# A System Approach to Concord Productivity and Fruit Quality in the Lake Erie Production Region

**Report to the Lake Erie Processor Group and the New York Wine and Grape Foundation**

Terence Bates (trb7@cornell.edu), Timothy Weigle, Luke Haggerty, Kevin Martin, Andy Muza
Cornell Lake Erie Research and Extension Laboratory
6592 West Main Road. Portland, New York 14769

The Concord System project is an integrated project that investigates the effect of various aspects of environment, genetics, pests and diseases, vine growth, and vine balance on Concord production efficiency. As the project continues to move forward and develop based on previous years' findings, the activities of the project themes may seem disconnected. However, the goal of each section is to contribute to the overall goal of economically viable high production of quality fruit.

Accomplishments from 2015 activities

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| 1. Environment: | Improved mid-season crop estimation to within 5% of actual harvest yield through the use of spatial data patterns, stratified sampling, and berry weight predictions. |
| 2. Genetics: | Continued importation process for early ripening Concord type selections. |
| 3. Plant Protection: | Identification of potential barriers to adoption of eNEWA information for GBM control. |
| 4. Vine Size: | Development of research-based educational videos on topics such as Nitrogen nutrition and dormant bud damage assessment. |
| 5. Crop Size: | Mechanical shoot thinning rate response performed for future use in variable rate vineyard crop management. |
| 6. Crop Load: | Proof of concept for spatial vineyard management with a demonstrated $223/acre yield income increase by improving vineyard NDVI mean and uniformity. |

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**1. Environment: Identifying Sub-Regional Differences in Concord Production: Berry Weight**

Results from the "nine-site" pruning trial showed little difference in fruit ripening potential from site to site if vines of equal vine size (light interception) and crop size (yield) were compared. Berry weight was different based on site soil type and differences in berry weight influenced juice soluble solids concentration (i.e. large berry weight delayed Brix accumulation). Fresh berry weight is a function of both cell number largely determined by cell division during stage I berry growth and water content largely determined by cell engustment during stage III berry growth.

We are currently looking for methods to predict and control berry growth in Concord and establish test procedures. In the 2014 season, we demonstrated a spatial data driven method for improving Concord crop estimation and adjustment; however, final berry weight continues to be a difficult measurement to accurately predict. For the 2015 season, we continued using spatial soil and canopy data to stratify sampling for crop estimation procedures and validate our prediction against yield monitor maps.

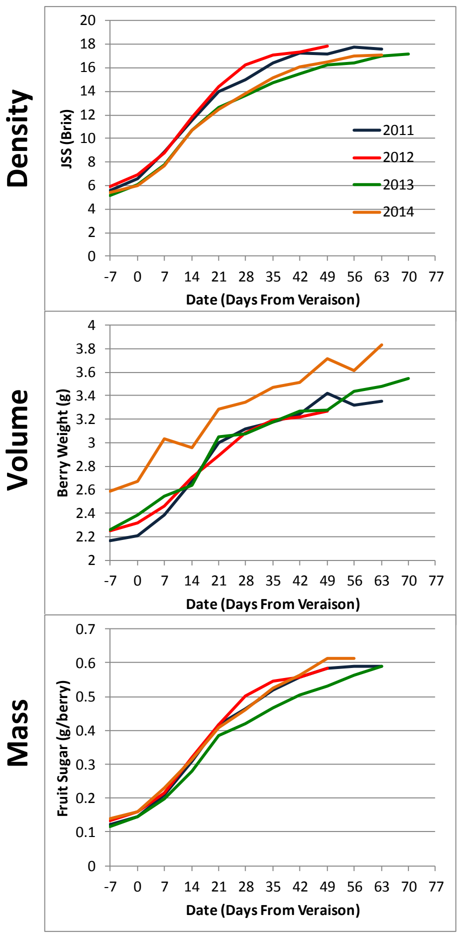


**Figure 1:** Mean Concord juice soluble solids, fresh berry weight, and berry sugar content curves from the nine-site study from 2011-2014. The three charts represent berry concentration (Brix), volume (fresh berry weight), and mass (grams of sugar per berry), respectively. The take-home message from these charts is that actual sugar production and translocation to Concord fruit is fairly consistent each year, especially in the first 3 to 4 weeks post-veraison (bottom chart). Carbohydrate production is dependent on photosynthesis from veraision to harvest which is, in turn, dependent on sunlight, canopy fill, temperature, and plant water status. In general, these factors are relatively consistent in the Lake Erie belt from year to year in healthy vineyards during ripening. The larger source of variation is in final fresh berry weight from season to season and from vineyard to vineyard and even within a vineyard. Changes in berry weight influence measured juice soluble solids (a concentration or sugar density measurement).

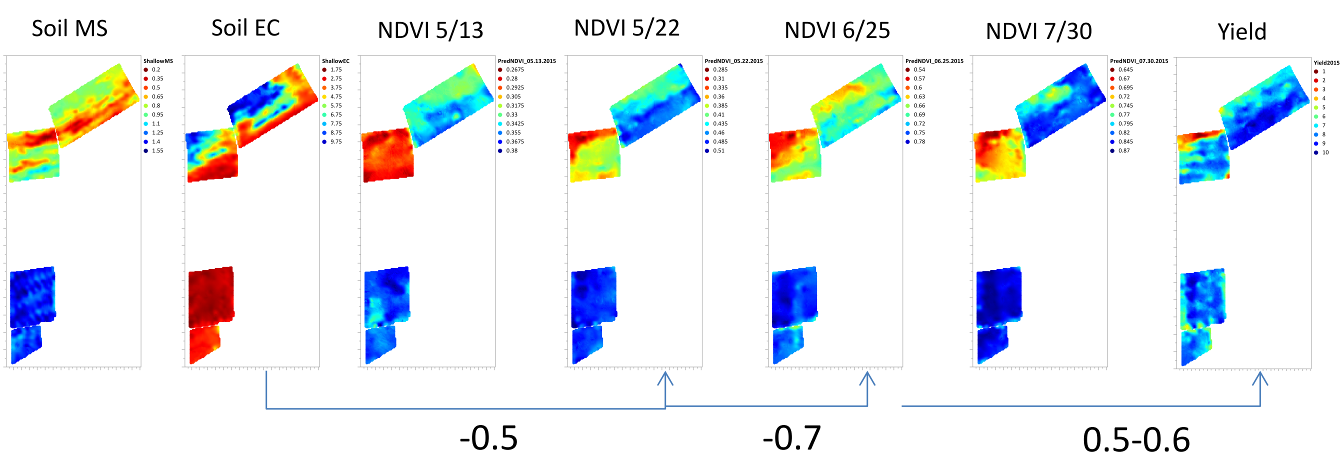


**Figure 2:** Spatial information is collected on vineyard soil (magnetic susceptibility, electrical conductivity), canopy (NDVI), and crop (grape yield monitor) and the spatial data layers are interrogated to determine relationships. In this example, there was a negative relationship between soil electrical conductivity and mid-season NDVI (numbers indicate correlation coefficients). There was also a positive relationship between NDVI and yield. The interpretation is that the heavier soils with more clay (higher EC) produced smaller vines (NDVI) with less yield.

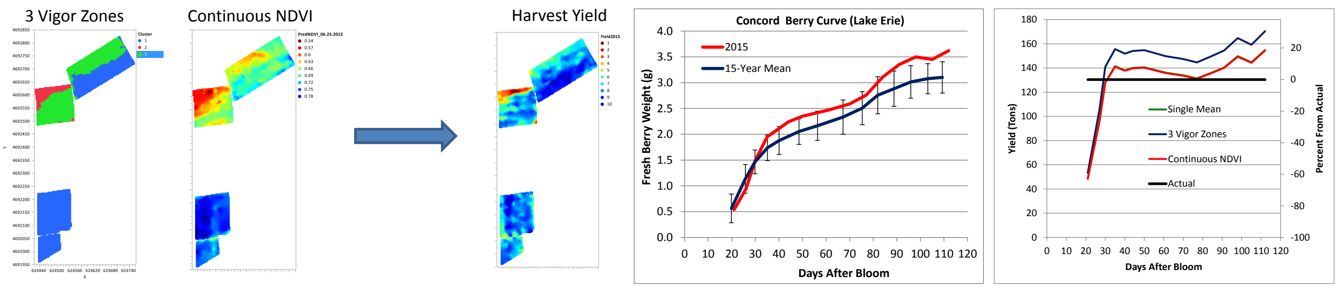


**Figure 3:** 2015 Crop Estimation Comparisons. Cluster analysis on soil and canopy spatial data was done to create 3 management classifications in the CLEREL vineyard. At 25 days after bloom, green fruit from 6-vine plots was harvested and weighed. Sample locations were stratified among the three management classifications. The relationship between green fruit weight and NDVI at the sample locations was determined. Crop estimation was then calculated based on a single vineyard mean, three vigor zones, or continuous with NDVI at multiple times throughout the season and compared to the actual harvest weight. The right chart shows the actual yield (black line) and the yield prediction from the different methods and time points. Based on the predictability in the berry curve, the best crop estimates were from 40-70 days after bloom.

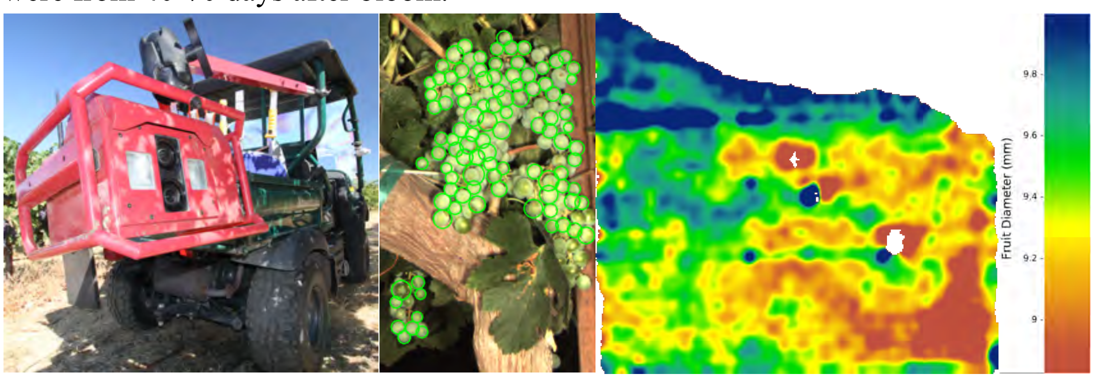


**Figure 4:** Future berry weight estimates. In cooperation with Dr. Steve Nuske (CMU) on the SCRI project, we propose to improve berry weight estimates through spatial berry image analysis. Fruit images are collected in the field (left), processed to detect berry dimensions (center), and mapped with other spatial information (left). We hope to use this information to better predict harvest berry weight across blocks and improve procedures.

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## 2. Genetics: Evaluation of Early Ripening and Color Clones of Concord

The goal of this activity is to import, propagate, and evaluate Concord clones for earlier ripening (Concord 'clone 30'), and color ('Damoth' and 'Glenfeld'). In 2012, clone 30 was imported into the U.S. from Brazil and is currently under the direction of Foundation Plant Services in California for virus testing and propagation. Damoth and Glenfeld propagation material was collected from the USDA germplasm block in Geneva and are being grown in a nursery planting at CLEREL. In addition, Bruce Reisch, Steve Luce, and Mike Colizzi have collected seven additional early ripening Concord type selections from the breeding program in Geneva. (NY36944, NY45747, NY61.0404.01, NY62.0105.04, NY62.0103.02, NY62.0105.01, NY61.0404.03). These selections will also be planted for propagation at CLEREL in 2016.

### 3. Plant Protection: Implementing Grape Forecast Models in Concord IPM

The eNEWA grape alert was started on May 19 with participants from across the Lake Erie region, as well as the other major grape growing regions of New York State. Thirty-five participants took part in the second year of beta testing in the following regions; Lake Erie (14), Finger Lakes (10), Hudson Valley (6), Long Island (4) and Northeastern NY (1). Participants received an email daily throughout the growing season, totaling 126 emails, with the last email sent on September 10, coinciding with the start of Concord harvest.

An anonymous end of season survey was completed and returned by fifteen participants using the on-line survey tool, Survey Monkey. Results were similar to the responses for the 2014 end-of-year survey. Overall, participants were very positive about their experience with the eNEWA-grape alert. When responding to the survey, participants could rate their experience as Extremely Useful, Very Useful, Useful, Somewhat Useful, or Not Useful. 93% of respondents found eNEWA-grapes to be either Extremely Useful (26.67%) or Very Useful (66.67%). Only 1 participant found eNEWA to be Not Useful. The reason behind this ranking was the user felt they did not get all the information they needed and therefore consulted the NEWA website on a regular basis, which eliminated the need for the daily email. Others mentioned that they "consulted eNEWA almost every day as part of my vineyard management planning" and "It kept me on top of changing situations".

When asked if eNEWA-grape was helpful to their Vineyard IPM Practices, all but one respondent found it Extremely Useful (33.33%), Very Useful (53.33%) or Useful (6.67%). One respondent commented "I have followed the grape berry moth (GBM) protocol for 2 years and have had nearly NO GBM damage. I heard from other vineyard managers in my area that this was a tough year." All respondents reported that the grape berry moth and disease model information was useful when making their spray decisions.

Participants were offered a chance to provide comments and constructive criticisms about the eNEWA-grape project. While the grape berry moth model information was once again mentioned as being one of the best parts of eNEWA, it also brought this comment "As the grape berry moth season winds down the GBM model says 'With the exception of extremely warm years, no further actions is required.' WELL, what should I do in extremely warm years? I would like to see further info based on the season we are having." And another comment sang the praises of the information on the NEWA website as opposed to eNEWA, "When I signed up for the alerts I assumed they would be in real time and would save me a trip to the web site. Not the case, therefore of very little value." However, overall comments were positive such as this one, "This is a very important tool on our farm for daily decisions. For spraying and watching the growing degree days for crop estimations. As our farm grows, this tool makes decisions more accurate for timing of sprays."

Input from the survey and discussions with growers during the year showed a desire for the ability to set an account using information specific to a vineyard operation that would be entered once and then saved for use in models. This would allow alerts to be sent only when action was required instead of a daily email. When asked if they would be willing to pay for this service 60% responded yes. This is up from the 36% who responded they would be willing to pay $5/month to receive the eNEWA-grapes daily email.

Grower training on the implementation of NEWA resources was conducted at the LERGP Growers conference, The Viticulture section of BEV, and at 17 Coffee Pot meetings across the Lake Erie Region.

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**4. Vine Size: Developing a Research-Based Resource for Concord Growers**

No funding was allocated to this activity in 2015. Education of past viticulture knowledge remains a priority for the industry and a summary resource is needed. After evaluating the process of updating Bulletin 111 and gathering feedback from growers, our program team has decided to create an alternative means of distributing research-based information. We are currently in the process of developing factsheets paired with video/narrations that summarizes current and past research that highlights the best viticultural practices to assess and manage Concord vine size. These resources will be available online.

In 2015, seven short videos were made and either posted to the web, distributed through crop updates, or used in conference presentations. In conjunction with the SCRI project on vineyard sensor technology, CLEREL will be hiring employees to assist with videography and web development. We will continue to produce videos and distribution of the videos will be improved as a central location is developed through web design.

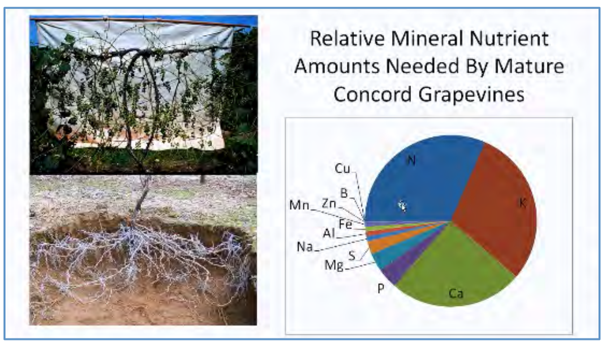



**Figure 5.** Screen shots from two videos produced in 2015. Topics included nitrogen nutrition (left), freeze damage (right), the Lake Erie AVA, the Sensor Technology Project, mechanical shoot thinning, and yield monitoring.

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**5. Crop Size: Mechanization Options for Concord Production**

A Concord vineyard mechanization trial was established in 2009 at the Cornell Lake Erie Research and Extension Laboratory in Portland, NY. The purpose of the trial was to compare the effect of mechanical pruning, shoot thinning, shoot positioning, and fruit thinning on Concord growth, yield, and profitability. Eight crop control treatments were established in a complete randomized block design with four complete blocks. The full results of that trial were reported in the 2014 progress report for this project and illustrated the potential use of mechanical shoot thinning and fruit thinning for Concord crop control.

In 2015, we performed a machine shoot thinning rate trial to determine the effect of paddle speed on the level of shoot removal and harvest yield. In a Concord vineyard, shoot thinning on 50-vine rows was performed at various paddle speeds ranging from 30-115 rotations per minute. In each row, five count vines were selected and shoots per vine were counted before and after mechanical shoot thinning to determine percent shoot removal. From 30-70 rpm paddle speed, there was a direct linear response of paddle speed to percent shoot reduction, which ranged from 9.4 to 35.7 %. Increasing paddle speed further did not result in an increase in shoot reduction (i.e. the response became saturated). Increasing paddle speed (and increasing shoot removal) also had a linear response in reducing harvest yield. Therefore, the relationship between percent shoot reduction and percent crop reduction was also linear, but it was not a 1 : 1 relationship (i.e. 30% shoot reduction did not equal 30% crop reduction). The relative yield reduction was greater than shoot reduction (slope = 1.4). One explanation for this is that mechanical shoot thinning tends to remove more shoots from the top of the canopy where the shoots are more fruitful than the ones lower in the canopy. These relationships will be used in 2016 field trials to determine paddle speed for desired crop reduction levels.

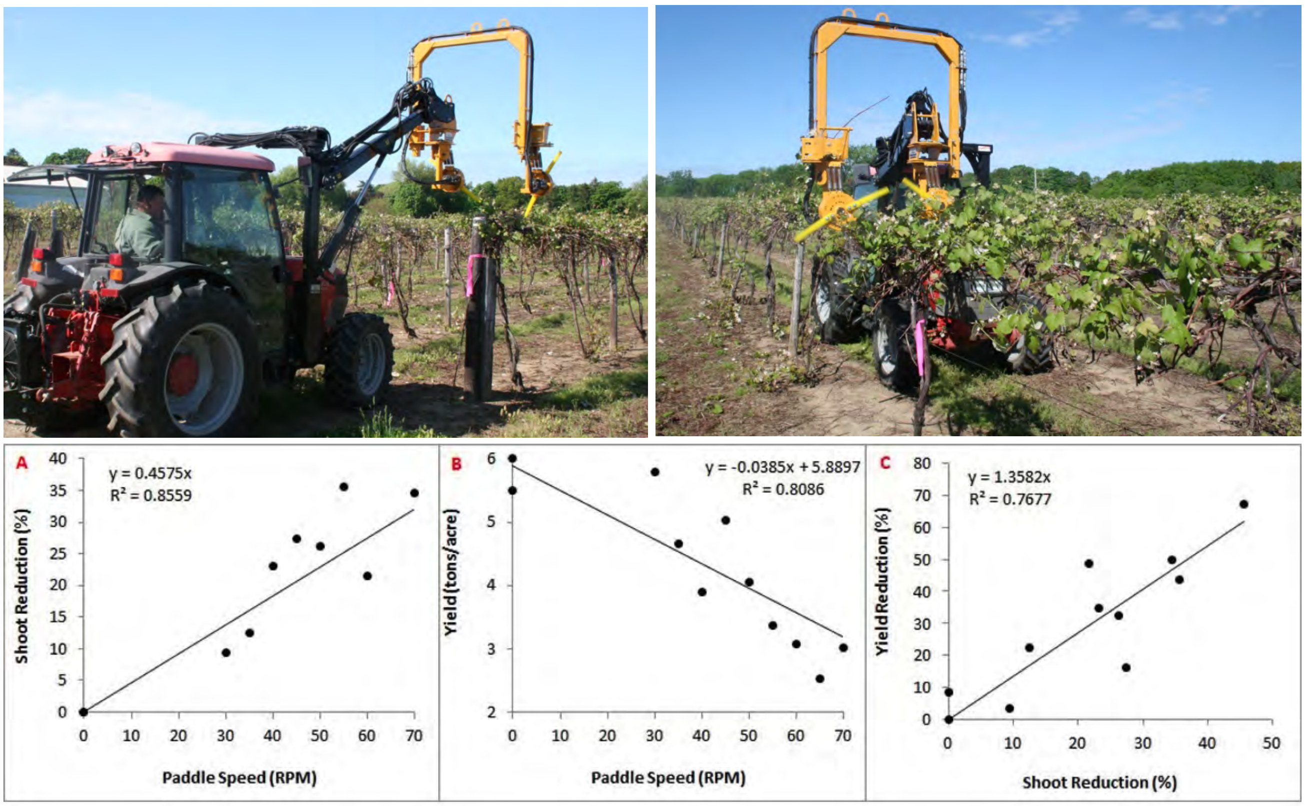


**Figure 6.** Mechanical shoot thinning rate response on Concord vines. Shoots were counted before and after mechanical thinning at various paddle speeds to determine the amount of shoots removed. This was followed-up at harvest time by recording the yield of the different treatments with a grape yield monitor.

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**6. Crop Load: Implementing GPS-Sensor Technology: Cost/Benefit analysis**:

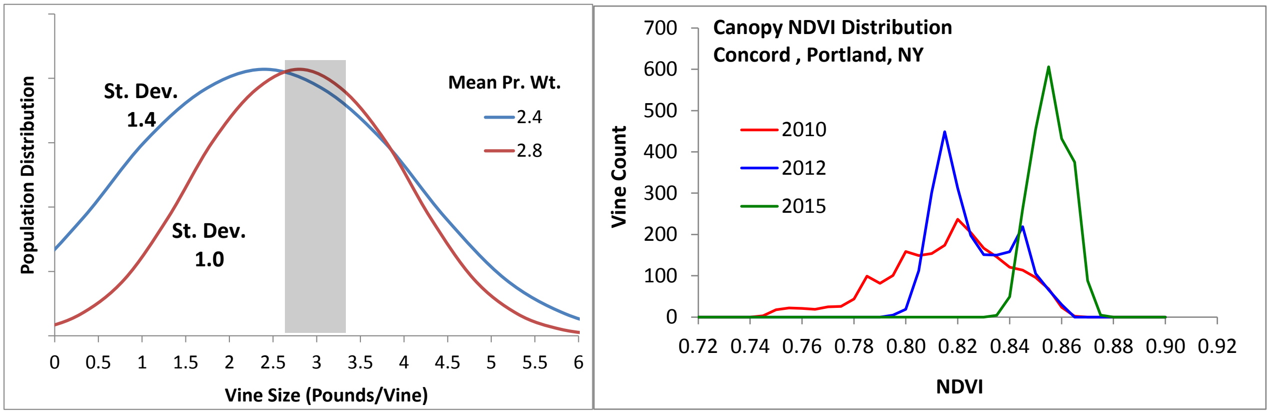


**Figure 7.** In most biological systems, measurements on large population data sets tend to fall into a normal distribution (i.e. bell shape curve). The population distributions can be described by their mean (average) and standard deviation (spread). Our goal in the sensor technology project is to identify and manage against factors causing variation in vineyard production so that we increase the mean and decrease the standard deviation of the population.


**Figure 8.** NDVI sensor measurements in a Concord vineyard at CLEREL in 2010 (left), 2012 (middle), 2015 (right). Measurements were taken mid-season with a side facing NDVI sensor and set to the same scale. The maps are a graphical representation of applying vine management to increase mean vine canopy growth and increase vineyard uniformity.

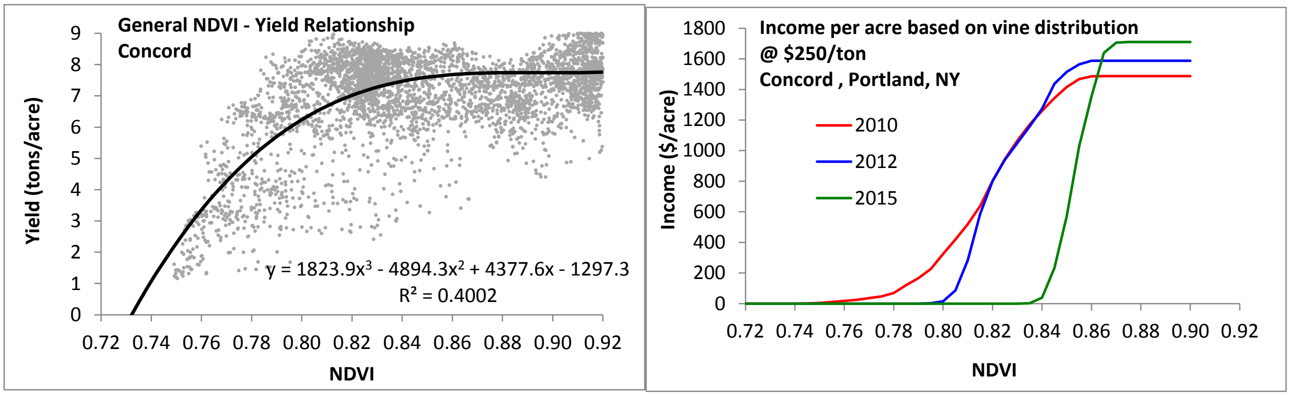


**Figure 9.** The NDVI and Yield monitor sensor data show a typical vine size-yield relationship (left) where vine productivity increases with vine leaf area but then plateaus when the alloted trellis space becomes full and light interception hits a maximum. The NDVI-Yield relationship was then applied to the three Concord population curves in the previous figure to calculate yield income per acre assuming $250/ton: 2010 = $1487/acre, 2012 = $1587/acre, 2015 = $1710/acre.

## <u>So what does this all mean?</u>

This combined project builds upon past research in viticulture and pest management to improve vine health and productivity. It is understood that larger vines with more leaf area and light interception are more productive. The vineyard sensor research shows how soil and canopy growth differs across vineyard blocks. Our research shows clear economic benfits to identifying and managing against sources of vineyard variation to make vines larger, more uniform, and more productive. Maintaining healthy vines also requires proper crop management and this requires a better understanding of crop production and crop estimation to make educated management decisions. Identifying spatial vineyard patterns has helped us improve our crop estimation proceedures and accuracy by accounting for yield components: shoots/vine, clusters/shoot, and berries/cluter. Current research focuses on understanding berry growth and how berry weight varies across vineyard blocks so we can add that factor to our crop estimation process. Our sensor data and data processing shows us patternes in vineyard soil, canopy, and crop characterisits and the next step is to manage those patterns with variable rate techniques. We have started working toward variable rate shoot thinning by looking at the response of paddle speed on shoot and yield reduction in Concord. Of course, implementing past and current research results requires outreach education to grape producers. This project looks at the implementation of eNEWA for vineyard IPM practices and the use of research-based educational videos on fundamental Concord production practices which can be posted on the web.