Project Report: Year 1 of 5 years

Improved grape and wine quality in a challenging environment:

An eastern US model for sustainability and economic vitality

Project Director: Dr.Tony Wolf, Virginia Tech

2011 (Year 1)

Cornell University

The Connecticut Agricultural Experiment Station

NC STATE UNIVERSITY

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Summary of year-1 progress

Improved grape and wine quality in a challenging environment: An eastern US model for sustainability and economic vitality

Objective 1. Develop applied means of defining and achieving vine balance under variable eastern US conditions

Progress: Field experiments were initiated in (a) the Finger Lakes of New York, (b) the Yadkin Valley of North Carolina, and (c) continued at Winchester, Virginia to research vineyard floor management practices and other techniques that could be used to more favorably affect vegetative growth of vigorous grapevines. All three experiments have common data collection measures of crop yield components, vine vegetative growth measures, and fruit chemistry, but also include data collection designed to address local concerns or considerations, including soil moisture leachate, vine ecophysiology, and resulting wine quality attributes. The specific treatments are generally applicable to the range of conditions that exist throughout the eastern United States, but are tailored to local conditions. For example, annual cover crops are used instead of perennial cover crops in the Finger Lakes, due to the need to hill and de-hill grapevine graft unions for winter protection. The Finger Lakes experiment uses Cabernet franc grapevines and was equipped in late 2010 with subsoil catchment basins to collect soil moisture to analyze for leaching nutrients and pesticides as a function of varied vineyard floor management practices. The North Carolina study, also using Cabernet franc grapevines, has varied herbicide widths under the trellis to generate a response curve of vine response to weed-free area. The Virginia experiment was in its sixth year in 2011 and explores several rootstocks, root restriction, as well as use of under-trellis cover crops to regulate vine growth. All three experiments consider the vineyard system in testing practical methods of altering vine balance – vine balance being the general vegetative performance of the vine relative to crop level, crop exposure, and ultimate wine quality. A fourth experiment was begun at Glen Manor Vineyards near Front Royal, Virginia in early 2011 to evaluate several rates and timing of two different forms of nitrogen fertilizer to Sauvignon blanc grapevines that have been grown with under-trellis cover crops for more than 5 years. This research is a linear extension of the under-trellis cover cropping work, which necessitates a more efficient means of supplying grapevines' need for fertilizer nitrogen under the competitive system of vine size suppression. An additional area of research under Objective 1 explores improved methods of assessing and quantifying canopy architecture, and putting these tools in growers' hands.

Objective 2. Develop research-based recommendations for optimally matching grape cultivars with site-specific environmental conditions

Progress: Grape variety evaluations as part of the multi-state research project, "NE-1020" were continued in 2011 in North Carolina, Maryland, Pennsylvania, New York, Ohio and Connecticut. The individual states' results and reports on these trials will form the basis of one component of a proposed Geographical Information System (GIS) designed to help users evaluate potential vineyard sites and to suggest suitable species and grape varieties that might be grown at those sites. A sub-objective of Objective 2 is the development of a sophisticated, on-line GIS application for vineyard site analysis. A prototype, eastern United States GIS was developed in 2011, and incorporates PRISM climate data, Natural Resource Conservation Service's Soil Survey Geographic (SSURGO) data, and digital topography data on a high-speed server on the Virginia Tech campus. The eastern US vineyard site evaluation tool, itself is based in part on a Virginia vineyard site evaluation tool (http://vmdev.cgit.vt.edu/Vineyards/) initiated in an earlier project, but further refined under the umbrella of this USDA/NIFA project.

Objective 3. Understand and capitalize on consumer attitudes towards eastern US wines through market exploration of consumer perception/demand, willingness to pay, and assessment of product quality-assurance programs

Progress: Activity within this objective was proposed for year 2 and beyond; however, principal investigators Rickard (Cornell) and Safley (North Carolina State University) both initiated consumer purchasing preference studies or surveys in 2011.

Objective 4. Implement a broad range of innovative learning resources to improve grape and wine quality, inform vineyard site evaluation, decrease production costs, train trainers and workforce labor, and ultimately improve the competitive basis of the eastern US wine industry

Progress: A range of activities were proposed under objective 4 and many were started or completed during the first year. Project Director Wolf convened the first annual meeting of project investigators and Project Advisory Council members in July 2011, the output of which was a review of preliminary progress and needs assessment. A baseline knowledge survey was conducted during 2011 by principal investigator Jayaratne (NCSU). The survey was circulated among 1094 industry members, 25% of whom responded. The response data will be integrated into a more detailed planning document being used by the principal investigators going into year 2 and beyond. Educational events were conducted in several of the participating states and several of the project principal investigators have also been involved with eViticulture, eXtension's national grape Community of Practice.

Background

The eastern US wine industry (defined here as eastern seaboard states from New England to north Georgia and extending west to include Pennsylvania, Ohio, Kentucky and Tennessee) has seen appreciable development over the past 20 years. The potential for further growth exists as per capita consumption of wine increases and consumers embrace locally produced foods; however, eastern US wines do not have a monopoly on wine sales. To sustain further growth, eastern US wine grapes and wines must be of consistently high quality and they must be produced on a cost-competitive basis. Two recurring features of the East's climate -- variable, but often excessive growing season precipitation, and winter cold damage -- pose significant challenges to sustainable and profitable wine grape production. Abundant soil moisture can translate to excessive vegetative vine growth with attendant increases in canopy management labor, fungal disease issues, and decreased fruit and wine quality. Cold damage reduces crop, causes additional vineyard variability, and ultimately erodes profitability.

We described these problems in our grant application (January 2010) and proposd research and extension solutions that have explicit, long-term goals of:

- more efficiently and precisely managing vine vegetative growth and vigor with the aim of promoting increased grape and wine quality, reducing canopy management labor, and reducing the use of herbicide inputs and nitrogen losses from the vineyard;
- reducing the occurrence of environmental stresses (including winter cold damage) through better cultivar and vineyard site matching tools;
- reducing costs of grape production while improving grape and wine quality;
- providing learning resources for producers, workforce development, and consumers;
- establishing a reputation for consistent, high quality grape and wine production in the East

Our vision is the creation, refinement and industry adoption of uniquely eastern US grape and wine production practices that integrate sound viticulture and enology recommendations with key market drivers to achieve a robust and sustainable eastern US wine industry. To achieve this vision we proposed specific research and extension objectives that represented a synthesis of industry *changes* that our stakeholders desired in the short-term (3-5 years). Those objectives are:

1. Develop applied means of defining and achieving vine balance under variable eastern US conditions
2. Develop research-based recommendations for optimally matching grape cultivars with site-specific environmental conditions
3. Understand and capitalize on consumer attitudes towards eastern US wines through market exploration of consumer perception/demand, willingness to pay, and assessment of product quality-assurance programs
4. Implement a broad range of innovative learning resources to improve grape and wine quality, inform vineyard site evaluation, decrease production costs, train trainers and workforce labor, and ultimately improve the competitive basis of the eastern US wine industry

Approach, progress, and future action

Objective #1a: Develop applied means of achieving vine balance under variable conditions

Team Leader: Tony K. Wolf, Virginia Tech

Issue: Variable but often surplus precipitation during the growing season frequently contributes to excess vegetative growth of grapevines. This exacerbates fungal diseases, and is associated with inferior wine quality due to fruit shading and overly vigorous grapevines that require increased canopy management labor. Conversely, drought, poor soil conditions, pest injury and occasionally other factors may constrain vine size. Optimal vine balance is achieved when the extent and duration of vegetative growth match the training/trellising system, crop level, and ultimate wine stylistic goals. The following experiments describe ongoing and proposed efforts to regulate vine vegetative growth so as to more closely achieve well balanced vines that produce high quality fruit.

Cover crops, rootstocks, and root restriction as means of optimizing vine balance (Wolf, Spayd, Merwin, Vanden Heuvel)

Specifics: Under-trellis cover crops (UTCC), low-vigor rootstocks, root restriction and other techniques are being explored in NY, VA and NC as practical means of restricting vegetative vine growth, creating more desirable canopy characteristics and, ultimately, increasing wine quality potential. While there are common goals with all three of these projects, each has unique aspects and sub-objectives, as discussed here:

Virginia experiments (PI = Wolf): A field experiment was initiated in 2006 at Virginia Tech's AHS Agricultural Research and Extension Center in Winchester, Virginia to examine a range of techniques that might restrict vegetative development of vines, either individually or in combination. The experiment uses Cabernet Sauvignon (clone #337), which exhibits a high degree of inherent vigor. The experiment was designed as a strip-split-split field plot in which main plot comparisons are (a) complete vineyard floor cover crop compared with (b) a conventional scheme of row-middle only grass combined with a 1-m under-trellis weed-free (herbicide) strip (see Figure 1). Within these main plots three rootstocks are compared as sub-plots: 101-14, 420-A, and riparia Gloire, listed in decreasing order of conferred scion vigor. The rootstock plots are further divided into three sub-sub plots that compare (a) the use of root-restriction bags (RBG), (b) the use of head-training and cane pruning, and (c) no root manipulation (NRM). The root restriction treatment was imposed by planting the vines at standard soil depth within root-restrictive fabric bags of approximately 0.16 m^3 volume. The synthetic, UV-stablized fabric bags, used primarily in the nursery industry, were successful in limiting apple tree vigor in previous studies. The head-training and cane pruning treatment reduces the volume of perennial wood (carbohydrate reserves) maintained on the vine, compared to cordon-training and spur-pruning used with all other treatments. Experimental units are 5-vine plots, and the 18 treatment combinations are replicated six times in a randomized complete block design. Drip irrigation (0.6 gal/hr in-line emitters at 1-foot intervals) is installed with separate systems for the more frequently watered RBG vines only, or for the entire set of treatments as needed. The vision for this experiment was to pursue a series of questions over a multi-year period, as:

- Can vegetative growth (and vigor) of vines be predictably regulated?
- If so, does the modification of vine growth have an impact on resultant wines?
- How would moisture availability alter the vines' response to treatment?
- Do treatments have impacts on vine longevity, nutrition, or pest resistance?

Progress: Virginia experiment (**Part A**):
Tony Wolf, Tremain Hatch, Cain Hickey

Can the aggressive use of vineyard floor cover crops, counter-balanced with available irrigation, be used to optimally adjust vine size and duration of shoot growth? (years 1-3): We pursued this initial question over the 2008 and 2009 seasons and reported that both the UTCC and RBG treatments could reduce shoot growth rate, vine canopy development and cane pruning weights (Hatch et al. 2011), as well as contribute to differences in wine quality potential, including color density (unpublished results). Wines from different treatments could be distinguished through triangle difference testing. We are scheduled to have wines more methodically evaluated as a function of field treatment by panelists at Brock University in Ontario in April 2012. The abstract from our initial publication on this work summarizes the vines' vegetative response to the field treatments:

> Root restriction and UTCC were independently effective in suppressing vegetative development as measured by rate and seasonal duration of shoot growth, lateral shoot development, trunk circumference, and dormant pruning weights. Riparia Gloire rootstock was the most effective rootstock in limiting vegetative development amongst the three evaluated; vines grafted to riparia Gloire had approximately 25% lower cane pruning weights than did vines grafted to 420-A or 101-14. Under trellis cover crop reduced cane pruning weights by 47% relative to vines grown on herbicide strips. Canopy architecture was generally improved by both UTCC and by root restriction, but generally unaffected by rootstock. Root restriction led to a greater discrimination against ^{13}C in both berries and leaf laminae tissue as measured by $\delta^{13}C$, while under-trellis floor management did not affect this parameter. The principal direct effect of the UTCC and the root-restriction treatments was a sustained reduction in stem (xylem) water potential (ψ_{stem}). Stomatal conductance (g_s) and net assimilation rate (A) were depressed by increasing water deficit, particularly for RR vines. Results suggest practical measures can be used to create a more favorable vine balance under conditions of variable rainfall, such as exist in the eastern USA.

Subsequent research conducted during the 2010 and 2011 seasons, led by graduate student Cain Hickey, has focused on the role of water status on fruit yield components and wine quality potential. Differential irrigation levels were added to some of the original experimental factors, described above, in order to create HIGH and LOW water stress conditions (fruit set to veraison) in the vineyard. Vegetative growth response data, similar to that collected in the first 2 years of the project, were again collected. Additional data were collected on berry weights and size, fruit chemistry, and fruit yield components (Table 1). Wines were made from these modified treatments in both 2010 and 2011.

Figure 1. Cabernet Sauvignon (clone 337) in vine size regulation experiment at Winchester, VA. Vines on left are grown with “conventional” floor management of interrow cover crop and intrarow (under-trellis) herbicide strip. Note the extent of lateral shoot development prior to veraison. On the same date, vines on right illustrate use of intra-row cover crop. Again, note the degree of lateral shoot development.

Components of Yield: Under-trellis cover crop (CC) significantly reduced yield (18%) in 2010, cluster weight in 2010 and 2011 (21% and 17%, respectively), and berry weight in 2010 and 2011 (9% and 4%, respectively) (Table 1).

Fruit Composition: Field treatments that resulted in small vines of high stress (RBG-HIGH + UTGC) had the lowest total titratable acidity (TA) levels and, in all cases, the under-trellis cover crop treatments resulted in less titratable acidity relative to Herb within each respective RM-Irr + UTGC treatment level (Table 2). The same trends for TA existed for malic acid (MAL) levels, with the exception of the RBG-HIGH + UTGC treatment levels, when CC resulted in slightly higher malic acid levels relative Herb (Table 2). Soluble solids (˚Brix) levels were lowest in RBG-HIGH + UTGC treatment levels in 2010 and, while less separation existed between treatment levels in 2011, the RBG-LOW + UTGC treatment levels resulted in lower ˚Brix levels relative to other RM-Irr + UTGC treatment levels. For each respective treatment level, TA and malic acid levels were higher and pH and ˚Brix levels lower in 2011 relative to 2010. Yeast-assimilable nitrogen (YAN) was typically depressed by under-trellis cover cropping (Table 2). This is not surprising given that the cover crops also depressed foliar levels of N (data not shown). This is one of the principal reasons why we initiated complementary research to explore options for more efficiently supplying fertilizer N to vines when using intrarow cover cropping.

Ecophysiology: Differential irrigation was implemented on 4-June 2010 and 13-June in 2011. The impact of treatments on vine water potential is illustrated with data from 2011 in Figure 2. "Water potential" basically means how well hydrated the vine is. The data of Figure 2 are shown in units called megaPascals (MPa), a measure of tension; the more negative the value, the more dehydrated (stressed) the vine is. Our previous results have shown that shoot growth is substantially slowed at a water potential around -0.5 to -0.6 MPa. If you look at the data of Figure 2 you can see that the treatments that included HIGH stress (less irrigation water), attained lower (more stressed) water potential readings earlier in the season that any of the other treatments. This was expected – our question was: How does this impact fruit quality and ultimately wine quality?

In both 2010 and 2011, the RBG-HIGH + UTGC treatment levels resulted in the most negative (i.e. most water stressed) average $\psi_{md,stem}$ throughout the entire season and the "low stress" treatments, RBG-LOW + UTGC and NRM-None + UTGC, resulted in average $\psi_{md,stem}$ values that were very similar to each other (Figure 2). The rebound of water potential (becoming less negative) observed in late-August 2011 reflects the rainfall that occurred with hurricane Irene.

Table 1. Factor and treatment effect on yield per vine and average cluster and berry weight, 2010 and 2011.

	Yield (kg)		Cluster weight[d] (g)		Berry weight (g)	
Factor or Treatment[a]	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
RM-Irr						
NRM-None	3.60 a	5.07 a	141 a	206 a	1.27 a	1.47 a
RBG-LOW	3.16 b	3.24 b	137 a	147 b	1.18 b	1.21 b
RBG-HIGH	2.43 c	1.91 c	96 b	97 c	0.98 c	1.18 b
RM-Irr + UTGC						
NRM-None+Herb	3.84 a	5.15 a	153 a	218 a	1.29 a	1.49 a
NRM-None+CC	3.36 ab	4.98 a	129 b	194 a	1.25 ab	1.45 a
RBG-LOW+Herb	3.35 ab	3.57 b	150 a	172 ab	1.24 abc	1.22 b
RBG-LOW+CC	2.96 b	2.91 bc	124 b	123 bc	1.12 bc	1.20 b
RBG-HIGH+Herb	2.89 b	2.00 c	114 b	102 c	1.06 cd	1.24 b
RBG-HIGH+CC	1.96 c	1.84 c	78 c	93 c	0.9 d	1.12 b
Significance[b]						
UTGC	0.0005*	ns	0.0005*	0.0104*	0.0046*	0.0398*
Stock	ns	ns	0.0304*	ns	0.0047*	ns
Stock*UTGC	ns	ns	ns	ns	ns	ns
RM-Irr	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*	<0.0001*
RM-Irr*UTGC	0.0292*	ns	ns	ns	ns	ns
RM-Irr*Stock	ns	ns	ns	ns	ns	ns
RM-Irr*UTGC*Stock	ns	ns	ns	ns	ns	ns

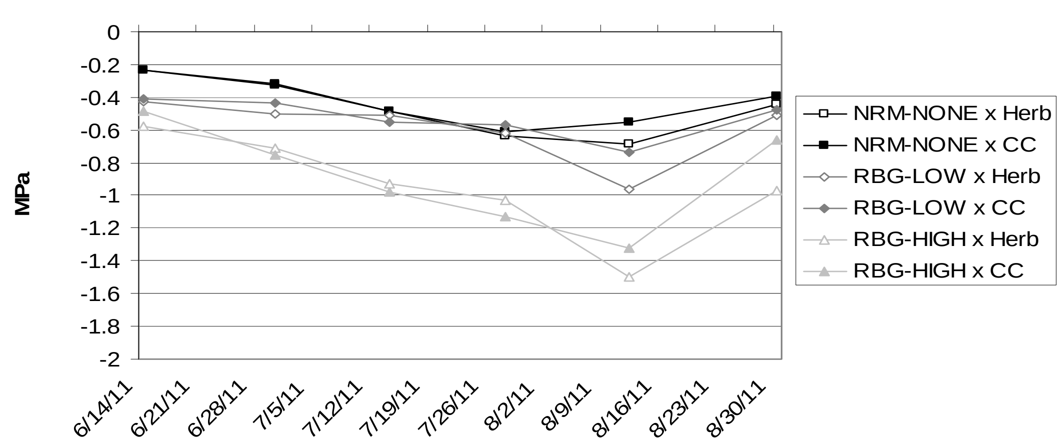
[a]Separation of means using Student's T-test (α = 0.05) for UTGC and Tukey's HSD (α = 0.05) for all others.
[b]Significance of factor and treatment effects on response variables, using mixed model REML and standard least squares with an emphasis on effect leverage (p > F; ns = not significant).
[c]Mean cluster weight was calculated using only sound clusters.

Table 2. RM-Irr + UTGC treatment level effects on fruit composition taken from juice samples from wine lots in 2010 and 2011.

Treatment[a]	Total titratable acidity (g/L)	Malic acid (g/L)	pH	Yeast assimilable nitrogen (mg/L N)	˚Brix
2010					
RBG-LOW + CC	4.28	1.37	3.79	62	26.0
RBG-LOW + Herb	5.21	1.75	3.79	73	24.8
RBG-HIGH + CC	3.86	1.23	3.89	65	23.6
RBG-HIGH + Herb	4.47	1.3	3.77	97	23.3
NRM-None + CC	4.84	2.34	3.97	69	25.3
NRM-None + Herb	5.5	2.71	3.98	85	24.9
2011					
RBG-LOW + CC	5.47	1.99	3.5	53	20.0
RBG-LOW + Herb	5.95	2.24	3.52	73	20.6
RBG-HIGH + CC	4.94	1.57	3.69	59	21.4
RBG-HIGH + Herb	5.73	1.46	3.58	80	21.2
NRM-None + CC	5.37	2.83	3.78	69	21.0
NRM-None + Herb	6.51	3.44	3.75	92	20.8

[a]In 2010, means for TA, pH and ˚Brix were derived from a total of 4 samples; all other compositional means in 2010 and all I 2011 were derived from 2 samples.

Figure 2. RM-Irr x UTGC effect on mean midday stem water potential, 2011



Just as intrarow cover crop and water status affected vine water potential, those same treatment factors also affected photosynthesis, as illustrated with the data of Figure 3. In particular, treatments that included HIGH stress (reduced irrigation) had the most consistently depressed photosynthesis rates. One goal of our work is to find a level of water stress that results in a desirable reduction in vegetative growth while minimizing the negative consequences of reducing photosynthesis rates, and possibly delaying fruit ripening.

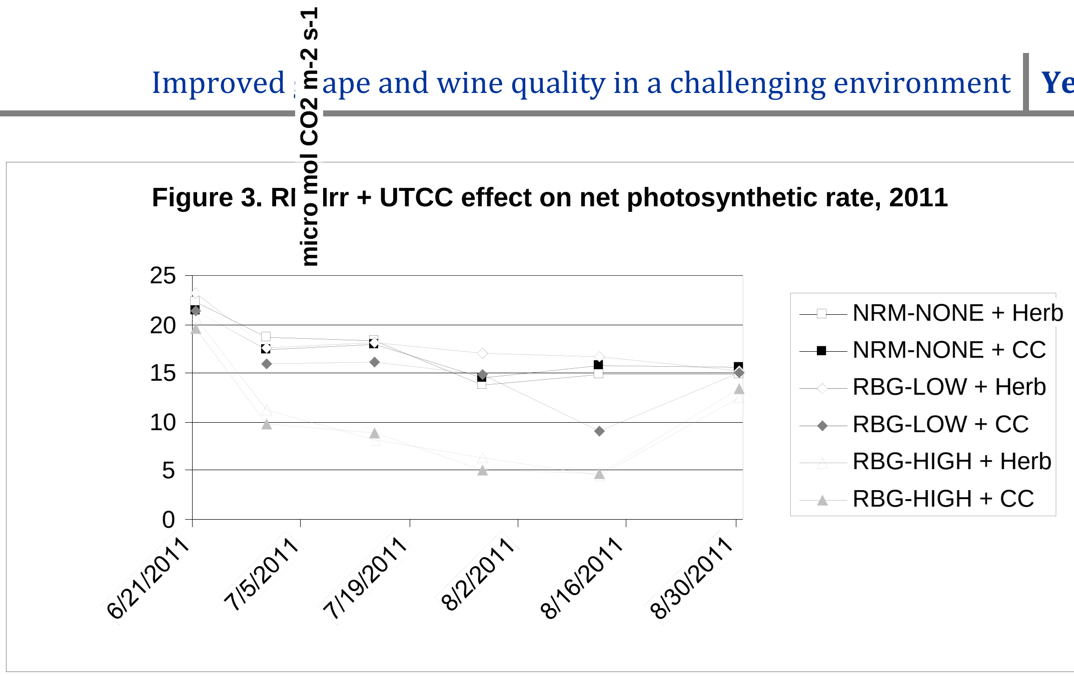


Figure 3. RBG Irr + UTCC effect on net photosynthetic rate, 2011

Triangle difference test: The initial (triangle sensory analyses) results point to treatment differences in both aroma and flavor of 2010 wines as a function of treatment (Table 3); however, more detailed, descriptive analyses are needed on the wines after further bottle aging. The most consistently and significantly distinguished sensory attribute was color, which was significantly distinguished in seven of the eight sessions, followed by flavor (six of the eight) and then aroma (three of the eight). The very first date of sensory sessions was the only session in which no sensory attributes were significantly distinguished and the second date was the only date in which only one sensory attribute was significantly distinguished (Table 3).

Table 3. Triangle difference test results for three different sesnory characteristics, 2010 vintage.

Treatment Comparison	Sig. Diff.*	Aroma	Color	Flavor
RBG-LOW + CC v. RBG-HIGH + Herb	Water status	ns	ns	ns
RBG-LOW + CC v. RBG-HIGH + CC	Both	ns	0.0030*	ns
RBG-LOW + CC v. NRM-None + Herb	Capacity	ns	<0.0001*	<0.0001*
RBG-LOW + Herb v. RBG-HIGH + CC	Both	0.0021*	<0.0001*	0.0146*
RBG-LOW + Herb v. RBG-HIGH + Herb	Water status	ns	0.0087*	0.0207*
RBG-LOW + Herb v. NRM-None + CC	ns	ns	<0.0001*	0.0033*
RBG-HIGH + CC v. NRM-None + Herb	Both	0.0007*	<0.0001*	<0.0001*
RBG-HIGH + Herb v. NRM-None + CC	Both	0.0018*	<0.0001*	0.0018*

[a]The table used to assess for significance was "Critical Number of Correct Responses in a Triangle Test" from Sensory Evaluation Techniques (Meilgaard et al. 2006).
*Significant differences in either vine capacity, water status, or both between treatment level comparisons.

Publications and presentations on this effort:

Hatch, T.A., C. C. Hickey, and T.K. Wolf. 2011. Cover crop, rootstock and root restriction regulate vegetative growth of Cabernet Sauvignon in a humid environment. Am. J. Enol. Vitic. 62:298-311.

Hickey, Cain and T.K. Wolf. "Influence of vine capacity and water status on wine quality attributes of Cabernet Sauvignon", presented at Eastern Section, ASEV meeting, Towson, MD. July 2011 (http://ajevonline.org/content/62/4/553A.full.pdf+html).

Wolf, T.K. "Cover crop, rootstock and root restriction effects on Cabernet Sauvignon dormant bud cold hardiness", presented at Eastern Section, ASEV meeting, Towson, MD. July 2011 (http://ajevonline.org/content/62/4/553A.full.pdf+html).

Future efforts:

The Winchester experiment is being continued with a comparative evaluation of head-training/cane-pruning, and cordon-training/spur-pruning followed at least through 2012-2014 seasons. We are also starting data collection in 2012 with a small project comparing different sizes of root-restriction bags in an effort to optimize the vine size response to this form of vegetative growth restriction. We still need to analyze the material and establishment costs of root restriction with root bags to determine whether annual savings in dormant pruning and summer canopy management offset the establishment costs of root restriction.

The cover crop work at Winchester VA and with student Gill Giese in Yadkin Valley NC has illustrated a potential pitfall associated with nitrogen deprivation. We aim to continue a longer-term evaluation of the cover crop plots to determine whether organic matter levels in those plots are increased over time to a point where cover crop and herbicide plots can be fertilized comparably (at modest rates of N application). We have also set up 2 separate nitrogen fertilizer studies at cooperating vineyards near Winchester (see following section, **Part B**).

Progress: Virginia experiment (**Part B**):
Efficient nitrogen fertilizer use in vineyards with under-trellis cover crops
Tremain Hatch and Tony Wolf

Issue: The aggressive use of cover crops, including under-trellis sward, has been shown to help regulate vine size and vine vigor with overly-vigorous vines in Virginia vineyards (Hatch et al., 2011). Under-trellis cover crops favorably reduce vine size therefore improving vine balance and lowering vineyard management costs. Competition between the under the trellis cover crop and vine for the same soil water and nutrients appears to be the principal mechanism behind the reduction in vine size. Under-trellis cover crops are also important in those situations (e.g., figure 4) where vineyards are being located on steep slopes in order to minimize the potential for soil erosion. The under-trellis (also called intra-row) cover crops are becoming more widely used in the Virginia industry and are either intentionally planted, or adopted as native vegetation (weeds). These companion crops, however, do have some undesirable effects. They can become over-competitive with vines for water, leading to drought stress. This can be avoided by judicious use of irrigation during dry weather to avoid water stress. Another problem encountered with the cover crops is that under-trellis cover crops can compete with the vines for essential nutrients, chiefly nitrogen (N). This research addresses growers' questions about how best to manage the competing goals of suppressing vine size with under-trellis cover crops, while minimizing the negative effects of those cover crops on vine nitrogen status. The overall goal is consistent with sustainable vineyard management practices.

Figure 4. Glen Manor vineyard illustrating steep, hillside plantings.

Objectives:

1) To reassess our tissue sampling protocol and diagnostic standards for evaluating vine nitrogen nutritional status with vigorous grapevines.
2) To determine optimal rates, materials, and timing of nitrogen fertilization in situations where companion cover crops are grown under the trellis to regulate vine growth and/or to minimize the potential for soil erosion.
3) To evaluate the influence of various nitrogen fertilization strategies on must fermentable nitrogen levels, berry color density, and other potential wine quality attributes.

Glen Manor Sauvignon blanc: This experiment evaluates different nitrogen fertilizers, rates and application methods effect on Sauvignon blanc nutrient status, leaf chlorophyll index, vine size, yield components, and fruit chemistry including 'yeast assimilable nitrogen' (YAN) in the fruit, which is important in fermentation and yeast development. Four treatments were applied to 12-year old Sauvignon blanc vines at Glen Manor Vineyards near Front Royal VA during the 2011 season. The vineyard block has been managed with an under-trellis cover crop over the past 5 years and the block has a perennial problem with low N status in the vines and in the must. The treatments were applied to 3-vine panels, each replicated 6 times in a randomized, complete block experimental design. Treatments were:

- Control: no additional nitrogen added to system
- 30 kg N/ha applied to soil at bloom (as calcium nitrate)
- 30 kg N/ha applied to soil at boom and 30 kg N/ha applied 6 weeks post bloom (as calcium nitrate) total application of 60 kg N/ha per season

- Foliar N (5kg N/ha) applied starting at bloom, 5 total applications equivalent to a total of 30 kg N/ha applied during the season (as urea at rate of 60 gal. water per acre application rate)

Treatment applications began in the 2011 growing season and will be repeated for at least 3 years.

Plant tissue analysis conducted at bloom in 2011, before the treatments were initiated, showed similar nutrient levels in the treatment vines (Table 1). A follow-up plant tissue analysis was conducted at veraison (start of final stage of fruit ripening) in late-summer, the earliest that we would expect to see treatment differences. While a statistical analysis has not yet been conducted with the data, the foliar tissue differences in N concentration between treatments were minor.

Leaf chlorophyll concentration was measured optically at veraison in 2011 and showed very small differences in chlorophyll concentration (Table 2). Chlorophyll is the green pigment in plants that is responsible for conversion of sunlight energy into chemical energy that the plant can use. Nitrogen concentration of leaves has a direct impact on chlorophyll concentration, thus our interest in monitoring this component.

Yield data were collected in late-August at the time of commercial harvest (Table 3). We do not anticipate substantial treatment effects on components of yield and would not expect to see treatment differences in the first year of treatment, in that flower buds and cluster number were determined in the previous year.

Pruning weights were collected in January 2012 and did not reveal substantial differences between treatments (Table 4) as would be expected for the first year of the project. Yeast-assimilable N levels in fruit at harvest are also shown in Table 4. These are the most interesting results of the 2011 season. Despite the minor or null results of treatment in the first year with foliar N levels, the must levels of N (YAN) appeared to respond measurably to the applied N.

Table 1 – Tissue concentration of Nitrogen in leaf blades and petioles at two growth stages.

	Nitrogen (%)			
	Bloom*		Veraison	
Treatment	Leaf Blades	Petioles	Blades	Petioles
Control	2.87	0.88	2.50	0.43
30 N Soil	.	.	2.53	0.47
2 X 30 N soil	.	.	2.59	0.48
Foliar N	.	.	2.53	0.48

*Bloom plant tissue samples were composite samples from replicate blocks

Table 2 – Leaf chlorophyll concentration index by treatment.

Treatment	Chlorophyll Concentration Index (veraison)
Control	19.5
30 N Soil	20.0
2 X 30 N soil	20.6
Foliar N	20.4

Table 3 – Yield components by treatment.

Treatment	Number of clusters	Yield per vine (kg)	Cluster weight (g)	Berry weight (g)	Berries per cluster
Control	21.4	6.1	291.0	2.0	144.3
30 N Soil	21.6	6.5	296.7	2.1	142.8
2 X 30 N soil	22.3	6.5	284.8	2.0	142.4
Foliar N	22.1	6.0	277.2	2.0	138.2

Table 4 – Cane pruning weights (2011 season) and fruit yeast-assimilable nitrogen (YAN).

Treatment	Pruning weights (grams/vine)	Yeast assimilable N (mg/L)
Control	803	119.1
30 N Soil	808	138.2
2 X 30 N soil	775	153.9
Foliar N	708	154.6

Chateau O'Brien: A second experiment was added in January 2012 at Cht. O'Brien vineyard near Markham, VA (approximately 20 miles from Winchester and within 15 miles of the Glen Manor Vineyard). Vineyard block of interest is a 9-year-old planting of Merlot planted on a relatively steep slope where intra-row cover cropping is used to suppress soil erosion and vine vigor. The block has chronically exhibited low nitrogen levels; severely in some cases. Treatments at Cht. O'Brien will be applied to 6-vine panels, replicated 5 times in a randomized, complete block design. Pruning weights were gathered by panel in February 2012, before the start of the experiment. Floor management will be standardized as permanent row middle fescue, with intra-row zones (50-85-cm wide) planted to mixed stand of red fescue and native (weed) vegetation, maintained with a hand-held line trimmer.

Treatments at Chateau O'Brien involve:

1) Control (no additional N)
2) Compost, **low** rate (roughly 30 lbs/acre of actual N total analysis)
3) Compost, **high** rate (roughly 60 lbs/acre of actual N total analysis)

4) Clover and compost, **low** rate (roughly 30 lbs/acre of actual N total analysis)
5) Clover and compost, **high** rate (roughly 60 lbs/acre of actual N total analysis)
6) Calcium nitrate, **low** rate (15 + 15 + 0) [numbers reflect pounds/acre N at one of 3 points in time: early-season + mid-season + post-harvest]
7) Calcium nitrate, **high** rate (30 + 30 + 0)
8) Calcium nitrate, **low** rate, applied post-harvest (0 + 0 + 30)

Treatments will commence (or be repeated) at bloom-time in 2012 and will be repeated each year for a minimum of three consecutive years during which time the following data will be collected:

- bloom-time (prior to N application) and veraison leaf petiole and leaf blade total N concentrations (this will allow a comparison of tissue type for assessing N status)
- soil (0 - 60 cm depth) nitrate-N at bud-break, fruit set, veraison, and one month post-harvest (soil nitrate-N with nitrate-specific electrode) (this will allow an assessment of how much mineralization of organic N is occurring and how much is present – and potentially leachable – in the fall)
- cane pruning weights collected each winter
- crop components of yield (berry wt., cluster wt., clusters per vine, crop wt. per vine, etc.)
- grape primary chemistry and YANC at harvest
- chlorophyll index of leaf samples at fruit set, veraison, and harvest (measured with Minolta SPAD 502DL chlorophyll meter, calibrated against adequately fertilized set of vines in each vineyard)

Outcomes and Benefits Expected:
We were interested to see that vine responses to applied N were observed within the first year (Glen Manor) in terms of impacting yeast fermentable nitrogen in harvested grapes. Registering increased nitrogen reserves in the grapevine, as assessed by tissue analysis, may take 2 or more years. Three or more years of data collection would be necessary before conclusions can be made about the most efficient timing and rate of applied nitrogen. Total rates of N may be adjusted up or down depending on measured responses; however, we would tentatively aim to maintain leaf petiole total N at or above 0.90% N through veraison, and must levels of YANC at or above 150 mg/L, but avoid having soil nitrate-N levels in excess of 20 kg/ha 30 days after harvest. This last point relates to our desire to avoid a pool of unused, potentially leachable, nitrates in the soil profile during the dormant period.

Progress: New York experiment (Merwin, Vanden Heuvel, Mansfield):

Vineyard floor management studies in Virginia (described above), California (Ingels et al. 2005; King and Berry, 2005), France (Celette et al., 2009) and Germany (Rupp, 1996) have shown that cover crops can be used to optimize vine balance, soil water status and nitrogen availability and retention in vineyards. A complicating factor in New York is the threat of cold damage during winter. Most NY vinifera growers hill soil up around the vines in early winter to protect the scion graft union from mid-winter cold damage. Hilling up operations require that soil be friable and cover crops be reestablished annually beneath the vine row. Our proposed cover crop strategies were devised to meet these vineyard management criteria, while providing soil protection to minimize erosion and agrochemical runoff. The vine-row cover crops represent three different levels of groundcover biomass and nutrient or water competition that will help to moderate growth on Cabernet franc, an overly vigorous cultivar at this site.

This experiment is located in a 0.5-ha planting of 760 Cabernet franc vines (clones 1, 4 and 312) on C.3309 rootstocks that was established in 2008 at a Cornell research farm near Ithaca NY. The soil at this site is a glacial till gravelly loam, with slopes of 5 to 8% toward the lake, averaging 2.5% organic matter. The vineyard floor treatments will include two main-plot drive lane grass covers—a low-vigor fine-leaf fescue (*Festuca duriuscula*), and a vigorous tall fescue (*F. arundinacea*)—combined with three 60-cm wide vine-row sub-plot treatments [post-emergence weed suppression with glyphosate herbicide; a low-growing subclover (*Trifolium subterraneum*) cover crop; and shallow cultivation beneath vines with a side mounted Lilliston Spider rotary harrow]. There will be five replications of each main and sub-plot treatment combination, blocked across the three Cabernet franc clones. The herbicide vine-row treatment represents standard vineyard practice for NY (Weigle and Muza, 2009). The Lilliston type cultivator provides effective weed suppression with minimal penetration into the vine root zone (www.tfrec.wsu.edu/pages/orgrte/Project/323). Subclovers have been extensively tested in California vineyards; they tolerate drought and mowing, and provide N fixation with less nutrient and water competition than other clovers (Ingels et al., 1998). The subclover will be reseeded annually in April annually if it does not overwinter as seed.

Nutrient (N and P) uptake, retention, and leaching losses will be monitored by installing 15 subsoil lysimeter troughs (1.5-m long, 0.7-m wide, by 0.4-m deep HDPE plastic catchment basins) beneath existing vines *in situ* at the vineyard, as described by Landry et al. (2005). Each lysimeter will drain downslope to a sampling station located in the next vine row. Nitrogen, phosphorus, and pesticide concentrations in leachate and runoff water will be sampled bi-weekly from May to Nov. in each groundcover subplot treatment. Outflow water volumes will be monitored with datalogged tipping buckets. Water sample turbidity (to quantify sediment loss and erosion) and concentrations of recently applied fungicides and insecticides (quantified by immunoassay methods) will be measured biweekly in lysimeter water samples, using established methods as described by Merwin et al. (1996). Leachate N from lysimeters will be analyzed using automated cadmium reduction by continuous-flow colorimetry (Perstorp Analytical, Alpkem, OR), and phosphorus by the ascorbic acid method, both as described by Clesceri et al. (1998). Plant nutrient availability and vine nutrient status will be monitored by sampling 20-cm-depth soil cores and vine petioles, at bloom and veraison annually in each treatment combination, and assessing plant nutrient availability by standard soil test methods at the Cornell University Nutrient Analysis Lab. Soil water infiltration rates in each groundcover treatment will be measured in mid Sept. annually, using the sprinkler-infiltrometer method as described in Oliveira and Merwin (2001). Soil microbial respiration (as CO2 evolution, an indicator of soil biological activity) will be measured for the upper 10-cm soil profile in soil cores sampled at veraison each summer, using a sealed jar incubation method employing a 0.5M NaOH alkali CO2 trap (Alef, 1998), during six weeks of incubation for intact soil cores extracted from the vine rows. Vine growth and berry composition will be evaluated using methods similar to those described above under **General Methodology**. If fruit composition is found to differ significantly among treatments in the first year of the study, fermentations will be completed in future years from some of the treatments to determine impact on final wine quality (**Mansfield**).

Progress: Finger Lakes (NY) experiment:

To test the hypothesis that different groundcover treatments influence vine nutrient and water status, moderate vine growth and improve berry composition of Cabernet franc, four groundcover treatments were established in 1-m-wide strips beneath vine rows in an existing, high-vigor, four-year-old Cabernet franc vineyard near Cayuga Lake during May 2011. Sampling lysimeters and soil moisture dataloggers were installed. Vine petiole samples were taken at veraison, and are being analyzed at the time of reporting. Soil water infiltration was measured and soil samples were obtained and are being analyzed for microbial respiration and nutrient status. Vines were balance pruned during March 2011, and a substantial harvest is expected in October. This work is progressing as expected, and should yield a complete data set to be analyzed during the coming dormant season.

Figure 1. Cabernet franc vineyard (Lansing, NY) used in cover crop study in Finger Lakes

Figure 2. In-ground catchment buckets used to collect leachate from NY cover crop experiment.

Progress: North Carolina study
Collaborators: Katie Jennings, Wayne Mitchem, David Monks, Sara Spayd, John Havlin, Josh Heitman, Lisa Hopkins (Technician)
Graduate Student Assigned Project: Brandon Smith

Background: Preliminary research in North Carolina has demonstrated that weed competition and herbicide strip width can influence grape vine growth and yield. However, NC growers are concerned about alternate hosts for Pierce's Disease within the vineyard, so this potential threat needs to be evaluated in the context of vineyard floor management as a means of achieving a desirable vine balance. A study will be conducted in a mature Cabernet franc vineyard over a five-year period beginning in 2011. Treatments will be applied to 5-vine plots, each replicated four times. The treatment design would be a 2 x 5 factorial, with one factor being duration of weed suppression: (weed-free through June or completely weed-free through harvest), the second factor being herbicide strip width (0, 30, 60, 90, 120 cm).Treatments will commence in 2011 and will be repeated for five consecutive years during which time the following data will be collected (for all treatments): Crop components of yield, dormant pruning weights, trunk circumferance (bloom-time), grape chemistry and YAN at harvest; cover crop and weed stand, canopy density. All measurements will be performed in-house at NCSU. The weed-free cover crop treatment evaluations include: Bloom-time and veraison leaf petiole N, P, and K; soil NO3, NH4, organic matter, pH, P, and K at 15-cm intervals to 60 cm; N, P, and K of fruit at harvest; stem water potential; and soil moisture. For the 0, 60, 120 cm weed-free cover crop treatments we will evaluate the incidence of summer bunch rot diseases and Pierce's disease. These plots will also be scouted for downy mildew and powdery mildew, and if the incidence of either is >5% in control plots, the incidence and severity of these diseases will be evaluated in all plots. Just prior to harvest, fruit from a subsample of vines will be examined for incidence and severity of bunch rot diseases. All clusters within the center 1-m of each cordon on each vine will be scored. At that time all vines in each plot will be scored for the severity of Pierce's disease using a 0-5 scale. Tissue and soil nutrients will be determined by the NC Department of Agriculture Soil and Tissue Analysis Laboratory. All other analyses will be performed in-house at NCSU. All data will be subjected to analysis of variance and appropriate means tests.

Progress: Studies were initiated at RayLen Vineyards and Winery in Mocksville, North Carolina to determine the impact of varying vegetation-free in-row strip width on wine grape yield and quality. Cabernet Franc grapes were planted in 2001. Treatments included 0, 1, 2, 4, and 8 ft wide strip widths. Plots were divided into a weed-free and a weedy subplot. The weed-free subplot was maintained weed-free using a nonselective post-emergence herbicide throughout the entire time. The weeds were allowed to establish in the weedy subplots and grow July 2011 through September 2011 (harvest). Weed pressure was relatively low and visually there was little difference between the weed-free and the weedy subplots. Strip width treatments were established in March 2011 and weeds were removed with subsequent herbicide sprays (glyphosate, glufosinate, or paraquat) or hand removed as needed. Vegetative measurements including vine cross sectional area (Feb. 2011 and Feb. 2012), pre-pruning weight (Feb. 2012), and lateral counts (Feb. 2012) were determined. Fruit measurements included crop yield, individual berry weight, cluster count, pH, acidity, and Brix. Production practices for wine grapes were according to North Carolina recommendations. Experimental design was a split-plot design with 6 replications.

Figure 3. Graduate student Brandon Smith at Raylen Vineyards experimental plots.

Vegetative measurements. Number of shoots per vine did not differ between strip widths. Vines with no vegetation-free in-row strip had fewer laterals per vine and per shoot than those with an 8' vegetation-free in-row strip. Weed stand had no effect on number of shoots/vine, laterals/vine, and laterals/shoot.

Pruning weight data and trunk cross-sectional measurements are to be analyzed.

Yield. As expected in the first year there were no differences yield, cluster count or cluster weight among treatments.

Fruit quality. Although there were no differences in yield there was a difference in Brix. The greatest Brix was observed in the 0, 1, and 2 ft strip width treatments in the weed-free and weedy subplots. The least amount of Brix was observed in the 4 and 8 ft treatments.

Water and nutrient status. Soil moisture sensors were installed in July (12 plots x 5 sensors per plot, as planned). We have been logging data since that time and have replaced several sensors that failed. The 2012-13 season will represent our first full season of data collection. There is a weather station (air temp, RH, windspeed, solar radiation, rainfall) on site that has been maintained since before the SCRI project was initiated. A pressure bomb and associated supplies that were turned over to Lisa for data collection. Vine water status monitoring will begin this summer as planned.

Soil samples were collected spring 2011. Petiole samples were taken at anthesis. No differences in either soil or vine nutrient status were found in 2011.

***Summary comments for Objective #1*:** Objective #1a entails several field experiments that are designed to restrict or otherwise modify vegetative growth. Expected outcomes include a strategy for predictably managing both the extent and duration of vine vegetative growth, which will directly reduce canopy management labor and have the potential to improve fruit composition and wine quality. We expect to see less soil leaching of nutrients (and certainly herbicides) with a more comprehensive use of either perennial or annual cover crops. We anticipate that meaningful responses in the nitrogen study (Virginia) will be observed within the first year of the experiments, but that up to three years of data collection may be necessary before conclusions can be made about the most efficient timing and rate of applied N. Total rates of N may be adjusted up or down depending on measured responses; however, we would tentatively aim to maintain leaf petiole total N at or above 0.90% N through veraison, and must (grape juice) levels of YAN at or above 150 mg/L, while maintaining soil nitrate-N levels below 20 kg/ha. The expected *indirect* benefits include reduced fungal disease pressure, and increased fruit and wine quality attributes. Use of perennial UTCCs (in sites that don't require hilling and de-hilling of graft unions for cold protection), will reduce the need for pre-emergent herbicide inputs. The *cost* of this strategy will include a more intensive monitoring of vine water status over the growing season (as is currently done in arid grape regions), and the desirability of having an irrigation system to minimize the potential for excessive water deficits.

Objective #1b: Develop canopy and crop management metrics to achieve consistent vine balance and canopy microclimate

***Issue**:* Research intended to improve grape quality generally tests treatment effects on fruit composition, but results are often confounded by variability in canopy density, cluster shading, or crop load. In addition, descriptions of canopy characteristics and crop load often lack the quantitative precision needed for unambiguous interpretation. We propose to further develop and apply quantitative methods for the description of canopy structure, light/temperature microclimate, and crop load to guide growers in determining optimal viticultural practices to improve fruit quality.

Experiment 1: Canopy description and development of tools for determining canopy metrics

Team Leader: Dr. Justine Vanden Heuvel, Cornell University

We recently developed a set of grower tools for use in determining descriptive canopy metrics and defining appropriate canopy architecture (Meyers and Vanden Heuvel, 2008). These tools, which easily determine the cluster and leaf exposure levels, have demonstrated that small differences in fruit exposure can impact fruit chemistry (Meyers et al., 2009). In years 1 and 2 of this study, additional field measurement and analysis tools will be developed to improve grower decision-making through a focus on four guiding principles: precision, efficiency, utility, and operational priority. Building upon Enhanced Point Quadrat Analysis (EPQA) and Exposure Mapping (EM) (Meyers & Vanden Heuvel, 2008), these new tools will expand canopy field measurements beyond the fruiting zone to better quantify light and temperature environments within whole vines. Expanded statistical analysis functionality will quantify both block-level and canopy-level variability with a minimal number of field measurements, through the use of spatially explicit sampling protocols and computational models that can be tuned for each grower's vineyard based on EPQA results. These protocols will guide growers/winemakers in selecting clusters that best represent variability within their vineyards, and instruct them on the potential consequences of measured vine variability on fruit quality and wine flavor/aroma profiles.

Progress, Experiment #1:

New approach for establishing canopy metrics. A computational model has been developed (article in press, AJEV 63:1) that helps growers to find optimal quantitative canopy architecture targets that balance competing production objectives. The article demonstrates the trade-offs between flavor development and pesticide use (individual responses shown in figure 1) when choosing a target for cluster exposure in Riesling (range of optimal metrics shown in figure 2). This model will be extended and adapted to Cab Franc production through the incorporation of the SCRI experimental data obtained from all Objective 1b experiments, additional project experiments related to other objectives, and from additional literature review as appropriate.

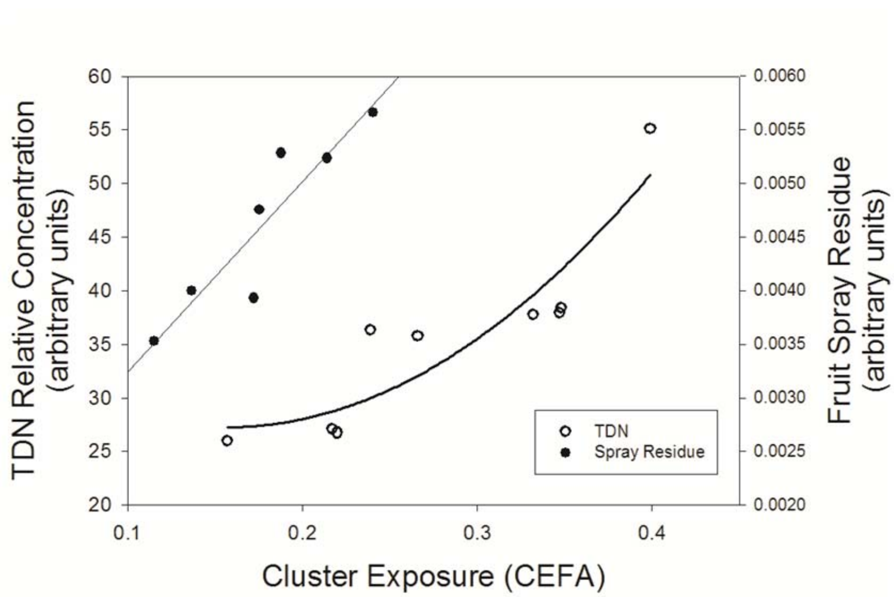


Figure 1 – Single-variable responses adapted to define the multiobjective optimization model. Cluster exposure flux availability (CEFA) vs. TDN concentration (open circle: $398.2x^2$-124.1x+36.9, R^2 = 0.83) was adapted from Meyers (PhD Thesis 2011). CEFA vs. fruit spray residue concentration (solid circle: 0.0178x + 0.0015, R^2 = 0.93) was adapted from Austin et al. (AJEV 2011).

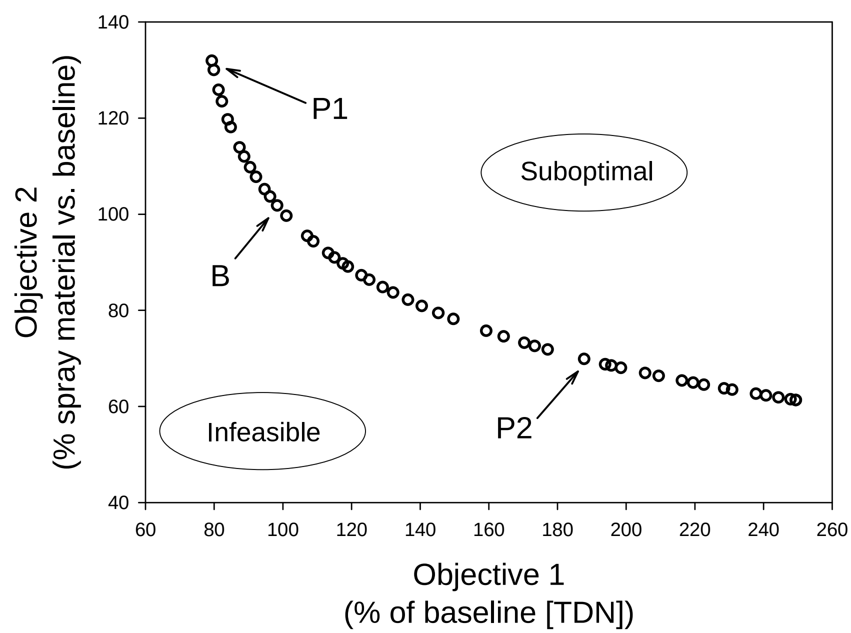


Figure 2 – Initial solutions for the two-objective optimization of TDN concentration vs. spray residue. Location 'B' represents the initial baseline (100%, 100%) as defined by the model. The arc of circles represents the Pareto-optimal solutions to the problem within the limits of the model constraints. P1 (80%, 131%) and P2 (188%, 70%) represent two optimal solutions for consideration, one with favors reduced TDN potential (i.e., P1) and one that favors reduced spray product (i.e., P2).

Cluster temperature model. Software development is underway to implement the berry temperature model described by Cola, et al. (Agricultural and Forest Meteorology, 149). The model is designed to estimate hourly berry temperature by deriving cluster conditions from local weather data and vineyard conditions. The model will need to be calibrated through direct measurement of cluster temperatures. As such, the internal cluster temperature of 10 Cabernet Franc clusters were monitored at 30 minute intervals during the 2011 growing season via thermocouple in a research vineyard at the Geneva experiment station. In addition, similar data from 2009 and 2010 has been obtained (using Riesling clusters from the same experimental vineyard block used in 2011). These data sets will be used in calibrating the model against local weather data collected over the same period.

Future activities.

- Complete initial implementation of berry temperature modeling software (Spring 2012)
- Identify appropriate Cabernet Franc responses for incorporation such as phenolic responses to light, temperature, and crop load (ongoing 2012-2015 per Objective 1b, experiment 2)
- Formalize the multi-objective decision models that are found to have the most potential for grower benefit and adoption (ongoing 2012-2015 per Objective 1b, experiment 2)
    - Review ongoing experimental results from Objective 1b experiments to determine if responses are strong enough to incorporate into multi-objective decision models
        - Each polynomial response curve (e.g. light vs. phenolic concentration) with a strong fit will be considered as a possible objective (i.e. dimension) in a multi-objective (i.e. multidimensional) decision model.
        - Any dose-response thresholds or other non-continuous responses will be considered as possible model constraints
    - As available, review broader experimental results (i.e., from other project objectives) for possible inclusion in the multi-objective optimization model.
- Implement the models in a software deliverable suitable for deployment (ongoing 2012-2015 per Objective 1b, experiment 2)

Experiment 2: Determine impact of light and temperature variation in canopies on specific flavor/aroma compounds and disease incidence across different geographic regions

Team leaders: Vanden Heuvel, Wolf, Lakso, Spayd:

Field experiments will be conducted with Cabernet franc in NY, VA and NC starting in 2012 to evaluate the impact of vineyard macroclimate and vine microclimate on fruit composition and wine quality attributes. Twenty panels of each cultivar will be selected based on measured natural vineyard variation in cluster exposure to ensure a broad range of exposures. Canopy architecture will be quantified using EPQA (Meyers and Vanden Heuvel, 2008) with ceptometer readings at berry set and veraison. Spatial and temporal variability in berry temperature will be estimated through a simulation model (Cola et al., 2009), which will be validated using data from temperature monitoring in clusters of east and west exposure and in the shaded interior in the differing climates of NY and NC. Our model will be adapted to integrate both EPQA-measured canopy variability and local weather information. At harvest, fruit from varying exposure treatments will be pressed separately, and light and temperature response curves will be generated using Cabernet franc/Cabernet sauvignon must for isobutylmethoxypyrazine (green bell pepper aroma), catechin and epicatechin (bitterness, astringency), quercetin and myricetin (bitterness, astringency, color stabilization), anthocyanins (color), and B-damascenone (amplifies fruit aromas) using either UV-vis HPLC or GCxGC-TOF-MS where appropriate. Response curves will be compared across regions (NY, NC, VA) to determine the impact of local climate and vineyard conditions on juice flavor and aroma profiles. If warranted, small-lot wine-making will occur to extend the viticultural assessments through wine sensory analysis (**Mansfield, Zoecklein**). Relative disease pressure from powdery mildew, downy mildew, botrytis, and black rot will be quantified prior to harvest in each panel, using conventional severity and incidence ratings (**Wilcox, Nita, Sutton**). Spray penetration will be quantified using water sensitive cards hung in the canopies at bloom, fruit set, and veraison. Light and temperature response curves can then be generated for diseases that respond to canopy differences as well as for spray penetration, facilitating cultural recommendations for both cooler and warmer regions that target specific wine styles (i.e., flavor and aroma profiles) while optimizing canopy density to reduce disease pressure and optimize spray penetration.

Preliminary results (2011, Lakso):

Objective 1b. Impact of light and temperature variation in canopies on specific flavor/aroma compounds and disease incidence across different geographic regions.
Cluster temperatures of 20 west-facing Cabernet franc clusters of varying exposure on a VSP system from cluster closure (early August before veraison) until harvest in early October were monitored. Thermocouples attached to dataloggers were placed next to the rachis of the cluster to obtain cluster average temperatures (*not the most exposed individual berries)*, avoiding direct radiation on the sensor. Temperatures were recorded every 30 minutes. Miniature light sensors (photo) were placed next to 15 clusters of varying exposure and values were logged at 10-minute intervals for the same period as temperatures were monitored. The clusters that were logged in this study were collected and frozen for composition analyses.

The maximum recorded temperatures during ripening reached almost 42˚C(107F) for exposed clusters on a sunny day (see Fig. 3) versus 34˚C (94F) for shaded clusters. However, the 2011 ripening season in NY had relatively few sunny days so there were fewer days that showed clear effects on temperatures. Thus when averaged over all the hours of the ripening season, there was less than 1˚F difference amongst clusters. Another expression of temperature regime relevant to flavor and color development is the number of hours at temperatures over 30˚C/86˚F. Over the 1056 hours monitored, the shaded clusters were >30˚C for about 6 hours while the exposed clusters were over 30˚C for 15-24 hours. This represents about 0.5 and 2.5 % of the time, respectively.

Although in these conditions we did not see dramatic differences in cluster temperatures over long periods, the effects will clearly be stronger in clearer climates or years. This data is being used for the berry temperature modeling.

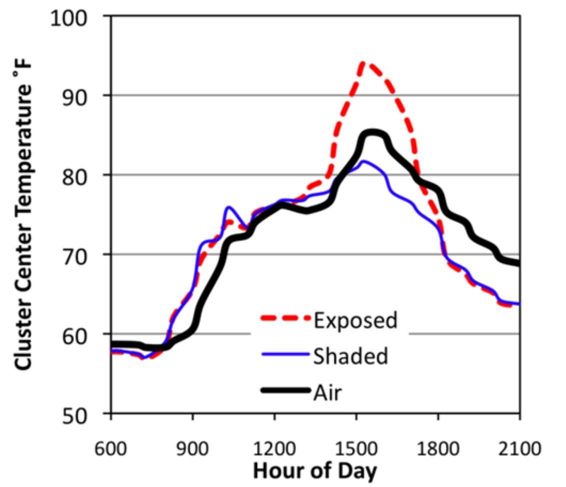


Fig. 3. Representative pattern of exposed cluster temperatures on a **sunny** day post-veraison.

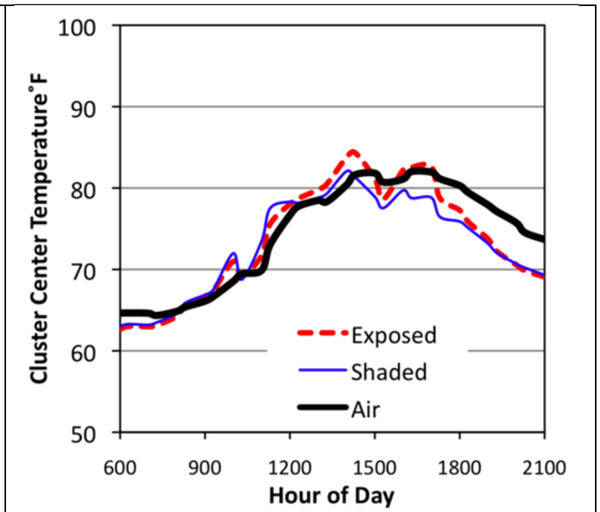


Fig. 4. Representative pattern of exposed cluster temperatures on a **cloudy** day post-veraison.

Experiment 3: Estimating climate-specific vineyard capacity for balancing vineyard crop loads.

Team Leader: Dr. Alan Lakso, Cornell University

A published model of light interception by solid hedgerows in the form of vineyard rows will be used to estimate potential vine capacity based on vineyard canopy dimensions (Jackson and Palmer, 1980). This potential capacity can then be adjusted to actual capacity based on trellis fill estimated by image analysis or calibrated visual ranking. These quantitative estimates will be validated in field trials in both the Finger Lakes (NY) and in Virginia in years 2-4 (2012-2014 seasons). Ten vineyards with a range of spacing and trellis fill that provide a wide range of vineyard light interception and thus vineyard capacity will be measured for light interception by measuring the shadow area cast by the vines over a daily cycle (Wunsche et al. 1995). Since climate varies among different states, adjustments between regions will be done by comparing vine dry matter production capacity with our "VitiSim" grape carbon balance model (Lakso 2006; Lakso et al., 2008) using long-term weather data from cooperating states. This simplified model (Fig. 5) integrates vine physiology with vineyard light interception and environmental data, and provides quantitative estimates of how much carbohydrate is available under varying conditions, and thus how much crop is feasible. Our initial estimates from benchmark vineyards indicate that this value for healthy commercial vineyards in NY with properly ripened crops is about 25-30% of total vine dry matter invested in fully ripening the crop. We will experimentally determine the yield-quality relationships of vineyards of varying capacity using four vineyards which vary in capacity. We will differentially thin the crops to 4 target levels of crop from very light to very heavy, and detailed canopy management will be used to provide consistent cluster exposure. Fruit will be sampled for composition, and wines will be made with standard procedures in university experimental wineries from each crop level. The resulting yield-quality relationships will be determined in each vineyard and optimal yield will be compared to that determined by the vineyard capacity estimation process. The experimental results will provide the basis for developing the grower guide to estimating their vineyard capacity.

Due to winter cold injury, variable climates and season lengths, and inexperience at matching vine vigor to sites, vineyards in the East often exhibit a tremendous variability in vine capacity, even within small vineyard blocks. A method has been developed to estimate vine capacity from a combination of (1) potential light interception by modeling vineyard dimensions, (2) adjusting to actual light interception by image analysis or visual estimation of trellis fill, and (3) modeling vine carbohydrate supply versus demand based on light interception and appropriate balance of vine to crop growth.

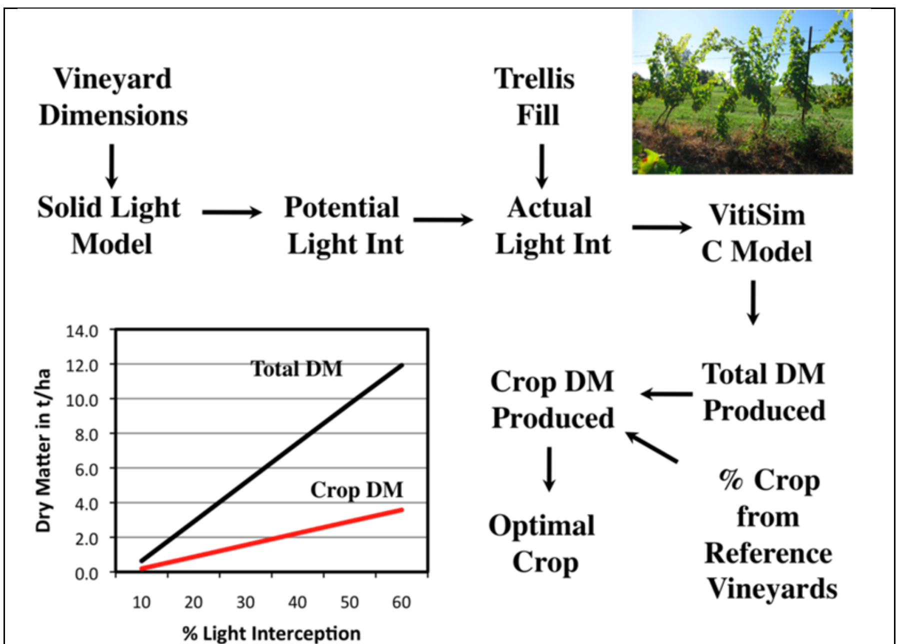


Fig. 5. Diagram of method of estimating target optimal crop via light interception and grapevine carbohydrate production models.

The dimensions of the vineyard (row spacing, canopy height and canopy thickness) to estimate potential vineyard light interception and capacity are simple. Estimating the actual light interception requires a model of adjusting the potential down to actual by estimating relative trellis fill of the canopies. At this stage of the research, trellis fill is being estimated via photography and image analysis of the canopy. Validation of the light interception estimates for the same vines from the models were done by determining actual light interception by digital shadow image analysis of images taken at intervals over a day and integrating the values. This was done across varying vine and canopy densities (example in Fig 6a and 6b).

Fig. 6a. Example of very good trellis fill of Riesling grapevines. Image analysis of this photo was used to determine percent trellis fill of this vine.

Fig. 6b. Shadow pattern of the same vine at 3 hours before solar noon. Image analysis was used to determine light interception of this vine.

Yield versus Vine Capacity - The optimal crop versus vegetative balance is being estimated from physiological modeling, experimental vineyards and reference commercial vineyards of proven history of balanced production of quality wine. The complementary information needed is the relationship between crop level, fruit composition and wine characters and vineyard capacity since vineyards of different capacity can produce different fruit at the same yield level. A field thinning trial was done with VSP-trained Cabernet franc with 40 shoots/vine (2.1x2.7m, 7x9 foot) thinned at set to four different crop levels (100% unthinned control, 75%, 50% and 25%) but with comparable exposures. Due to problems with excessive vine vigor of Cabernet franc common in NY vineyards, an adjacent trial was conducted. To control shoot vigor, 33 shoots/kg (15/pound) of winter pruning weights were left after pruning. To provide adequate exposure of about 16 shoots/m of trellis, a Lyre system was established with quadrilateral canes. At set thinning was done to 4 levels as in the VSP vines. Crop development was monitored at 2-week intervals after veraison and at harvest wines were made in 30 kg lots for later evaluation of effects on wine characteristics.

During the season after thinning we monitored the leaf net photosynthesis (Pn) rates of vines with different crop levels. The results showed that there were no clear effects of crop levels on leaf photosynthesis until after veraison (Fig. 7). Then, the higher crop level group of 6.7 tons/acre showed an increase in Pn, the moderate 4 t/ac crop was stable and the lowest crop of 2.7 t/ac declined. When the post-veraison dates were pooled for individual vines, it appears that when crop level fell below about 5 t/ac the Pn rate declined (Fig. 8). This indicates that vines with less than about 5 t/ac crop had excess unused capacity that feedback inhibited the leaf Pn rate. From the carbon and energy perspective, reducing crops on these vines with full canopies to less than 4 t/ac would be under-cropping the vines. Of course, carbon capacity of the vine does not necessarily indicative of other quality attributes such as flavors as long as the carbon supply is adequate.

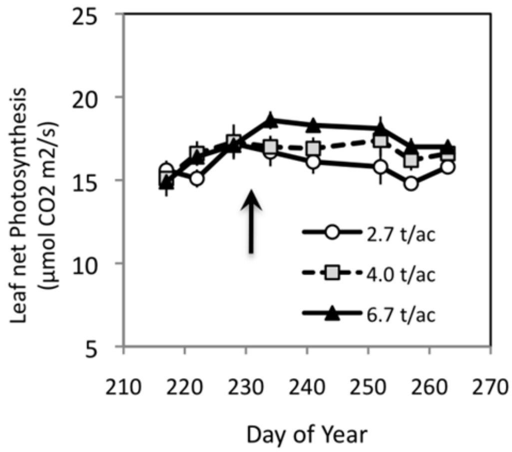


Fig. 7. Seasonal pattern of exposed leaf photosynthesis of Cabernet franc vines grouped by crop level (tons/acre). Thinning was done to establish crop levels shortly after fruit set (about Day 190). Arrow indicates veraison.

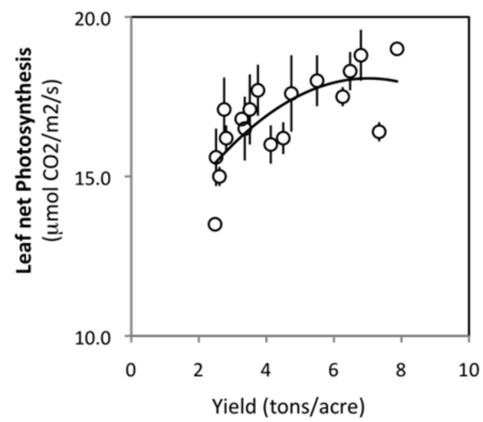


Fig. 8. Mean post-veraison leaf photosynthesis of individual vines over 5 dates. It appears that below about 5 tons/acre, there is a down-regulation of photosynthesis likely due to a limitation in sink strength with low crops.

The relationship relationship of juice Brix to vine yield was monitored at several times during the ripening period (Fig below left). In general there did not appear to be a significant effect of yield on Brix when yields were below 4 tons/acre. However, above 4 t/acre the Brix declined. Early in the ripening period (29 August, about 10 days after veraison), juice brix was of the heaviest crop levels was about 4˚ lower than the lightest crop. By harvest, however, the largest difference was less than 2˚ indicating that the heavier crops partially caught up by the end of the season.

***Expected outcomes*:** The proposed research in **Objective #1b** aims to develop refined metrics for canopy characterization (cropload and cluster light environment), as well as improved recommendations for canopy architecture and cropload to optimize fruit composition in each region. These toolsets will be easy-to-use so that they are readily adoptable by industry, as our previous EPQA methods have been. Through the use of these tools we expect grape growers to be able to better determine optimal cropload and canopy architecture for improving quality, and to allocate limited labor/financial resources to specific vineyard blocks accordingly to address these issues through viticultural intervention.

Objective 2. Develop research-based recommendations for optimally matching grape cultivars with site-specific environmental conditions

Objective 2a: Evaluation of viticultural and enological performances of novel wine grape cultivars (linkage with NE-1020 project) (Crassweller, Dami, Fiola, Mansfield, Nail, Schloemann, Spayd, Vanden Heuvel, Wolf, and Zoecklein)

Team Leaders: Imed Dami, The Ohio State University (Viticulture)
Anna Katharine Mansfield, Cornell University (Enology)

Issue: Cultivar and clone evaluation is an on-going, dynamic exercise in the eastern wine industry. The dynamics are caused by changes in availability of cultivars and clones, consumer preferences, climate change, and the novelty of grape and wine production in some parts of the region. The acclaim of a wine region frequently hinges on the relative success of one or two fortuitous matches of cultivar to local conditions, such as Pinot noir in the Willamette Valley of Oregon, or Sauvignon blanc in Marlborough, New Zealand. Consumer recognition of "signature" grape cultivars associated with specific states or sub-regions in the East remains elusive. Cultivar evaluation provides a sound footing for developing such cultivar recognition.

We intend to link this objective with the existing USDA/NIFA (formerly CSREES) Research Project, NE-1020 ("Multi-state evaluation of wine grape cultivars and clones") of which many of the PIs and collaborators (Crassweller, Dami, Fiola, Mansfield, Nail, Schloemann, Spayd, Vanden Heuvel, Wolf, Zoecklein) are members. The NE-1020 is a national project for grape cultivar and clone evaluation, the goals of which are recognized as a high priority with the National Grape and Wine Initiative (http://www.ngwi.org/). The historical justification, goals, and membership of the NE-1020 project are at the NE-1020 web site (http://www.nimss.umd.edu/homepages/outline.cfm?trackID=4034). The entire NE-1020 project membership comprises researchers in 29 states. The approach described here involves members (and plantings) in CT, MA, MD, NC, NY, OH, and PA. Participating states are climatologically divided into six groups based on similar growing as well as dormant season thermal regimes.

Cultivars: Cultivars from the NE-1020 project will be used. In order to standardize comparison among state regions, two core or standard cultivars that are in each NE-1020 trial will be used. The collaborating states in this project planted the following core cultivars: Cabernet franc, Cabernet Sauvignon, Merlot, Pinot noir, Chambourcin, and Vidal blanc. In addition, some new cultivars planted in the NE1020 trials will be used in our project as well. Each planting comprises 20 to 30 cultivars in a replicated design with six replications of 4-vine plot units.

Measurement of viticultural performance: All cultivars will be maintained under similar viticultural practices as outlined by the NE1020 protocol (lgu.umd.edu/lgu_v2/homepages/saes.cfm?trackID=4034). The viticultural data to be collected are based on the NE-1020 guidelines as described in objective #1, and will include the following: recording phenology (bud break, bloom, veraison, ripening, and leaf fall based on development stages scale by Eichhorn and Lorenz (1977)), and determining vine size, fruitfulness, yield components and fruit composition at harvest, and computing crop load (years 1 -5).

Measurement of cold hardiness: Due to the high number of cultivars per NE1020 site, we will determine bud cold hardiness of only a certain number of selected cultivars (5 to 10). Cold hardiness will be determined for a minimum of 2 years and up to 4 years in some states (NY, OH, VA). Bud cold hardiness will be measured at two stages: 1) during fall acclimation a minimum of three freezing tests will be conducted in Sept., Oct., and Nov.; and 2) during mid-winter, a minimum of three freezing tests will be conducted in Dec., Jan., and February. Cold hardiness in the fall will identify the rate of cold acclimation of novel cultivars. Mid-winter cold hardiness will determine the maximum level of cold hardiness of novel cultivars. Cold hardiness determination will be conducted at Ohio State University-OARDC in Wooster; OH; Virginia Tech-AREC in Winchester, VA, and NY State Agricultural Experiment Station-Geneva, NY where equipment exists and is currently used to do this work. Methodology is the same as described in **Objective #1**. Canes collected from vineyards other than those located at the listed stations (e.g. CT) will be shipped overnight to one of the testing labs.

Wine-making: Two projects specific to fruit processing were identified as issues across the region: those of phenolic induced bitterness in aromatic white wines, and of low phenolic content in hybrid red cultivars. Both wine types are of particular economic interest in the East; the former group includes regionally characteristic wines (i.e., Riesling in the Finger Lakes and Pinot gris in Ohio) and the latter, grapes grown for the majority of bulk wine production. This work will generate specific recommendations to improve processing techniques for both grape types, which will ultimately improve quality and subsequent economic returns to producers.

<u>*Experiment 1: Enological performances of NE-1020 cultivars:*</u> Fruit from cultivars in the NE-1020 project will be processed using wine making procedures that follow standard methods currently implemented by the NE1020 project and described in the general methodology for objective #1. Winemaking will be handled by NE1020 particpating enologists and the associated expenses will be funded/requested from other sources (e.g. state funding and Viticulture Consortium). Thus, funds for Experiment 1 are not requested in this application.

<u>Experiment 2: Evaluating the effect of enological parameters on the phenolic profile of white wines</u>. White wine cultivars Riesling, and Traminette will be harvested from collaborating vineyards and divided into approximately 40 kg duplicate lots. A skin contact trial will consist of the following treatments: (a) **Control**—following crushing and pressing, juice will be allowed to settle at -1°C for 24 hr, then racked off the lees and immediately inoculated and fermented to dryness; (b) **Cold soak for 6, 24, or 48 hours**—following crush, must will be treated with dimethyl dicarbonate to prevent microbial spoilage, and one lot each held at 2°C for 6, 24 or 48 hours. Must will then be pressed, and the juice inoculated and fermented as above; (c) **fermentation on the skins**—grapes will be mechanically crushed and destemmed, inoculated and fermented at 13°C for 7 days before being pressed and processed as above.

<u>Experiment 3: Evaluating the effect of enological parameters on the phenolic profile of red hybrid wines</u>. Red wine cultivars Corot noir and Maréchal Foch will be harvested from collaborating vineyards and divided into approximately 100 lb duplicate lots to be used for the following treatments: (a) **Control**—grapes will be mechanically crushed and inoculated. Fermentation will proceed at 20°C for 7 days, then pressed, processed and bottled; (b) **24-hr cold soak**—grapes will be mechanically crushed and destemmed, treated with

dimethyl dicarbonate, and held at 2°C for 24 hr. Must will then be fermented and processed as described above; (c) **Maceration enzymes**—grapes will be crushed; treated with enzymes designed to enhance phenolic release, then fermented and processed as described above (d) **Enological tannin addition**—grapes will be crushed, treated with enological tannins, then fermented and processed as described above. The protocol for tannin addition will be developed during the spring of 2010, after completion of preliminary tannin addition work currently underway; and (e) **Hot press**—grapes will be mechanically crushed, heated to 15°C in a jacketed steam kettle and held for 20 min., then pressed, inoculated and fermented as white wines, above.

Instrumental and sensory analysis of wines produced in Experiments 2 & 3: Standard procedures for juice chemistry, YAN, phenolics (Singleton et al., 1999), specific anthocyanins and phenolics (Betés-Saura et al., 1996; Ritchey and Waterhouse, 1999; Castellari et al., 2002) and sensory analysis (General Methodology section) will be performed.

Expected outputs of Objective 2a: We will identify pros and cons of cultivars newly released or new to the East from the NE1020 project. Of paramount importance is their cold hardiness (most limiting factor). We will also develop a coordinated database of several quality attributes, in particular the amount of YAN and phenolics in fruit and wine. The best fruit processing and vinification practices will also be identified to optimize phenolics in white and red wines.

Progress:

Evaluation of viticultural and enological performances of novel wine grape cultivars (linkage with NE-1020 project)

Maryland: This intent of this project is for The UME Viticulture and Enology Program to collaborate in a coordinated approach to the evaluation, and dissemination of knowledge gained by evaluation of existing and newly released wine grape varieties in the eastern USA. The coordination is fostered by cooperator involvement in the USDA/CSREES national project, "NE-1020, Multi-state evaluation of wine grape varieties and clones". Materials and procedures for evaluation of wine grape varieties are standardized within the framework of the NE-1020 project to ensure dependable regional comparison of performance. The aim of this research is to evaluate both the viticultural as well enological merits of historical and newly developed wine grape varieties in novel environments, including:

- Assess vineyard performance and wine quality of existing and newly planted Italian, Spanish, Portuguese, and French varieties in Western, Southern, and Eastern Shores (Obj. 2a).
- Assess vineyard performance and wine quality existing and newly planted advanced selections from the Soviet Union at University and Commercial sites in Eastern Maryland (Obj. 2a).

Experiments

- ***Planting of varieties and clones of varieties with high potential for Mountain Maryland and the Piedmont Plateau*** (WMREC, Keedysville, MD). Clones of varieties that are grown in other warm summer/cold winter climates (zone 6b) of the world such as Northern areas of Italy, Spain, Portugal, and France will be tested in Washington County (mountain) Maryland. These varieties are included in the NE1020 National Variety Trial.
- ***Advanced trails of that have been imported from Italy and warm climate areas.*** Varieties that are grown in other hot climates of the world such as Southern areas of Italy, Spain, Portugal, and France will be tested in replicated design at appropriate University and Commercial sites in the Southern and Eastern Shores (zones 7a, 7b).
- ***Advanced trails of that have been imported from the Soviet Union.*** Advance selected varieties that have shown promise in Keedysville will be tested at University and commercial sites in Eastern Maryland.
- ***Advanced commercial and replicated trails of 'Linae,' a proprietary variety owned by the University of Maryland.*** Wine from the 'Linae' variety has won major awards in nation competitions (including Best of Show of 800 wines in 2003) and has sparked great commercial interest. The vines have been propagated and will be disseminated to selected commercial farms and planted in replicated cultural trials at University R&D vineyards.

Data collection will include: monitoring of growth characteristics, monitoring the pest complex, fruit sampling and harvest components (yield, cluster size, berry weight), basic fruit chemistry analyses (pH, Brix%, TA). Small batch fermentations will be conducted on each treatment within each experiment, over multiple years.

Summary of Major Research Accomplishments and Results by Objective

The 2010 growing and harvest season produced one of the best vintages in recent history. Adequate spring moisture followed by a warm dry growing and harvest season produced an early harvest of high quality fruit. The young vines in the newly established vineyard however experienced some drought stress so the quality was variable by variety. The 2010 was good vintage to see what the best case scenario would be for a variety, as most reached full ripeness in plenty of time before frost or leaf fall.

Mountain Maryland and the Piedmont Plateau (WMREC, Keedysville, MD). The 2010 growing and harvest season produced one of the best vintages in recent history. The vineyard was in its 7th leaf so it was able to withstand the severe drought conditions of midsummer. Due to water stress conditions fruit was thinned at verasion to less than "normal" yields. Fruit ripened well and all varieties achieved full ripening (see table below). However juice yield was way below average (about 60-75%). Varietal highlights in the Western vineyard included Barbera and Chambourcin. Small batch winemaking was conducted on all varieties and preliminary wine evaluation revealed good color, ripe tannin structure, and ripe aromas.

Southern Maryland (CMREC, Upper Marlboro, MD). The 2010 growing and harvest season produced one of the better vintages. The oldest vineyard plantings was in its 11th leaf and was able to withstand the severe drought conditions of midsummer however the newest planting was in its 6th leaf and showed some stress. Very high daytime and nighttime heat, typical of this region, was not best for fruit quality. Powdery mildew became a problem as fungicide sprays were suspended prior to harvest and there was some late defoliation from Downy mildew. Fruit ripened reasonably well and all varieties achieved full ripening (Table 1). Again, juice yield was way below average (about 60-75%). Preliminary wine evaluation revealed adequate color and medium ripe aromas. Varietal highlights in the Southern vineyard included Merlot, Chardonel, Vidal, Traminette, and Petit Manseng. Hybrids continue to perform best in this stressful environment. Small batch winemaking was conducted on all varieties.

Eastern Maryland (WyeREC, Queenstown, MD). The 2010 growing and harvest season produced one the best vintages in recent history. The oldest vineyard planting was in its 15th leaf and was able to withstand the severe drought conditions of midsummer. The newest planting was in its 6th leaf and but showed little stress. Fruit ripened very well and all varieties achieved full ripening (see table below). Juice yield was way below average (about 60-75%). Preliminary wine evaluation revealed good color, and ripe aromas. Varietal highlights in the Eastern vineyard included Linae, SK 77-5-3, Chardonel, and Petit Manseng. Small batch winemaking was conducted on all varieties and preliminary wine evaluation revealed good color and ripe aromas.

Table 1. Performance of winegrape varieties in trials in Western (WMREC), Southern (CMREC), and Eastern Shore (WyeREC) Maryland.

Cultivar/Clone	REC	Crop yield (lbs/A)	10 cluster wt (lbs)	50 berry wt (g)	Brix	pH
Linae	WyeREC	5130	1.6	229	17	3.68
Kozma 55 (Wye7)	WyeREC	6110	1.6	75	18.9	4.04
SK77-12/6 (Wye12)	WyeREC	4960	3.2	68	19.8	3.59
Chardonel (Wye26)	WyeREC	5410	4.3	150	19.9	3.67
Sauv Blanc (Wye24)	WyeREC	4830	3.9	109	21.1	3.74
Pinot Gris	CMREC	5230	0.9	56	17.4	4.03
Sauv Blanc	CMREC	4820	1	97	18.9	3.9
Chardonel	CMREC	5940	2.8	140	18.5	3.8
Merlot	CMREC	6540	3.1	130	20.2	4.1
Vidal	CMREC	6850	2.4	107	18.7	3.6
Traminette	CMREC		2.8	120	19.4	3.55
Petit Manseng	CMREC	5220	1.2	85	19	3.4
Sangiovese 2	WMREC	5840	4	128	19.4	4.02
Sangiovese 6	WMREC	5630	5.7	125	19.5	4.06
Sangiovese 19	WMREC	5930	4.8	131	19.2	4
Sangiovese 23	WMREC	5420	5	136	19.5	4.08
Barbera 1	WMREC	5360	5.3	131	19.8	3.98
Barbera 15	WMREC	5150	4.5	121	20	3.96
Barbera 19	WMREC	5090	5.2	118	20.2	3.94
Chambourcin	WMREC	5660	3.3	122	18	3.55

1. Publications and Presentations of Research Findings.

Fiola, J.A. 2010. The Grape and Wine Program at the University of Maryland. The Maryland Grapevine 30(4):7.

Fiola, J.A. 2011. What Are We Learning About Regional Grape Variety Performance from Our R&D Vineyards in Maryland? *and* Evaluation of Wines of Promising Experimental Varieties. MGGA/MWA/UME Annual Meeting. Oxon Hill, Maryland.

Fiola, J.A. 2011. Grape Varieties for the Diverse Regions of Maryland. New Growers' Workshop. Annapolis, Maryland.

Fiola, J.A. 2011. Grape Varieties for the Mid-Atlantic. Beginners' Grape Growing Workshop. Biglerville, Pennsylvania.

Fiola, J.A. 2010. The 'Norton' Grape Variety – Unique History and Bright Future. The Maryland Grapevine 31(1):8.

Fiola, J.A. 2011. Evaluating Experimental Varieties in Southern Maryland. UME Twilight Meeting. Lusby, Maryland.

Fiola, J.A. 2011. Promising Experimental Varieties from Southern Maryland. MGGA/MWA/UME Annual Summer Field Day. Leonardtown, Maryland.

Fiola, J.A. 2011. Evaluating Wine from Varieties grown at the University of Maryland R&D Vineyards. MWA Winemaker's Workshop. Annapolis, Maryland.

Fiola, J.A. 2011. Experimental Varieties Performance in Southern Maryland. CMREC Twilight Meeting. Upper Marlboro, Maryland.

Fiola, J.A. 2011. Recommended Winegrape Variety for Maryland. Contributed variety recommendations which are posted on the MGGA website.

2. Research Success Statements

This research has provided Maryland growers and other growers in similar environments in the Mid-Atlantic with specific regional (West, South, and East) experimental and conventional varieital performance, including disease resistance/susceptibility, heat tolerance, and ability to ripen. Growers have the opportunity to see the variety performance in their environment and taste the wine from the variety in that location. This has allowed the development of specific variety recommendations, both which to plant and, sometimes more importantly, which not to plant.

3. Funds Status

Category	Allocated	Used	Balance
Salary & Benefits-Ag Worker	$10,783.00	$ 4,822.82	$ 5,960.18
Salary & Benefits-Gen Asst	$ 4,320.00	$ 2,750.64	$ 1,569.36
Travel	$ 6,000.00	$ 1,677.56	$ 4,322.44
Supplies	$ 6,000.00	$ 4,417.92	$ 1,582.08
F & A	$ 7,047.00	$ 3,161.58	$ 3,885.42
Totals	**$34,150.00**	**$16,830.52**	**$17,319.48**

Some budget notes.

1. Since the project and budget officially started in October, the previous growing season had just ended so there were not major expenditures for the data provided.
2. Since this was the first year of the grant, there was some existing funding from other grants with deadlines that were used before we started using the SCRI funds.
3. My main enology technician left during the year and it took a while to find a suitable replacement. And once the new employee started there is a month lag before approval and starting on payroll.
4. Reduced harvest and processing in 2011 due to first year of production of the vines (limited crop), poor growing conditions (significant rainfall), and significant very early bird predation.
5. Since we do not have to adhere to a strict annual budget or could we distribute the funds over the whole term of the grant since there will be more work in later years when the vines are all fully fruitful.
6. I had placed a large order for supplies (>$1000) but it did not post to the credit card in time to be included in September 30 deadline.

The research on the grant is being accomplished as proposed.

Pennsylvania: Vines at the Fruit Research and Extension Center (FREC) in Biglerville and the Lake Erie Regional Grape Research and Extension Center (LERGREC) were pruned and pruning weights measured during the past year. Bloom phenology was monitored and initial cluster and shoot counts were collected. Shoots were thinned to four shoots per foot of canopy length. Clusters were counted post thinning to determine the number of clusters remaining per vine. Considerable bird depredation occurred to some cultivars until we were able to cover the vines with netting. All the Muscat Ottonal at FREC were lost due to bird feeding. Wine is being made from the Merlot and Albarino grapes from the FREC planting by our Extension Enologist. Cultivars to be made into wine from LERGREC are Chambourcin, Vidal blanc and Traminette. Once again the Malbec vines at LERGREC died back to the trunk. A mid-summer evaluation of the vines at FREC with Drs. Tony Wolf and Joe Fiola showed evidence of numerous vines potentially infected with Grapevine Yellows.

Principal Investigator/Cooperators: Robert M. Crassweller, Department of Horticulture, The Pennsylvania State University, 102 Tyson Building, University Park, PA 16802, 814-863-6163, rmc7@psu.edu

Objective(s) and Experiments Conducted to Meet Stated Objective(s) Objective 2a: Evaluation of viticultural and enological performances of novel wine grape cultivars (linkage with NE-1020 project)

Summary of Major Research Accomplishments and Results by Objective: Malbec vines at LERGREC died back to the trunk in early spring and resprouted over the summer. At FREC the most vigorous cultivar based upon pruning weights was Syrah and Sangiovese. The least vigorous cultivar was Chancellor. At LERGREC the most vigorous cultivars based on pruning weights were Marquette and MN 1235. The least vigorous was Muscat Ottonel. Two other cultivars had low pruning weights, however these were only second year vines having been planted in 2009 rather than 2008 as the others were. In 2010 Muscat Ottonel had the greatest individual berry weight at 2.04 grams, while Malbec had the lowest at 0.91 grams. Vidal had the heaviest cluster weights at LERGREC. Berry quality parameters at FREC were not recorded as fruit was removed shortly after bloom.

Publications and Presentations of Research Findings: Fruit Grower Field Day at FREC July 13, 2011

Research Success Statements: This was the first year the vines were of sufficient size that there was a measurable harvest and wine making. Harvest is ongoing at the present time and data has not been summarized completely. This will be accomplished over the winter after harvest.

North Carolina:
Collaborators: Sara Spayd, Lisa Hopkins (Technician), Gill Giese and Vance Marion (Both of the latter collaborators are at Surry Community College and are not official project collaborators)

The purpose of this project is to characterize the viticultural, grape and wine quality potential of economically significant and emerging cultivars, scion and rootstock. The vineyard was established in 2008 at Surry Community College in Dobson, NC. With exceptions where noted, all scion cultivars were grafted to 101-14MGT rootstock. Cultivars under evaluation are being compared against the sentinel cultivars Cabernet Sauvignon clone 8 and Merlot clone 3. The cultivars under evaluation are: Aglianico, Carmenere, Cabernet Sauvignon clone 9, Grignolino, Lemberger, Merlot clone 3 on 3309R, Nebbiolo, Tinto Cao and Touriga Nacionale.

Pruning weight data from the 2010 growing season ranged from 0.26 (Aglianico) to 0.45 (Tinta Cao) kg/m of cordon. Shoots/m of cordon ranged from 5.0 to 6.8. Lowest shoot weights were found on Merlot cl 3 x 3309 (45 g/shoot) and highest on Cabernet Sauvignon cl 9 (69 g/shoot).

The 2011 season was the first full production season for most of the cultivars. Vines were cluster thinned to reduce yield, where necessary, and to reduce fruit-on-fruit contact for disease management. Two of the cultivars did not perform to commercially acceptable standards.

Carmenere produced 0.13 and Nebbiolo 1.17 kg of fruit/m of row, respectively. Additionally, the canopy architecture (very small leaves) of Nebbiolo was excessively open to sunlight, thereby over exposing the fruit to sun and caused sunburn to the fruit. After thinning, the remaining cultivars had at least commercially acceptable yields that ranged from 1.88 to 3.28 kg/m of vine row. Timing of harvest was based on fruit condition (good fruit integrity and freedom from rot) and ^{o}Brix with condition being the overriding factor for when to harvest. With the exception of Aglianico (19.4^{o}Brix) and Merlot cl. 3 on 3309R (17.6 ^{o}Brix), all cultivars attained at least 20^{o}Brix. The lightly cropped Nebbiolo reached 23.4^{o}Brix, followed by Grignolino (22.3^{o}), Tinta Cao and Touriga Nacionale (21.6^{o}), Carmenere (21.4^{o}), Cabernet Sauvignon clone 9 and Merlot cl. 3 x 3309 (21.2 ^{o}), Lemberger (21.1 ^{o}) and Cabernet Sauvignon cl 8 (20.6 ^{o}). All berry weights were between 1.54 (Cabernet Sauvignon cl 8) and 2.31 (Aglianico) g/berry. By comparison, in semi-arid to arid, irrigated regions of the western US berry weights are more typically 1.0 g/berry. Fruit pH ranged from 3.45 (Aglianico) to 3.97 (Carmenere). All fruit titratable acid concentrations were low (less than 3.5 g/L of juice) and ranged from 1.87 (Merlot cl 3 x 101-13MGT) to 3.21 (Aglianico) g/L of juice. Additional frozen fruit analyses are planned as soon as a laboratory remodel is completed this spring.

Pruning season 2011-2012 is in progress.

Ohio:
Principal Investigator: Imed Dami

- Dr. Dami attended the NE0102 meeting held on 10-11 Novemeber 2010 in Traverse City, MI. He assisted witht the NE1020 group in developing a standardized viticultural practices and a viticulure protocol for data collection. Those guidelines have been implemented by all collaborating PIs during 2010-2011.

- Assessment of cold hardiness was conducted only twice in Wooster due to infrastructure and research equipment damage from a tornado that hit OARDC on 16 Sept 2010. In Janaury 2011, temperatures dipped to -3F in Wooster and -7F in Kingsville. Results of the freezing tests and bud injury assessment are summarized in Tables 1 and 2. Our preliminary evaluation has already showed differences on cold hardiness among varieties.

- In 2011, phenology, yield, and fruit composition data have been collected from Vitis vinifera cultivars at both vineyards. Harvest data are still being collected at the time of the report submission. In addition of yield and fruit quality data, we collected data on cultivar susceptibility to bunch rot.

Objective 2b: Develop a GIS-based model incorporating climaitc, topographic, and edaphic parameters to improve "site-cultivar" suitability knowledge.
This sub-objective is led by Dr. Peter Sforza at Virginia Tech. Our role in Ohio is to assist with inquiring climate data that is not otherwise available; geolocalizing commercial vineyards in Ohio; and fine tuning the GIS model by validation with existing commercial vineyards.

Historical minimum and maximum temperatures have been gathered from weather stations in Ohio.

1. Publications and Presentations of Research Findings:

<u>Extension Newsletter:</u>

Dami, I. and Y. Zhang. 2011. OSU Grape Variety Trial Update. Ohio Grape-Wine Electronic Newsletter (OGEN), Ohio State University, 31 August.
Wolf, K.T., and I. Dami. 2011. Invitation to Participate in an Industry Survey to Benchmark Knowledge and Practices. Ohio Grape-Wine Electronic Newsletter (OGEN), Ohio State University, 5 July.

Dami, I., S. Ennahli, Y. Zhang, and G. Johns. 2011.Sub-Zero Temperatures in 2011…Not 2009 again! Ohio Grape-Wine Electronic Newsletter (OGEN), Ohio State University, 10 February.

<u>Extension Presentation:</u>
Dami, I. OSU Grape Variety Trials – NE1020 Project. Field Day. Ashtabula Agricultural Research Station - Ohio State University, Kingsville. 19 August 2011.

<u>Research Presentation:</u>

Dr. Dami presented a progress report at the first SCRI project co-PI meeting held on 14 July 2011 in Baltimore, MD.

2. Research Success Statements:

We could already observe: 1) the limitation of some V. vinifera cultivars on freezing tolerance at both sites 2) the growing season requirements to ripen the fruit and the shoots at both sites. Even though it is early in the evaluation process, we are confident on what cultivars "not to recommend" under certain environmental conditions. Promising cultivars need further evaluation.

3. Fund Status:

Expenses incurred from 1 January 2011 through 30 September 2011, or nine months. During that period, a total of ~$30,000 were spent as follows:

- Salaries and benefits: Graduate student stipends: Yi Zhang and wages for undergraduate summer students.
- Materials and supplies: field and lab supplies, desktop computer and color laser printer.
- Travel (in-state trips).
- Contractual services.

The following are personnel updates from OSU and the reasons why the amount spent is less than the amount requested in Year 1:

- The delay of funds release and the tornado had affected the timeline of the project and delayed expenditures for materials and supplies, and labor hiring in the first year.
- Dr. Ennahli is no longer with OSU. Dr. Dami is in the process of recruiting a replacement to conduct the GIS work in Ohio. Thus the salary and FB committed for year 1 was not fully utilized.
- Dr. Maurus Brown left OSU. Therefore, his commitment to the project is no longer possible.
- Vines were propagated in 2007 and transplanted to the field in 2008. 2010 was the first year of harvest, although the vines were still relatively young. Standard vegetative and fruit quality data were collected according of the experimental protocols established by "NE-1020- Multistate evaluation of winegrape cultivars and clones". Other observational data such as disease incidence and severity, dates of budbreak, veraison, and harvest, and weather data were also collected. Vines were pruned in the spring and trained to a high-wire, downward training system for hybrid cultivars, or to a low-wire, upward training system for *Vitis vinifera* cultivars. Shoot thinning, leaf pulling, suckering, and removal of lateral shoots was performed at appropriate phenological times.
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- A frost the night of April 26-27 severely injured early-budding cultivars, especially those with *Vitis riparia* heritage. Cultivars demonstrated various susceptibilities to birds and fungal pathogens. Some cultivars, especially early maturing red cultivars, suffered heavy bird predation. Multi-row netting was installed in 2011. Three cultivars (Skunjish 675, Auxerroris, and Pinot Blanc) were significantly affected by harvest rot fungi in spite of am IPM disease management program. Several other cultivars performed well despite the young age of the vines.
- As standard IPM pest management program was followed throughout the period. There was a late season outbreak of foliar downy mildew in 2011. This was experienced by most growers in the state. The spotted wing Drysophila, a new pest to the area, was identified in the vineyard in September, 2011. Damage, if extant, has not yet been determined.
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- A seasonal worker was hired from mid-May through October, 2011. This worker assisted in vineyard management activities described above as well as other general vineyard maintenance activities. Harvest began on September 27, 2011 and will continue for at least two more weeks.

Table 1. Cold hardiness (LT50) of cultivars grown in Wooster in 2010.

Cultivars	Collection date: Nov. 11, 2010		Collection date: Dec. 16, 2010	
	LT50 (°C)	LT50 (°F)	LT50 (°C)	LT50 (°F)
Arneis	-16.4	2.5	-21.3	-6.3
Barbera	-16.2	2.8	-21.0	-5.8
Cab. Sauv.	-18.7	-1.7	-18.8	-1.8
Carmenere	-18.4	-1.1	-15.6	3.9
Dolcetto	-17.0	1.4	-21.6	-6.9
Durif	-15.5	4.1	-21.6	-6.9
Gamay noir	-19.6	-3.3	-24.4	-11.9
Lagrein	-17.3	0.9	-19.2	-2.6
Malbec	-16.0	3.2	-17.4	0.7
Malvesia	-19.9	-3.8	-19.8	-3.6
Merlot	-15.5	4.1	-17.5	0.5
Pinotage	-21.8	-7.2	-24.2	-11.6
Regent	-20.4	-4.7	-22.0	-7.6
Rotberger	-21.5	-6.7	-21.2	-6.2
Sangiovese	-17.2	1.0	-21.3	-6.3
Sauv. Blanc #7	-19.2	-2.6	-18.4	-1.1
Sauv. Blanc #14	-17.2	1.0	-18.8	-1.8
Sauv. Blanc #25	-18.4	-1.1	-19.4	-2.9
Sauv. Blanc #27	-20.3	-4.5	-20.6	-5.1
Siegerrebe	-15.7	3.7	-19.7	-3.5
Syrah	-20.4	-4.7	-20.1	-4.2
Tempranillo	-16.7	1.9	-19.8	-3.6
Teroldego	-18.7	-1.7	-22.5	-8.5

Table 2. Winter injury (percent of primary bud injury) of cultivars grown in two OSU locations following freezing events in 2011.

Cultivars	AARS-Kingsville / Jan. 24, 2011 / -7 °F	Cultivars	OARDC-Wooster / Jan. 22, 2011/ -3 °F
Albarino	24	Arneis	17
Arneis	55	Barbera	10
Dolcetto	98	Cab Sauv	25
Gamay noir	23	Carmenere	7
Gruner Veltliner	62	Cabernet franc	31
Kerner	28	Chardonnay	5
Pinot noir	36	Dolcetto	26
pinot noir precoce	22	Durif	47
Refosco	60	Gamay noir	2
Regent	18	Lagrein	25
Sangiovese	82	Malbec	81
Sauv. Blanc	66	Malvesia	18
Sauv. gris	44	Merlot	4
Semillon	44	Pinotage	0
Tempranillo	81	Regent	3
Tocai Frilano	68	Rotberger	15
		Sangiovese	33
		Sauv. Blanc #14	13
		Sauv. Blanc #25	36
		Sauv. Blanc #27	13
		Sauv. Blanc #7	9
		Siegerrebe	7
		Syrah	46
		Tempranillo	27
		Teroldego	7

The Connecticut Agricultural Experiment Station
Principal Investigator: William R. Nail

A planting of 24 cultivars was established at Lockwood Farm in Hamden CT, in 2008. A smaller planting, consisting of six cultivars, was established the same year at the CAES Valley Laboratory in Windsor, CT. These experimental vineyards were established as part of "NE-1020: Multistate Evaluation of Winegrape Cultivars and Clones". Data collection began in spring, 2010. These cultivars include the cool-climate "core cultivars" (common to all participating plantings) Pinot Noir and Cabernet Franc in Hamden, and the cold- and very cold-climate cultivars Chambourcin, Vidal, Frontenac, and St. Croix at both locations. These are compared with other established cultivars as well as untested and unreleased cultivars to determine the latter's suitability to the region.

Experimental wines from selected cultivars will be made beginning in September, 2011 at the New York Agricultural Experiment Station (NYSAES) in Geneva, NY.

Summary of Major Research Accomplishments and Results by Objective

All data were collected according to the established protocols of NE-1020 beginning in spring, 2010 (Table 1). While most vines were healthy, they were young, so did not produce a full crop. *Vitis riparia*-based cultivars did not have significant yield due to a late spring frost. There was not enough yield to make experimental wines in fall, 2010. However, wines will be made from twelve selected cultivars in 2011.

Publications and Presentations of Research Findings

Preliminary data have been shown and discussed at various regional grower and trade association meetings. However, the vines are too young to form any definitive conclusions as to the suitability of untested and unreleased cultivars for the region.

Research Success Statements

This research has provided grape growers and wine makers suggestions as to what new cultivars might be suitable to the region. Of equal importance is identifying cultivars that are of interest to growers but are not suitable for the region. This can be for a variety of reasons, including lack of cold-hardiness, disease susceptibility, lack of fruitfulness, and poor fruit quality. Vineyard plantings are long-lived enterprises, so mistakes avoided at the cultivar selection phase can have long-lasting impacts. Conversely, data demonstrating that a new cultivar for a region is viticulturally sound and produces high quality wine can provide significant positive economic impact to the regional wine industry.

Funds Status

A seasonal worker was hired beginning in late May, and continues to work part-time through harvest in October. Her main duties are to perform various vineyard maintenance tasks and assist in collecting data.

Travel costs have not yet been charged. There will be travel costs incurred in September and October to transport selected cultivars to the NYSAES for wine making.

A sub-sub-contract was established with NYSAES/Cornell for wine making and basic analysis as per the submitted budget.

Table 1. Pruning and harvest data, NE-1020, Lockwood Farm, Hamden, CT 2010

Cultivar	Pruning wt (Kg)	Yield/vine (kg)	#Clusters	Berry wt (g)	Brix	pH	TA (g/L)
Auxerrois	0.20	0.05	13	1.6	19.0	4.05	3.632
Cabernet Franc	0.37	1.44	X	1.3	21.8	4.11	3.941
Cayuga White	0.12	1.44	45	2.7	22.7	3.82	4.172
Chambourcin	0.20	3.6	21	2.1	23.9	3.87	5.515
Dornfelder	0.29	0.18	5	2.2	1.8	3.97	5.082
Frontenac	0.41	X[z]	X	1.0	26.0	3.75	7.863
Frontenac Gris	0.41	0.57	27	1.0	26.2	3.83	7.836
Grüner Veltliner	0.21	0.02	30	1.1	20.2	4.13	3.168
Marquette	0.55	X	X	1.1	25.9	4.02	6.978
MN 1189	0.50	X	X	1.6	20.2	3.72	5.831
MN 1235	0.57	X	X	1.1	22.0	3.70	8.170
Noiret	0.57	0.45	7	1.8	19.9	3.96	4.471
NY76.0844.24	0.65	X	X	1.5	20.6	3.90	5.270
NY81,0315.17	0.47	0.08	3	1.4	21.3	3.87	4.420
Pinot Blanc	0.23	0.12	18	1.4	19.7	4.12	3.865
Pinot Noir	0.26	X	X	1.4	19.8	4.01	4.470
Rkatsitelli	0.21	1.17	13	1.9	19.8	4.00	4.550
Skunjish 675	0.13	X	X	1.3	24.8	3.88	4.638
St. Croix	0.35	X	X	1.6	19.9	4.12	5.219
Syrah	0.19	0.07	7	1.5	20.2	3.97	4.463
Traminette	0.45	0.91	8	1.6	23.5	3.93	4.300
Vidal	0.30	3.92	13	1.7	23.4	4.01	4.709
Zweigelt	0.19	0.99	10	1.7	18.7	3.82	4.297

[z]There was not enough fruit to harvest, only berry samples were taken.

Cornell University
Principal Investigator: Justine Vanden Heuvel

Data collection continues in Cornell's NE-1020 hybrid trial, which includes 9 cultivars/breeding selections: Noiret, Corot Noir, Chancellor, Vidal, La Crescent, St. Croix, Traminette, Vidal, and NY76.0844.24. Research wines were produced from all cultivars in 2010 and are being produced in 2011. Basic chemical and instrumental analyses were performed on all wines, and sensory evaluation on wines produced in 2010 will be performed in fall 2011. (This experiment is supported by external funding from 2010-2013, and is not financed by the SCRI grant.)

Enology
Principal Investigator: Anna Katharine Mansfield, Cornell University

Enological performance of NE-1020 cultivars: Wines were produced from eight of the nine cultivars grown in the Cornell's NE-1020 variety trial (Table 1). All cultivars were hand-harvested into standard lugs and transported to the Viticulture and Brewing Laboratory (V&B) at the New York State Agriculture Experiment Station in Geneva, NY for processing. Red cultivar St. Croix was not processed due to poor fruit quality proceeding from late-season weather events.

Table 1- Wines produced from Cornell NE-1020 cultivars in 2011.

Cultivar	Harvest date	Color	Yeast/LAB strain (reds only)[1]
Chancellor	9/23/2011	Red	GRE/Alpha
Corot noir	10/6/2011	Red	GRE/Alpha
La Crescent	9/13/2011	White	EC 1118
NY 76.0844.24	9/27/2011	White	QA23
Noiret	10/19/2011	Red	GRE/Alpha
Traminette	10/6/2011	White	V1116
Valvin Muscat	9/26/2011	White	QA23
Vidal	10/19/2011	White	DV10

[1]*All yeast and LAB cultures from Lallemand (Montréal, CA)*

All musts were analyzed for pH, soluble solids by refractometer, and titratable acidity (TA) by titration (Table 2). A Chemwell 2910 multianalyzer with Software Version 6.3 (*Awareness Technology*) was used for YAN determination by enzymatic analyses.

Table 2- Juice chemistry of Cornell NE-1020 cultivars in 2011.

Cultivar	Brix	pH	TA[1] (g/L)	AMM (mg N/L)	PAN (mg N/L)	YAN (mg N/L)
Chancellor	20.3	3.00	9.7	4.9	111	116
Corot noir	18.2	3.11	8.1	4.9	127	132
La Crescent	22.8	3.15	13.9	0	181	181
Noiret	19.6	3.23	7.6	18.1	114	132
NY 76.0844.24	21.2	3.03	10.3	5.8	166	172
Traminette	22.1	3.05	8.5	6.6	89	96
Valvin Muscat	18.5	3.16	8.3	51.1	84	135
Vidal	21.1	3.16	9.4	20.6	132	153

[1]*Expressed as Tartaric Acid Equivalents (TAE)*

White grapes were crushed, pressed, and the juice settled overnight; yeast strains (all sourced from Lallemand) were selected based on previous optimization trials. Grapes harvested with low soluble solids were chaptalized to 20°Brix. Following fermentation at ambient temperature (21°C), wines were racked into full containers and cold stabilized for two weeks. Deacidification was performed as necessary for sensory evaluation, and wines were bottled under screw caps in standard 750 mL bottles.

Red grapes were crushed and fermented on the skins with yeast strain GRE (*Lallemand).* Lots over 30 gallons were fermented in jacketed, stainless steel vessels (*Vance Metal Fabricators, Geneva, NY)* with temperature control and monitoring. After seven days of fermentation on the skins, all reds were pressed and inoculated with malolactic bacteria strain Alpha (*Lallemand*). Following completion of MLF, all wines were cold stabilized and bottled following the standard protocol, above.

Fruit from eleven cultivars grown at the Connecticut Agricultural Experiment Station were transported via refrigerated truck for processing at the V&B (Table 3). Wine production and chemical analysis (Table 4) proceeded as described above.

Table 3- Wines produced from CAES NE-1020 cultivars in 2011.

Cultivar	Harvest date	Color	Yeast/LAB strain (reds only)[1]
Cabernet Franc	10/11/2011	Red	ICV-GRE/Alpha
Cayuga White	9/27/2011	White	QA23
Chambourcin	10/11/2011	Red	ICV-GRE/Alpha
MN 1235	9/27/2011	Red	ICV-GRE/Alpha
NY 81.0315.17	9/27/2011	White	QA23
Pinot noir	10/11/2011	Red	ICV-GRE/Alpha
Rkatsitelli	10/11/2011	White	DV10
St. Croix	9/27/2011	Red	ICV-GRE/Alpha
Traminette	10/11/2011	White	DV10
Vidal	10/11/2011	White	DV10
Zweigelt	10/11/2011	Red	ICV-GRE/Alpha

[1]*All yeast and LAB cultures from Lallemand (Montréal, CA)*

Table 4- Juice chemistry of CAES NE-1020 cultivars in 2011.

Cultivar	Brix	pH	TA[1] (g/L)	AMM (mg N/L)	PAN (mg N/L)	YAN (mg N/L)
Cabernet Franc	13.1	3.36	7.5	68.4	73	141
Cayuga White	18.7	3.25	6.5	18.1	236	254
Chambourcin	17.5	3.16	8.9	16.5	66	82
Gruener Veltliener	15.2	3.60	7.2	92.3	306	398
MN 1235	17.2	3.39	10.9	67.6	459	527
NY 81.0315.17	18.0	3.28	7.3	33	254	287
Pinot Noir	17.3	3.72	7.4	53.6	171	225
Rkatsitelli	15.0	3.23	10.3	42	39	81
St. Croix	16.2	3.73	11.6	33	232	356
Traminette	18.3	3.17	9.4	11.5	127	139
Vidal	13.6	3.20	9.2	41.2	140	181
Zweigelt	16.7	3.41	9.7	57.7	45	103

[1]*Expressed as Tartaric Acid Equivalents (TAE)*

Experiment 2: Evaluating the effect of enological parameters on the phenolic profile of white wines (Mansfield):

Half-ton lots of Riesling, Gewüztraminer, and Traminette, and various smaller lots of Valvin Muscat, Frontenac gris, and La Crescent, were received from local collaborators (Table 5.) Riesling was mechanically harvested into a half-ton bin, all other cultivars were hand-harvested into standard picking lugs, and all fruit transported to the Viticulture and Brewing Laboratory (V&B) at the New York State Agriculture Experiment Station in Geneva, NY for processing.

Table 5- Grape varieties, sources, and harvest date, fall 2011 white wine production.

Grape Variety	Source	Location	Date
Valvin Muscat	Knapp Winery	Romulus, NY	9/20/2011
La Crescent	Black Diamond Farm	Trumansburg, NY	9/26-9/27/2011
Frontenac gris	Black Diamond Farm	Trumansburg, NY	9/26/2011
Gewürztraminer	Lamoreaux Landing	Lodi, NY	9/28/2011
Riesling	Anthony Road Winery	Penn Yan, NY	10/5/2011
Traminette	Bedient Farm	Branchport, NY	10/10/2011

All musts were analyzed for soluble solids, titratable acidity, and pH using standard protocols. A Chemwell 2910 multianalyzer with Software Version 6.3 (*Awareness Technology*) was used for YAN determination.

Cold Soak and Skin Fermentation Treatments (Table 6): Grapes were mechanically destemmed and crushed, then divided into equivalent treatment lots by weight. For cold soak treatments, one 60-kg lot of must was pressed, settled, and separated into two equivalent lots for fermentation. For skin fermentation treatments, 30-kg lots were placed in replicate containers, and sulfur dioxide was added at a rate of 50ppm for the 0h, 2h, 4h, and 6h treatments after pressing, and at 100ppm for the remainder of the cold soak and skin fermentation treatments after crushing.

Table 6- Processing treatments of aromatic white grape cultivars

Grape Variety	Cold Soak Treatments	Skin Fermentation
Valvin Muscat	0h, 6h, 24h, 48h	14d
La Cresecnt	0h, 24h	7d
Frontenac gris	0h,24h	7d
Gewürztraminer	2h, 4h, 24h, 24h with Lallzyme C*, 48h	7d
Riesling	2h, 4h, 24h, 24h with Lallzyme C, 48h	7d
Traminette	2h, 4h, 24h, 24h with Lallzyme C, 48h	7d

*Lallzyme C (Lallemand, California) was added at a rate of 0.03g/L.

After dejuicing, cold-soak fermentations were chaptalized as needed to reach 21°Brix and were inoculated with yeast strain R2 *(Lallemand)* at a rate of 1g/gal; skin fermentation treatments were similarly chaptalized and inoculated 24h after crushing. GoFerm yeast nutrient was also added at 0.3g/L *(Lallemand).* Dimmonium phosphate *(Presque Isle Wine Cellars)* and Fermaid K *(Lallemand)* was added to treatments 24 after inoculation, as needed, to bring the total yeast assimilable nitrogen (YAN) concentration up to 200mg N/L. All lots were fermented to dryness in coolers held at 14°C, then were racked and sulfur dioxide was added to maintain 60 mg/L free SO_2. Acids in La Crescent and Frontenac gris were adjusted to 9 g/L TAE via additions of potassium bicarbonate, and all wines were cold stabilized at 2°C for eight weeks. Free and total SO_2 were measured prior to bottling by a FIAstar 5000 system *(Foss).* The wines were screened for faults by an expert panel prior to bottling in 750mL olive green glass bottles with screw-caps, and stored at 20°C until analyzed. Wines were analyzed for pH and TA as described above, and ethanol analysis was performed using a modified GC-FID method (AOAC Official Method

983.13) on a Hewlett Packard GS 5890 Series II gas chromatography unit *(Agilent)* equipped with a FactorFour ™ VF-WAXms column, 30 m x 0.25 mm x 1.0 µm *(Varian, Inc.).*

Phenolic analysis: Whole berry samples were taken prior to processing and frozen for storage. Must and wine samples were taken at crush, at pressing, and at bottling; juice samples were preserved with an addition of 0.1% ascorbic acid, and all were frozen pending analysis.

A novel fractionation and High-Pressure Liquid Chromatography (HPLC) method was designed to separate and analyze key juice and wine phenolic compounds, and is currently undergoing final validation stages (Manns et al., publication in progress). Juices and wines were thawed and centrifuged, then sequentially fractionated to separate sugars, organic acids, and alcohols from anthocyanins and tannins, allowing full or semi-quantitative analysis of phenolic compounds of interest. A modified method, requiring less fractionation, has been developed for white wine analysis.

Following fractionation, samples were passed through a polyethersulfone (PES) filter before injection. Total flavan-3-ol monomer content and polyphenolic content in grape must and wine was measured by reversed phase HPLC using a fused-core C18 column (100mm, 2.6 µm particle size, 4.6 mm inside diameter). Eluting flavan-3-ol monomers and polymeric substituents were identified and quantified using catechin and epicathechin standards, and the proportion of seed and skin proanthocyanidins extracted into wine was calculated using a previously described method (Peyrot des Gachons and Kennedy 2003). Total anthocyanin content was measured by reversed phase HPLC fitted with a fused-core PFP column (2.6 µm particle size, 2.1 mm inside diameter). Anthocyanins were identified and quantified using malvidin-3-glucoside and malvidin-3-diglucoside standards. HPLC analysis started in early March 2012 and is currently underway.

Experiment 3: Evaluating the effect of enological parameters on the phenolic profile of red hybrid wines (Mansfield):

Half-ton lots of Maréchal Foch and Corot noir, and a quarter-ton lot of Marquette, were received from Cornell vineyards or local collaborators (Table 7). Maréchal Foch and Marquette were hand-harvested into standard picking lugs, and Corot noir was machine-harvested into a single half-ton bin; all grapes were transported to the V&B and stored overnight in a cooler (2°C) before processing. Must was analyzed for chemical parameters as described above.

Table 7- Grape varieties, sources, and harvest date, fall 2011 red wine production.

Grape Variety	Source	Location	Date
Maréchal Foch	Cornell University Orchards	Ithaca, NY	9/4/2011
Marquette	Black Diamond Farm	Trumansburg, NY	10/3/2011
Corot noir	Swedish Hill	Romulus, NY	10/11/2011

Wines were produced in triplicate for each Corot noir and with Maréchal Foch treatment, and in duplicate for Marquette. For each replicate, 21 kg fruit was crushed/destemmed and treated with 50mg/L sulfur dioxide; GoFerm (*Lallemand*), Fermaid K (*Lallemand*), and DAP phosphate (*Presque Isle Wine Cellars*) were added as outlined above.

Fermentation on the solids was carried out in 13-gallon stainless steel pots and manually punched down twice daily. For control wines, must was inoculated with R2 yeast *(Lalvin*), and fermentations proceeded in room held at 20°C. After seven days, wines were pressed and transferred to a 3-gallon glass carboy to complete fermentation. With Maréchal Foch and Corot noir, an additional four treatments-- pectolytic enzyme addition, exogenous tannin addition, cold soak, and hot press—were produced; Marquette was used for a hot press treatment. Treatment procedures, as variants from the control, are shown in Table 8.

Table 8- Processing treatments for red wines.

Enzyme Addition	Tannin Addition	Cold Soak	Hot Press
70mL/ton ColorPro (Scottzyme) to crushed must	40g/hl BioTan (Laffort) to crushed must	Held at 5°C 24 hours prior to inoculation	Crushed must heated to and held at 65°C in steam kettle, pressed immediately, treated with 25 mg/L SO_2

At dryness, wines were inoculated with lactic acid bacteria strain Alpha (*Lalvin*) according to the manufacturer's guidelines. Upon completion of malolactic fermentation, wines were racked and sulfur dioxide added to maintain 40 mg/L free SO_2 before being cold stabilized at 2°C for eight weeks. Titratable acidity was adjusted to 8 g/L by the addition of tartaric acid or potassium carbonate after cold stabilization. Wine analysis and bottling proceeded as described above.

Phenolic analysis: Whole berry samples were taken prior to processing and frozen for storage. Must and wine samples were taken at crush, at pressing, and at bottling, and were frozen pending analysis. Fractionation and HPLC analysis proceeded as described above, and was completed in mid-March 2012. Data analysis is currently underway.

Works Cited

Kennedy, J.A. and G.P. Jones. 2001. Analysis of proanthocyanidin cleavage products following acid-catalysis in the presence of excess phloroglucinol. J.Agric.Food Chem. 49:1740-6.

Peyrot des Gachons, C., and J.A. Kennedy. 2003. Direct Method for Determining Seed and Skin Proanthocyanidin Extraction into Red Wine. J.Agric.Food Chem.Journal of Agricultural and Food Chemistry. 51:5877-5881.

As a corollary to the enological trials, a short e-mail survey was designed and administered during summer 2011 to assess common processing methods for red hybrid wines across four states, including NY and PA. MN and WI were also surveyed to contrast Midwestern production methods those from the east coast. Analytical methods were developed and validated for extraction and HPLC analysis of phenolic compounds important in red wine sensory profiles.

Objective 2b. Develop a GIS-based model incorporating climatic, topographic, and edaphic parameters to improve "site-cultivar" suitability knowledge. (Dami, Ennahli, Jones, Lakso, Nail, Sforza, and Wolf)

Team Leader: Peter Sforza, Virginia Tech

Issue: Vineyard site and cultivar decisions are often driven more by emotion and market perception than by research-based information; fruit quality and consistency of production often suffer as a consequence. Objective 2b proposes an ambitious synthesis of the cultivar performance data collected in sub-objective 2a, with contemporary climate, topographic, and soils datasets in an interactive GIS platform. We will develop the next generation GIS viticulture decision-aide that builds on ones previously developed in VA in the late-nineties, as well as more recent platforms developed for NY (http://www.nyvineyardsite.org). By combining efforts across the eastern US, we avoid duplication and redundancy, creating tools available to existing and potential growers throughout the East.

Methodology: The general approach is to generate state-wide digital maps reflecting "basic factors" such as historical (30-year) macroclimate (growing season length, heat accumulation, and growing season average temperature), mesoclimate (absolute elevation, slope, aspect or solar potential), soil properties and current land-use. These factors will be used to create high-resolution digital maps of vineyard suitability based on a ranking score system. A second set of state-wide maps will be generated based on "risk factors" for grape production in a given region, including winter freeze, spring and fall frost occurence, ripening period rainfall, Pierce's disease, and the potential for phenoxyacetic herbicide drift. These maps will be customized for each state, because the risk factors vary from one region to another. Performance period will be years 1-5.

Specifics: In order to accomplish the above, Geographic Information Systems (GIS) technology will be utilized. Spatial information systems are appropriate for this because criteria can be represented spatially as layers of geographic data, aggregating and assessing combinations of criteria, or different weightings to criteria. The result will be a composite map that identifies suitable and potential sites using Multi-Criteria Evaluation (MCE) (Malczewski, 1999). We will include both *basic* site physical and climate data, and *risk factors* in the GIS as follows.

Basic factors: Macroclimate parameters: To assess the climate suitability of the studied region, the PRISM (Parameter-elevation Regressions on Independent Slopes Model) model—derived from a combination of point data, digital elevation data, and other spatial data sets—will be used to create estimates of monthly and annual climate variables gridded at a 400 m (1312 ft) resolution (Daly et al., 2008; 1971-2000 climate normals). Using these data, predicted surfaces and contours fitted to terrain will be generated, using geostatistical procedures and applying the appropriate analysis by investigating climatic variables.

Length of growing season (or Frost-Free Days): Grape cultivars have different requirements of growing season length (defined as the consecutive days above 0°C) to ripen their fruit and harden-off their shoots. Generally, grapevines require between 160 FFD and 190 FFD. Based on daily minimum temperature observation, the length of FFD of each weather station in the past 3 decades will be calculated to obtain 30-year FFD normals.

Temperature during the growing season: There are several methods by which the warmth of the growing season is determined. The most common method is based on growing degree-day accumulation (GDD) from April 1 to Oct. 31 using a base temperature of 10°C. This concept was applied by Winkler et al (1974) who designated five California grape growing regions ranging from the coolest (<1,400 GDD) to the warmest (>2,200 GDD). Another method, based on the average growing season temperature (GST), was recently developed by Jones (2006), and is computed as the mean temperature from April 1 through Oct. 30. Using GSTs, Jones categorized grape growing climates into cool (13–15°C) intermediate (15–17°C), warm (17–19°C), hot (19–24°C) and very hot (21–24°C) winegrape maturity classes.

Mesoclimate parameters: Digital maps on a county-by-county basis will be developed utilizing 1/3 arc second (10 m x 10 m) USGS digital elevation models (DEMs). The ArcGIS 9.3 (ESRI, 2009) advanced Spatial Analyst extension will be used to perform a 'surface analysis' and generate maps of:

Absolute elevation (feet above sea level): The suitability of elevations will be based on the practical experiences and knowledge of the variations in climate structure over the landscape in the region. It will be developed on a region-by-region basis and will be assessed based on regional relative relief criteria. The best suited elevations will be given the highest value.

Slope (land inclination): Slopes will be categorized into classes with the best slope ranges between 5-15%; those above 30% will be classed not suitable for vineyard establishment.

Aspect: Aspect refers to the compass direction that a hillside or slope faces. The aspect of the landscape is normally used to describe solar exposure.

Soil properties: Data will be obtained from the Soil Survey Geographic SSURGO site suitability relative to soils will be analyzed using the Soils Suitability Extension (SSE). Physical properties used will include soil internal water drainage, available water holding capacity, and soil depth to bedrock. Chemical properties will include soil pH and organic matter.

Land use suitability: To incorporate land use issues relative to agricultural development, a statewide generalized zoning coverage will be used in the analysis sourced from each state's geospatial data state's department of natural resources. For this analysis only lands zoned agriculture, and commercial forest/mixed use are considered as agriculturally viable parcels.

Composite maps: These layers (macro- and meso-climate parameters described above) will be arithmetically compiled and weighted using a raster calculator in ArcGIS 9.3 software. This composite layer will then be converted to a feature layer preserving the same resolution, and reclassified into predicted site categories ranging from "Excellent" to "Unsuitable" sites.

Risk Factors: In addition to basic climate, terrain and soils data, user reports will be provided with site-specific risk factors that may affect decisions on site suitability. These will include:

Winter injury: Winter injury is common in eastern US vineyards and is primarily caused by critical temperatures, defined as low temperatures that lead to 50% injury of buds (Zabadal et al. 2007). Sites that experience those critical temperatures frequently are economically not viable and therefore not suitable for winegrape production. Critical temperatures vary with the environment, genotype, and cultural practices (Zabadal et al. 2007).

Frequency of minimum temperature (FMT): *Vitis vinifera* are the most cold sensitive grape species; hybrids and American species are more cold hardy. We will determine the frequency of

-23°C (critical temperature for vinifera), and -26°C (critical temperature for hybrids) events by decade over a 30-year period based on historical temperature data. An adjusted parameter, which takes into account the duration of the minimum temperature event, will also be determined.

Spring / fall frost: A spring frost index (SFI) will be included to highlight the risk of damaging spring frost (Wolf et al., 2008). The SFI is based on the range between average *mean* and average *minimum* temperatures (an index of "continentality") during budbreak months (April and May). A similar approach will be applied for determining fall frost risk (FFI) (Oct-Nov).

Expected outcomes: The practical output of this objective will be an interactive, web-based Geographic Information System which end-users can query to produce detailed vineyard site evaluation reports (soil, climate, additional site risks), as well as obtain localized recommendations on grape cultivars that would be suitable for the site. Cultivar recommendations would be based in part on the performance of cultivars in the NE1020 project, and would be updated as information is annually compiled on the NE-1020 project. The geographic coverage is intended for all of the states institutionally involved with this project, and others in the eastern US as time and data resources allow. A full description of the physical resources that would underpin this effort is included with "facilities and other resources".

Progress:

Summary

Virginia Tech Center for Geospatial Information Technology (CGIT) was tasked with developing a GIS based assessment and web application designed to evaluate site suitability for viticulture and improve matching of specific grape varieties with specific sites. CGIT has made significant progress in accomplishing this task by calculating server requirements, determining data parameters needed, assembling and analyzing datasets, and beginning website planning and development during the first year of the project.

Most of the base data has been collected and is being assembled and/or in the processing and analysis phase. Elevation data was collected and assembled, then used to create absolute elevation, slope, and aspect map layers for the area of study. Land cover data was gathered for the region. Soils data was obtained and CGIT is in the process of scripting a method of extracting soil parameters for the entire region that relate to viticulture. Climate data was collected from multiple sources and experiments are being conducted to determine which of these sources is most accurate and what method of interpolation is appropriate in this region. Other climate-based parameters will be derived using these base climate layers

The website planning and development is underway. A beta version of the website is up and running. CGIT used the ArcGIS API for Flex as a base and built a widget tool that allows the user to delineate their site by drawing a polygon. This tool will eventually be plugged into a geo-processing model that evaluates the user's site based on the given geometry and provide a PDF reporting on their site's conditions. The geo-processing model is still under construction so the tool is calling on a geo-processing model that only works for Virginia in this beta version.

At this time, CGIT has accomplished the objectives laid out in Scope of Work for year one with the exception of calculating all the climate parameter data layers. However, this process is well underway as we are investigating data options to ensure the most accurate data source is utilized

Other researchers from CGIT on this project include Erica Adams, GIS Analyst; Jaixun Chai, GIS Analyst; Thomas Dickerson, Project Associate; Allisyn Hudson-Dunn, PhD Candidate: Geospatial and Environmental Analysis

Objectives and Experiments Conducted to Meet Stated Objectives

The main objective assigned to CGIT in this project can be referenced as Objective 2b in the original proposal sub-contract, and it poses the following: "Develop a GIS-based model incorporating climatic, topographic, and edaphic parameters to improve "site-cultivar" suitability knowledge." The vision behind this is to provide a tool that evaluates specific parameters of a site and provides supportive interpretive information to guide a user in understanding their site's suitability for viticulture. The performance period of this task is 1-5 years. The area of study was identified as nineteen states in the eastern United States, including 13 states with a coastal boundary. The following identifies the actions necessary in year one to move towards meeting this goal:

- Calculate and prepare storage requirements for large amount of data
- Determine specific parameters to be reported by final model
- Data Collection, Processing
    - Elevation Data
    - Land Cover Data
    - Soils Data
    - Climate and Weather Data
- Preliminary Data Analysis
- Begin website planning and development
- Attend Annual Project co-PI meeting – Baltimore, MD (July 2011) in conjunction with ASEV/ES

Summary of Major research Accomplishments and Results by Objective

This section identifies the actions that have been taken to move towards meeting the goals and objectives mentioned in the previous section.

Determine specific parameters to be reported by final model

There are many different criteria that could be taken into account when determining the suitability of a site for viticulture. There is ongoing discussion between project investigators and stakeholders to determine the specific parameters which will be derived and used for this suitability model. Table 1 lists the currently agreed upon parameters to be evaluated based on the type of dataset needed to derive them. This list is still growing and active as we continue to research the necessary criteria for healthy grape and wine production. Most of the parameters used for this project are derived from general datasets retrieved from national or private entities.

Table 1. Viticulture suitability parameters are listed under data type from which they are derived. (Italicized parameters note completed datasets)

Land Cover Data	Elevation Data	Soils Data	Climate/Weather Data
Land Cover Type	*Absolute Elevation*	pH	*Length of growing Season*
	Slope	Organic Matter	Growing Degree-day Accumulation
	Aspect	Ksat	*Average Temperature during Growing Season*
		Soil Depth to Bedrock	*Average Precipitation during Growing Season*
		Available Water Holding Capacity	Monthly Min/Max/Mean Temperature during Growing Season
		Internal Water Drainage	Frequency of Minimum Temperature

Data Collection, Processing and Analysis
A fair amount of time was spent researching and gathering the best available data for the different criteria over the area of study. This is an ongoing process as we are continuing to experiment with different forms and versions of data to determine the best alternatives for parameters, specifically in relation to climate and weather based parameters. Figure 1 displays a few samples of completed data layers. At this point, it has been determined that no ranking of suitability will be determined server-side, so no scored maps of each parameter have been created.

Completed data layers exist for parameters italicized in Table 1. Progress by data type is as follows:

<u>Elevation Data:</u> 1/3 arc second USGS digital elevation models (DEMs) were collected and assembled to cover the entire area of study. USGS National Elevation Data was determined to be the best available data because of its reliability and its availability at a fine resolution over the entire region. ArcGIS 10 Spatial Analyst extension was used to perform surface analysis to generate maps of absolute elevation, slope, and aspect.

<u>Land Cover Data:</u> 2006 National Land Cover Data from the Multi-Resolution land Characteristics Consortium was collected for the area of study. This is the most recent broad scale land cover data available free to the public. The original proposal called for statewide generalized zoning data, however, there is no known provider of national or statewide zoning/land use data. Where this data is available, it is very fine scale (county or city scale) and very expensive.

<u>Soils Data:</u> Soils Data has been acquired and imported via SSURGO and STATSGO. Discussion and research has begun on how to process this large amount of data efficiently. Currently we are

looking at scripting and building a new tool to get this data into format that is usable in a geo-processing tool.

<u>Climate and Weather Data:</u> This data is more complex and requires the most background research in determining what is the best available data and what is the most appropriate way to process it. Climate and weather data can be very error-prone because data is collected at single point locations and interpolated over broad areas to provide regional grids of parameters such as temperature and precipitation. These base grids are used to calculate other parameters such as growing degree-days or growing season length, and errors will propagate to the secondary parameters. The basic daily and monthly climate factors we need and have collected are minimum, mean, and maximum temperature, and precipitation.

Experiment: To ensure the most accurate data source, we have collected temperature data from three sources: PRISM Climate group interpolated temperature grids, NASA MODIS remotely sensed land-surface temperature, and NOAA National Climactic Data Center (NCDC) weather station data. We are analyzing them to find significant difference and determine which is best to use as a base for calculating climate parameters for this project. We are also researching and experimenting with different interpolation methods to determine what covariates are needed to accurately interpolate climate factors in this region. Ultimately, we would prefer to script our own unique interpolation algorithm including factors that specifically affect climate and weather factors in the eastern US.

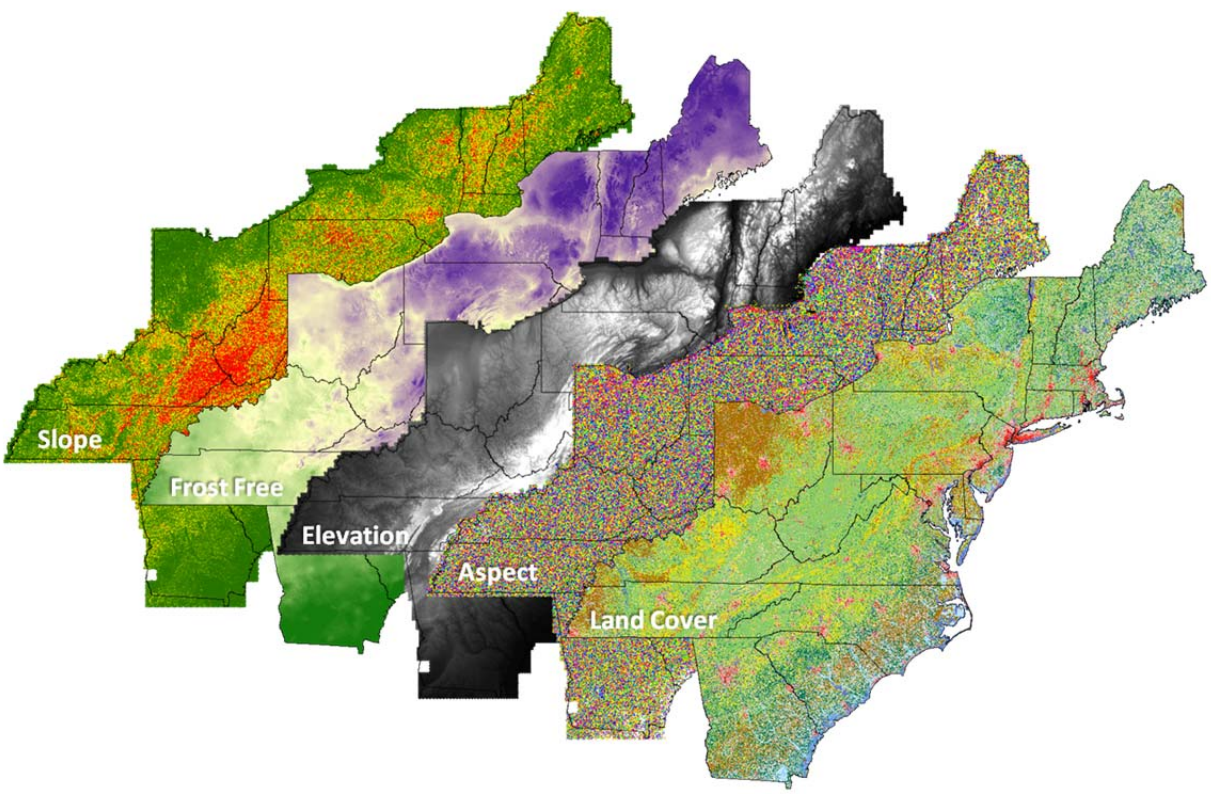
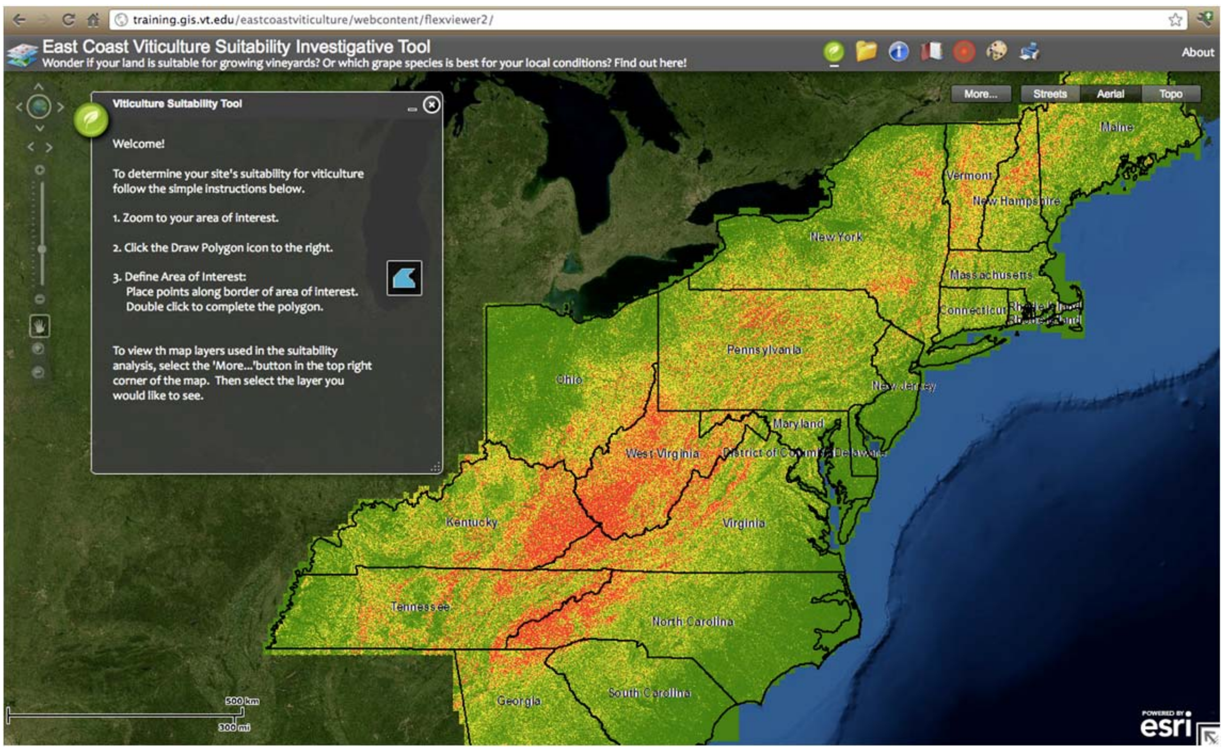


Figure 1. Samples of completed data layers for the area of study.

Begin Website Planning and Development

A significant amount of work has taken place in this area. A beta version of the website is up and able to be viewed at this time. It was built using the ArcGIS API for Flex. This API allows us to display interactive maps using our own data and develop tools and widgets that can be plugged into our geo-processing models. There are other APIs available using different scripting languages, however we chose the Flex-based API because it has excellent graphics, is easy to use both client and server-side, and comes highly recommended. Figure 2 shows the current website with an Aerial base map and a slope map overlay of the east coast region being studied in this project.



At this time, the webpage displays three base map types and seven overlays of data layers we have completed for this project. More overlays will be added for display purposes as we complete them. We have created a widget with a tool built in (shown in Figure 2), where the user draws a polygon and that polygon is sent back to our geo-processing service. The geo-processing model runs server-side based on the geometry input by the user and returns a PDF. At this time the tool is hooked up to a geo-processing model that was built only for Virginia, for testing purposes. The geo-processing model for the east coast region is still under construction.

The major task to complete in website development is finishing the geo-processing model for the entire east coast, which will not be possible until all data layers are complete. Other future work includes updating the layout and widget to be more appealing to the eye and easy for the layperson to use. To view the beta version of the website, direct your browser to http://training.gis.vt.edu/EastCoastViticulture/webcontent/flexviewer2.

Publications and Presentations of Research Findings
Because this project is still in its early stages, no publications or presentations have been completed at this time. However, we have submitted an abstract to present at the Association of American Geographers Annual Meeting in February 2012. We are also planning to publish the results of the previously mentioned research related to accuracy in climate data types and interpolation methods, that is a subset of this project. As we experiment with data types, interpolation methods, model building, and suitability analysis, we hope to publish and present our findings in outlets that communicate the findings to the end users and academic world. In order to do this we are looking into scholarly journals and conferences as well as more broadly known media sources.

Research Success Statements
The viticulture industry benefits from this research by having a web based mapping tool for vineyard assessment readily available, at no cost. A report can be generated for the user specified area of interest. The web application currently provides access to basic information regarding general soil characteristics, climate, and topographic features. The website is being regularly updated as analysis is completed and data is loaded onto the server.

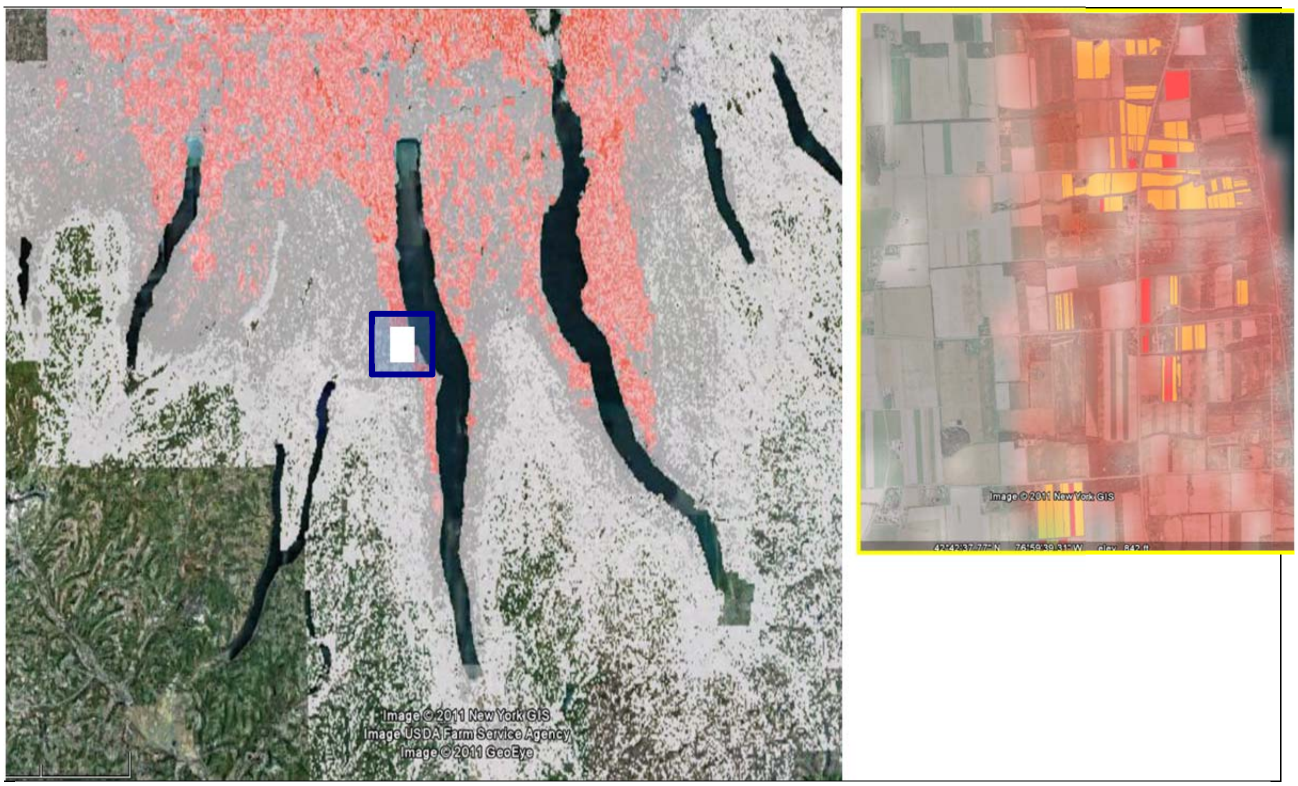
Funds Status

Personnel expenditures for full- and part-time employees working on this project make up the Direct costs from project inception through Sept 30. 2011 is $33,920.89 and indirect charges equal $8,819.44. A total of $3,400 was spent on the PRISM data , which included Tmax, Tmin, precip, and frost free days. Originally $5,600 was budgeted for this, resulting in $2,200 for anticipated data costs in the future.

Progress with New York GIS version (Lakso):

Prior to our award of this project, researchers in New York State had begun developing a state GIS model for vineyard site evaluation. Many of the model elements were similar to those eventually used in the "Eastern US" model described above, although differences also existed and the user interfaces were somewhat different. Initial collaborations of the NY program with the Objective leaders at Virginia Tech have focused on the developing a compatible project structure and selection of appropriate databases, especially climate, for the Eastern US. The range of states and climates represented require flexibility in model structure and weighting (e.g. winter minima are critical in the Northeast but summer maxima more important in the Southeast). Work specifically for NY has continued the development of the earlier GIS project that produced the NY Vineyard Site Evaluation online system (http://www.nyvineyardsite.org) . For more detailed development we have focused on the Finger Lakes as a region of great growth in plantings of cold-tender wine grapes, but also with a limited number sites that are well-suited for these varieties. A detailed farm-scale temperature-topography model is being developed and will be validated with a 6-year database of 30-minute vineyard temperatures collected in varying topography in the vineyard zone. Additionally, GIS site selection models are being developed based on identifying only locations that meet specific sets of criteria for particular varieties of interest.

The temperature interpolation by PRISM or the DeGaetano algorithms (DeGaetano and Beelcher, 2007) is very useful for identifying general mesoclimates for viticulture. However, it is desirable to develop a finer farm-scale model for estimation of viticulturally-relevant temperature variation. Once general mesoclimates are identified, then the farm scale model can be superimposed over the broader model in key areas. In collaboration with Dr. A. DeGaetano, Director of the Northeast Climate Center at Cornell University, an Atmospheric Sciences graduate student has begun to develop a farm scale temperature-topography model. It will be validated with our 6-year database of 30-minute temperatures from loggers located in the vine canopies in over 90 locations of varying topography in 7 vineyards in the Finger Lakes.



Left figure: A preliminary composite map of the sites that meet the criteria as the most preferable for Riesling grape cultivation (reddish color along the lake shores and to the north). Right figure: A section along Seneca Lake in box on left showing the composite preferable sites with an overlay of existing vinifera vineyards indicating good agreement.

DeGaetano, A.T. and B.N. Belcher. 2007. Spatial interpolation of daily maximum and minimum air temperature based on meteorological model analyses and independent observations. J. Appl. Meteorol. Climatol. 46:1981-1992.

Objective #3: Understand and capitalize on regional wine style through market exploration of consumer perception/demand, willingness to pay (WTP), and influence of quality-assurance programs (Rickard, Safley)

Team Leader: Brad Rickard, Cornell University

Issue: Eastern US wine regions can be thought of as small but growing economic *clusters* (exhibiting a range of economic activity within a defined geographical area). Successful clusters include strengths in the areas of demand, factor conditions, firm structure, and industry support. Market strengths and weaknesses are poorly understood within the eastern US wine industry.

Specifics: This project aims to achieve the following: 1) Determine the key factors that influence consumer decisions to purchase wines at independent wineries, such as product selection, product quality, prices, and competing wines. 2) Determine the effectiveness of advertising and promotional programs for influencing customers to purchase wines from independent wineries. 3) Determine consumer satisfaction with the wines currently offered at various marketing outlets such as grocery stores, wine stores and competing independent wineries. 4) Identify and characterize the various market segments for wine. 5) Determine how consumers view the East Coast wine industry and how the industry could build customer satisfaction and loyalty to increase its market share. 6) Recommend specific changes that will assist winery managers to improve their marketing, advertising, and promotional programs. 7) Use experimental economics to study how alternative advertising approaches influence consumers' willingness to pay (WTP) for wines produced in the East.

During Year 1 (2010-11) we began to develop a plan for studying the key economic considerations for various stakeholders in the wine industry in the Eastern United States. The economic objective consists of two interrelated components; one focuses on economic issues in "upstream" markets that are more related to producers, and the second focuses on "downstream" markets that are more related to consumers. The first component of such an analysis will examine "upstream" economic issues that are important in the production of wine grapes and wine, including the relative cost of producing grapes and wine in the Eastern United States (led by economists at NCSU). The second component of the economic analysis will examine issues that are important in "downstream" markets, specifically studying consumer response to wines, including wine marketing techniques, that are produced in Eastern States (led by economists at Cornell).

These two components of the economic objective are being conducted separately, but once the results from each component have been interpreted, our plan is to integrate the two pieces to provide us with a better understanding of how economic conditions might impact all stakeholders along the supply chain in the Eastern U.S. wine industry. This approach allows us to develop a more holistic framework to examine the relevant economic issues facing the eastern U.S. wine industry. As one example of this, the information that describes consumer preferences for Eastern U.S. wines—and the factors that influence such preferences—will be integrated into the cost analysis of different production practices to provide a more holistic evaluation of the economic outlook for specific wines produced in specific eastern regions. As a second example, we will identify per unit costs for key inputs used in wine production, and try to assess how consumers may respond to wines that use more or less of these inputs. As a result, we see many opportunities for integration between the two economic components in the project as well as integration between the economic objective and the other production- and extension-related objectives.

Progress:

Using a laboratory experiment to better understand consumer valuation of eastern U.S. wines
Principal Investigator: Brad Rickard, Cornell University

The economic component that is examining consumer response to eastern U.S. wines is scheduled to occur in Year 2 (2011-12) and Year 3 (2012-13). One of the first tasks in examining wine consumption patterns for east coast wines is to study the role of reputations. The development of a brand for a wine product can be enhanced by the firm's reputation and by the collective reputation for a geographic region. Geographical Indicators are a good example of collective reputation efforts used in the European Union and to a lesser degree in the United States and elsewhere. Appellations are considered to be the main source of collective reputation in wine markets; research has shown that collective reputations are often an important determinant in the price of wine, notably for wines from well-established appellations.

Part of our plan here is to extend the idea of collective reputation to include both the geographic region where a wine is produced and another well-established appellation with similar production characteristics with a focus on eastern U.S. wines. Although there is an agreement in place between the United States and the European Union that prohibits the use of each other's appellations on wine labels, we still see many references to European appellations in Western U.S. wine markets (e.g., the Hospice du Rhône event in Central California and the Alsace Festival in Northern California). We are particularly interested in understanding the impact of reputation spillovers in emerging eastern wine regions in the United States.

The existing models of dual reputation (firm reputation and collective reputation) are extended in our conceptual framework to include the role of reputation spillovers. Our central hypothesis is that reputation spillovers will have a positive influence on consumers' valuation of wine products, and that the effect will be greater for wines from lesser known regions in the United States. Our hypothesis is empirically testable using experimental economics in a laboratory setting using commercial wines from various U.S. appellations.

During 2011-12 we are introducing seven white wines (three from California, two from Oregon, and two from Virginia) to 264 non-student subjects; all wines were produced from grapes harvested in 2009, used similar styles of labels, and received wine expert scores that ranged between 80 and 89 (out of 100). Subjects were paid $25 to participate and randomly signed up for a session in one of three treatments differentiated by the information presented; each treatment was replicated four times and the order of the wine auctions was randomized in each session. Subjects in the first treatment received no information about appellations, subjects in the second treatment received information about the American Viticultural Area (AVA) for each wine, and subjects in the third treatment received information about the AVA and about a similar wine appellation in France. All subjects were asked to place bids on all seven wines, and following the auctions all subjects completed a survey that collected demographic information plus food and beverage preferences and wine knowledge. We asked subjects to place bids that characterize the most they would be willing to pay for each bottle of wine.

Data collected in the experiment show that the average age of our subjects was 42; in addition, 74% were female, 32% had children living at home, and 78% were the primary wine shopper in the household. Subjects indicated that they were most familiar with Chardonnay (average score of 3.49 out of 5) and least familiar with Voignier (average score of 1.84 out of 5); they were most familiar with California wines (average score of 3.21 out of 5) and least familiar with Virginia wines (average score of 1.71 out of 5). The average bid for all wines across all treatments was $9.06; regression results show that there was a statistically significant premium of about $0.55 for Pinot Gris wines (relative to Chardonnay) and that wines from Oregon and Virginia received bids that were approximately $1.05 less than wines from California. We used these data to estimate consumers' willingness to pay (WTP) for the wines; an unrestricted model is estimated using all data and a restricted model is estimated using data from subjects with average bids that exceed $3.00 (to remove the few subjects that were thought to be "gaming" the system).

Our empirical model estimates the effects of information treatments, wine regions, wine varietals, interactions between information treatments and wine regions, and various demographic variables on consumers' WTP for wines. Econometric results show that the estimated coefficient on wines identified as produced in Oregon and Virginia (relative to California) was negative and statistically significant. Overall, the information treatment effects (relative to no information) were not statistically significant; however, the estimated coefficient on the information treatment that linked AVAs to regions in Europe was positive and statistically significant among subjects that were relatively familiar with wine regions. The interaction term between the lesser known regions (Oregon and Virginia) and the treatment that introduced information about AVAs was not statistically significant, but the interaction term between the lesser known regions and the treatment that introduced information about AVAs and French appellations was positive and statistically significant in all models. These interaction effects were even stronger for the subjects that were relatively familiar with wine regions and wine varietals.

Our results have two important implications for wineries in emerging regions in the United States. First, drawing attention to AVAs for wines from emerging regions does not seem to impact consumers' valuation, even among consumers that are relatively familiar with wine varietals and regions. However, efforts to highlight AVAs in emerging regions may be a critical part of developing a long term strategy for building reputations of new wine appellations in the United States. Second, our results suggest that information that uses references to well-established regions in France did resonate with subjects in our experiment, and indicates that making such links to more established regions in France may prove to be an effective marketing strategy for wines from emerging regions, notably among consumers with some wine knowledge. Results from this analysis will be coupled with the cost of production research to compare the net economic benefits—and to understand in a relative way—of demand enhancing strategies versus strategies that influence the costs of producing wines in eastern U.S. regions.

North Carolina Survey
Principal Investigator: Charles Safley

Year 1 Objectives

- Meet and/or communicate with stakeholders to finalize needs
- Write the survey instrument (w/ Ag Statistics, NCDA&CS)
- Stakeholders review survey instrument
- Finalize survey instrument (w/ Ag Statistics, NCDA&CS)
- Develop survey plan (with Ag Statistics, NCDA&CS)

Drs. Charles Safley and Sara Spayd met with NCDA statisticians (the contracted group to implement the telephone survey to be conducted in 2012) for preliminary discussions of key information to collect in the survey. The survey instrument is under construction. [Safley, Spayd]

Progress:

We met with the USDA Statistical group based with the NC Department of Agriculture. The survey instrument is under development. Examples of similar surveys from other regions are being reviewed, combined, and edited. We plan to implement the survey by fall 2012, before the group is potentially transferred to Kentucky.

Objective #4: Develop a range of resources including decision-assisting tools to encourage implementation of production practices that improve grape and wine quality, decrease production costs, and improve the competitiveness of the Eastern US wine industry.

The goal of the *research* component of this project is to provide solutions to fundamental constraints to grape and quality wine production in the East. The goal of the *Extension* component is the informed transformation of those solutions by industry members into sustainable practices for the production of high quality, regionally branded wines that compete favorably in the market. To do this, we will use a suite of traditional as well as contemporary approaches that consider our diverse audience—producers, students, employees, and consumers. We recognize that farmers utilize a range of instructional tools and have preferences for some over others. We will therefore use several media and methods to ensure the widest possible adoption of the knowledge and recommendations generated by our research. We will use a program action-logic model (Taylor-Powell, et al., 2002) to: 1) produce a baseline of clientele knowledge and grape-growing practices (year 1); 2) provide project performance relative to intended outcomes; and 3) assess outcomes and impacts. As part of this process, we have assembled a Project Advisory Council (PAC) (**Appendix D)** to provide annual input and to monitor the project's progress. The PAC will provide a statement of performance to accompany our annual progress report to our sponsors including USDA/NIFA. The PAC represents a demographically diverse cross-section of stakeholders invited to participate in the proposal development. Its members have therefore been involved since the inception of the proposal.

Proposed and ongoing Extension activities are as follows:

1) *Annual meetings of project staff and the PAC, reception and use of ongoing feedback (all co-PIs):* We will convene annual project investigator and PAC meetings to review performance of the project, and to coordinate extension presentations and publications for each ensuing year. These meetings are tentatively planned to be held in conjunction with the Eastern Section meetings of the American Society for Enology and Viticulture. This group will use the program action – logic model to guide program description and evaluation. Annual evaluations will be focused on which aspects of the project are progressing and which activities need improvement to achieve the intended outcomes, or to cease.

Progress:

First annual meeting was held in July 2011 in Towson, MD, following ASEV/ES meeting (see Appendix C. This led to a number of action items, most of which have been executed. The current need is to coordinate a project annual meeting for 2012 to evaluate current progress and chart additional extension activities.

2) *Panel survey of Eastern grape wine growers in Years 1 and 4:* In order to gauge the outcomes and impacts of our program outputs we will work with the Virginia Tech Survey Center to survey 1,000 eastern wine-grape growers by providing a series of regionally standardized concept awareness questions about grapevine canopy management strategies, winemaking issues, site and cultivar interaction, and wine marketing issues. Additional, region-specific questions will be developed to reflect unique climate or market parameters. We propose a baseline survey of several pages that will use a number of approaches to increase response rate, including reminder postcards and follow-up telephone calls. The target audiences will be selected from membership lists of grower associations and wineries in sub-regions, and will reflect the demographics, grape varietal mix, and market objectives of each group. The survey will be repeated in year 4, including additional questions regarding respondent exposure to and use of information provided by the project. The initial survey questionnaire will establish benchmarks of knowledge, grower and vintner application, and perceived benefits of methods and management practices explored with this project application. We will design and implement the survey in Nov. 2010 in concert with members of the PAC. In order to promote a high response rate for the survey in year 4, we will hold focus-group meetings for interested and available growers in year 3. The focus-group approach will help us learn what growers think is working and what we might need to change. It will also allow another point of contact with the growers that we anticipate will help improve our survey response rate in year 4. We intend to host three sessions of approximately 30 growers each.

Progress:

Dr. Jayaratne, the project evaluator, collected input from other participants in the SCRI and developed the baseline survey instrument to determine the status of knowledge of the eastern US grape industry members (nearly 1100 surveyed). The survey instrument was executed through the VT survey center and results returned to Dr. Jayratne for evaluation (See **Appendix E**).

3) *Educational events/media (all co-PIs and collaborators Brown, Creasap Gee, Gerling, Chien, Ennahli, Walter-Peterson, and Schloemann):* We will provide in-depth shortcourses, hands-on field workshops, and demonstrations for producers. The structure for annual workshops and industry meetings is largely in place and typically coordinated through state-specific grower/vintner organizations, such as the Pennsylvania Association of Winegrowers (PAW), Ohio Grape and Wine Conference (OWPA), the Virginia Vineyards Association (VVA), and the Finger Lakes Grape Grower's Convention. We propose a continued cooperation with these industry organizations through specific program contributions related to the research aspects of this project. We also propose partnering with Wineries Unlimited (http://wineriesunlimited.vwm-online.com/) to provide a full-day program on vine balance issues in the **3rd year** of this project (March 2013). Principal Investigators, graduate students, and cooperative grower panel discussions would be used to share research and experiential data.

4) *Educational events for Cooperative Extension agents and educators (Dami, Fiola, Spayd, Wolf):* We will train Cooperative Extension agents by conducting in-service training workshops in key grape growing counties (or multi-county areas) of participating states. We will partner with other funding agencies (e.g. Southern Region Small Fruit Consortium, and SARE) to host a wine grape canopy management workshop in each of three states (NC, VA, and NY) in 2011 or 2012. Assessment of outcomes will entail methods used by the PD in previous in-service training sessions in VA (see: http://www.smallfruits.org/Newsletter/Vol7-Issue1.pdf for example).

Progress:

Although not planned in the first year, Wolf et al. conducted an in-service training workshop on commercial grape growing for Virginia Cooperative Extension agents on 6 December 2011. A regional meeting of the same nature was proposed to the Southern Region Small Fruit Consortium, to be held in Virginia in 2013 (team taught).

5) *Outreach to workforce-development focused viticulture educational programs:* Based on stakeholder input and interests (**Appendix A**), we recognize that sustainable growth of the eastern US grape and wine industries will depend in part on training industry members at varied skill levels. While we cannot commit USDA resources to education, *per se*, the educational resources that are generated in this project should be easily adapted to community college instructional format. For example, the Wine Grape Production Guide for Eastern North America (NRAES, 2008) is used as the principal viticulture text by a number of community colleges, including Patrick Henry and Piedmont Virginia in VA; Surry, in NC; and Santa Rosa Junior College in CA. We will use existing documentation and an informal survey of community colleges and other viticulture programs in Eastern North America to determine which texts, resources and approaches instructors use for their learners. After gathering this information, we will suggest to respondents resources that they may not be familiar with that are relevant to them and that are products of this project. This listing of resources will be used as an incentive to increase participation in the survey and dissemination of the knowledge of these resources.

6) *On-line decision support tools (Dami, Lakso, Jones, Sforza, Wolf):* We will develop the next generation Geographic Information System (GIS) to promote logical growth and development of the eastern US wine grape industry. This relates primarily to Objective #2 and the refinement of cultivar and environment matching. Virginia Tech will host this interactive GIS-based vineyard evaluation tool (see "facilities"). We intend that the user interface will ask each visitor questions to evaluate the GIS tool. Prior to use, users will be asked their top 2-3 reasons for using the site. Immediately after using the site, users will be asked about their satisfaction with their experience with the site and their intended uses of the information. Depending on volume, we may proceed with follow-up contacts to determine how the GIS information was incorporated (or not) into site selection, business and/or production planning.

7) *Continued involvement and development of the eXtension Community of Practice (co-PIs with extension appointments and collaborators):* Our project includes an eXtension Communities of Practice (CoP) component. Communities of Practice are virtual networks of individuals who share common interests, and learn together by sharing experiences and knowledge. The availability of high-speed internet access and national hosting organizations such as eXtension is redefining the way information and practical knowledge are accessed. We will partner with the fledgling grape CoP by providing initial modules of recommendations generated and/or refined by the research of this project. This sub-objective meshes well with a goal of the National Viticulture and Enology Extension Leadership Conference (http://www.reeis.usda.gov/web/crisprojectpages/206760.html) assembly to implement national, web-based resources for grape and wine producers. Proposed areas of CoP contribution (by 4th year) include (i) definitions of vine balance; (ii) conventional metrics applicable to managers and unskilled workers to assess vine balance; (iii) means of reducing variability in vine size and vigor within the vineyard; (iv) sustainable vineyard floor management practices; and (v) sustainable vineyard nitrogen fertilization practices. To be valued, we envision regular eXtension contributions from team members or their students and staff, including periodic addressing of posted questions.We will determine the appeal of the CoP with a user survey in years 1 and 4 of the project, focusing on use of resources and growth in the diversity of membership groups.

8) *Development of vineyard capacity assessment resources (Lakso and Wolf) and additional canopy architecture metrics (Vanden Heuvel)*: A practical method to estimate vineyard capacities as well as cluster light environment will be developed as a deliverable for the project using the methods discussed in **Objective #1b**. The grower will be guided to 1) take dimensions of their vineyard (spacing, trellis height, canopy thickness) to find the estimate of potential light interception on a graph; 2) estimate their trellis fill by choosing a photograph that most closely represents their vineyard; and 3) entering the potential and the trellis fill values into a simple equation in a spreadsheet or on a website. The calculated value will estimate the largest crop that can be ripened adequately. Although each unique set of vineyard and weather conditions will vary, this quantitative method will provide a beginning point for site-specific management. The vineyard capacity estimation process and canopy architecture determination metrics will be explained and demonstrated to growers at winter meetings, in small group sessions and via the web tutorials. The project will assess grower use of these grower tools through end-of-session feedback forms.

9) *Leadership development and knowledge transfer (all co-PIs):* We consider the training of graduate students to be an important outcome of this research, as these students will be needed to assume vital industry and academic roles in the future to sustain the growth and development of the Eastern wine-grape industry.

Progress:

A number of graduate students and two post-doctoral research associates are supported on this project, including (PI advisor in parentheses):

Cornell:

Joe Perla, MSc candidate (Rickard)
Dr. David C. Manns, post-doctoral research associate (Mansfield)
Céline Coquard Lenerz, Master's candidate, (5/12) (Mansfield)
Diane M. Schmitt, MSc candidate (Mansfield)
Dr. James Meyers, post-doctoral research associate (Vanden Heuvel)
Ms. Rebecca Sirianni, MSc candidate (Vanden Heuvel)

North Carolina State University:

Mr. Brandon Smith, MSc candidate, (Spayd)

Ohio State University:

Yi Zhang, PhD candidate, aspects of NE-1020 variety evaluation

Virginia Tech:

Mr. Cain Hickey, MSc degree (2012) "Optimized grape potential through root system and soil moisture manipulations" (Wolf)
Mr. Cain Hickey, MSc completed 5/12; PhD, starting 5/12 (Wolf)
Ms. DeAnna D'Attilio, MSc, starting 5/12 (Wolf)
Mr. Kyle Schutt, MSc, candidate, Computer Science (Sforza et al.)

Appendix A. Proposed timeline of work (from original proposal)

	Year				
Objectives/Task	**1**	**2**	**3**	**4**	**5**
Objective 1: Develop applied means to optimize vine balance and increase quality while minimizing environmental impact.					
Sub A: Under-trellis viticultural practices	*	*	*	*	*
Sub B: Canopy and crop measuring tools	*	*	*	*	
Sub C: Impact of light and temperature variation	*	*	*		
Objective 2: Optimally match grape varieties with site					
Sub A: Performance of novel wine grape cultivars	*	*	*	*	*
Sub B: Develop GIS decision aide	*	*	*	*	*
Objective 3: Market exploration of consumer perception/demand, willingness to pay, and impact of quality-assurance programs					
Sub A: Consumer decisions to purchase wines	*	*	*		
Sub B: Advertising and promotional programs		*	*	*	
Sub C: Consumer satisfaction		*	*		
Sub D: Market segments			*	*	
Sub E: Increase market share		*	*	*	
Sub F: Improving marketing, advertising, and promotional programs				*	*
Sub G: Alternative advertising and willingness to pay (WTP)	*	*	*	*	
Objective 4: Encourage implementation of production practices that improve industry well-being and improve competitiveness of the Eastern wine market					
Sub A: Benchmark baseline knowledge/skills level and establish desired competency targets	*				
Sub B: Produce and use outcomes/deliverables		*	*	*	*
Sub C: Obtain stakeholder feedback			*	*	*

Appendix B. Project director, principal investigators, and collaborators

Program Staff (after PD, co-PIs are listed alphbetically by institution and then name):

Dr. Tony K. Wolf (PD and co-PI), Professor of Viticulture, 75% Extension & 25% Research; AHS Jr. Agricultural Research and Extension Center, Virginia Tech, 595 Laurel Grove Rd., Winchester VA 22602; vitis@vt.edu

Dr. William R. Nail (co-PI), Assistant Scientist II, 100% Research. The Connecticut Agricultural Experiment Station, 123 Huntington Street, New Haven, CT 06504, william.nail@ct.gov

Dr. Alan Lakso (co-PI), Professor, 70% Research, 20% Extension & 10%Teaching, Dept. of Horticultural Sciences, Cornell University, NY State Agricultural Experiment Station, Geneva, NY 14456; anl2@cornell.edu

Dr. Anna Katharine Mansfield (co-PI), Assistant Professor of Enology, 60% Extension & 40% Research; Dept. of Food Science & Technology, NYSAES, Cornell University, 630 W North St., Geneva, NY 14456 akm87@cornell.edu

Dr. Ian Merwin (co-PI), Herman M. Cohn Professor of Horticulture; 50% Teaching, 45% Research, 5% Extension; Dept. of Horticulture, Cornell University, Ithaca, NY, 14853; im13@cornell.edu

Dr. Brad Rickard (co-PI), Assistant Professor of Applied Economics and Management, 50% Extension & 50% Research; Cornell University, 255 Warren Hall, Ithaca, NY 14853 bjr83@cornell.edu

Dr. Justine Vanden Heuvel (co-PI), Assistant Professor of Viticulture, 50% research & 50% teaching, Cornell University, Ithaca NY, 14853; jev32@cornell.edu

Dr. Wayne Wilcox (co-PI), Professor of Plant Pathology, 15% Research, 35% Extension, 10% Teaching, 40% Administration, Dept. of Plant Pathology, Cornell University, NY State Agricultural Experiment Station, Geneva, NY 14456 wfw1@cornell.edu

Dr. Imed Dami (co-PI), Associate Professor, 60% Research & 40% Extension. Department of Horticulture and Crop Science, Ohio Agricultural Research and Development Center, 1680 Madison Ave., Wooster OH 44691; dami.1@osu.edu

Dr. John Havlin (co-PI), Professor of Soil Science, 17% Extension, 8% Research, 75% Academic, Dept. Soil Science, Campus Box 7619, NC State University, Raleigh, NC 27695-7619 john_havlin@ncsu.edu

Dr. K.S.U. (Jay) Jayaratne (co-PI). Assistant Professor and State Leader for Program Evaluation. Campus Box 7607. NC State University, Raleigh, NC 27695-7607 jay_jayaratne@ncsu.edu

Dr. Katie Jennings (co-PI), Research Assistant Professor, 100% Research, Dept. Hort. Science, Campus Box 7609. NC State University, Raleigh, NC 27695-7609 katie_jennings@ncsu.edu

Mr. Wayne Mitchem (co-PI), Extension Associate, 67% Research, 33% Extension, Mtn. Hort. Crops Res. Ext. Ctr., 455 Research Drive, NCSU, Hope Mills, NC 28732, wayne_mitchem@ncsu.edu

Dr. Charles Safley (co-PI), Professor of Agricultural and Resource Economics, 87% Extension, 13% Academic, Department of Agric. Res. Econ., Campus Box 8109, North Carolina State University, Raleigh, NC 27695-8109 Charles_Safley@ncsu.edu

Dr. Sara Spayd (co-PI), Extension Viticulture Specialist/Professor, 60% Extension & 40% Research; Department of Horticultural Science, Campus Box 7609, NC State University, Raleigh, NC 27695-7609; sara_spayd@ncsu.edu

Dr. Turner Sutton (co-PI), Professor of Plant Pathology, 20% Extension, 60% Research, 20% Academic Affairs, Dept. Plant Pathology, Campus Box 7405, NC State University, Raleigh, NC 27695-7405 turner_sutton@ncsu.edu
Dr. Robert Crassweller (co-PI), Professor of Tree Fruit, 85% Extension & 15% Research; Penn State University, 102 Tyson Building, University Park, PA 16802, rmc7@psu.edu
Dr. Joseph A. Fiola (co-PI), Professor and Specialist in Viticulture and Small Fruit (85% Extension, 15% Research), Western MD Research & Education Center, 18330 Keedysville Road, Keedysville, MD 21756-1104; jfiola@umd.edu
Mr. Peter Sforza (co-PI), Co-Director and Research Scientist, Center for Geospatial Information Technology, 2060 Torgersen Hall, Virginia Tech, Blacksburg, VA 24061, sforza@vt.edu
Dr. Bruce Zoecklein (co-PI), Professor of Enology, 50% Research, 45% Extension, 5% Teaching; Virginia Tech, Food Science and Technology, Blacksburg, VA 24061 bzoeckle@vt.edu

Collaborators: Collaborators involved with this project include:
- Mr. Mark Chien, Wine Grape Extension Educator, Penn State
- Dr. Jodi Creasap Gee, Viticulture Extension Specialist, Cornell
- Mr. Chris Gerling, Enology Extension Associate, Cornell
- Dr. Joshua Heitman, Assistant Professor, Soil Science, North Carolina State University
- Dr. Gregory Jones, Professor of Environmental Studies and Climatologist, Southern Oregon University
- Dr. David Monks, Professor, Department of Horticultural Science and Assistant Director, NCARS, NC State University
- Dr. Mizuho Nita, Grape Pathologist, Virginia Tech
- Ms. Sonia Schloemann, Extension Fruit Specialist, University of Massachusetts
- Mr. Hans Walter-Peterson, Finger Lakes Viticulture Extension Instructor, Cornell

Appendix C. Project PI and PAC annual meeting notes, 14 July 2011, Baltimore, MD.

Meeting started 1:30 pm and lasted until 4:00 pm; held as post-conference meeting to ASEV/ES annual meeting.

Attending:

Principal Investigators

- Tony Wolf (Virginia Tech)
- Tremain Hatch (Virginia Tech)
- Bruce Zoecklein (Virginia Tech)
- Peter Sforza (Virginia Tech)
- Alan Lakso (Cornell)
- Bill Nail (CT Ag Expt. Station)
- Imed Dami (Ohio State)
- Sara Spayd (NCSU)
- Rob Crassweller (Penn State)
- Denise Gardener (Penn State)
- Joe Fiola (U of MD)
- Jim Myers (Cornell, for JVH)

Project Advisory Committee members

- David Schroeder
- Keith Striegler
- Jim Benefiel
- Rock Stephens
- Kenner Love
- Tim Martinson
- Joyce Rigby

Project Director (TK Wolf) asked for self-introductions and provided an overview of where the project stands, 9 months into performance. Wolf also spoke to the purpose of the Project Advisory Committee members and thanked those present for attending (see action items). The project is moving forward on many fronts and this has been facilitated by having a few key PIs coordinate activities and reporting within their respective institutions (Cornell and NCSU in particular). The project formally began on 1 October 2010; however, a number of the sub-contractors did not have accounts set up until early 2011. Short, interim reports were handed out and much of the meeting time was spent reviewing reports from those attending the meeting, principally in the order that the Objectives were laid out in the proposal.

Objective 1a. Develop applied means of achieving vine balance under variable conditions (**Wolf leads**)

- Cover crops, rootstocks and root restriction as means of optimizing vine balance

Virginia: Wolf reviewed on-going project at Winchester with Cab Sauvignon and that an associated experiment to evaluate mode and timing of N fertilization was started in 2011. This will be expanded in 2012 to include at least one additional vineyard. Both components of project progressing well, with data collection on-going.
New York: Project report from Ian Merwin and Justine Vanden Heuvel was handed out. Note: Wolf visited the Dryden NY site on 15 August, meeting with both Merwin and Vanden Heuvel. Details will be provided in the annual report. Project is in 4th leaf and progressing well. Site was equipped with under-vine drainage basins (lysimeters) to allow water sampling to monitor nutrient and pesticide leaching through soil profile as function of vineyard floor cover. Data being collected.
North Carolina: Project set-up at Raylen Vineyards in Yadkin Valley. Project compares width of herbicide strip under-trellis and response of vines and soil moisture dynamics. A graduate student was hired to conduct the day-to-day operations. Note: Wolf visited this site on 7 July and met with Sara Spayd, graduate student and Steve Shepherd (project stakeholder).

Objective 1b. Develop canopy and crop management metrics to achieve consistent vine balance and canopy microclimate

- Canopy description: Vanden Heuvel had prepared an interim report on activities with this sub-objective. The goal is to develop and refine tools that growers can use to define and reach canopy architecture targets (what is desirable? How can growers best achieve the desired architecture?). The metrics also need to be adapted as influenced by the findings of the other two sub-objectives of 1b (**Vanden Heuvel leads**)

- Impact of light and temperature variation in canopies on specific flavor and aroma compounds…across different geographic regions: The basic question being asked by this work is whether the macroclimate of a region should dictate a specific approach to canopy fruit exposure to optimize flavor and aroma potential. Should, for example, the canopies of Cabernet franc grown in North Carolina's Piedmont be managed the same way for Cabernet franc grown in the Finger Lakes? This part of Objective will be done in NY, VA and NC. The project started in NY in 2011, but will not be set up in vineyards in NC or VA until 2012. Some questions arose about what fruit components should be examined and who decides which are important (this could vary by region). Also, necessary to differentiate between temperature and light effects on grape composition. Need to involve viticulturists and wine chemists together on this sub-objective. Exposure treatments (up to 4) would be set-up with vines as blocks so that all exposure levels found on each vine. Wines would be made and evaluated for longevity, quality and the reductive potential of phenolics
Action item: This sub-objective requires a leader to coordinate the work. Will ask Justine Vanden Heuvel

- Estimating climate-specific vineyard capacity for balancing vineyard crop loads: Alan Lakso discussed the basis of this sub-objective -- a need to estimate vineyard capacity, to more efficiently use sunlight and to crop vines at levels that are appropriate for vines' variable capacity. There ensued a good bit of discussion (including from some PAC members) about tolerable crop levels from a wine quality potential standpoint.

Details on this sub-objective need to be better defined. As proposed, the work would involve vineyards in VA and NY would involve varied crop levels on the treatment vines. A concern that I have (TKW) is that crop loads that produce crops that meet fruit compositional standards, still might not meet wine quality expectations/standards. Thus, should wines be produced? If so, this increases the amount of work needed to accomplish the sub-objective.
Action item: I would ask Alan Lakso to coordinate a phone conversation with other PIs involved with this subobjective to further define details this fall.

Objective 2. Develop research-based recommendations for optimally matching grape cultivars with site-specific environmental conditions

- 2a. Evaluation of viticultural and enological performance of novel wine grape cultivars [NE-1020 project and others] **(I. Dami to lead)**
- 2a. Wine-making (**A.K. Mansfield to lead**)

Imed Dami reviewed their work on this sub-objective in Ohio and mentioned that winter injury, and the threat of winter injury (-15F) is a primary limitation in central OH. They have capacity for testing plant cold hardiness, although the NE-1020 vines were not large enough in 2010/2011 winter to sacrifice canes for that purpose. Cold hardiness tests in 2011/2012 winter will need to be coordinated: some to be done at Winchester (Wolf), and some at Ohio (Dami). Either Imed or Bill Nail can represent the project at the NE-1020 meeting in Idaho this November.
Action item: Imed Dami to develop a plan with input from Spayd and Wolf on cold hardiness testing of NC, MD, and OH plant material. Similar effort needs to address needs of NY and CT (others). Testing at Geneva, but need a plan in place.

Both Bill Nail (CT) and Joe Fiola (MD) also provided updates on their respective NE-1020 plantings. The CT planting is doing well and wine will be made at Geneva (AKM, TKW and B. Nail have had subsequent dialogue on getting the plans for CT wines set up before harvest. Maryland planting(s) in third leaf. Wolf will visit Fiola at Keedysville during crush. Wolf visited Biglerville planting of NE-1020 on 16 August with Gardener and Crassweller. Vineyard looked good, but suffering some bird damage. Netting to be applied. Gardener has outlined plans for ferments for 2011.
Action item: Need more detail on which varieties, and in which states, the NE-1020 varieties will be made into wine. (Cornell, Ohio, MD, and NC – as well as CT)

Objective 2b. Develop a GIS-based model incorporating climatic, topographic, and edaphic parameters to improve matching of cultivar with site.
Peter Sforza (VT) provided an overview of their progress on the development of an east coast GIS tool to aid vineyard site evaluation. They (CGIT) have been assembling datasets and calculating server requirements (enterprise technologies) for handling the large amount of data required. Peter has hired a full-time geographer (Erica Adams) to assist with development.
Action item: I've asked Peter Sforza to lead this sub-objective, and would ask Imed Dami and Alan Lakso, as well as stakeholder Jim Benefiel, to serve on a sub-committee to move this sub-objective forward. I met with Sforza et al. on 8 August and we will arrange a follow-up conference call the week of 29 August to further flesh out plans. DONE or in progress.

The east coast GIS model will not take the place of the NY or VA tools that already exist. Both the VA and NY models may be able to offer more specific information. The vision at this point is to have a tool that evaluates various parameters of a potential or existing site, and provides interpretive information, but leaves the "rating" of the site up to the user. Peter will need input from others on this model as it is developed. Ultimately, the GIS tool will also incorporate the NE-1020 (and other) variety performance information. Tim Martinson commented on utility of soils app for smart phone use. Would be nice to have this ease of use with the east coast GIS tool.

Objective 3. Develop research-based recommendations for optimally matching grape cultivars with site-specific environmental conditions

Safely at NCSU is moving forward with survey that will include NC, VA, NY (interim report was provided). An update: Dr. Safely injured in a biking accident in August. He is recovering at home but hopes to be back to work shortly.

Action items: I have had some communication with Brad Rickard at Cornell regarding a consumer evaluation panel of eastern US wines this fall. However, need more specifics on contributions towards this objective. DONE

Objective 4: Develop a range of resources including decision-assisting tools…

Dr. K.S.U. (Jay) Jayaratne (NCSU) provided a written update to the industry year-1 survey that has now been issued to ca. 1100 industry members. Survey was developed over late-winter/spring and was prepared in consultation with Virginia Tech's Center for Survey Research. Pilot testing with 40 industry members was first conduced. The full survey was issued in July. As of 24 August, 15% of addresses had responded to the on-line survey.

Action item: PIs need to advertise to their industry members that the survey has been launched and that respondent feedback is needed. DONE

eXtension: Tremain Hatch reported briefly on the eXtension involvement. While we are early in our period of grant performance, it is possible to contribute content to eXtension, specifically to the Grape Community of Practices. If you have not done so, please join by going to the following site and following instructions: https://www.extension.org/people/login. The Grape CoP is administered by Eric Stafne and Lane Greer of Oklahoma State University.

Action item: We will have to show active participation in eXtension in keeping with proposed activities. This may come as early as second year. I (Wolf) will establish a sub-group to help with this effort.

Future PI meetings: There were some votes for keeping with ASEV/ES, although this is not as good a forum for the PAC members as would be a meeting such as Wineries Unlimited. It was agreed that an annual meeting would be useful. In looking ahead to 2012, I would suggest that we give some thought to meeting for an entire day. This would allow time for sub-committees to discuss progress in a more in-depth fashion and to share details with the rest of the SCRI project PIs and PAC members.

Agent training: Our proposal had proposed an agent-training program on canopy management sometime in 2011 or 2012.

Update: T.K. Wolf proposed (January 2012) that this agent training workshop be held either in NC or in VA in either July or August 2013. Partial funding would be sought from the Southern

Region Small Fruit Consortium, particularly to support agent travel from states that are not part of the SCRI grant. Content would include:

- General aspects of grapevine physiology
- Canopy management and canopy assessment methodology
- Review of varieties that have some tolerance to Pierce's Disease

Other items: Keith Striegler asked about possible representation on the National Grape and Wine Initiative, **NGWI** (http://ngwi.org/). Two positions were sought: one from industry representing the Production Efficiency sub-committee of NGWI, the other an Extension Outreach sub-committee representative. Update: Joyce Rigby (Rigby Consulting) agreed to serve on the NGWI "Production Efficiency" sub-committee. This was communicated to Jean-Marie Peltier and Keith Striegler. I (Tony Wolf) agreed to serve as the representative to the extension outreach committee.

Other updates. T. Wolf and J. Rigby participated in a USDA/NIFA grants writing workshop in Knoxville TN on 9 August 2011. Tony was asked to contribute to a Project Director's panel and Joyce participated on a stakeholder panel. The presentations will be available for review here: http://www.csrees.usda.gov/business/training/cpworkshops_past.html
Action Item: Alan Lakso graciously agreed to attend a NIFA Project Directors' meeting in association with the ASHS meeting in Waikoloa Hawaii in September ** (see note below)
Publicity: Some of you may have local publicity on this project that you would be willing to share. We have posted some of these releases here: http://www.arec.vaes.vt.edu/alson-h-smith/grapes/viticulture/research/scri-index.html Please share whatever press releases that you might have as the project relates locally to your situation.
Annual report: I will be contacting each PI directly about the annual report needs for this project. I am also in the process of reviewing budgets and cross-checking invoices received with projected expenses.

Appendix D: Project Advisory Council (PAC)

Jim Benefiel, Benevino Vineyards, Virginia, jwbenefiel@aol.com

Dave Breeden, Sheldrake Point, New York, breeden@sheldrakepoint.com

Nick Ferrante, Ferrante Winery, Ohio, nick@ferrantewinery.com

Marilyn Konopka, Constellation Wines US, New York, Marilyn.Konopka@cwine.com

Kenner Love, Virginia Cooperative Extension, Virginia, klove@vt.edu

Tim Martinson, Cornell Cooperative Extension, New York, tem2@cornell.edu

Jean-Mari Peltier, National Grape and Wine Initiative, California, jmpeltier@ngwi.org

Joyce Rigby, Rigby Consulting Services, Pennsylvania, jrigby@yadtel.net

Dave Schroder, Bacchus Importers, Maryland, DavidS@bacchusImportersLTD.com

Steve Shepard, Ray Len Vineyards, North Carolina, steve@raylenvineyards.com

Jeff White, Glen Manor Vineyards, Virginia, gmvwine@glenmanorvineyards.com

Appendix E. Grape grower and wine-maker survey: Year 1 (2011)

Summary of results

Compiled by: K. S. U. (Jay) Jayaratne, North Carolina State University

Total number of individuals invited to the survey: 1,094

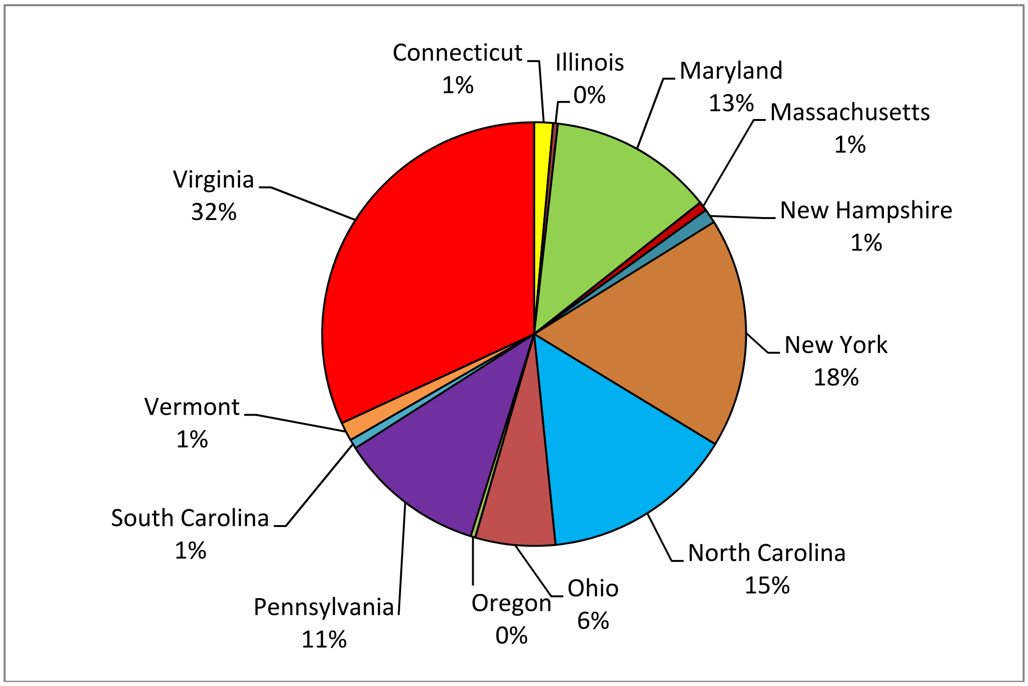
- Total number of responses received: 272
- Response rate: 25%

How do you identify your business operation? (Please check the most applicable response to you)

a. **56.6% of the respondents identified as** Wine grape grower and wine maker
b. **37.5% of the respondents identified as** Wine grape grower 37.5%
c. **5.9% of the respondents identified as** Wine maker 5.9%

Distribution of respondents by state of their business location:

State	N	%
Virginia	89	31.9%
New York	49	17.6%
North Carolina	41	14.7%
Maryland	35	12.5%
Pennsylvania	31	11.1%
Ohio	17	6.1%
Connecticut	4	1.4%
Vermont	4	1.7%
New Hampshire	3	1.1%
Massachusetts	2	0.7%
South Carolina	2	0.7%
Illinois	1	0.4%
Oregon	1	0.4%
Total	279	



WINE GRAPE GROWERS' RESPONSES

Wine Grape Acreage	Minimum	Maximum	Mean	SD
What is your total acreage of wine grape?	1	250	17.8	28.48
Of which, how many acres are bearing?	0	250	16.3	27.99
How many years of experience do you have as a wine grape grower	0	53	12.9	11.7

Please circle the appropriate number to indicate your level of knowledge about the following topics.

The Scale used for rating:

1. Very Low = Don't know anything about this topic.
2. Low = Know very little about this topic
3. Moderate = Know about this topic but there are more things to learn
4. High = Have good knowledge but there are things to learn
5. Very High = Know almost everything about this topic

How do you rate your knowledge about:	Mean	SD
Assessing grapevine canopy characteristics associated with high fruit quality?	3.50	.894
Practical measures to regulate vine vegetative development to achieve optimal canopy characteristics?	3.35	.913

The relationship between fruit/wine quality and crop level in vineyards that exhibit variable vine size and vigor?	3.39	.926
Vine balance and how to measure it.	3.19	.924
The most efficient methods of assessing vine nitrogen status?	2.85	.941
The key factors determining the selection of varieties in relation to site characteristics?	3.22	.922
Competitiveness of weeds and ground cover with grapevines?	3.57	.845
Specific canopy management practices that can help manage fungal diseases?	3.63	.970
The effect of planting decisions (site, cultivar, spacing, and clone) on subsequent disease management needs?	3.40	.922
Cold hardiness of grapevines (i.e. cold acclimation, dormancy) and cold injury protection methods.	3.37	.925
Grape and wine information resources such as Extension, associations etc. in your state.	3.80	.906
Viticultural Communities of Practice (CoP) on the USDA's eXtension website?	2.06	.933

Please circle the number that best describes your *confidence* to do the following

The scale used for confidence recording:

1. Not confident = 1
2. A little confident = 2
3. Somewhat confident =3
4. Confident =4
5. Very Confident =5

How confident are you in your ability to:	Mean	SD
Interpret soil test results?	3.31	.967
Interpret plant tissue analysis results?	2.96	1.148
Evaluate grape cultivar characteristics for their suitability to your current or potential site(s)	3.14	1.019
Quantitatively assess "vine balance" in your vineyard block(s)?	3.10	1.067
Design a vineyard nitrogen fertilization program that efficiently integrates vine and cover crop nitrogen needs?	2.74	1.045
Set the optimum crop and yield in vineyards that have variable vine vigor and vine size?	2.96	1.114
Evaluate a site for a new planting?	3.46	1.021
Use herbicides to manage under-trellis vineyard floor?	3.67	1.031
Integrate all available techniques to manage diseases economically and sustainably?	3.27	.951

Please circle the number that corresponds with your answer to each of the following practices

Do you:	**Percentage of the participants who said Yes**
Adjust the seasonal duration of growth of vineyard floor cover crops to regulate vine vigor and vine capacity?	42.6%
Adapt vigor management techniques selectively to individual cultivars or vineyard mesoclimates?	55.8%
Adjust vineyard floor cover competition in response to drought or excessive rainfall during the growing season?	53.4%
Select different vineyard floor covers to improve soil physical and/or biological conditions in your vineyard?	23.9%
Balance the yield level in variable vineyards to account for vineyards' ability to support the crop?	67.4%
Use a systematic method to integrate all the factors involved in selecting a vineyard site for each variety?	40.3%
Use canopy management practices for controlling diseases?	87.9%
Routinely use plant tissue (i.e. petioles at full bloom or veraison) analysis to monitor vine nutrition and guide nutrient management decisions?	45.1%
Use foliar application of nutrients to correct nutrient deficiencies?	59.8%
Monitor weather conditions at or nearby your vineyard?	94.6%
Consult websites or blogs for tips on vineyard management?	83.5%
Assess bud injury before pruning after sub-zero temperature (e.g. -5F)	63.8%

Have you completed any viticulture course at college level?

a) **29.9% of the wine grape growers said** 'Yes'

b) **70.1% of the wine grape growers said** 'No'

What are your major sources of viticulture information? (Please check all that are applicable to you)

a. **69% of the respondents said** Cooperative Extension
b. **69% of the respondents said** Printed publications
c. **68% of the respondents said** Vine growers' association
d. **67% of the respondents said** The Internet
e. **65% of the respondents said** Conferences
f. **45% of the respondents said** University and community colleges
g. **29% of the respondents said** Paid consultants
h. **8% of the respondents said** Experienced other growers/Vineyard managers

i. **8% of the respondents said** Other sources such as Tony Wolf, Chemical supplier representatives, European Wine masters, Mistakes, lessons learned in the field, Working with folks at Virginia Tech (Winchester Experiment Station, etc.)

What is your preferred educational method for learning about viticulture?

a. **29% of the respondents said** Field days and demonstrations

b. **19% of the respondents said** Printed materials such as newsletters and factsheets

c. **17% of the respondents said** Training workshops

d. **13% of the respondents said** Information on the Internet (Including online newsletters)

e. **8% of the respondents said** One-on-one consultation

f. **8% of the respondents said** Short courses

g. **6% of the respondents said** Other methods such as online courses, learning from fellow growers, and resources from winery association.

Information Needs of Wine Grape Growers

Information Needs	Number of respondents made the comment
Information Needs Related to Pest And Disease Control	
Ability to identify and correct (new to me) vine diseases and pests.	1
Better ways to control disease and pests.	1
Better disease control standards.	1
Better disease identification, and the various ways of rectification.	1
Clear info on disease management -- especially on diseases such as powdery mildew and sprays for it during/after ver.	1
Changes in disease pressure due to resistance and changing climate.	1
Continuing information need for disease management.	1
Disease and insect management practices. Since I am a grower only, current grape prices as well as what grapes are in greatest demand in my area (NC).	1
Managing disease, what fungicides to use, and where to buy them.	1
Disease and pest information.	1
Disease and weed management, spray cocktails.	1
Disease control and assessing maturity.	1
Disease information.	1
Disease issues in my area.	1
Disease management techniques.	3
Pest management/control.	2
New methods in disease control, new methods in vine size regulation.	1
New pesticides and chemicals available to use and the effectiveness of them.	1
Pesticide updates each year for new label registration. Also how to manage vigor, we have very healthy soils and the vines just want to grow and grow.	1
Pesticide usage and new product updates.	1
We know nothing about spraying for diseases or pests. We only had some June bugs this year and got rid of them but we don't know anything about diseases and what to look for.	1
Specific fungicide recommendations.	1
Updates on pest management practices.	1
Updates on pesticide label changes and/or resistance development.	1
Vine growth and spray measures.	1

We have a solid understanding of physical vine canopy/fruit balance, but limited as to the "why" regarding the actual chemical and phenolic impact on the fruit and winemaking process. Not necessary to know, but it enhances why we do what we do to manage growth. We have also learned a great deal over the years about pest management regarding fungicides and herbicides and have a solid spray program that introduces new formulations each year, but I feel our understanding of the chemical classifications of insecticides is more limited, in particular what is effective for different insect types and how that impacts the overall biological profile of the vineyard regarding impact on beneficial and potential outbreaks of unwanted pests due to overuse or mistiming.	1
Weather with recommendations related to insects and disease control.	1
Early symptoms of common fungal disease (as opposed to fully developed symptoms, which are easy to distinguish) ; Clear classification of fungicides into groups. Example: it would be good to know at a glance when looking at a spray guide, that trflumizole (Procure), myclobutanil (Rally) and fenarimol (Rubigan, Vintage) are all DMI fungicides. (Avoiding resistance and cross-resistance).	1
Fungicide and pesticide effectiveness updates....new materials, modes of action, etc.	1
Fungicide efficacy, timing and application.	1
New spray chemicals, market trends.	1
Timely updates on current and more recent viticultural research. Periodic review and updates of best vineyard management practices. Periodic review and updates related to chemical control of diseases, insects, weeds. Dissemination of basic and advanced knowledge to growers (we are a wine producer that buys a lot of grapes from 15 or more growers). Direction of potential growers to the correct sources of viticultural resources BEFORE they buy land or plant.	1
How to deal with new pest or disease issues and development of drug resistance to old or current treatments.	1
More information on recognizing diseases and how to combat them.	1
How to improve quantity and control disease.	1
Keeping aware of diseases/insects and how to combat them.	1
Keeping up to date on new chemicals.	1
How to keep the vines healthy.	1
Up to date pest management. Stink bugs management for example.	1
Learning new techniques and the use of new materials to control vineyard diseases.	1
Local conditions which influence spray program.	1
I'm still not overly confident in identifying grapevine diseases other than Powdery, Downy and Blackrot. Training on identifying mite damage, Esca versus some other disease, nutrition, etc. would be useful.	1

Help in picking varieties to plant, more information about grape disease alternative sprays (controls), more information about hybrid grapes.	1
Appropriate pesticides, fungicides, herbicides and timing.	1
The major problem we have or I have as a grape grower in Virginia is over spraying of herbicides from bean fields next to my vineyard. I planted in 1999 and I have never had a harvest due to overspray of herbicides from bean fields next to my vineyard. The year 2009 my vineyard was destroyed by overspray of herbicides from bean fields. My vineyard is at topping Virginia Middlex Virginia.	1
How to combat grape vine yellows. Reducing vigor.	1
More research to be done on solutions for crown gall, grapevine yellows and late season rot prevention.	1
Timeline and characteristics of next generation fungicides. Strategies for controlling stink bugs (and other invasive species).	1
Spraying and chemical information - vine ailments.	1
Spray materials.	1
Spray programs.	2
Spray schedule.	1
Resistance to spray applications.	1
Current disease and insect situation which is available at Cornell's IPM website.	1
Current trends, research results, current IPM programs, current conditions and diseases.	1
IPM information.	1
Information Needs Related to Soil and Nutrition Balance	
Mid Atlantic varietal needs including; GDD, soil preference, disease susceptibility/resistance, clone phenotype and berry chemistry.	1
Fertilizer and spray needs.	1
Analysis of soil and foliar reports.	1
Leaf blade testing vs. petiole testing results and interpretation. Cover crop choices to reduce vine vigor.	1
More specific advice and suggestions for sustainable practices individual to my vineyard, soil needs, etc.	1
Timely soil and leaf blade reports.	1
Soil conditioning and weed control.	1
Soil nutrition balance.	1
More information about vine nutritional needs and winter cold hardiness.	1
Soil requirements to maintain vine health and disease recognition.	1
Vine nutrition is most important.	1
Understanding soils.	1
Other Information Needs	
Organic vineyard management.	1

As a new grower, I am not yet sure of my most pressing need.	1
Assessment of current vineyard status and vineyard needs for improvement. Have pulled petiole samples for nitrogen analysis and need to forward them to a lab for analysis.	1
Best business practices and labor issues.	1
I don't know what I don't know... ignorance is bliss or dangerous. One area of concern is finding vineyard labor. Spray rotation and the most effective and least expensive options.	1
Educated labor. You can have all of the knowledge on how to do great things in the vineyard but if you do not have the labor you cannot get it done.	1
Better understanding of phenolic ripeness and creation of anthocyanins in wine grapes. Also, potassium accumulation.	1
Crop balance methods to maintain high quality fruit.	1
Current chemical updates i.e., pesticides/fungicides/herbicides.	1
Canopy floor management and weed control.	1
Canopy management and spraying.	1
Clones, rootstocks, planting density.	1
Current topics effecting quality, such as, 100 degree + temperature effect on vines, stink bugs, new FRAC class chemicals and chemicals that develop resistance, grapevine yellow identification on red grapes, irrigation measuring, bird guard and bird netting. Give us some how to videos that can be accessed online. Show the growers new time saving technologies and equipment. Get with manufacturers and video some field demos on equipment and make them available online. Equipment like sprayers, hedger, herbicide sprayers, pruners, post pounders and trellis installations, deer fencing, wine grape eating predator deterrent methods.	1
Data collection.	1
Extension. Vineyard consultant.	1
Federal and state income tax expertise for small business and the different type of corporations relating to vineyards and wineries.	1
Feedback on latest "best practice" techniques and processes.	1
Fruit wine maker.	1
General learning curve issues as a relatively new to the industry person.	1
How to become a sustainable wine grower.	1
How to renew an existing vineyard short of ripping it all out and starting over.	1
I am graduating from beginner to novice and don't know a whole lot about vine nutrition and how to apply it.	1
I have no needs as such. I know how and where to get the information I need, the only thing I really need is more experience and that comes one year at a time.	1

I really like getting the timely emails from Joe Fiola. This really helps us pay attention to what we should be doing at various times of the year. We only have two people running this operation and both have other jobs so it helps to have this information delivered electronically so we can react accordingly. Also, I find working with Jennie Schmidt on an as needed basis is extremely valuable and I feel lucky to have someone like her that I can consult when necessary. Having other vineyards close by is a big help. We have several vineyards in the area and the owners always seem happy to share information and resources.	1
Information on new practices for growing grapes -sprays-mechanical operations.	1
Information presented in a practical and easily understood manner.	1
Just planted vines in the last year.	1
Lab analysis.	1
Latest proven techniques for increasing quality and profitability explained to the industry in clear understandable terms. Also, changes in regulations, new products, market trends, etc.	1
Latest research data.	1
Learning about calculating optimal Brix for specific grape varieties. More help for certified organic grape growing practices and resistant varieties.	1
Manage vine yields.	1
Marketing	2
More information about new and upcoming chemicals to hit the market and what they do how they are used etc.	1
Need new information and techniques and information to new studies.	1
New materials and methods.	1
New product registration, any new rules or regulation changes, new practices, etc.	1
New research, stretching and challenging previous protocols are always a good thing.	1
Practical hands-on information from other experienced wine growers.	1
Recommended varietals based on our hot humid climate, varieties that will ripen consistently.	1
Specificity towards individual grape varieties.	1
The information isn't the real problem anymore; it's finding the time to do what you know needs to be done.	1
Timeliness.	1
Understanding soil pH, rootstock selection, clone selection and plant stress as it relates to wine quality.	1
Vine management for yearly crops.	1
Vine management tactics.	1

We are taking the range of viticulture courses at the community college. At this point I would say that we are in the process of integrating book knowledge with the reality of the vineyard. Also I would like to note that we have taken the decision to increase our vineyard over time as we gain experience.	1
We have planted chardonnay & cab franc, worried about regular production (winter hardiness), previously only worked with hybrids.	1
Weather forecast.	1
What is long term consequence of GLRaV? What is likely cost/benefit trade to install irrigation? What are some cost efficient techniques to combat mid season weeds when I have replacement plants down among them?	1
What to do in current conditions.	1

WINE MAKERS' RESPONSES

Please provide the following information about your operation	Minimum	Maximum	Mean	SD
What is your current, total case production/year?	0	10,000,000	74,824	838,848
What proportion of your grapes/wine is from sources East of the Rocky Mountains?	0	100%	44%	39
What proportion of your grapes/wine is from West Coast/International sources?	0	100%	7%	20
What proportion of your grapes/wine is from your own estate?	0	100%	52%	42

Grape Varieties by Preferential Rank

Rank of Preference	Varieties	Number of respondents identified the variety as preferred
The most preferred	Cabernet Franc	52
2nd most preferred	Chardonnay	40
2nd most preferred	Merlot	40
2nd most preferred	Chambourcin	35
4th most preferred	Cabernet Sauvignon	31
5th most preferred	Riesling	28

6th most preferred	Petit Verdot	26
7th most preferred	Viognier	25
8th most preferred	Vidal	18
9th most preferred	Vidal Blanc	17
10th most preferred	Traminette	14
11th most preferred	Petit Manseng	13
11th most preferred	Pinot Noir	13
12th most preferred	Sauvignon Blanc	12
13th most preferred	Concord	11
14th most preferred	Chardonel	10
14th most preferred	Gewurztraminer	10
15th most preferred	Cayuga	9
16th most preferred	Niagara	8
16th most preferred	Norton	8
16th most preferred	Pinot gris	8
17th most preferred	Vignoles	7
18th most preferred	Barbera	6
19th most preferred	Lamberger	5
19th most preferred	Malbec	5
19th most preferred	Sangiovese	5
19th most preferred	Syrah	5
20th most preferred	Seyval	4
21st most preferred	Marquette	3
21st most preferred	Noiret	3
21st most preferred	Pinot Grigio	3
21st most preferred	Seteuben	3
21st most preferred	Seyval Blanc	3
21st most preferred	Tannat	3
21st most preferred	Zinfandel	3
22nd most preferred	Albarino	2
22nd most preferred	Baco Noir	2
22nd most preferred	Brianna	2
22nd most preferred	De Chaunac	2
22nd most preferred	Dornfelder	2
22nd most preferred	Frontenac	2

22nd most preferred	La Crescent	2
22nd most preferred	Louise Swenson	2
22nd most preferred	Muscat	2
23rd most preferred	Albarino	1
23rd most preferred	Aurore	1
23rd most preferred	Bianca	1
23rd most preferred	Blaufrankish	1
23rd most preferred	Catawba	1
23rd most preferred	Cayuga White	1
23rd most preferred	Chardonel	1
23rd most preferred	Chancellor	1
23rd most preferred	Chenin Blanc	1
23rd most preferred	Cynthiana	1
23rd most preferred	Elvira	1
23rd most preferred	Fredonia	1
23rd most preferred	Gruner Veltliner	1
23rd most preferred	Honey	1
23rd most preferred	Marechal Foch	1
23rd most preferred	Meritage Blends	1
23rd most preferred	Minn Varieties	1
23rd most preferred	Nebbiolo	1
23rd most preferred	Off Shore Red	1
23rd most preferred	Off Shore White	1
23rd most preferred	Pinotage	1
23rd most preferred	Pinot Blanc	1
23rd most preferred	Red Hybrids	1
23rd most preferred	Regent	1
23rd most preferred	Saperavi	1
23rd most preferred	Semillion	1
23rd most preferred	Shiraz	1
23rd most preferred	St. Vincent	1
23rd most preferred	Tempranillo	1
23rd most preferred	Valvin Muscat	1
23rd most preferred	Vinifera	1

Production of Wine by White Varieties

White Variety	Cases
Albarino	200
Apple	1,050
Aurore	1,200,000
Barrel Fermented Chardonnay	500
Bianca	100
Brianna	10
Cabernet Franc	610
Carlos Muscadine	300
Carlos	2,000
Catawba	2,502
Cayuga White	3,185
Cayuga	14,811
Cayuga/Vidal/Seyval Blend	500
Chambourcin	500
Champagne (Sparkling White)	100
Chardonel	924
Chardonnay Non-estate	600
Chardonnay	26,998
Chardonnay, oak aged	200
Chardonnay, pine aged	25
Chardonnay-estate	1,100
Delaware	716
Dry Riesling	100
Elvira	1,700,000
Frontenac Gris	290
Fruit Wine	500
Gewurztraminer	3,065
Gewurztraminer-estate	300
Gruner Veltliner	198
Highly variable based on quality	2,000
Hybrid Red and White	2,400
La Crescent	700
Labrusca Red and White	2,800
Late Harvest Vidal Blanc	100
Louise Swenson	300
Louise/Prairie Star	190
Mead	100
Mics Vinifera	500
Muscat and White Fruit	150
Muscat Canelli	175
Muscat	100
Native Blends	1,500
Niagra	21,482
Nouvelle (like nouveau from vidal)	45
Orange Muscat	100
Petit Manseng	850
Petit Verdot	5
Pinot Blanc	500
Pinot Grigio Non-estate	700
Pinot Grigio	1,135
Pinot Gris	1,182
Pinot Gris-estate	500
Pinot Noir	107
Prairie Star	200
Reliance	15
Riesling	52,402
Rose	400
Sauvignon Blanc Non-estate	500
Sauvignon Blanc	5,177
Semillon/Sauvignon Blanc	50
Seyval Blanc	1,790
Seyval	3,085
Shiraz	200
Sparkling	2,100
St. Vincent	300
Steuben	2
Traminette Blend	375
Traminette	9,423
Unoaked Chardonnay	500
Vidal Blanc	5,630
Vidal	9,362
Vidal/Chambourcin Rose	280
Vidal/Petite Manseng Blend	150
Vignoles	4,200
Vinifera Red and White	2,400
Viognier	5,831
White Blend	10,550

Production of Wine by Red Varieties

Variety	Cases
Baco Noir	937
Barbera	495
Blend	770
Blush	39
Bordeaux Mix	1,010
Cabernet Franc	16,319
Cabernet	10,262
Carmine	160
Catawba	550
Chamb. Rose	100
Chambourcin	18,635
Chancellor	825
Concord	3,014,651
Country Blush	300
CS/M/CF/PV Blend	20
Cynthiana	20
DeChaunac	1,305
Dornfelder	300
Dry Concord	100
First Capital (blend)	500
Foch and Chancellor	300
Foch	25
Fr Am Reds	5,000
Frontenac	530
Fruit Wines	9,850
Gamay Noir	150
GR-7 (Cornell)	240
Highly variable based on quality	3,000
Hybrid Blends	3,000
Vincent	100
Vinifera Blends	1,250
Zinfandel	1,270
Lemberger	1,402
Leon Millot	650
Malbec	585
Marechel Foch	140
Mars	1,470
Meritage	775
Merlot	10,629
Merlot Blend	470
Misc Vinifera	500
Native Blends	1,000
Nebbiolo	200
Nobel	2,500
Noiret	330
Norton	775
Other Hybrids	100
Petit Syrah Non-estate	350
Petit Verdot	2,630
Pinot Noir	4,683
Pinotage	50
Red Hybrid Blends (chambourcin/pinot noir)	9,260
Sangria	1,055
Separavie	242
Shiraz	300
Spiced Red	300
St. Croix	1,260
Steuben	435
Sweet Concord	400
Syrah	2,540
Tannat	520
Tobacco Road Blues	300
Touriga	50

Please circle the appropriate number to indicate your level of knowledge about the following topics.

Rating Scale
:

1. Very Low = Don't know anything about this topic.
2. Low = Know very little about this topic
3. Moderate = Know about this topic but there are more things to learn
4. High = Have good knowledge but there are things to learn
5. Very High = Know almost everything about this topic

How do you rate your knowledge about:	Mean	SD
Typical varietal wine sensory characteristics?	3.48	.902
Dealing with herbaceous flavors or aromas?	3.32	.939
The impact of cluster light environment on development of flavor and aroma compounds?	3.32	.960
The effects of phenolics on white wine bitterness?	3.02	.984
Acid/pH relationships in wine?	3.62	.906
Managing SO_2 in wine based on wine pH?	3.75	.984
Filtration?	3.54	.995
Origins, other than cork, of "cork" taint?	3.11	1.117
Flaws in wine	3.36	.983
Eastern region consumer preferences?	3.43	1.014

Please circle the number that best describes your *confidence* to do the following

Confidence Recording Scale:

Not confident = 1
A little confident = 2
Somewhat confident =3
Very Confident =5

How confident are you in your ability to:	Mean	SD
Control Brettanomyces?	3.07	1.154
Adapt winemaking techniques to new cultivars that may have "nontraditional" fruit characteristics?	2.88	1.173
Determine and apply the appropriate viticultural practices required to produce fruit for a specific wine style (for example, a fruity Riesling)?	3.09	1.191
Enhance phenolic profiles in red hybrid wines with winemaking techniques?	2.87	1.281
Manage a malolactic fermentation?	3.54	1.146
Perform basic wine analyses (SO_2, residual sugar, alcohol, titratable acidity, pH, volatile acid, completeness of malolactic fermentation)?	3.70	1.079
Analyze the eastern region wine industry trends?	2.94	1.153

Please circle the number that corresponds with your answer to each of the following practices

Do you:	**Percentage of the participants who said Yes**
Follow a standard winery sanitation protocol regularly?	92.9%
Adjust winemaking procedures based on measured fruit parameters to achieve a uniform wine style?	80.8%
Regularly use enological tannin additives?	52.0%
Use a cold soak or skin contact regimen in aromatic white wine production?	44.8%
Alter wine chemistry by removal of water (eg. reverse osmosis)?	9.6%
Add acid?	69.8%
Reduce acidity other than using malolactic fermentation (eg. acidex)?	38.9%
Use SO_2 at harvest to control microbes?	84.9%
Use CO_2-ice at harvest to control microbes?	20.8%
Analyze in-house for SO_2?	81.6%
Analyze in-house for residual sugar?	80.8%
Add yeast nutrients?	95.2%
Control fermentation temperature of red musts?	72.2%
Use oak alternatives?	72.2%
Use plastic storage and fermentation tanks?	54.8%
Analyze industry trends with respect to consumer preference?	66.7%

Wine Making Experience	**Minimum**	**Maximum**	**Mean**	**SD**
How many years of experience do you have as a wine maker?	0	53	13	12.3

Have you completed any enology course at college level?

a) **34% of the participants said** 'Yes'
b) **66% of the participants said** 'No'

What are the major educational sources you look for wine making information? (Please check all that are applicable to you)

a. **47% of the respondents said** Cooperative Extension
b. **42% of the respondents said** University and community colleges
c. **50% of the respondents said** Wine makers' association
d. **28% of the respondents said** Paid consultants

e. **57% of the respondents said** Conferences

f. **52% of the respondents said** The Internet

g. **57% of the respondents said** Printed publications

h. **10% of the respondents said** Colleagues/Friends/Family

i. **5% of the respondents said** Other sources such as: Suppliers of vines, chemicals, equipment, etc, ; Basic handbooks by authors such as A. J. Winkler, Amerine, Peynod Books; Travel; Virginia Tech. short course; We lean heavily on any Bruce Zoecklin information & seminars, etc; PWA and PQA

What is your preferred educational method for learning about enology?

a. **8.7% of the respondents said** Field days and demonstrations

b. **12.7% of the respondents said** One-on-one consultation

c. **30.2% of the respondents said** Training workshops

d. **15.9% of the respondents said** Short courses

e. **4.8% of the respondents said** Information on the Internet

f. **23.8% of the respondents said** Printed materials such as newsletters and factsheets

g. **1% of the respondents said** learning from other wine makers

h. **3% of the respondents said** Other methods such as use of multiple methods

Information Needs of Wine Makers

Information Needs	Number of respondents making the comment
1. Producing fruit-forward reds from unripe eastern hybrids/viniferas 2. Better methods for pH reduction in high acid /high pH musts/wines.	1
So new, I really don't know what I need; lots to learn.	3
Almost everything available is focused toward grape wines. As a winemaker, who does not use grapes, I have to adapt everything I learn accordingly. Some information on honey and non-grape fruit wines would be helpful too.	1
An active state extension and enologist with access to analytical and corrective measures.	1
As with grape growing I know where and how to acquire the information I need.	1
Cold soaking whites.	1
Consumer preferences.	1

Correcting flaws.	1
Could stand to know a little more across the board, the whole winemaking process.	1
Creation of a basic organizational method.	1
Current proven practices to produce high quality reds in the eastern U.S.	1
Dealing with flaws in a timely manner	1
Dealing with wine faults, preventing wine faults, making better wines, fining whites and reds.	1
Defect prevention at the crush pad, based on chemistry, variety, and style.	1
Enology research and new practical approaches , new processing technologies, equipment, supplies production cost reduction custom crush management compliance; audit experiences regional wine purchase demographics.	1
Honest evaluations of new products and techniques. Local forums for winemaker exchanges.	1
How to adjust the must, and the wine. The chemistry of wine making.	1
How to control Bret from vineyard to cellar (simple test that can be performed by small wineries in house) ... better price on all-in one test meter that can test 7-12 basic winemaking parameters that cost less than $5K.	1
How to eliminate herbaceousness when making wine from under ripe grapes.	1
How to get good fruit and how to sell good wine.	1
How to grow and make wine which can make our estate grape/wine operation sustainable.	1
How to handle the unusual occurrences.	1
How to improve wine making skills.	1
How to pass it to the next generation.	1
I'd like to learn more about different techniques. I talk a lot to other winemakers about what they're doing, but it would be nice to have a resource to go to when I want to try something different.	1
Information on latest products and research.	1
Information on new yeasts, nutrients, tannins, enzymes and tasting different wines using these additives. Information on healthy fermentations.	1
Keeping the process clean without problems. 80% of wine quality happens in the vineyard.	1
Knowledge of federal and state laws regarding wine making, labor issues, online courses.	1
Lab analysis, Lab procedures, grape/wine behavior.	2
Making red in Ohio.	1
Marketing wine other than the way we have been doing it (tasting room and wine festivals).	1
More education such as HACC.	1
More information on fruit wine.	1
More practical experience and more quantity. I am currently a home wine maker and do not sell any wines to the general public.	1

More sensory analysis training. More knowledge on nutrient additions versus measured YANS, etc. More knowledge on ML co-fermentation, barrel aging effects (this is #1) for example, we sample wines after 6 months in oak and would like more information on a) leaving wine in oak; b) moving toward bottle in SS; c) moving toward bottle with more oak (such as move into newer barrels, use alternatives, etc.)	1
More specific information on cold-hardy varietals from MN and Swenson.	1
More technical information on operations at a very small level.	1
New technology, methods, materials and processes.	1
Periodic review of current and recent enological research. Practical reviews of enological equipment including lab equipment for moderate size wineries. Continuation of research and extension work being done by Bruce Z. and Tony W. at VT . An unbiased approach to research and market research on what wines sell, not just what wines winemakers like to make. Research and development that seeks to obtain new wine consumers, not redistribute existing wine consumers among different suppliers. Continue some of the research work currently being promoted by Tim Hanni on consumer preferences and palatte differences.	1
Practical Winery the publication!	1
Preferring a low input approach, what are the most sound methods to reliably produce the wine that will express that vintage's potential?	1
Proven knowledge disseminated in an understandable way, not "here's how you could do it if you had an extra five million."	1
Quest for knowledge, more courses available at a reasonable cost and time frame.	1
Research into cold fermentations (less than 45F). Information on antioxidative effect of long term surlees aging.	1
Sales information.	1
Sensing what adjustments might be needed before bottling.	1
Testing for PH and acid levels preventing oxidation.	1
To understand those 12 letter words. After 30 years, I feel we are always learning new methods. At times it's hard to change but change is good.	1
Understanding how to market wines in our area (Ohio). Many of the more experienced wine makers and winery owners feel that the only way to get press for the industry is to grow your own fruit and that fruit needs to be predominately vinifera. The majority of our consumers however enjoys sweeter wines and could care less about what wine writers have to say. This is a contradiction that I have yet to reconcile. I also think there needs to be a concerted effort to learn to make great wines from the fruit that grows well here. French American hybrids are considered second class citizens in the wine world (never mind native American varieties). Through learning to make great wine and good marketing techniques we should be able to change that perception.	1

Understanding phenolic extraction.	1
Understanding the finer points of adjusting acid levels in our eastern wine. Additional research on best ways to make better wine with our traditional Labrusca varieties. Additional information about fruit other than grape wines.	1
Understanding the influence of aging on red wines or wines in general.	1
Ways to keep up with changing information on wine making.	1
What do my customers want to drink?	1
What to do when things don't go as planned. As with the vineyard work, there is never enough time.	1
While we mostly do fruit wines (berries, tree fruits) I'd like to become confident and educated enough to grow my own grapes.	1

Appendix F. Project background and rationale (from original proposal)

Grape yield and quality are profoundly influenced by both climate and the viticultural practices intrinsic to a particular region. Varietal choice, trellis/training system, canopy management practices, planting density, choice of rootstock, crop level, and vineyard floor management are some of the major variables that producers can choose to vary. Climate, on the other hand, is omnipotent; it can be adapted to, but not controlled.

Climatic and vine vegetative management: Climatic conditions of a region (Winkler et al., 1974; Jackson and Lombard, 1993) and within the canopy (Dokoozlian and Kliewer, 1995a, 1995b; Bergqvist et al., 2001; Spayd et al., 2002) affect fruit maturation, composition and date of harvest. Canopy management through either proper trellis selection or manipulation of leaves or shoots (Reynolds and coworkers, 1989a, 1989b, 1996; Smart, 1985, 1988; Smart and Robinson, 1991; Vanden Heuvel et al., 2004; Wolf et al., 1990; Zoecklein et al., 1992) can also be utilized to alter fruit yield and quality. A distinguishing feature of eastern US viticulture is the climatic *variability* under which vines are grown. Because grapevines exhibit an indeterminate growth habit, shoot growth and new leaf area development persist with ample heat and moisture, and growth is not curtailed by decreasing photoperiod. Abundant moisture can translate to excessive vegetative growth, with a plethora of negative consequences. Highest wine quality is most consistently obtained from fruit produced on vines with an optimal and stable balance of leaf area and crop. "Balance" can be quantitatively expressed as *cropload* (e.g., 5 to 7 kg of crop per kg of pruned canes as a proxy for vine capacity) or as leaf area to crop ratios (e.g., 1.2 to 1.5 m^2 of healthy, exposed leaf area for each kg of crop without the need for continual shoot trimming). Outside these ranges, vines can be considered "out of balance" and grape and wine quality invariably suffer. The National Viticulture and Enology Extension Leadership Conference (www.reeis.usda.gov/web/crisprojectpages/206760.html) identified the definition and measurement of vine balance as one of its highest priorities.

Balance is a particularly elusive goal in many eastern vineyards due to the seasonal availability of rainfall and the depth and fertility of many vineyard soils. The combination of a naturally vigorous cultivar planted on a deep, fertile soil is particularly unsatisfactory as fruit can be heavily shaded, resulting in poor fruit quality (Dokoozlian and Kliewer, 1996; Downey et al., 2004; Ryona et al., 2008). Remedial practices such as leaf pulling and shoot hedging to improve cluster light exposure are widely practiced in the East (Reynolds and Wolf, 2008) but these practices are expensive and only offer short-term solutions to vine imbalance. The underlying problem is that soils high in nutrient and water availability foster excessive, persistent vegetative growth that shades clusters and directly competes with fruit maturation, delaying *veraison* (onset of grape ripening) and harvest. There is also some evidence that the persistence of vegetative growth can lead to elevated, residual levels of undesirable grape aromas such as methoxypyrazines (MPs) (Roujou de Boubee, 2003; Roujou de Boubee et al., 2000; Lakso and Sacks, 2009), which are acutely odor-active chemicals. We propose to study a number of means of addressing vine imbalance in this proposal, including development of cropload and additional cluster light environment metrics to better identify problem vines and vineyards, as well as viticultural means to address vine imbalance such as cropload management and vineyard floor management practices to reduce moisture availability.

Cropload and cluster light environment metrics: The direct effects of crop load on wine quality are frequently discussed, but while there is little debate that there is an upper (and lower) limit to how much fruit a vine can mature before wine quality suffers, the definition of that limit is elusive in practice. A complicating factor when considering cropload is the indirect impact on cluster light environment, as high croploads can result in excessive fruit exposure, while low croploads can result in excessive fruit shading and it is unclear how much fruit exposure is required for optimizing fruit composition or producing wines with particular flavor and aroma profiles. Vineyard managers often take a "cookie-cutter" approach to vine management resulting in some vines being over-cropped and some under-cropped, and overall quality suffers. Growers can, to an extent, control crop level with dormant pruning and thinning, but in vineyards that exhibit high variability of size and vigor they have no easy way to determine the vine *capacity* (i.e., the total dry matter production of a vine, Winkler et al., 1974) or the cluster light environment required to properly ripen the crop. Due to winter cold injury, variable climates, and inexperience at matching vine vigor to sites, vineyards in the East often exhibit tremendous variability in vine capacity. Unfortunately, vine capacity is not easy to directly measure. Dormant pruning weight is commonly used to estimate vine capacity; however it is only an indirect measure (Lakso and Eissenstat, 2005) and actual vine capacity, determined by sunlight interception, depends on canopy and vine spacing, training system, canopy display, uniformity of trellis fill and environmental stresses. While a recent tool set called Enhanced Point Quadrat Analysis (EPQA) has been developed to help growers better quantify cluster light environment in their vineyards (Meyers and Vanden Heuvel, 2008), practical tools for growers to estimate vine capacity are not readily available. *We will develop practical methods to estimate vine capacity to allow growers to define their optimum crop levels, and enhance our EPQA metrics to better quantify the indirect effects of cropload, allowing growers to better target their fruit quality goals.*

Vineyard floor management: Historically, vineyard floor management in the juice grape industry was driven by the need to grow large vines that could produce high crop yields that met minimal quality requirements. This strategy often entailed clean cultivation or post-emergence herbicide application of row middles and pre-emergence herbicide application under the trellis during the growing season. Similar strategies were adopted for wine grapes in the East, however cold-tender, grafted *V. vinifera* vines require hilling and de-hilling of soil over graft unions for winter protection. Cover crops are utilized in vineyards for erosion control, addition of organic matter, improved soil structure and water penetration, reduction of excessive soil moisture (and vine size/vigor management), as well as enhanced pest management (Hartwig and Ammon 2002; Ingels et al., 2005). Cover crops also influence vineyard environment, grapevine performance and the flora and fauna of the vineyard (Donaldson et al., 1993; Ingels et al., 1998). Cover crops to compete with vines for water and nutrients, and root restriction to reduce water and nutrient uptake offer potential alternatives for achieving an optimal vine balance (Byers, 2004; Giese and Wolf, 2009; Hatch and Wolf, 2009; Wang, 2001). Reduced vegetative growth of root-restricted plants is due to depletion of plant available water in the restricted root volume and increased root hydraulic resistance, and possibly also root-to-shoot hormonal signaling (Stoll et al., 2000). *We propose extending on-going research to examine the merits of aggressive use of cover crops and other root system manipulations to achieve a more optimal vine balance, improved cluster light environment, and hence improved fruit composition.*

Cultivar Evaluation: Formal evaluation of *Vitis* cultivars and hybrids has been invaluable to the development and emergence of several wine grape producing states (Clore et al., 1972; Nagel et al., 1972; Amerine and Fong, 1974; Carter et al., 1974; Hamman, 1993; Kasimatis et al., 1979; Kiyomoto, 1994; Ough et al., 1973; Pool et al., 1976; Schoffling and Stellmach, 1996; Striegler and Morris, 1984; Wolf and Warren, 2000). A USDA Regional Project (NE-1020) involving participants from many grape producing states was begun in 2004 for the purpose of *coordinating* evaluation of grape plant materials between states and regions across the United States (http://www.nimss.umd.edu/homepages/home.cfm?trackID=4034). Matching cultivar, clone and rootstock is site-dependent, but new tools can be used to help determine the best combinations using baseline data. New Geographic Information Systems (GIS) technologies, relevant digital databases (soils, topography, climate), and internet access are now available to provide unprecedented access to critical educational information and data needed for informed site selection. The access to this information allows growers to focus on areas of promise, and can prevent costly mistakes. *As knowledge is gained from the NE-1020 multistate project, we will feed this information into our proposed GIS work.*

*Enology***:** Developing wine industries in the eastern US are largely based on traditional production methods borrowed from more established wine regions. As the industry has grown, the limitations of this imitative approach have become apparent, as has the need to characterize Eastern wines as unique products expressing the characteristics of the region. Subsequently, while the Eastern US uses many of the same grape cultivars and processing approaches as do other wine regions, climatic variations result in different fruit composition, requiring unique production methods. Modified processing parameters may include variations in skin contact time or temperature, use of specific wine additives, specialized nutrition management and yeast strain selection. *While much of the enology proposed within the context of this grant application is an extension of viticultural treatments, we have, with our stakeholders, identified two key areas of winemaking that warrant specific research; one related to juice nitrogen concentration, the other related to fruit phenolics.*

Yeasts require nitrogen in the form of amino acids and ammonia (together called yeast assimilable nitrogen or YAN) for growth and fermentation. Insufficient YAN in grape must is a primary cause of slow or sluggish fermentation and can also result in off-odors detrimental to wine quality (Wang et al., 2003; Ugliano, et al. 2009). Grape YAN varies widely, and is affected by grape cultivar, microclimate, season, and viticultural practices (Huang and Ough, 1989; Spayd et al., 1995; Spayd and Andersen-Bagge, 1996; Bell and Henschke, 2005). Screening a broad range of winegrape cultivars, grown under various cultural and climatic conditions and over several years, will clarify the role that these parameters play in YAN accumulation, and will allow us to develop baseline values for the eastern US grapes. We also anticipate that some of the proposed vineyard studies, particularly those involving aggressive use of cover crops to restrict vegetative vine development, may have depressive effects on YAN. *We consider it imperative to integrate the measurement of YAN with our viticultural treatments.*

Phenolics: In addition to aroma compounds and acid/sugar balance, the content and type of phenols present are key to wine quality and influence color, flavor, and texture (Kennedy et al., 2006). The final phenolic content of wine is influenced by cultivar, year, site, fruit exposure, vine vigor, vinification methods, and the use of enological additives (Bautista-Ortin and coworkers, 2005, 2007; Cortell et al., 2007; Guadalupe and Ayestaran, 2008). Unacceptable color and phenol profiles are perceived quality problems for red wines in the Eastern US. In the production of aromatic white wines, excessive phenol extraction can produce wines perceived as overly bitter (Hernanz et al., 2007). Phenol extraction and stability from red varieties (Harbertson and Spayd, 2006; Harbertson et al., 2008; Baiano et al., 2009; Gambuti et al., 2009; Heredia et al. 2010) and white grapes (Singleton and Trousdale, 1983; Cheynier et al., 1989; Darias-Martin et al., 2000; Hernanz et al., 2007) has been examined in other regions. The problems are complex and increasingly recognized as specific to vintage, region, and cultivar (Singleton and Trousdale, 1983; Cagnasso, et al. 2008; Gambuti et al., 2009). Much of the current knowledge on how vineyard practices impact phenolics is based on work performed under more arid environments than those found in the Eastern US. *An examination of the phenolic profiles specific to the cultivars and experimental conditions proposed here, coupled with targeted evaluations of current methods of phenol management, would allow eastern US winemakers to better reach their stylistic goals and avoid overuse of expensive enological additives.*

Economics and Marketing: Currently, there are a number of generic, regional, and branded wine advertising programs in the US and abroad; however, unless advertising is successful in increasing the total amount of wine each consumer purchases, individual programs simply compete for a share of total sales in a destructive game of advertising competition. There has been very little economic research examining the effectiveness of such marketing programs for wine, yet there exists a more substantial literature for food products (e.g., Kaiser et al., 1998). Research in the marketing literature has shown that such “umbrella branding” among consumer packaged goods can improve advertising efficiency (Erdem and Sun, 2002) and a similar type of “halo effect” has been detected in unbranded fresh produce (Richards et al., 1997). Crespi and Marette (2002) demonstrated that generic advertising can reduce the extent of product differentiation and thus reduce the incentives for product-specific advertising to firms that invest in quality improvements or brand-specific advertising. An empirical analysis of branded and generic advertising among food products in California revealed that the category or aggregate effect of generic advertising is sufficiently strong as to reduce the incentive for differentiation strategies. Relatively little research has been conducted on wine purchasing patterns by US consumers. Folwell and Dailey (1971) examined wine consumption, constraints, and potential for expansion of US wine sales. In a 1984 study, quantity of wine purchased was positively related to purchaser’s income, while prices paid per 750 mL bottle were inversely related to income (Folwell et al. 1974). Buyers with little knowledge of wine may use price as a signal of wine quality (Mahenc, 2005). If there are small numbers of knowledgeable wine buyers sufficiently skeptical about the relationship between high price and high quality, then price signaling weakens. However, consumers expect product variability within a wine brand (Charters, 2009). *More information is needed regarding choice of wines produced in the eastern US by consumers in the eastern US.*

Rationale and significance

Growth of the eastern US wine industry has been appreciable over the last 20+ years. Today there are approximately 880 wineries in 13 major eastern wine growing states (www.ttb.gov), including those in NY (230), VA (150), OH (126), PA (123), NC (92). Independent grape producers, numerous allied service industries, and consumers are additional dynamic elements of this industry. Economic impact assessments conducted by MKF Marketing (e.g., MKF Research, 2005, 2007) since 2005 have illustrated the significant, annual impact of some of these industries, including $3.4 Billion (NY), $700M (PA), $362M (VA), $400M (OH) and $813M (NC). Because most wineries are located in rural areas, the impact on rural communities is particularly noteworthy. While impressive gains have been made in aggregate acreage, grape production and employment, the potential for further growth is much greater. The US per capita wine consumption increased from 1.95 gal./person in 1998 to 2.48 gal./person in 2008 (www.wineinstitute.org) while our society increasingly embraced the evidence that moderate wine consumption can be a component of a healthy lifestyle. Increased interest in locally produced foods, agro-tourism, and preservation of green space also enhances the potential for future growth and development.

The problem: While the above metrics appear positive, constraints to growth and development of the eastern US wine industry exist. Consumer perception of value of eastern US wines is often lower than that of other domestic and many imported wines, in part due to the higher production costs associated with small eastern wineries, and in part due to real or perceived quality issues. Wine quality has dramatically improved in many sub-regions of the East due to use of superior grape cultivars, increased technical expertise of grape and wine producers, and implementation of effective pest management strategies, but market share of local wines is still very low. For example, 4% of wines sold in Virginia are produced in Virginia. Oregon wines, by contrast, enjoy a 14% market share (www.OregonWine.org). Profitability of eastern grape and wine enterprises remains tenuous. Recent financial analyses of vineyard establishment project costs of $15,000 to $18,000 per acre before crops are borne (Wolf et al., 2008), not including land cost. Winery development is on the order of $185 per ft^2 capacity (Zoecklein, pers comm., 2010). The steep investment associated with vineyards and wineries is often exacerbated by the small scale of economy at which many eastern US vineyards and wineries operate. We anticipate that relative costs of grape production will remain high in the eastern US, but that increased grape and wine quality will help mitigate negative perceptions about eastern US wine values.

Climate, particularly temperature and precipitation, has a profound impact on wine quality (Gladstones, 1992; Jackson and Lombard, 1993; van Leeuwen et al., 2004). This is particularly true in the variable climate of the eastern US. Compared with most other established grape producing regions of the world, the eastern US experiences more variable growing season rainfall and temperature extremes, and has a much greater risk of winter cold damage from the mid-Atlantic region north. The humid growing season fosters excessive vegetative vine growth that promotes fungal diseases and excessive cluster shading that can reduce fruit quality.

Viticultural, enological, and market development of grape cultivars is ongoing in the eastern US. The global fascination of consumers with a relatively small set of world-class cultivars [Cabernet Sauvignon, Chardonnay, Merlot, Pinot noir, Sauvignon blanc, and Syrah (Shiraz)] has perpetuated a resistance to explore lesser-known cultivars. With a few exceptions (Riesling and Pinot noir in the Finger Lakes, Bordeaux reds on Long Island and in Virginia, and Pinot gris in Ohio) most eastern US states struggle to gain consumer awareness of their varietal strengths.

The solution: We have assembled a constellation of the East's leading viticulture, enology and wine economic personnel, and coordinated a research and extension project with stakeholder input to address these constraints. This Standard Research and Extension Project application is aligned with the SCRI focus area #3, "Efforts to improve production efficiency, productivity, and profitability over the long term (including specialty crop policy and marketing)". Our research is aimed at applied approaches to improving grape and wine quality through better vine size and vigor management (optimized "vine balance"), superior matching of cultivars to site, improved winemaking techniques for unique eastern US wine cultivars, and better understanding market drivers and constraints for eastern US wines. Our deliverables include:

- sustainable approaches to vineyard floor management that also promote better vine balance via vegetative growth management, reduce nutrient and pesticide leaching, and have the potential to improve wine quality;
- refined metrics for both researchers and commercial producers to assess and reduce variability of crop level and fruit maturity and to inform harvest decisions;
- accelerated, formal evaluation of novel grape cultivars in sub-regions of the East;
- novel, interactive GIS tools to assist with vineyard site evaluation and cultivar selection;
- research-based recommendations provided via a range of media, including on-farm workshops, distance learning resources, print publications and shortcourse content.

The approach builds on existing extension outputs by some of the team members (e.g., Dami et al., 2005; NRAES, 2008) and ongoing, coordinated cultivar evaluation (NE-1020 project), while minimizing duplication of effort amongst the leading grape and wine institutions of the East.