to the success of this project. During the initial trap set in February 2015 informative door hangers were placed on homes throughout the Carolina/Kure & Caswell Beach communities to inform homeowners and tourists about the project and its importance (Figure 15). Various news outlets covered the project in their newspapers and we created a webpage (see below under 'Additional Information') to explain the sweetpotato weevil quarantine. We created a QR code (quick response code that can be scanned with a smart device; see example on Figure 15) to direct people to our website where they could learn more about the sweetpotato weevil. We labeled all of our SPW traps with the QR code. Additionally, NCDA&CS personnel working in the SPWQ regularly engaged with the community to provide information about the program and why eradicating SPW from North Carolina is so important.

The sweetpotato weevil population ecology data collected during this project will be crucial for conducting a successful eradication program. We now know precisely where populations of SPW and their host plants occur in the North Carolina SPW quarantined areas which is significant for pest eradication.

- Goal established: Determine the temporal and spatial distribution and density of sweetpotato weevils (SPW) and their host populations in the North Carolina SPW quarantined area (NC-SPWQ; portions of New Hanover and Brunswick Counties)
  - Actual accomplishments: We began this project in February 2015 when the Project Leader (State Regulatory Entomologist) along with six North Carolina Department of Agriculture & Consumer Services - Plant Industry Division - Plant Protection Section (NCDA&CS-PID-PPS) personnel and one temporary employee set up a detection grid consisting of 405 universal moth traps (buckets traps; Figure 1) in a hexagonal grid pattern in the NC-SPWQ areas to obtain a baseline determination of the spatial and temporal distribution of SPW populations (Figures 2&3). The quarantined areas in North Carolina consist of portions of Carolina Beach and Kure Beach (New Hanover County) and Caswell Beach (Brunswick County). The traps were set at an average distance of 150 yards apart and a hexagonal grid pattern was utilized to allow for maximum pheromone lure coverage. Traps were baited with a rubber septa lure containing 10µg of a female-specific SPW sex pheromone and a Vaportape™ insecticidal kill strip and checked for weevils every two weeks. Lures were replaced once per month and kill strips were replaced every three months. Data was collected using a mobile GIS application called Avenza Maps on iPad devices. The traps remained in place for the entirety of 2015.

    Based on the number of weevils caught per trap over time a total of 11 population clusters were identified in New Hanover County and five in Brunswick County (Figures 4 & 5). These are well-defined areas where SPWs are found in significant numbers and define the spatial distribution of SPW populations in the NC-SPWQ areas. Two types of population clusters were found: low-density clusters (LDC) represented by a few weevil detections throughout the year ($n \leq 5$) and high-density clusters (HDC) represented by high numbers of weevils collected over the entire survey season ($n \geq 6$). Of the 11 population clusters detected in New Hanover County, three were HDCs (Figure 4: clusters 6, 9, and 10) and eight were LDCs (Figure 4: clusters 1-5, 7-8, and 11). In Brunswick County, the high-density clusters represented a significantly higher number of weevils than those in New Hanover County (Figure 5).

    Although adult weevils were expected to become active in May and June, traps in the Carolina Beach area first caught weevils as early as March 2015 (Table 1; Figure 6). The weevil count steadily increased through the spring and summer months, peaking in September with 134 weevils caught for the month (nine in New Hanover County and 125 in Brunswick County). A combined 418 weevils were caught in both counties in 2015 with 83% collected in Brunswick County and only 17% from New Hanover County. The temporal distribution of SPW populations is consistent across both New Hanover and Brunswick Counties with low numbers seen in February through April and peaks during the months of September and October.

    The results obtained from the detection survey completed in 2015 were used to layout the sites where traps were set for the delimiting surveys in 2016 (Figures 7 & 8). Traps were set in and around the areas where population clusters were detected. A total of 336 traps were set in January 2016 at an average distance of 50-yards between traps. The number of traps in each delimiting grid cluster was determined based on the cumulative number of weevils found throughout the 2015 season in that cluster. LDCs received fewer traps than HDCs.

    The information collected from the delimiting grids was used to determine with high precision the spatial distribution of SPW populations and provided a more detailed

representation of the SPW spatial and temporal distribution. In addition to the traps set in the delimiting grid, two to three traps from the detection grid remained set to serve as a control. The delimiting traps were checked on a weekly basis with lures (increased to 100µg concentration in 2016) replaced every other week to maximize pheromone efficiency and thus improve detection sensitivity.

The temporal and spatial distribution of sweetpotato weevils utilizing the delimiting grid was consistent with the results of the detection grid—SPW began to slowly become active in the spring, with a population explosion in August that peaked in October (Table 1; Figure 9). A total of 3,834 weevils were caught in 2016 with 97% (n=3,715) of the weevils collected in Brunswick County and the remaining 3% (n=119) collected in New Hanover County. Of the 339 traps set in the delimiting grid, only 93 traps caught weevils. Five traps (all in Brunswick County) were responsible for 33% of the total weevils captured in 2016. Those five traps correspond with the largest population clusters in Brunswick County (Figures 5 & 8) and with the largest concentration of host material in the area (discussed further below).

The delimiting grid traps corresponding to New Hanover LDCs 2, 3, 5, 7, & 8 and Brunswick LDCs 4 & 5 were all negative for the entire duration of 2016 suggesting that those clusters were a result of drift via wind rather than established populations. Results of trap checks during the first half of 2017 remained consistent with the previous year's temporal and spatial distribution results (Figure 10). Notably, 2017 was the first year we were able to collect data in January and trap catch results showed the weevils experienced a brief spike in population. Since this was the only year of the project we have been able to collect data for the month of January, we are not certain if this was an unusual population spike or something that happens annually. Despite this phase of the project ending, we will continue to monitor the weevil populations as we move forward with our plans for eradication.

Density, abundance, and presence of host species, specifically morning glory, (Ipomoea spp. L.; Convulvulaceae), were determined through visual surveys in the SPWQ. There are 11 species of morning glory known to occur in Brunswick and New Hanover counties and of those 11, three species were found in abundance in the SPWQ, Ipomoea cordatotriloba, I. imperati, and I. sagittata (Figure 11). Of those species, I. imperati is the most noteworthy as it is strongly associated with the large SPW population clusters detected in Caswell Beach. I. imperati is a rare, typically evergreen species of morning glory and is only found in small pockets along the coast of North Carolina, including along the dunes of Caswell Beach (Figure 12). While conducting visual surveys of the host material, all but one life stage of the weevil were recovered directly from I. imperati along Caswell Beach (larva, pupa, and adult; Figure 13). We monitored the growth of I. imperati over time and found that in the summer and fall when the morning glory is at its most dense, the weevil population explodes and during the winter and spring months when the morning glory has died back, the weevil populations drop off (Figure 14). In the New Hanover portion of the SPWQ the morning glory species are deciduous which might explain why the weevil populations are significantly smaller than in Brunswick County. The information gathered from these surveys will be critical in implementing an integrated pest management and eradication plan for SPW.

- Goal established: Establish the basis for a collaborative work using sterile male weevil releases with agencies in Florida
  - Actual accomplishments: The original project leader reached out to multiple agencies to initiate a collaborative effort to rear and sterilize male sweetpotato weevils but was unfortunately unsuccessful. He was unable to find a facility to mass rear the male weevils and the sterile insect technique work proposed turned out to come with exorbitantly high production costs and unrealistic time requirements. This objective was ultimately abandoned, however, an alternative method of eradication was proposed for Phase 2, which has been approved, and we hope to have success moving forward.

- Goal established: Raise awareness of the importance of eradicating sweetpotato weevils in North Carolina through outreach in the NC-SPWQ area
  - Actual accomplishments: We conducted outreach through various methods in the NC sweetpotato weevil quarantine area. In February 2015, informative door hangers were placed on homes throughout the NC-SPWQ areas of Carolina/Kure & Caswell Beach communities to inform homeowners and tourists about the project, the weevil, and the importance of eradication. We worked with several news outlets to cover the project and created a new webpage on the North Carolina Department of Agriculture & Consumer Services website to provide information on the weevil, the quarantine, and the efforts to eradicate the pest from North Carolina. All of the SPW traps in the quarantine area were labeled with a QR code to direct people to the webpage. Additionally, NCDA&CS personnel regularly engaged with the community to provide information about the project and why eradicating SPW from North Carolina is important.

BENEFICIARIES

The successful eradication of sweetpotato weevil from North Carolina will directly benefit sweet potato growers and North Carolina commerce by reducing the risk of introduction of sweetpotato weevils into sweet potato production areas, lifting regulatory restrictions associated with the movement and production of sweet potatoes and reducing production costs for growers and market value for consumers. While these long-term goals have yet to be achieved, the work accomplished during this project is essential for moving forward with eradication.

The success of this project (both Phase 1 [complete] & Phase 2 [initiated January 2018]) will benefit over 400 sweet potato farmers in North Carolina—an industry with a crop value of $345 million for the state (roughly $700 million for the U.S.). The successful eradication of sweetpotato weevil from North Carolina will lead to the lifting of the SPW quarantine in the state. This will lead to potentially expanding sweet potato production areas, opening and expanding new markets, and ideally lead to an eradication program for the southeast.

LESSONS LEARNED

This project truly highlighted the importance of communication, organization, and flexibility. With the original project leader leaving mid-project, we had to work quickly to transfer leadership and ensure that nothing was overlooked during the transition. There was a steep learning curve that came with taking over leadership in the middle of a project but our team worked together to keep the project moving forward.

Having to face the reality that we would be unable to meet our objective for establishing a collaborative work effort to conduct sterile male weevil releases was disappointing, but we do not want to let that failure stop us from continuing towards our goal of eradication of the sweetpotato weevil from North Carolina. Ultimately, this project was a success and everything we learned during its course, both positive and negative, will be useful towards conducting a successful integrated pest management and eradication plan.

CONTACT PERSON

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(919) 707-3732
Phil.Wilson@ncagr.gov

ADDITIONAL INFORMATION

- Figures and tables:

Figure 1. Universal moth trap (bucket trap) used to catch sweetpotato weevil (*Cylas formicarius*) in the North Carolina sweetpotato weevil quarantined areas of New Hanover and Brunswick Counties. Each trap is baited with a 10µg male-specific SPW sex pheromone lure to attract males and a Vaportape™ insecticidal kill strip.

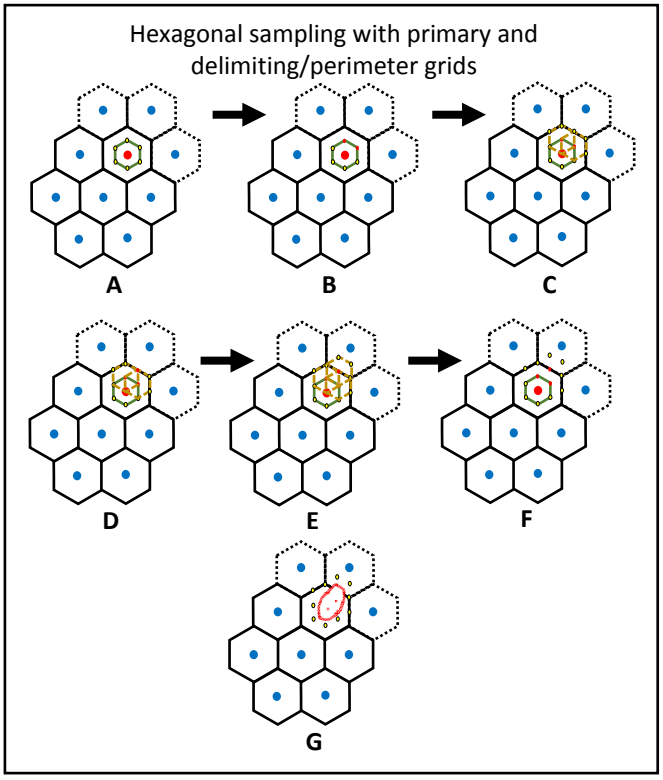


Figure 2. Hexagonal grid pattern showing primary detection grid design with delimiting grids. The hexagonal grid pattern allows for maximum pheromone lure coverage.

Figure 3. Detection grid showing A) the target circles (red circles) and the actual trap site (green dot with green label), B) population clusters in New Hanover County and C) Brunswick County, and D) a delimiting grid in the Kure Beach area of New Hanover County.

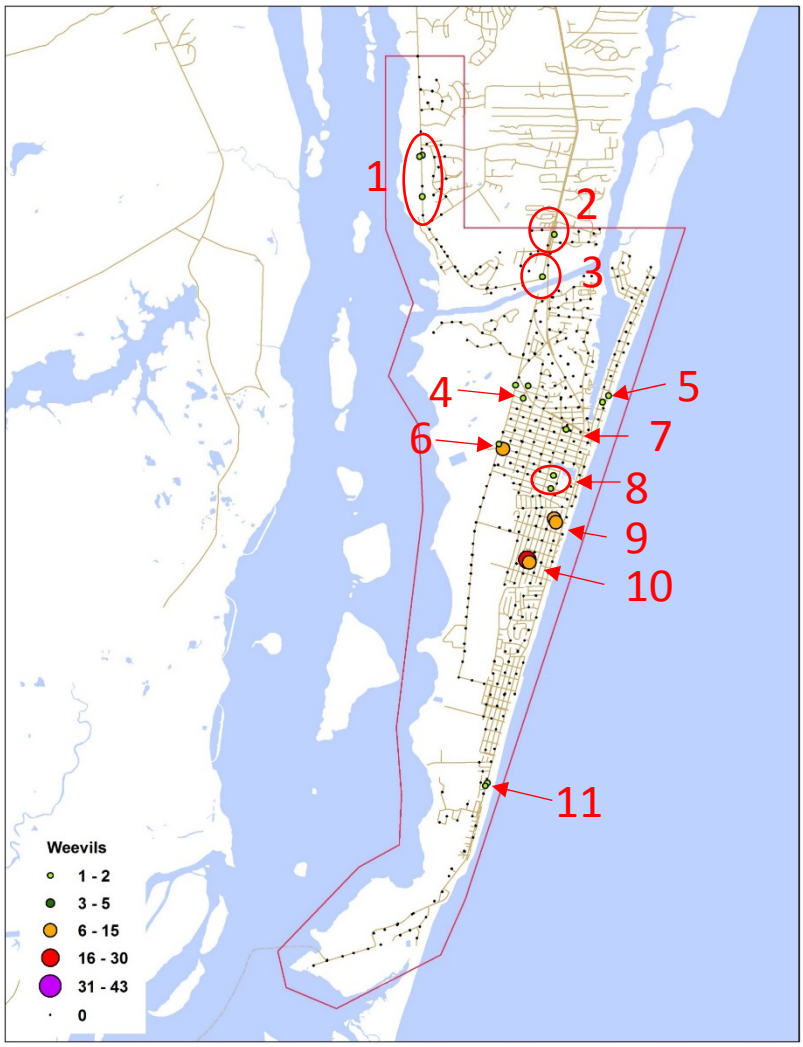


Figure 4. Sweetpotato weevil detection grid illustrating the spatial distribution of sweetpotato weevil populations in New Hanover County (11 population clusters detected from data collected February to December 2015).

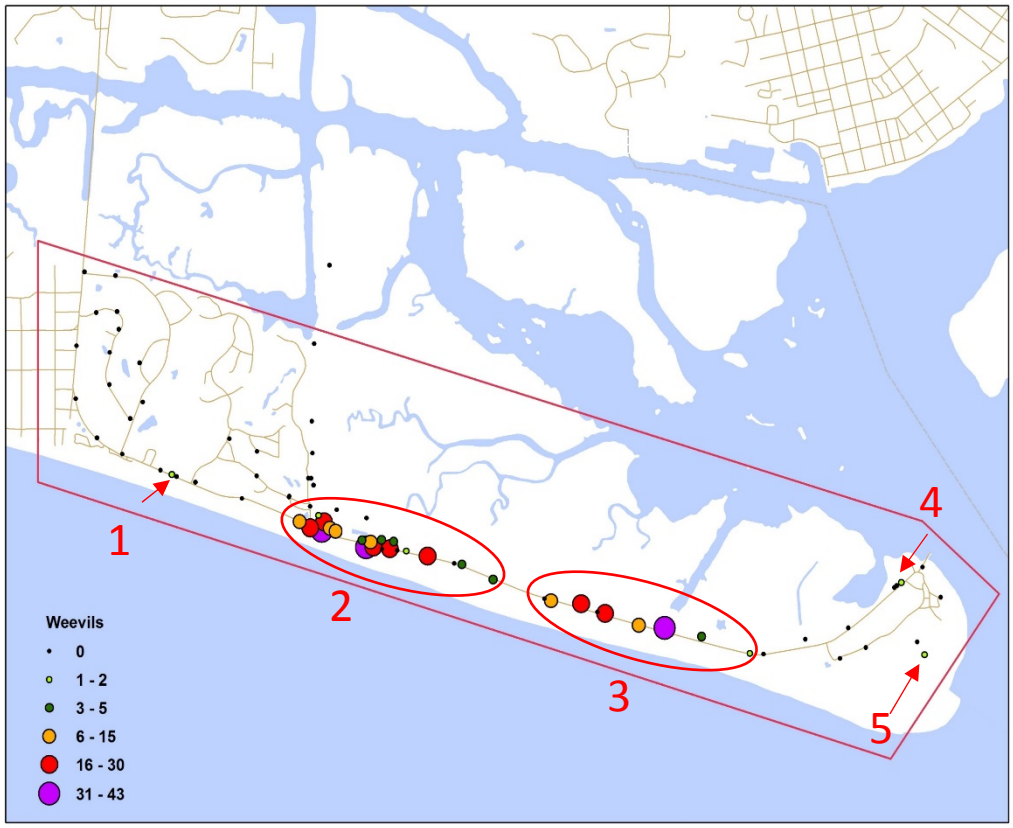


Figure 5. Sweetpotato weevil detection grid illustrating spatial distribution of SPW populations in Brunswick County (five population clusters detected from data collected February to December 2015).

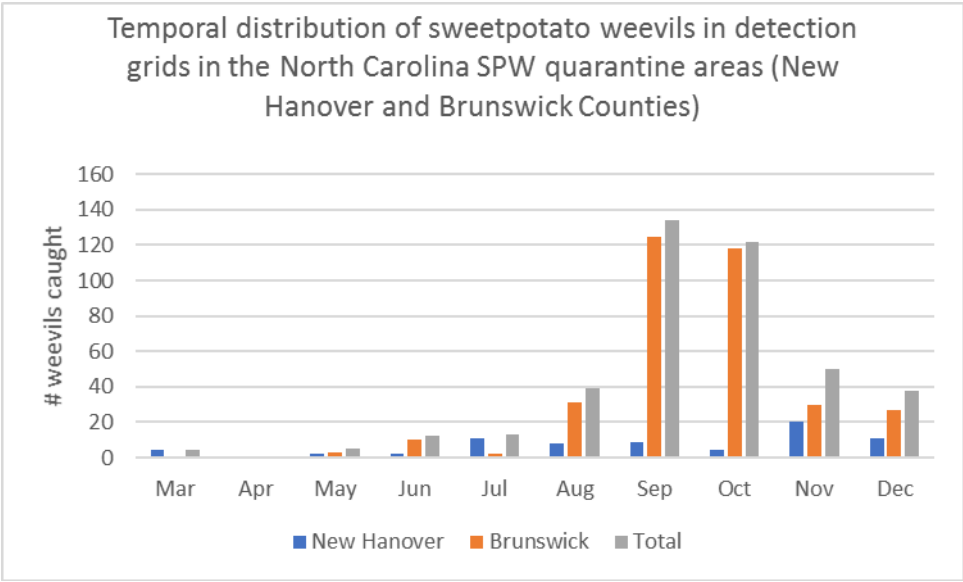


Figure 6. Temporal distribution of sweetpotato weevils in detection grids in the North Carolina SPW quarantine areas (New Hanover and Brunswick Counties) in 2015.

Table 1. Weevils collected in detection and delimiting grids in the North Carolina SPW quarantine areas (New Hanover and Brunswick Counties) from 2015-2017.

	New Hanover County	Brunswick County	Total
March 2015[a]	4	0	**4**
April 2015	1	0	**1**
May 2015	2	3	**5**
June 2015	2	10	**12**
July 2015	11	2	**13**
August 2015	8	31	**39**
September 2015	9	125	**134**
October 2015	4	118	**122**
November 2015	20	30	**50**
December 2015	11	27	**38**
February 2016[b]	3	1	**4**
March 2016	5	61	**66**
April 2016	1	33	**34**
May 2016	5	52	**57**
June 2016	18	91	**109**
July 2016	22	521	**543**
August 2016	23	924	**947**
September 2016	19	785	**804**
October 2016	10	1048	**1058**
November 2016	8	135	**143**
December 2016	5	64	**69**
January 2017	3	108	**111**
February 2017	1	17	**18**
March 2017	1	6	**7**
April 2017	0	9	**9**
May 2017	4	67	**71**
June 2017	1	121	**122**
Total	**201**	**4389**	**4590**

[a] Detection grid

[b] Delimiting grid (trap layout was changed in January 2016, thus there are no trap results for the month)

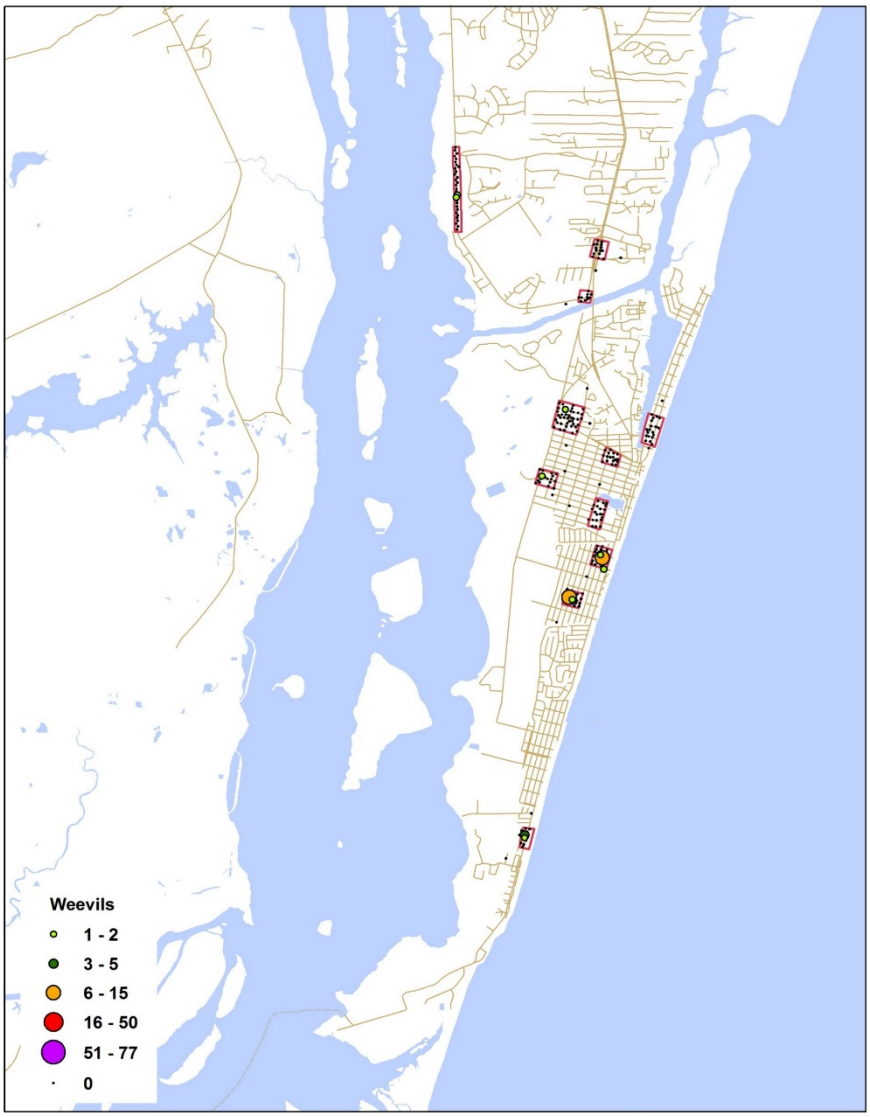


Figure 7. Sweetpotato weevil delimiting grid illustrating spatial distribution of SPW populations in New Hanover County.

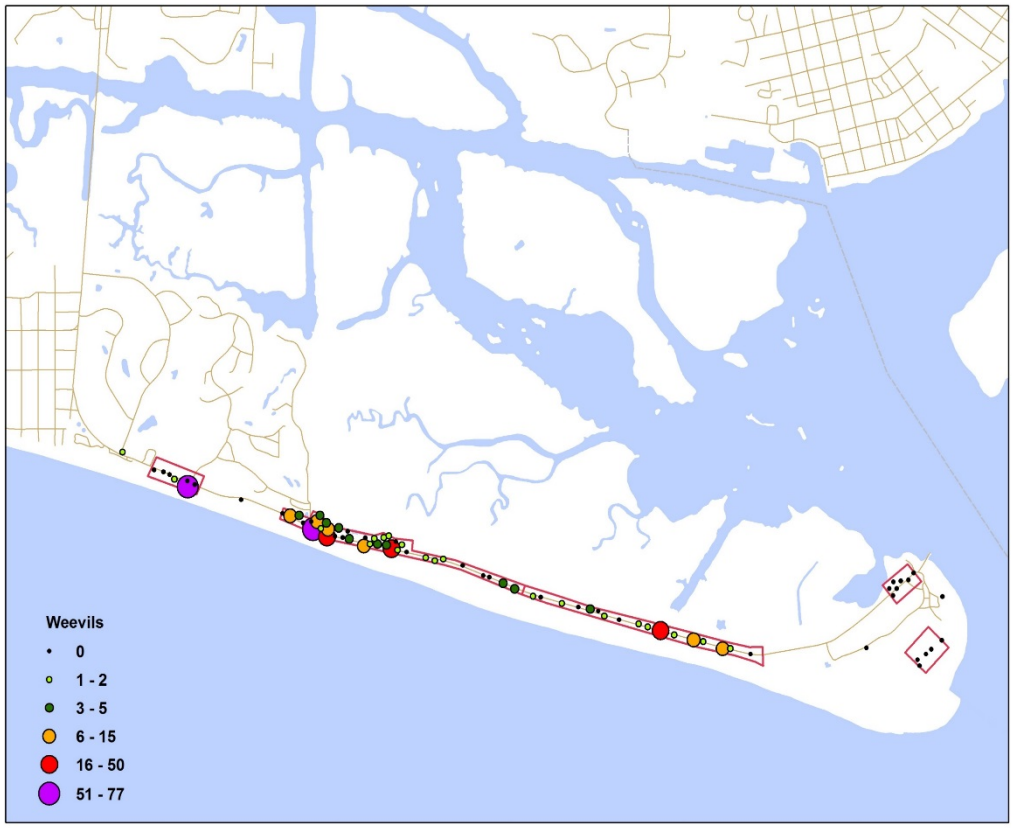


Figure 8. Sweetpotato weevil delimiting grid illustrating spatial distribution of SPW populations in Brunswick County.

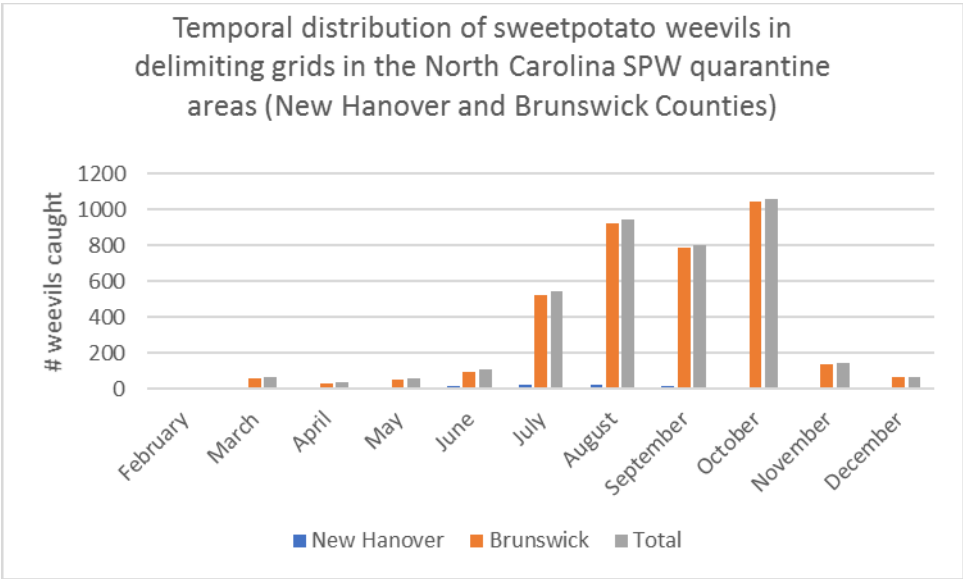


Figure 9. Temporal distribution of sweetpotato weevils in delimiting grids in the North Carolina SPW quarantine areas (New Hanover and Brunswick Counties) in 2016.

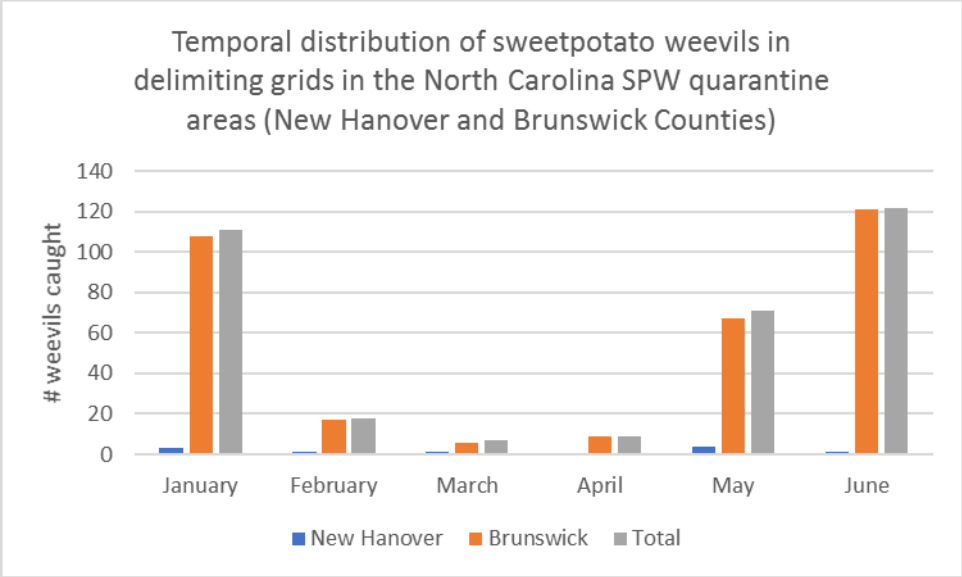


Figure 10. Temporal distribution of sweetpotato weevils in delimiting grids in the North Carolina SPW quarantine areas (New Hanover and Brunswick Counties) in 2017.

Figure 11. Three common morning glory species (*Ipomoea* L.; Convulvulaceae) identified in the sweetpotato weevil quarantined areas: a) *I. cordatotriloba*; b) *I. imperati*; c) *I. sagittata*.

Figure 12. *Ipomoea imperati* along dunes of Caswell Beach.

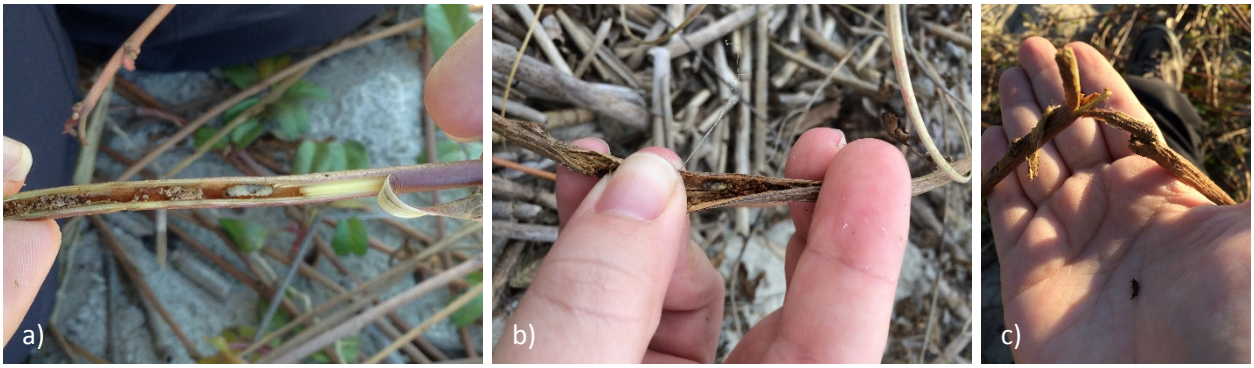


Figure 13. Sweetpotato weevil life stages found in stems of *Ipomoea imperati* along dunes of Caswell Beach: a) larva; b) pupa; c) adult

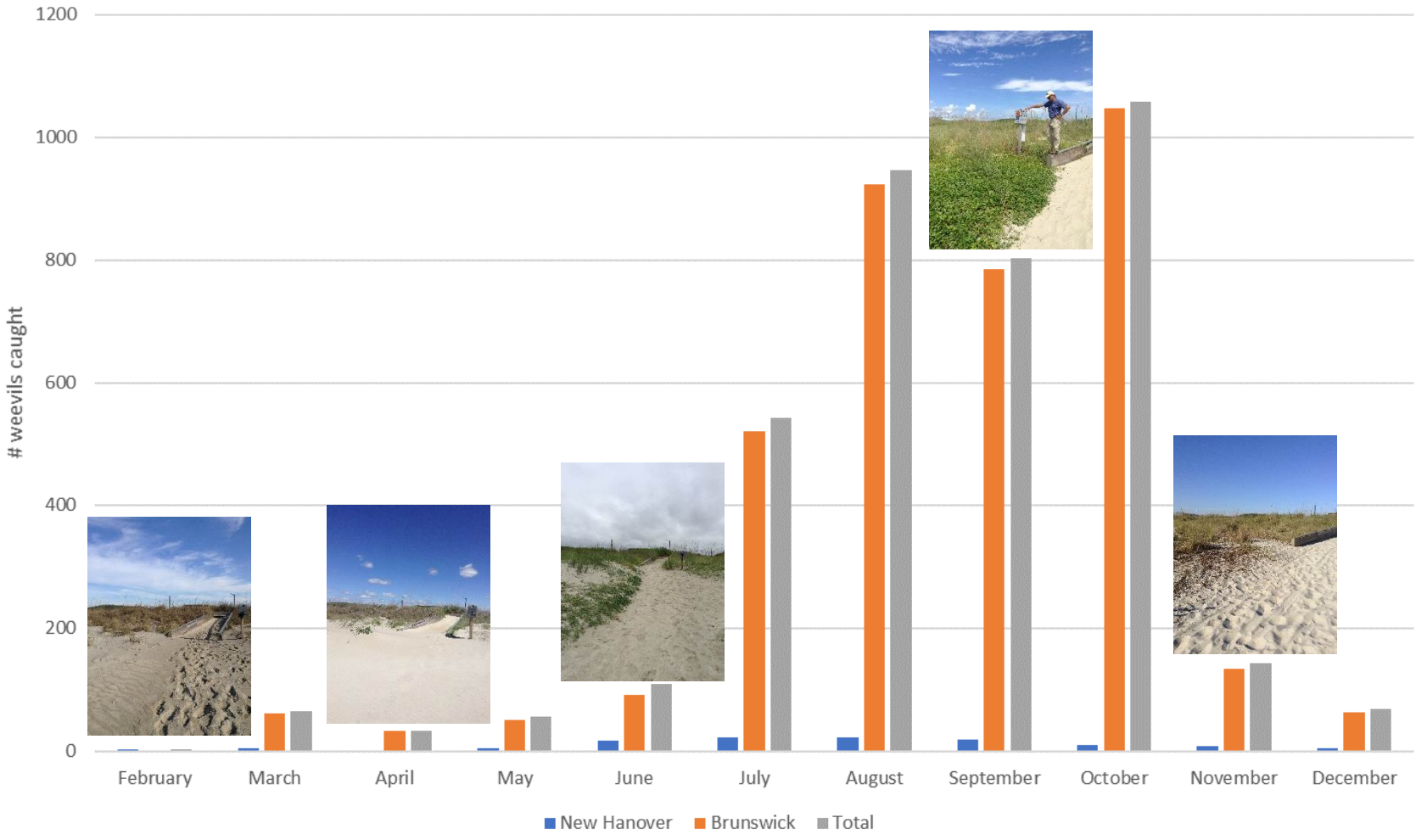


Figure 14. Presence of morning glory, *Ipomoea imperati*, compared against weevil catches by month (2016 data shown). As the morning glory becomes more abundant throughout the year, the weevil populations increase. The photos were taken at the same location throughout the year to illustrate the change in morning glory density over time.

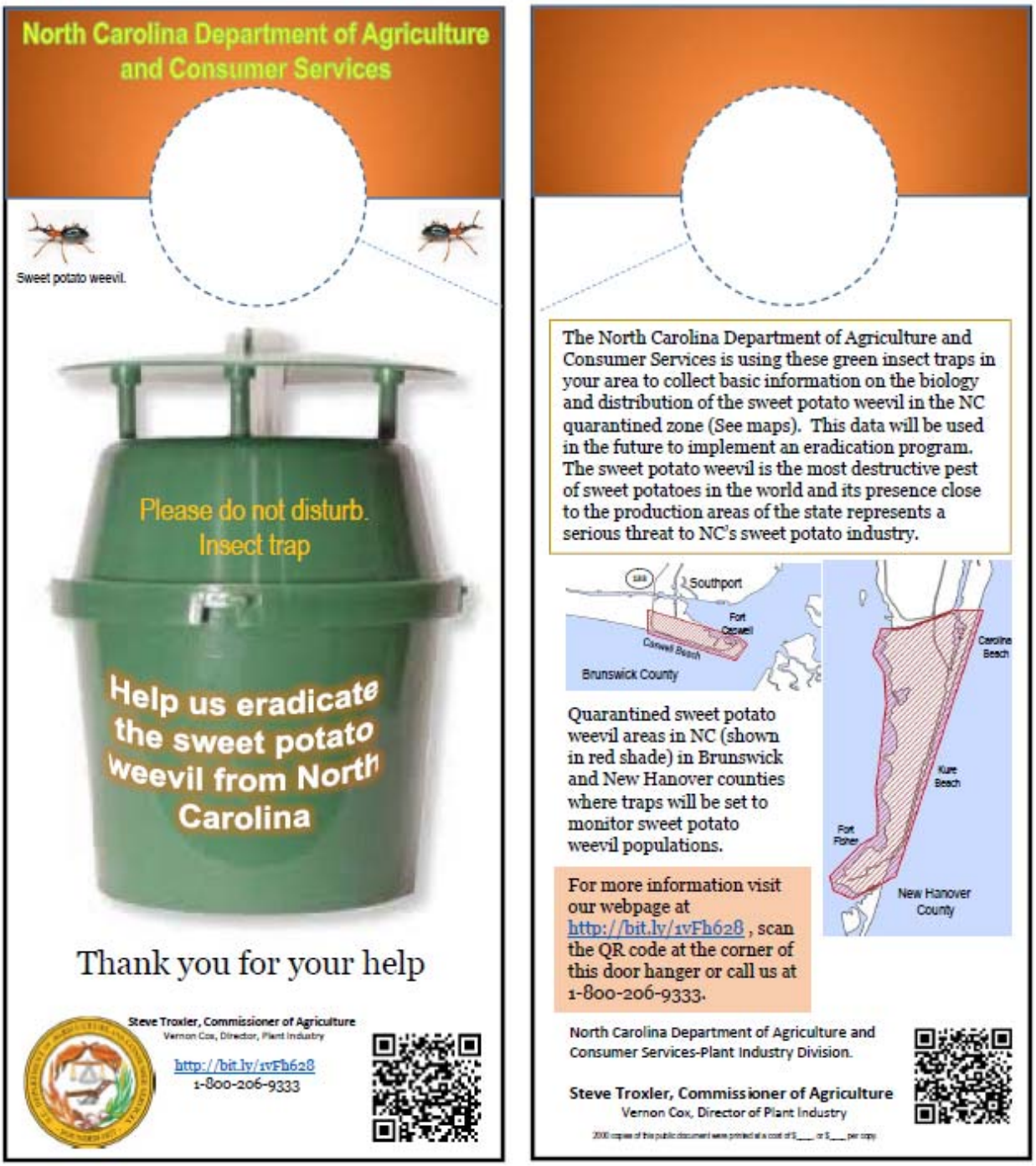
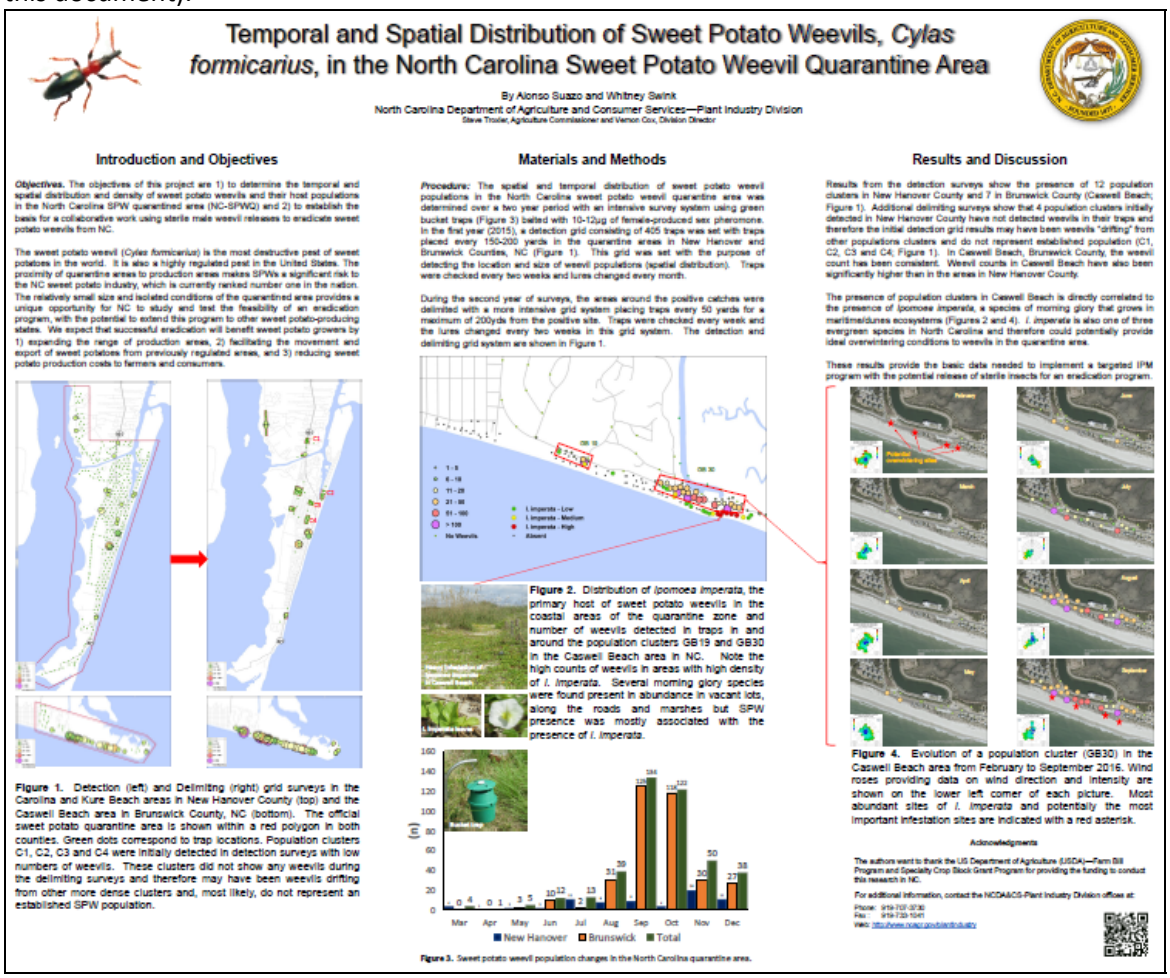


Figure 15. An example of outreach material (e.g. door hangers) developed for dissemination to the Carolina/Kure & Caswell Beach communities which summarizes the project and the ongoing NCDA&CS presence in the SPWQ.

- We created a webpage to explain the North Carolina sweetpotato weevil quarantine and the trapping conducted in the area: www.ncagr.gov/plantidustry/plant/entomology/SPW/quarantine.htm
- NCDA&CS Public Affairs published a press release highlighting the project:

http://www.ncagr.gov/paffairs/release/2015/1-15sweetpotatoweevilsurvey.htm

- The Star News Online interviewed our staff and published a news article highlighting our project: http://www.starnewsonline.com/news/20150210/officials-aim-to-protect-area-sweet-potatoes-with-weevil-survey
- We presented a project poster at the International Congress of Entomology/Annual Entomological Society of America meeting in Orlando, FL (September 2016) (shown below but sized down to fit into this document):



Temporal and Spatial Distribution of Sweet Potato Weevils, *Cylas formicarius*, in the North Carolina Sweet Potato Weevil Quarantine Area

By Alonso Suazo and Whitney Swink
North Carolina Department of Agriculture and Consumer Services—Plant Industry Division
Steve Troxler, Agriculture Commissioner and Vernon Cox, Division Director

Introduction and Objectives

Materials and Methods

Results and Discussion

- We met with the North Carolina Plant Conservation Board and Scientific Committee in Raleigh, NC (April 2017) to discuss the possibility of removing host material (e.g. *Ipomoea imperati*) from the dunes in Caswell Beach to aid in the eradication of SPW (this effort is still ongoing).

PROJECT TITLE: Turfgrass Sod Enhanced Promotional Campaign

PROJECT SUMMARY

In the years between 2005 and 2010 sod production in North Carolina decreased from 20,800 acres to 13,000 acres. That is a 37.5% reduction in sod production. The decrease is attributed to the financial collapse of 2008 and years of a stagnating economy the ensued. Through previous USDA SCBGs, the NC Sod Producers Association has been afforded the ability to successfully sustain and begin to rebuild industry production. The goal of this grant was to return production and sales to its height in 2005 and expand North Carolina sales and production by building consumer awareness of the product. Previously funded projects included the rebuild and marketing of the Association's website, ncsod.org, to create a user-friendly educational tool and sod locator for quality North Carolina Turfgrass Sod. This project took those measures one step further by working with wral.com to run a three month long campaign to promote educational materials on quality North Carolina Turfgrass Sod. These materials, directed to consumers, included the topics of soil erosion control, water quality, and property value benefits of North Carolina quality Turfgrass Sod.

PROJECT APPROACH

A survey of NC sod producers was conducted in March 2015 and in March of 2016. A marketing plan was completed and details worked out with WRAL in the summer of 2015. Fall media messages were developed and distributed along with existing videos. The WRAL Lawn Improvement Program was initiated in September of 2015. This campaign resulted in 318,800 impressions with 2,487 clicks and 207,583 page views. These results were reviewed in February of 2016 in preparation for the 2016 spring campaign.

The spring 2016 advertising portion of the campaign ran with WRAL.com February 29th through April 15, 2016. This portion of the campaign resulted in a total of 211,350 impressions of the sponsored content with 665 clicks and 7,819 page views.

In addition to the spring 2016 campaign with WRAL, per the project activity outlined in the work plan, media messages were distributed through social media and ncsod.org to coordinate with the WRAL message and beyond the end of the scheduled campaign with WRAL.

During the spring campaign, there were a total of 15 posts on the Association's Facebook page that were related to the campaign. Of those 15 posts, there was a reach of 2,399 and 160 clicks.
Since the spring campaign, and in efforts to expand social media presence utilizing the resources of information afforded to the Association through the grant, there has been a total of 16 posts in this period which allowed a reach of 3,537 and increased number of page likes by 35 people to 299 "likes".

NC Turfgrass Sod was the sole targeted specialty crop beneficiary of this grant program and there were no other contributors on this project aside from the roles played by NC Turf CENTERE to provide quality content for the campaign and WRAL.com to execute the advertising portion of the campaign.

The North Carolina Department of Agriculture and Consumer Services Marketing Division assisted project planners in developing a marketing plan and developing the video production aspect of the project to be used on their social media pages.

GOALS AND OUTCOMES ACHIEVED

A fall 2015 and spring 2016 marketing campaign were conducted to build awareness of NC sod and drive traffic to the association's website. The campaign with WRAL.com resulted in a large number of visits on their site. The fall 2015 campaign resulted in a total impression of 318,800 and 207,583 page views. The Click through rate (CTR) for this portion of the campaign averaged .78%, which is ten times higher than the industry standard. The spring portion of the campaign did not fare as well in terms of data pulled from WRAL.com. Overall, there were 211,350 impressions, 7,819 page views and a CTR of .31%. The redemption of the lowered numbers with the spring 2016 campaign is that the campaign resulted in substantially higher numbers of page views on www.ncsod.org than the fall 2015 campaign.

During the fall 2015 campaign, www.ncsod.org saw a total of **1,547 session** and a total of **1,368 users.** During spring 2016 campaign, www.ncsod.org saw a total of **3,262 sessions** (or visitors). The combined total for the campaign is **4,809 sessions** which was just shy of achieving the target goal of securing 5,000 visitors during the peak times of the campaign.

The fall campaign saw a decline of users on the website during the campaign from 1,788 sessions in the 6 weeks prior to the campaign, to 1547 sessions in the 6 weeks of the campaign, amounting to a 13% decrease in number of sessions. However in that same time frame of 2016, when there was **not** an active campaign, there was a 29% decrease in the number of sessions on the site. The spring 2016 campaign proved better numbers on the website, the six weeks prior to the start of the campaign resulted in 1356 sessions, which **increased** 241% to 3,262 sessions. During that same time period in the year prior, there was a 51% **decrease** in that time period. Upon reviewing the data, it is accurate to observe and associate a positive impact from the campaign with WRAL on to the number of visitors to www.ncsod.org. While the goal outcome was not reached, progress in achieving the goal was exhibited and the project still succeeded in substantially increasing foot traffic to the Association's website which in turn allows consumers to learn more about NC Sod and locate a supplier to purchase NC Sod.

Due to changes in Facebook policy, it has become more difficult to achieve "likes" through the purchase of an ad campaign. In effort to achieve the set goal, the Social Media plan had to be adjusted to a goal of reaching 300 "likes" by the end of 2016. We drafted and published a total of 15 posts during the 6 week campaign to build exposure. After the campaign, 16 additional posts

were made to increase “likes” further. When the project began, the Association had fewer than 150 page likes, now that the project has reached its completion, and has 299 “likes”.

All these numbers achieve one goal, and that is to build consumer awareness of NC turfgrass sod and in turn grow the industry. Based on the results of a survey conducted in early 2016, that goal has been achieved. According to the results, growers have seen an increased acreage of 16% over the past three years. A portion of this increase can be attributed to the efforts made in the fall 2015 and spring 2016 Marketing campaigns.

The goal of this campaign is to market via social and digital media. To date, digital promotions have had 1,018,439 impressions with a reach of 21,449 page views. On social media, the association has reached 72,902 people with 55,388 page views. These numbers are using less than half of the grant’s budget amount. The remaining project spending will be completed in 2018. A survey is underway to measure the increase in sales.

BENEFICIARIES

Beneficiaries include the 42 Turfgrass Sod Growers in North Carolina, countless landscapers that lay the sod and the lawn care companies that service the sod.

LESSONS LEARNED

The main take away from this project is the need for adaptability and understanding how best to reach your intended goals. When this grant was written and applied for, the policies that allowed for building “likes” on Facebook through WRAL.com was different than when it came time to execute the campaign. Since the ability to gain likes through WRAL.com changed, the focus shifted to a campaign to reach a large audience through WRAL.com and the focus on social media was secondary. In doing this refocus, the campaign reached a total of 500,000 people through the WRAL.com. In doing so, the goal of building awareness was still achieved and according to surveys, sales in the industry rose as well.

It was also learned that over the content topics posted, some specifically focused on gardening and property value, while others related sod to sports, specifically football. The article relating to football was the most popular by far of all the articles posted.

As a result of the changes in Facebook’s policy, the goal of 1,000 likes was not met, and instead reset to 300. This is a goal that the Association will continue to strive for.

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PROJECT TITLE: NC Produce Awareness Campaign

PROJECT SUMMARY

The NC produce and flower industries had a wet year before and during this project hurting crop yields subsequently, reducing available products for sale. Traditional ties with out of state wholesalers were damaged or severed for the growers due to a lack of marketable product. That damage resulted in a need to rebuild those relationships and expand the potential sales of the upcoming crops into traditional and new market areas. This project enabled growers to increase their visibility in the public eye and to wholesale buyers (both inter- and intra-state buyers were included) for the project's duration.

The project had 3 main objectives: Increase consumer awareness of the seasonality of locally grown produce, increase sales by 10% over 2 years for local growers and expand market area for specialty crops into new wholesale lines. By accomplishing these objectives this project enhanced the competitiveness of the NC produce and flower industry. It increased awareness and sales on a consumer level and thereby allowed a continuation beyond the life of this grant. Furthermore, an expansion into new markets (increase in sales in these markets) has enabled growers to expand their operations and increase in produce/flower production.

This project was not based on a previously funded project.

PROJECT APPROACH

Over the past 2 years the NC Vegetable Growers Association worked with the NC Watermelon Association, NC Greenhouse Vegetable Growers Association and the NC Flower Growers Association to develop a comprehensive and exhaustive marketing strategy to promote NC grown and produced vegetables and flowers. The strategy incorporated time-tested media and networking opportunities and modern-age venues with definitive and quantifiable metrics. The associations were represented at the Produce Marketing Association (Fresh Summit) event held in Atlanta GA in 2015 and at Orlando FL 2016. During which times there were over 5 members of the association present and all represented by a booth with contact information distributed to over 300 buyers and allied professionals in attendance.

The associations purchased media ads on a variety of print material (Our State Magazine, WNC Magazine and Triangle Gardener) reaching over 2.5 million readers over the past 2 years. They also purchased advertising on radio stations crossing the entire state, reaching a total of 9 million people over the past 2 years. Through the efforts of the association there was a substantial increase in sales for most vegetables and flowers of 5-20% over the past 2 years according to USDA ag Statistics.

GOALS AND OUTCOMES ACHIEVED

A media campaign was launched over the 2-year project with an emphasis on purchasing fresh fruits, vegetables and flowers. The campaign incorporated tv, radio, magazines ads as well as social media and networking opportunities. These events provided the following results:
The North Carolina Department of Agriculture and Consumer Services Ag Statistics report for 2016 compared the previous 5 years of vegetable and melon production. From 2012 to 2016 there has been an increase of 39.6% in cash receipts from farm marketing. These receipts are directly related to an increase in production for most fruits and vegetables and an increase in cost as a direct result of demand pressure from consumers. The project had a strong message to buy local and use NC products reaching across the state to over 9 million consumers. The added networking opportunity for growers through PMA and other outlets further increased the demand for these products.

BENEFICIARIES

This project served the vegetable, Watermelon, Greenhouse Vegetable and flower growing industry of NC. According to USDA Ag Statistics 2012 Ag Census there were 977 watermelon farms, 3283 vegetable farms, over 700 floriculture operations and 284 greenhouse vegetable operations that benefitted from this project. That does not include the subsequent hires for each operation.

LESSONS LEARNED

As with other projects this too reinforced the knowledge that one method of promotion does not effectively make a marketing strategy. By using several methods of promotion and networking in conjunction with many different associations a strategy was created that comprehensively touted the message of buying and using local products. This message resonated with both wholesale and retail buyers to create a stronger demand for the products as a whole.

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