

# Specialty Crops Program – Final Report

**Grant Title:** Application of Crop Modeling for Sustainable Grape Production

**Organization:** Rocky Mountain Association of Vintners & Viticulturists (RMAVV)

**Technical Advisors:** Harold Larsen, Horst Caspari, Rod Sharp

## Summary:

In the third year of this 3-year study, no grape powdery mildew was detected until late June / early July in four out of five participating vineyards. At all sites, the incidence and severity of leaf infection were higher in the integrated disease management program than in the grower standard program. However, overall both the incidence of leaf infection and the severity on infected leaves were low, and there was no fruit infection in either program. Spray applications in response to initial observations of powdery mildew infections reduced incidence and severity to levels similar to that of a season-long control program while reducing the number of applications. Control costs were lower as a consequence on three vineyards, but higher on two vineyards compared to the grower standard program.

Overall, the project has demonstrated that the integrated disease management program has the potential to substantially reduce both the number of spray applications and application costs compared to a calendar-based spray program. Under favorable weather conditions, i.e. dry spring and early summer, it is feasible to control powdery mildew with as little as 1-2 spray applications compared to 7-8 applications in a calendar-based program.

## Introduction and Objectives:

Grape powdery mildew is one of the most serious and ubiquitous diseases of grape throughout the world. It is the primary disease of *Vitis vinifera* grapes in Colorado historically, and control has required multiple (two to eight) mildewcide sprays through the season with a seasonal cost of \$40 - 115 per acre for a four spray seasonal program typically used by grape producers.

The typical grape powdery mildew control program in western Colorado vineyards has been preventative in nature, with the use of prophylactic sprays applied beginning with early shoot growth and continuing through veraison at intervals determined by the spray longevity of the materials used. This has historically resulted in four to as many as eight sprays applied each season.

Often, however, such a prophylactic approach may not be needed in the more arid climate of western Colorado. There are many years in which grape powdery mildew infection periods (defined as 12 hour time periods in which temperatures range between 50 and 85 °F with high humidity and leaf wetness periods of 12 hours or more) do not occur until mid-summer. Prophylactic sprays applied prior to such infection periods are likely unneeded for disease control and an unnecessary expense for producers.

The present study investigates the use of electronic weather data to monitor and forecast the risk of powdery mildew infection based on such weather data. Predicted mildew infection risk is verified by on-site monitoring of actual powdery mildew incidence and severity through the season. Finally, comparisons are made of mildew control and costs for adjacent plots that use a “grower’s standard control program” with that of plots that use an “integrated mildew control program” which limits sprays to times associated with actual infection risk.

## Materials and Methods:

Five cooperator vineyards were identified with a minimum 2 acres of a single grape variety (four Chardonnay, vineyards A, B, C & E, and one Sauvignon blanc, vineyard D). Grower cooperators were to use their choice of control programs (grower's standard control program) for grape powdery mildew control on one half of the block (minimum of 1 acre) and to use the control program designated by the researchers for the other half of the block (minimum of 1 acre, which included the site of a remote weather station described below). The spray programs varied from one spray per season to seven sprays per season (Tables 1 - 5).

Table 1. Powdery mildew spray programs used at cooperator vineyard A during the 2004 season.

Grower's Standard Mildew Program			Integrated Disease Management Program		
Date	Materials & rates used	Cost <sup>z</sup>	Date	Materials & rates used	Cost <sup>z</sup>
4/26	Sulfur 6L @ 0.5 gal/a	\$2.50	4/26	Sulfur 6L @ 0.5 gal/a	\$2.50
5/10	Sulfur 6L @ 0.5 gal/a	\$2.50			
5/28	<i>Stylet-Oil @ 1.0%</i> <sup>y</sup>	\$7.25 <sup>y</sup>	5/28	<i>Stylet-Oil @ 1.0%</i> <sup>y</sup>	\$7.25 <sup>y</sup>
6/11	Rubigan 1E @ 4 oz./a	\$9.43			
6/24	Stylet-Oil @ 1.5%	\$10.88			
			7/2	Rubigan 1E @ 4 oz./a + Sulfur 6L @ 2 qt/a	\$11.93
7/6	Rubigan 1E @ 4 oz./a + Sulfur 6L @ 2 qt/a	\$11.93			
7/22	Sovran 50W @ 4 oz./a + Stylet-Oil @ 1.0%	\$33.00			
8/6	Bayleton 50DF @ 4 oz./a	\$15.75	8/6	Bayleton 50DF @ 4 oz./a	\$15.75
Total Spray Program Cost		<b>\$93.24<sup>y</sup></b>	Total Spray Program Cost		<b>\$37.43<sup>y</sup></b>

<sup>z</sup> Costs per acre for spray material only.

<sup>y</sup> Although Stylet-Oil was applied at 1% to control leafhoppers it is likely to have had some fungicidal activity. The costs for this spray are excluded from the total.

Automated Adcon weather stations were installed at two vineyards in 2002, two additional vineyards in 2003, and one additional vineyard in 2004. The stations each were equipped with sensors to measure air temperature, humidity, leaf wetness, precipitation, wind speed and direction, and solar radiation. Data was relayed back to a base station via radio telemetry on 15-minute intervals. The base station database was then accessed using the Thomas-Gubler powdery mildew disease model to assess mildew infection risk.

Field scouts assessed powdery mildew infection incidence and severity on variable intervals, typically once a week. Incidence and severity of powdery mildew infections on shoots and leaves were recorded from late May to mid August 2004 (about two weeks after veraison). Our sampling protocol was changed from the previous season to include both basal (near the fruit zone) and more apical leaves at each sampling time. Also, 25 vines were tagged in each block at the beginning of the season and were monitored throughout the season, with an additional 25 vines selected at random at each sampling date. Funding for the technicians/scouts has been obtained through an EPA grant that was awarded in July 2002. The EPA grant covers personnel costs for the scout; prior existence of the Specialty Crops Grant greatly expedited approval of that EPA grant. Further, EPA

has awarded a 2-year extension to continue with this project for two more seasons, albeit in a modified form.

Table 2. Powdery mildew spray programs used at cooperator vineyard B during the 2004 season.

<b>Grower's Standard Mildew Program</b>			<b>Integrated Disease Management Program</b>		
Date	Materials & rates used	Cost <sup>z</sup>	Date	Materials & rates used	Cost <sup>z</sup>
4/20	Thiolux 80DF @ 5 lbs/a	\$4.25	4/20	Thiolux 80DF @ 5 lbs/a	\$4.25
5/18	Nova 40W @ 3.3 oz./a	\$14.19			
6/10	Flint 50WDG @ 2 oz./a	\$30.00			
6/15	Nova 40W @ 5 oz./a	\$21.50	6/15	Nova 40W @ 5 oz./a	21.50
7/6	Stylet-Oil @ 1.5%	\$19.50			
7/12	Flint 50WDG @ 2 oz./a	\$30.00	7/12	Flint 50WDG @ 2 oz./a	\$30.00
			7/30	Thiolux 80 DF @ 3 lbs/a	\$2.55
8/9	Nova 40W @ 3 oz./a + Thiolux 80DF @ 3 lbs/a	\$15.45			
Total Spray Program Cost		<b>\$134.89</b>	Total Spray Program Cost		<b>\$58.30</b>

<sup>z</sup> Costs per acre for spray material only.

Table 3. Powdery mildew spray programs used at cooperator vineyard C during the 2004 season.

<b>Grower's Standard Mildew Program</b>			<b>Integrated Disease Management Program</b>		
Date	Materials & rates used	Cost <sup>z</sup>	Date	Materials & rates used	Cost <sup>z</sup>
6/25	Sulfur 6L @ 4 qts/a + Nova 40W @ 5 oz./a	\$26.50			
			7/8	Sulfur 6L @ 0.6 gal/a	\$3.00
7/30	Thiolux 80DF @ 3 lb/a	\$2.55	7/30	Thiolux 80DF @ 3 lb/a	\$2.55
Total Spray Program Cost		<b>\$29.05</b>	Total Spray Program Cost		<b>\$5.55</b>

<sup>z</sup> Costs per acre for spray material only.

Table 4. Powdery mildew spray programs used at cooperator vineyard D during the 2004 season.

<b>Grower's Standard Mildew Program</b>			<b>Integrated Disease Management Program</b>		
Date	Materials & rates used	Cost <sup>z</sup>	Date	Materials & rates used	Cost <sup>z</sup>
5/26	Sulfur 6L @ 7 pts/a	\$4.38	5/26	Sulfur 6L @ 7 pts/a	\$4.38
6/11	Sulfur 6L @ 7 pts/a	\$4.38			
7/14	Thiolux 80DF @ 6 lbs/a	\$5.10			
7/29	Thiolux 80DF @ 6 lbs/a	\$5.10			
			8/2	Thiolux 80DF @ 3 lbs/a + Flint 50WDG @ 2 oz/a	\$32.55
Total Spray Program Cost		<b>\$18.96</b>	Total Spray Program Cost		<b>\$36.93</b>

<sup>z</sup> Costs per acre for spray material only.

Table 5. Powdery mildew spray programs used at cooperator vineyard E during the 2004 season

Grower's Standard Mildew Program			Integrated Disease Management Program		
Date	Materials & rates used	Cost <sup>z</sup>	Date	Materials & rates used	Cost <sup>z</sup>
7/9	Sulfur 6L @ 2.4 qts/a	\$3.00			
			7/20	Sulfur 6L @ 1.6 lbs/a + Nova 40WP @ 2.63 oz./a	\$12.60
Total Spray Program Cost		<b>\$3.00</b>	Total Spray Program Cost		<b>\$12.60</b>

<sup>z</sup> Costs per acre for spray material only.

### Results:

Weather conditions in the spring of 2004 differed markedly from those of 2003. April 2004 was the wettest April on record in the Grand Valley with 11 days of measurable precipitation for a total of 3.3 inches at the Orchard Mesa Research Center. There were seven days with precipitation exceeding 0.1 inch compared to only 1 day in 2003. In contrast, there was only one day with significant rainfall in May 2004 compared to three days in 2003. Despite the wet April as well as the rainfall event in mid May no powdery mildew was found in any of the monitored vineyards until mid June (vineyard C) or July (all other sites; Fig. 1a,b). This lack of early-season infection is likely due to the low temperatures during rain events in April, and a short duration of leaf wetness in May. It is unclear why powdery mildew was found at vineyard C in mid June, as there was no significant rainfall until late June. At vineyard C, many vines had to be retrained from the ground following winter damage and it is possible that wetting of basal leaves via drip irrigation may have created artificial wetness periods sufficient to cause primary infections. This hypothesis is supported by the occurrence of an extended leaf wetness period on June 11/12 that was not detected at any other site. The first powdery mildew was observed five days later.

While the wetness period at vineyard C might explain the earlier onset of powdery mildew at that site, powdery mildew was also found, albeit at later dates, at all other monitored vineyards without extended wetness periods that are deemed required to cause a primary infection. At this point we can only speculate about the mechanism(s). It is possible that a primary infection occurred during the rainfall events in spring (April, May) but powdery mildew didn't develop much further until later in the season. This is unlikely as the weather conditions throughout May and June were very conducive to secondary infections. The most probable cause is that powdery mildew spores were blown in from other infected vineyards where artificial wetness periods caused a powdery mildew infection. Once powdery mildew is established conidial spores can be dispersed over longer distances by wind and, under favorable weather conditions, can start new infections. Temperatures and humidity in June and early July were indeed were favorable for secondary mildew infections. The establishment of powdery mildew without an apparent primary infection on site also illustrates the importance of vineyard monitoring.

With the exception of vineyard A, where no powdery mildew was found at all in the grower program, all vineyards had low levels of incidence and severity, irrespective of spray program (Fig. 1a,b). There was a tendency for higher levels early in the season in the integrated disease program, however disease incidence and severity were similar to the grower program once treatments were initiated. The model program led to a reduction in spray applications on four vineyards, while there was only one application in both programs in vineyard E.

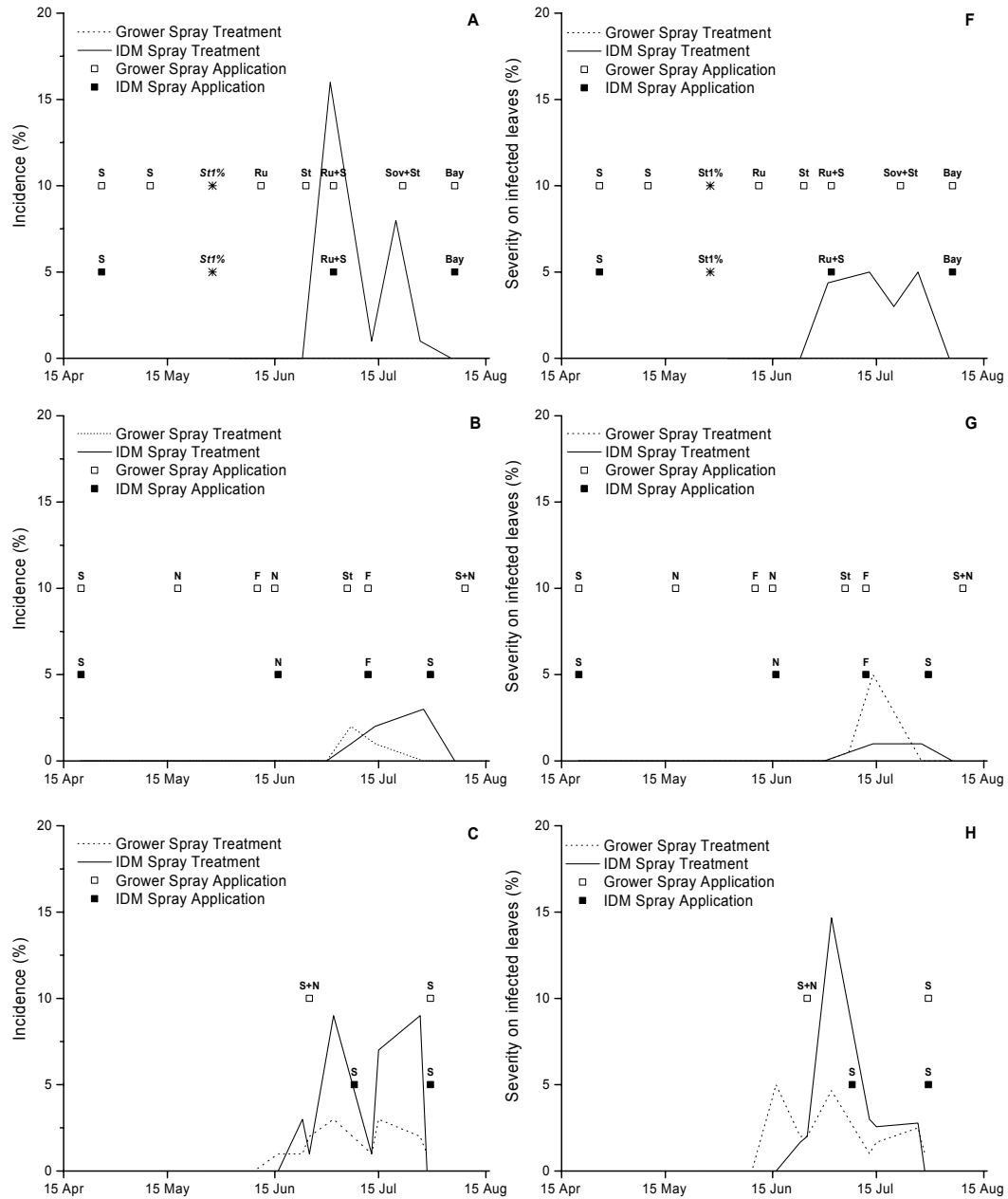


Figure 1a. Incidence (A-C) and severity (F-H) of grape powdery mildew on Chardonnay leaves at three Colorado vineyards in 2004. Note that the severity is for infected leaves only. At each site, the grower's standard spray program was compared to a reduced (IDM) spray program. Spray applications are indicated by "□" (grower program) and "■" (IDM program). Abbreviations: Bay - Bayleton, F - Flint, N - Nova, Ru - Rubigan, S - sulfur, Sov - Sovran, St - Styler Oil.

Spray costs (materials only) were reduced by up to \$76 per acre (Table 6). Vineyards C and E had the same number of application in both programs, and costs were either higher (vineyard C) or lower (vineyard E) in the integrated program, depending on the spray material used. Likewise, costs for spray material were higher in the integrated program for vineyard D as the grower used a sulfur-only program with four applications versus only two applications - one sulfur, and one Flint and sulfur - in the integrated program. The higher costs in the integrated program were due to the higher cost for Flint.

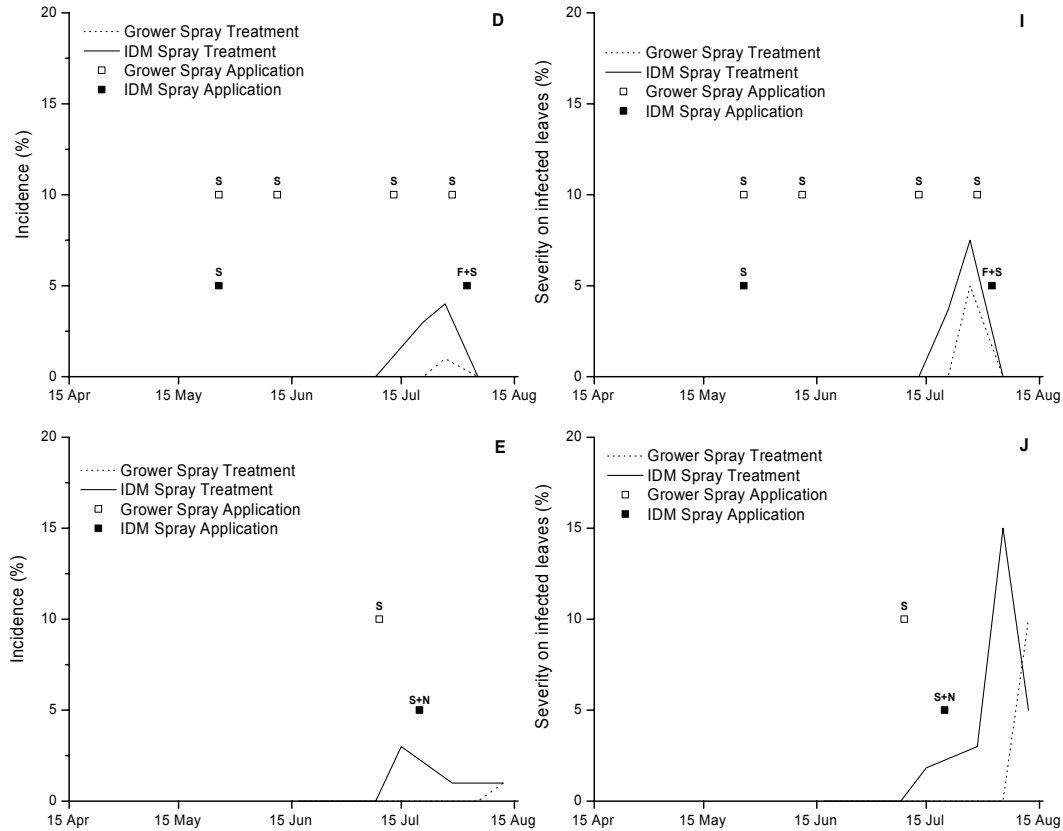


Figure 1b. Incidence (D-E) and severity (I-J) of grape powdery mildew on Chardonnay (E, J) and Sauvignon blanc (D, I) leaves at two Colorado vineyards in 2004. Note that the severity is for infected leaves only. At each site, the grower's standard spray program was compared to a reduced (IDM) spray program. Spray applications are indicated by "□" (grower program) and "■" (IDM program). Abbreviations: Bay - Bayleton, F - Flint, N - Nova, Ru - Rubigan, S - sulfur, Sov - Sovran, St - Stylet Oil.

This project has shown that grape powdery mildew can be effectively controlled with a spray program that is reactive rather than preventative in nature. Using such a program can lead to significant reductions in both spray applications and the costs for spray materials. However, early detection of powdery mildew infection is critical for the success of any control strategy, including

the integrated program. When initial infections are missed, such as in 2003, costs to control the disease might equal those of a calendar-based program due to the requirement to use more expensive material to control an infection. It should also be noted that powdery mildew developed rather late in the three years of this project, and there may be no cost savings in years when a powdery mildew infection happens in early spring. Nevertheless, in years when climatic conditions are less favorable for powdery mildew, significant cost savings can be achieved.

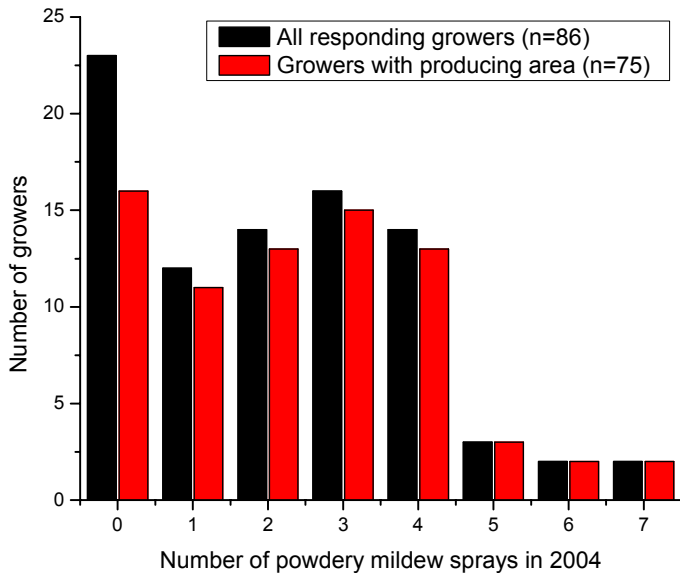
Table 6. Multi-year comparison of number of sprays applied and costs per acre for five cooperator vineyards in western Colorado that used the grower’s standard program and the integrated (model-driven) program to control grape powdery mildew (2002-2004).

Vineyard	YIP <sup>z</sup>	Grower						IDM					
		2002		2003		2004		2002		2003		2004	
		#	Cost <sup>y</sup>	#	Cost <sup>y</sup>	#	Cost <sup>y</sup>	#	Cost <sup>y</sup>	#	Cost <sup>y</sup>	#	Cost <sup>y</sup>
A	3	4	\$32.06	8	\$154.20	7	\$93.24	4	\$32.06	6	\$149.45	3	\$37.43
B	3	7	\$118.55	5	\$110.40	7	\$134.89	2	\$19.05	4	\$115.49	4	\$58.30
C	2			6	\$83.36	2	\$29.50			2	\$40.26	2	\$5.55
D	2			1	\$2.55	4	\$18.96			1	\$2.55	2	\$36.93
E	1					1	\$3.00					1	\$12.60

<sup>z</sup> Years participating in the program.

<sup>y</sup> Costs per acre for spray material only.

In the "2004 Colorado Wine Grower Survey" we asked growers how many powdery mildew sprays they had applied in the 2004 season. Eightysix out of 99 survey respondents provided information on their spray program.



More than 25 % of the growers did not apply a powdery mildew spray in 2004, and more than half the growers used two or less sprays (Fig. 2). In contrast, less than 10 % applied five or more sprays to control powdery mildew. When only the producing vineyard area is considered the percentages change slightly, however the overall trend remains the same. These data suggest that many growers have adopted a spray program that is in response to powdery mildew infection rather than a calendar-based program.

Figure 2. Number of powdery mildew sprays applied in 2004 by Colorado grape growers.

**Outreach:**

Additions and modifications to the dedicated web page were made throughout the year. Aside from the public part of the web page that provides access to the weather information the participating growers had access to site-specific information such as the powdery mildew risk index

The technical advisors also had numerous informal meetings with the grower cooperators throughout the season.

A final report on the project will be given at a meeting of the Rocky Mountain Association of Vintners and Viticulturists (RMAVV) on 19 February 2005.

**Acknowledgments:**

Field evaluations were done by Lyndsi Brumback, Tana Hawk, and Amy Montano. Sprays were applied by the field staff of the cooperating vineyards: Canyon Wind, Garfield Estates Winery and Vineyard, Lovie's Vineyard, Grande River Vineyards (Riverview Vineyard), and Two Rivers Winery. Cooperation provided by Norm Christianson and Ben Parsons (Canyon Wind), Bob Paxton and Brandon Armitage (Garfield Estates), Ken Loveland (Lovie's Vineyard), Jim Mayrose and Stephen Smith (Riverview Vineyard), and Glen Foster and Bob Witham (Two Rivers Winery).