A Statewide Crop Estimate Effort in New York State

Mario Miranda Sazo[1], Matt Wells[1], Anna Wallis[2], Dan Donahue[2], Gemma Reig[3], Craig Kahlke[1], Elizabeth Tee[1]
[1]Cornell Cooperative Extension, Lake Ontario Fruit Program
[2]Cornell Cooperative Extension, Eastern New York Commercial Horticulture Program
[3]Horticulture Section, School of Integrative Plant Science, Hudson Valley Research Laboratory, Cornell University, Highland, NY

This research was partially supported by the New York Apple Research and Development Program

The U.S. apple industry as a whole and the individual apple producing states rely on accurate pre-harvest crop estimates to successfully harvest and market each season's crop. Unfortunately, no one state has a reliable method to forecast their crops. In NY, the industry has historically relied on seasonal National Agricultural Statistics Service (NASS) publications, combined with input from industry organizations and individual growers, to estimate the state's crop. While in some seasons the industry's pre-season forecast has been relatively accurate, there have been other times when the crop picked out much larger or smaller than anticipated.

> **"The industry really does not know how many acres of apples it had in the past, has today, or will have in the future, and this lack of information will make it difficult for the industry to forecast or extrapolate crop estimates."**

It is very important that the industry report the most accurate number possible. Both under- and overestimating the crop size has negative effects on the broader industry. In the case of the 2014 crop, buyers and marketers established early season pricing at lower prices than would have otherwise been established if the crop estimate had reflected a lower and more accurate number. In the case of 2012, the poor crop was underestimated, which forced some businesses to radically adjust their marketing/sales plans, which could have been avoided with a better estimate.

New York is known for growing high quality fruit by best-in-class growers. It is important for the NY apple industry to be known for accurate crop estimates and transparency. Having a less subjective, larger data set and a sound method for estimating the crop will prevent false market pricing. It will also allow marketers to accurately portray the crop to the media and buyers. Lastly, the New York apple crop is expected to grow in volume as new acreage begins to increase in yields. Not only does the industry need to be able to determine crop changes from one year to the next, but it must be able to quantify the new volume that will bear in the future.

This project researches two types of methods for predicting crop size. The first is a field methodology that determines whether growers can sample and count apples in orchards and extrapolate crop yields. The second method researches a web-based survey platform that solicits information from all NYS growers, which is used to extrapolate a state crop forecast.

Figure 1. Using the Forshey method, all the fruits on selected branches were picked, counted, and weighed.

Methods

Fruit Count and Fruit Size Methods: Two different fruit count extrapolation methods were trialed in McIntosh orchards. One, developed by C.G. Forshey (1977), that required selecting subsamples on limbs within trees and taking measurements; and the other, a simple fruit count of entire trees. In each trial orchard, a subsample selection of five trees was made at full bloom to ensure crop load potential was uniform. The five subsample trees that were selected would be used to test each method described above.

To test Forshey's three-year research on McIntosh crop prediction, the cooperators sampled fruit size on the sample trees by selecting two branches in the lower section, two branches in the middle section, and two branches in the upper section on August 1. Selected branches were well exposed to light and were on opposite sides of the tree. Only branches 10–15 cm in circumference (or less, in many cases) were selected. During fruit sampling, all of the fruits were harvested from the point at which circumference was determined on the branch. The fruits were picked, counted, and weighed (Figure 1) (combined weight of all fruits on a branch) and the circumference of the branch was determined (Figure 2). From this information, a crop load prediction could be made based on Forshey's work. According to Forshey, *"A crop load of less than 260 gr/cm of branch circumference (as in 1976) is indicative of a light McIntosh crop and a crop load of more than 290 gr/cm of branch circumference (as in 1975) is indicative of a heavy crop."*

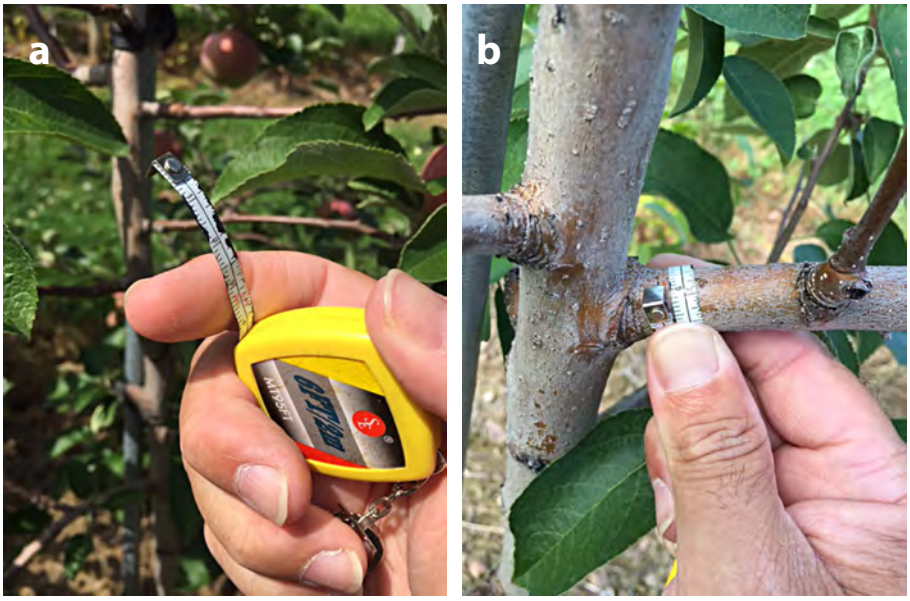

Figure 2. A tape measure (2a) was used to measure the circumference (2b) of selected branches.

To test the simple fruit count method, the researchers counted all fruit on the five representative trees and then calculated the average number of fruit per tree. Additionally, each cooperator gathered information about planting density, tree age, rootstock, and the actual 2015 yield data. With the average fruit numbers per tree, the total number of fruits per acre could be determined. Estimating fruit size at 88 and 100 counts, the bushels per acre were extrapolated.

Statewide Electronic Survey of Commercial Growers and Field Personnel Method: An on-line survey was created using the Qualtrics on-line survey platform. The survey questions were designed to gather high level information regarding the 2015 crop and allowed respondents to complete the survey in less than 10 minutes. These questions also were designed to easily aggregate all responses and be able to extrapolate the total crop potential. The questions were focused on three areas:

- **Individual Production Forecast:** Asked for actual volumes produced in 2014 and the forecast for 2015.
- **Individual Variety Projection:** Asked to describe each variety's crop potential.
- **Total State Crop Forecast:** Asked respondents to estimate the total NYS crop.

A key component was using a survey platform that allowed anonymous responses, to protect each grower's privacy. Apple growers were informed of use of the survey by Cornell Cooperative Extension publications and the Core Report. 506 NYS apple growers were mailed a survey notice on July 24. This list of growers was provided by NYS Ag & Markets via a freedom of information (FOIL) request. The survey was open for use on July 25 and closed on August 8. In addition to issuing the survey to NYS apple growers, an additional survey was created for businesses that employ field personnel who spend considerable time in orchards and would have a good perspective on the crop.

Results

Fruit Count and Fruit Size Results: The results of the Forshey predictive model were variable (Table 1). These mid-season fruit size measurements did not correlate with the results previously reported by Forshey in 1977. The results from the fruit count-yield extrapolation method are shown in Table 2. Like the Forshey method, there was variability in the results and no conclusive correlation. It should be noted that the Clarke and Staples sites both had hail events that negatively impacted yields. If those sites are discounted, and we only consider the Coy and VanStrein sites, the fruit count extrapolation method was accurate.

Statewide Electronic Survey of Commercial Growers and Field Personnel Results: The survey results were reviewed, analyzed and reported to the industry on August 14, 2015. The full report can accessed at the Lake Ontario Fruit Team website: http://cce-at-prod.hosting.cornell.edu/ccecp-prod/htdocs/rvpadmin/uploads/doc_327.pdf
The overall participation rate was 17% of the potential 509 growers (Table 3). While the response was lower than desired, the total acres represented was 19% of the state total. The survey was designed to see responses by each major apple region.

The first series of questions asked for 2014 actual production and 2015 production forecast. From these quantitative responses, the year over year change by region could be determined (Table 4). From this information, it was clear that the Hudson Valley was expecting a much larger crop, while the Western and Champlain regions were expecting similar crops each year. The second series of questions allowed for the presentation of each variety relative

Table 1: Forshey Crop Load Prediction Model vs. Actual Crop Load

Site	Evaluation Date	Trees /Acre	Rootstock	Crop Load (gr/cm of branch circumference)	Forshey Model Prediction	Actual Crop Load	Model Vs. Actual
Coy HV	Aug. 1st 2015	691	M.9	219.68	Light	Heavy	Understated
Clarke HV	Aug. 1st 2015	242	Interstem	255.9	Light	Light	Accurate
Staples WNY	Aug. 1st 2015	182	Interstem	269.11	Moderate	Moderate	Accurate
Staples WNY	Sept. 1st 2015	182	Interstem	355.77	Heavy	Moderate	Overstated
VanStrein WNY	Aug. 1st 2015	302	G.30	225.13	Light	Heavy	Understated
VanStrein WNY	Sept. 1st 2015	302	G.30	264.32	Moderate	Heavy	Understated

to each other and compared with an average crop (Figure 3). This data and chart gave a good visual representation of the crop potential by variety. The third question area asked respondents to give a crop forecast for the entire state; the distribution of the results are shown in Figure 4. While these results were subjective, it allowed growers to share their opinion on the total crop size.

These questions gave the desired information to effectively analyze and illustrate results for the final report. One piece of information that was missing or not requested was the grower's opinion on the last season's crop size. The 2014 crop as reported by NASS was 31M bushels. If this had been the case, based on the respondents either reporting larger or similar crops to a year ago, the crop would likely pick out above 30M bushels. Yet, when growers estimated the crop, the average response was between 26–27M bushels. Either the 2014 crop was smaller than NASS reported, or growers were more pessimistic in their forecast for the entire state's crop than for their own farm operation.

Table 2: Total Tree Fruit Count – Yield Extrapolation Method

Site	Trees/ Acre	Rootstock	Yield Prediction at 88 ct	Yield Prediction at 100 ct	Actual Yield (bu./ac.)	Extrapolation vs. Actual	Comments
Coy HV	691	M.9	2,180	1,980	1,940	Accurate	
Clarke HV	242	Interstem	1,060	960	500	Overstated	Hail damage
Staples WNY	182	Interstem	1,480	1,340	820	Overstated	Hail damage
VanStrein WNY	302	G.30	1,700	1,540	1,620	Accurate	

Table 3: Survey Participation Statistics

Region	Participation Count	Mailed Count	Percent Participation	Total Survey Acres	NYS Total Acres (NASS - 2011)*	Percent of Total Acres
Western	40	238	17%	6,400	26,871	24%
Champlain	2	12	17%	758	3,268	23%
Hudson	3	106	3%	470	7,744	6%
Other	8	153	5%	287	3,826	8%
Total	**53**	**509**	**10.4%**	**7,915**	**41,709**	**19%**

Table 4: Total Bushels 2015 Forecast vs. 2014 Actual

Region	2014 Actual	2015 Forecast	Year over Year Change	Percent Change
Western	4,368,912	4,337,416	(31,496)	-1%
Champlain	365,500	372,000	6,500	2%
Hudson	227,862	287,750	59,888	26%
Other	155,895	208,750	52,855	34%
Total	**5,118,169**	**5,205,916**	**87,747**	**2%**

Discussion

Harvesting, counting, and weighing all the fruit from each sample branch using the Forshey method was very time consuming. However, at a minimum, it seems that obtaining an accurate estimate of fruit size will involve measuring several fruits from the inner , mid- and outer sections of a branch located in the top, mid-section and bottom of the canopy. If we want to predict fruit size, we will have to collect good data from several orchards over several years to develop appropriate data for each cultivar. These efforts have been initiated in other apple industries around the world.

The fruit count-yield extrapolation method was also very time consuming, as it requires counting the all fruit on sample trees, but it is more accurate if a good fruit size prediction can be made in August. The tree is 3-dimensional and we can only see two dimensions, but we need to be able to see the fruit in the interior of the tree. Therefore, one area where we need additional research is in developing a method for accurately estimating number of

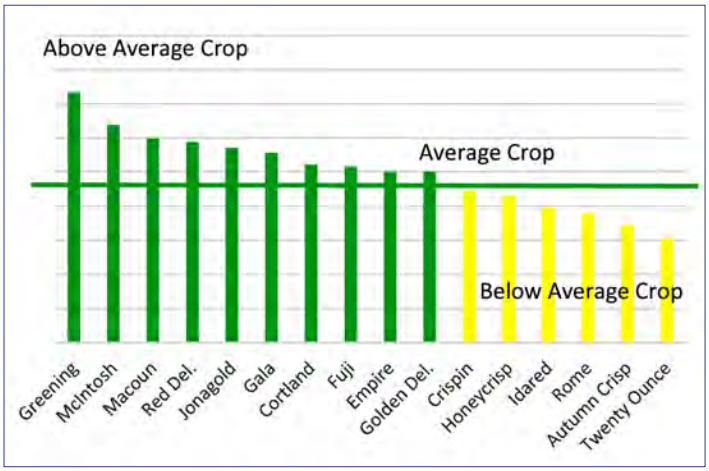

Figure 3. 2015 projections by variety.

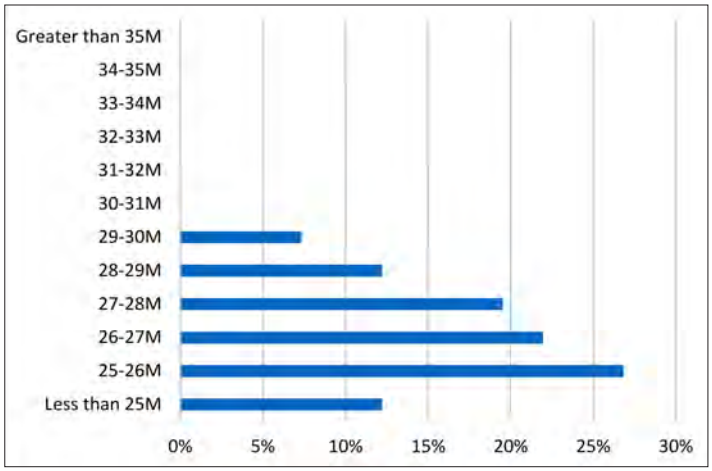

Figure 4. New York State crop projection.

fruit per tree. This effort will be easiest for high-density orchards and for those spindle orchards that are currently transitioning to fruiting walls via mechanical dormant and/or summer pruning in NY. Narrower canopies will allow us to see into the interior of the trees more easily. In addition, these types of canopies will also improve fruit size uniformity from the bottom to the top of the trees. Various machines and techniques (drones, image analysis software) will be developed for fruit counts and fruit size measurements for these types of tree canopies in the near future in Europe and the U.S.

Recent image analysis conducted at Klein-Altendorf Research Station at the University of Bonn, Germany, have shown promising results for yield predictions (Stajnko and Blanke 2011). The researchers investigated a low-cost, low-resolution image with a simple digital camera, but used high-tech image analysis and orchard data records to process the information. The image analysis software was optimized over the three years for the majority of orchards (all fully grown Braeburn, Gala, Elstar, and Golden Delicious on M.9), with best results in the 25–50 ton/ha yield range. The upper limit for the image analysis software was 200 fruit/tree. Yields larger than 50 ton/ha were underestimated, because larger fruit loads on the tree resulted in overlapping fruit segments in the images, giving an underestimation of fruit number and yield; similarly, yields lower than 25 ton/ha were overestimated.

State-wide Electronic Survey to Commercial Growers and Field Personnel Discussion: The design, implementation and reporting of the first-ever electronic statewide crop survey was very successful. However, it remains to be seen if the estimate was accurate. Based on conversations with growers and industry members, many feel the 2015 crop picked out "long", due primarily to exceptional fruit size in Western NY, and secondarily, there were more apples as a result of increasing yields from new bearing surfaces. It's possible the state's crop will be reported by NASS to be above 30M bushels. If the crop did in fact pick out long due to fruit size that was not anticipated in late July (at the time of the survey), how could this be factored into the crop survey? Additionally, like most major apple producing regions in the U.S., New York has seen an increase in high-density fresh apple plantings, some of which are replacing existing blocks, while some farms are increasing in total acreage. However, the fact is that the industry really does not know how many acres of apples it had in the past, has today, or will have in the future, and this lack of information will make it difficult for the industry to forecast or extrapolate crop estimates.

Conclusions

Two approaches were trialed as a means of estimating crops. The first was a very specific, individual orchard method, and the second was a more holistic statewide estimate method. In theory, if growers had a reliable field method, they would then be able to accurately estimate their individual crop, which would be reflected in the statewide on-line survey.

The results of the fruit count and size methods were not conclusive, nor could the methods serve as a predictive model. Both methods were time-consuming, especially on larger trees. The Forshey method did not correlate well to actual yields, and this may be due to tree size and planting systems that are much different today than when the method was developed. The fruit count method, in which all fruit is counted and used to extrapolate yields, has the potential to be accurate if fruit size can be estimated, and would require less time to conduct on very small trees in a high-density system.

A larger ground survey including the collaboration of CCE personnel with consultants and growers could be more costly and labor-intensive, and could incur some level of inaccuracy if not conducted properly. A simulation of apple yield in NY through the integration of remote sensing and ground data could increase the accuracy of the yield prediction in the future. The apple carbohydrate model (MALUSIM model developed at Cornell) simulates growth of an Empire tree by linking tree growth with maximum and minimum daily temperatures and solar radiation. A new approach with this model could take into account other factors that affect apple yield during normal and extreme weather seasons (late freeze events, low temperatures during pollination, dry summers, etc.). This new application for estimating apple yield on a regional scale (Western NY, Champlain, and/or Hudson Valley) could become a powerful tool for our NY apple industry.

The electronic survey design and implementation was a relatively simple means to collect information from every apple grower in the state. With survey design work completed in the first year, future implementation of the survey will be inexpensive and should require minimal administration. It is believed that with industry backing, more growers will participate in the future, which will improve the data set and the accuracy of the forecast in future years.

Literature Cited

Forshey, C. G. 1977. McIntosh Apple Crop Prediction Grower Sampling Instructions. New York's Food and Life Sciences Bulletin, No. 65, March 1977. 3 pp. At: https://ecommons.cornell.edu/handle/1813/5069

Stajnko, D., and M. M. Blanke. 2011. Yield prediction in fruit crops using image analysis. Proc. IXth IS on Orchard Systems. Acta Hort. 903, ISHS 2011. pp. 1115–1120.

Mario Miranda Sazo is an Extension Associate who specializes in orchard management and orchard mechanization with the Lake Ontario Fruit Program, CCE. **Matt Wells** is an Extension Support Specialist who specializes in production economics and business management with the Lake Ontario Fruit Program, CCE. **Anna Wallis** is an Extension Associate with the Eastern NY Commercial Horticulture Program, CCE. **Dan Donahue** is a Senior Extension Educator with the Eastern NY Commercial Horticulture Program, CCE. **Gemma Reig** is a Postdoctoral Research Associate at the Hudson Valley Research Lab. **Craig Kahlke** is an Extension Associate who specializes in fruit quality management with the Lake Ontario Fruit Program, CCE. **Elizabeth Tee** is the program aide for the Lake Ontario Fruit Program, CCE.

Every Farmer Needs Farm Bureau
Farm Bureau Needs Every Farmer

Join or Renew Now to Support the Fruit Growing Community

GM

Farm Bureau members are eligible for $500 off the purchase or lease of qualified 2015 and 2016 Chevrolet, Buick or GMC vehicles, from Silverado to Encore to Terrain and more!

Contact Us Today With Any Questions!
1.800.342.4143NYFB.org

FARM BUREAU NEW YORK®

EVERY FARMER

NYFB.org
1-800-342-4143

LOVES horseback riding, family time, farm-to-table meals, and payroll.

Preparing payroll may not be most people's idea of a good time, but for Farm Credit East payroll service expert Alleasa Hosmer, nothing says fun like preparing payroll. In fact, all of our payroll experts love helping our clients manage their payroll, whether you have five employees or 50, seasonal or yearly.

Sure, Alleasa's love of payroll may seem a little unusual, but when it comes to making sure that your payroll is timely and accurate, we wouldn't have it any other way — because WE ARE YOU.

Our associates love what they do. How about you? Send us your selfie at FarmCreditEast.com/WeAreYou.

FARM CREDIT EAST

800.562.2235
FarmCreditEast.com/Payroll