

**Ozark Mountain Vineyard Sustainability  
Assessment Workbook**  
A Self-Assessment of Management Practices

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We greatly appreciate the Viticulture Consortium, the University of Arkansas Division of Agriculture and Missouri Wine and Grape Board for partial funding of this workbook.

The Ozark Mountain Vineyard Sustainability Assessment Workbook relied heavily on the grower self-assessment models developed by Farm\*A\*Syst / Home\*A\*Syst (FAS) (Madison, Wisc.) that were incorporated into the Lodi Winegrower's Workbook (Lodi-Woodbridge Wine Grape Commission, Lodi, Calif.), the New York Guide to Sustainable Viticulture Practices Grower Self-Assessment Workbook (Cornell University Cooperative Extension), Code of Sustainable Winegrowing Practices Workbook (Dlott et al. 2002) and the Michigan Grape-A-Syst Workbook. These workbooks provided growers with educational material and aided growers in self-assessing their farming management practices, developing a plan for addressing concerns and implementing management practices to improve farm sustainability and minimize ecological impact.

The major farming issues or concerns and educational materials presented in this Ozark Mountain Vineyard Sustainability Assessment Workbook were identified from both a baseline survey of vineyard best management practice adoption in the Ozark Mountain region conducted in 2005 by Keith Striegler, Donn Johnson, Andy Allen and Eli Bergmeier (unpublished data), and several years of tailgate meetings in six vineyard sites. We have discussed vineyard problems and solutions with more than 100 grape growers from Arkansas, Illinois, Kansas, Missouri and Oklahoma. The survey results indicated that wine grape acreage is increasing, and the number of wineries and wine production in the Ozark region is growing rapidly. Several cultural practices for disease control, including

scouting and vine canopy management, were more commonly employed by respondents. Other best management practices have achieved low adoption, including selecting cultivars with high disease resistance, petiole analysis for monitoring vine nutrition, removing alternate hosts of pests, use of vineyard scouting coupled with degree day models for timing pesticide applications, identification of weed species, or planting grape phylloxera-susceptible cultivars on resistant rootstock. Sustainable grape production incorporates an evolving set of practices; as new vineyard issues emerge and new information is developed, it will be incorporated into future issues of the workbook.

**Photo credits:** Authors of pictures are listed in alphabetical order: Andy Allen: soil profile (p. 9), petiole sampling (p. 14), diseases (pp. 51-52); Donn Johnson: covers, insect pests (p. 43), plant symptoms of insect damage (p. 44).

**Disclaimer:** Please note that this workbook is not a production guide but will be used to assess progress in implementation of viticulture practices. Not all issues will apply to your vineyard nor are the options listed for management the only possible solutions. The authors have included the most up-to-date information for each of the issues discussed.

The Ozark Mountain Vineyard Assessment Workbook was one of four objectives of a project funded from 2005 to 2009 titled, "Demonstration & Verification of Best Management Practices for Wine Grape Production in the Ozark Mountain Region," which had the goal of increasing vineyard **sustainability** and the adoption of environmentally-friendly vineyard management practices. The project had the following objectives:

- To conduct surveys to establish a benchmark and quantify progress in adopting grape best management practices (BMP) and to identify constraints to implementation in Arkansas and Missouri.
- To demonstrate grape best management practices.
- To disseminate grape management, pest and disease event information in a timely manner.
- To produce a Wine Grape Integrated Production Systems Workbook for use in grower grape best management practices workshops.

The summarized responses of a 2005 survey of Arkansas and Missouri grape growers identifies current grapevine canopy, insect and disease management practices. Half-day field workshops were held in April, May, June, July and early December (yearly research summary) at the six demonstration vineyard sites from 2006 to 2008 in Altus and Hindsville, Ark. and Ste. Genevieve, St. James, Hermann and Rocheport, Mo.

### **The best wine grape management practices topics covered or demonstrated included the following:**

- Canopy and crop load management practices for Merlot, Chambourcin, Chardonel, Norton and Vignoles, including shoot thinning, shoot positioning, leaf removal and cluster thinning; collected yield, cluster counts, average berry weight, fruit composition analysis and, where appropriate, bunch rot incidence data and presented analyzed

data to growers. For Vignoles, these treatments were designed to reduce cluster susceptibility to bunch rot by altering the very tight cluster architecture which is highly susceptible to bunch rot;

- Petiole and soil sampling for vineyard nutrient management;
- Irrigation;
- Weed management;
- Use of weather station data to run grape disease models (Spectrum Technologies, Inc., Plainfield, Ill.) to identify weather conditions that lead to disease events (spray dates) for black rot, downy mildew, powdery mildew, botrytis and phomopsis diseases;
- Grape pest scouting and decision-making pest management programs for grape berry moth, grape phylloxera, grape root borer, grape scale, Japanese beetle and green June beetle;
- Surveying and ranking foliar and root grape phylloxera infestations on the major wine grape cultivars growing either as self-rooted or grafted on rootstocks in the Ozark Region;
- Comparison of efficacy and timing of various insecticides and **biopesticides** against grape berry moth, grape phylloxera, Japanese beetle and green June beetles;
- Assessing density of grape root borer per vine across the Ozark Regions and evaluate mass trapping as a tactic to reduce this pest.

### **The current phase of our program is**

- to verify and implement at the grower level improved practices for managing vineyard canopies and crop load, pests and weeds;
- to conduct a regional weed survey culminating in a weed fact sheet, summarize disease management information and prepare a grape disease fact sheet;
- to develop a real-time and predictive information delivery system;
- to use this workbook to develop and implement

grower self-assessment of vineyard practices;

- to develop rules so a grower can be certified as using a minimum level of ecological or sustainable vineyard practices.

### **The Ozark Vineyard Assessment Workbook will**

1. be easy to follow;
2. be used by most growers in the Ozark Region;
3. achieve positive peer image and peer recognition;
4. present a positive public image of grape production in the Ozark;
5. identify, improve and promote the most effective grape BMP.

### **The Ozark Vineyard Assessment Workbook will achieve the above goals by helping growers to implement BMP that**

1. improve vine health;
2. improve wine quality and year-to-year consistency;
3. improve vineyard sustainability through education programs;
4. develop a voluntary Vineyard Sustainability Certification Program that will improve the adoption of sustainable winegrowing practices in the Ozark Region;
5. create public awareness that vineyard and winery practices are part of a good land stewardship program.

### **So what is sustainable winegrape production?**

A total-farm philosophy, sustainable winegrape production emphasizes the use of vineyard management practices that minimize impact on the environment, are economically feasible, and address needs and interests of the community (Dlott et al. 2002).

The workbook covers site selection, soils, site preparation, soil and vine nutrition management, cultivars and rootstocks, canopy management, crop load management, fertilizer storage, irrigation, weed management, pest management, disease management, pesticides and safety, pesticide application and pesticide equipment. Workbooks will be distributed to interested grape growers prior to attending a workshop of 6 to 10 growers that will be advertised for strategic geographic regions of Arkansas and Missouri. Some chapters cite references or have highlighted **terms**, which are listed in either the **Literature Cited** or **Glossary** at the end of the workbook.

At a workshop, the authors will help each grower go through the workbook, become better informed about viticulture and the current grape BMP being recommended, fill out their score sheet for each chapter and develop an action plan for implementing appropriate BMP into their farm system.

See the Example Worksheet to the right. Each worksheet will state an issue in the left column, followed by four categories ranging from Category 4 (most sustainable and most preferred response for the given issue) to Category 1 (indicating the grower currently is not addressing or not in the position to address this issue in a sustainable manner).

We are hopeful that growers will participate in Continuing Education workshops as they become available. Each workshop group will discuss and be asked to come to an agreement as to the criteria for a Vineyard Sustainability Certification Program (voluntary). Once the Certification Program is available, growers can voluntarily request their farm system be evaluated and receive certification.

## Example Worksheet

Pest and damage identification				
Issue	Most sustainable	←----->		Least sustainable
	Category 4	Category 3	Category 2	Category 1
55. What resources are used to identify insect pests and corresponding damage in the vineyard?	Vineyard manager and workers can identify insect pests and damage symptoms and know which cultivars are susceptible to each pest.	Vineyard manager can identify insect pests and damage symptoms but workers use posted color photo fact sheets.	Only the vineyard manager can identify cause of fruit or foliar damage.	No one can identify the major insect pests or damage that each causes.
<p><b>Notes:</b> (Write notes to yourself about how this issue affects your farm.)</p>				

- Read the 4 categories and decide which one best fits how you deal with this **Issue no.**
- Go to **Summary Evaluation Sheets** on pages 62-67, locate the **Issue no.** and check the appropriate category box.
- If you plan to change how you deal with this **Issue no.**, go to **Action Plan** on pages 68-69 and briefly describe how you will implement a higher category.

## Example Summary Evaluation Sheet

Issue	Page no.	Category				NR
		4	3	2	1	
1. Is vineyard located on a site with higher elevation?	4		✓			
5. Evaluate soil profile to identify location of hardpans and compaction	6	✓				
30. Are leaves removed as necessary for healthy clusters?	21					✓
34. What are the methods and timing of crop thinning?	23			✓		
42. What is the soil's water holding capacity?	27				VC	
46. What resources are used to identify weeds in the vineyard?	30			M	VC	
55. What resources are used to identify insect pests and corresponding damage in the vineyard?	42			✓		
80. Is foliage sprayer properly maintained?	60	✓				

- Check the category that best represents how you deal with this issue.
- Check **NR** if the issue is not relevant to your vineyard.
- Insert vineyard initials (**example: M, V, C**) in the appropriate boxes when scoring 2 or more blocks.

# I. SITE SELECTION

Proper site selection is one of the most important, yet most under-appreciated, components of successful grape production. A critical element of sustainable viticulture, poor site selection will often lead to failure of the vineyard enterprise. The best approach to locating a vineyard is to understand the characteristics of a site that make it well-suited for grape production and then to look for land that possesses those characteristics.

The elevation of a particular site has its greatest impact on temperature relations in the vineyard, so consider both the relative and the absolute elevation of a site. The relative elevation of a site is its elevation in relation to the immediate surrounding area. Its importance lies in the fact that cold air is heavy and flows downhill like water. As it flows downward, it displaces warmer air to a higher altitude. This type of freeze event, where the air becomes stratified into layers with the colder air at ground level, is known as a radiational freeze and is the type generally encountered in late winter/early spring frost situations. The vineyard site needs to be high enough above the lower surrounding area that the cold air can flow completely out of the vineyard. This is important for both frost and freeze protection and is the single best step in preventing frost and freeze damage.

The slope of a site is the rate of incline from the bottom of the site to the top. It is defined as the amount of rise (or increase in elevation) in feet per hundred feet of run (horizontal distance) and is expressed as a percentage (i.e. 5%). Slopes promote and accelerate cold air drainage, the greater the degree of slope the faster air drains out of a site. Slopes of 3 to 5 percent are adequate for cold air drainage, with a 5 percent slope being better. Slopes of 5 to 10 percent are good, however, as one goes beyond a 5 or 6 percent slope the risk of erosion begins to increase significantly —

especially with more erodible soil types — and may force a change in vineyard row orientation from that which the vineyardist would prefer. Flat sites (slope=0%) can be either good or bad depending on whether they are located on the tops of hills or ridges, and thus have cold air drainage away from them (good), or at the bottom of hills or in valleys and thus have cold air drainage toward them (bad).

Elevation				
Issue	Category 4	Category 3	Category 2	Category 1
1. Is vineyard located on a site with higher elevation?	Vineyard site is located on hilltop or ridge and is substantially higher than surrounding terrain.	Vineyard site is located on hill slopes and is somewhat higher than surrounding terrain.		Vineyard site is on lower slopes or lower lying areas and is not higher than surrounding terrain.
<p><b>Notes:</b> Cold air settles to lower elevations. Locating vineyards at higher elevations is necessary to keep vineyards out of frost pockets or areas where cold air gathers and concentrates. Harsh winter freezes can cause severe damage to grapevines or even vine loss. Winter freeze injury to grapevine trunks can also lead to problems with crown gall. Spring frost injury is a common occurrence in Midwestern vineyards and can result in mild to heavy crop losses. Selecting vineyard sites at higher elevations is the first best step to avoiding winter freeze or spring frost injuries that can lead to vine or crop loss.</p>				

Slope				
Issue	Category 4	Category 3	Category 2	Category 1
2. Does vineyard site have a slope to discourage erosion?	Site is nearly flat on ridge top (0 to 3% slope). <b>With</b> Very low risk of erosion.	Site has a slight slope (3 to 5%). <b>With</b> Moderate risk of erosion potential.	Site has moderate slope (5 to 10%) that allows moderate to severe erosion potential.	Site has steep slope (>10%) capable of causing severe erosion problem. <b>Or</b> Site is flatland (0% slope) in low-lying area that could be flooded.
<p><b>Notes:</b></p>				



## Air drainage

Issue	Category 4	Category 3	Category 2	Category 1
3. Does vineyard site encourage good air drainage?	The vineyard is located on higher ground, and there are no obstacles to cold airflow downhill. <b>And</b> Cover crops are managed to keep radiation freeze height near soil surface.	The vineyard is located on higher ground, and there are no obstacles to cold airflow downhill.	The obstacles to cold airflow downhill are being removed to improve cold air drainage.	The obstacles to cold airflow downhill cannot be modified to permit cold air to drain.

**Notes:** Buildings, trees (especially evergreens such as cedars), tall cover crops, brush and other obstacles to cold air movement downhill can result in cold air building up in the vineyard, even if the vineyard has good elevation and cold air does eventually drain away from the site. Clearing underbrush in the woods or clearing swaths through the woods at intervals can allow more rapid cold air movement away from the vineyard.

## Air movement

Issue	Category 4	Category 3	Category 2	Category 1
4. Does vineyard site allow for good air movement for rapid drying and lower humidity?	Site is in open area and is completely exposed to airflow during growing season, which lessens disease potential.	Site is in moderately open area and most of vineyard is exposed to airflow.	Site is mostly enclosed by woods but still has some airflow through the vineyard.	Site is crowded by dense woods, leaving only small open area for vineyard with little or no airflow.

**Notes:** Air movement through the vineyard during the growing season can help reduce disease pressure by reducing stagnant, humid air masses around the vines. This creates an environment that is less favorable for some diseases, such as powdery mildew. Sites such as open or sparsely-wooded hilltops allow good air movement through the vineyard. At sites with more dense woodlands surrounding the vineyard, keep the vines far enough away from tree lines to permit airflow through the entire vineyard; avoid dead air “pockets.”

One of the basic factors in effective grape production is assessing the soil type's suitability for grape growing. Grapevines can be grown on a wide range of soils, as evidenced by the many regions and different soil types around the world where commercial viticulture is successfully practiced. Imperfect soils can be modified to make them more favorable for grape production. For example, soil chemistry (pH and nutrient element content) can be altered through an appropriate liming and fertilization program. Soils subject to prolonged dryness can be irrigated to provide enough water to support vine growth and productivity.

The two most important characteristics of the soil are soil depth and internal drainage. The soil should preferably be at least 3 feet deep before any impervious layers are reached in order to allow the vine to exploit a large enough soil volume to meet its water requirements during the summer. Soils less than 3 feet deep, especially those with a low water-holding capacity, are usable but will require irrigation to provide water during the dry summer months.

While a good water-holding capacity is desirable, good vineyard soils must also have good internal drainage. Dense, compacted soils or impervious layers that impede water percolation through the soil will result in soils that remain excessively wet for extended

periods. Due to poor oxygen levels in these wet soils, root function and development will be impaired. Drain lines can improve the internal drainage of heavy soils but are an expensive fix. Whether or not drainage lines need to be installed should be determined before the vines are planted; waiting until the vines are suffering from poor root function to install drainage lines can result in poor vine growth, reduced yields or even vine death.

Dense soils can also physically impede root growth and soil exploration. Grapevine roots cannot penetrate soils where the bulk density is greater than 1.6 to 1.7 g/cm<sup>3</sup>. Fracturing plowpans, hardpans or other compacted layers can allow grapevine roots to exploit greater soil volumes to acquire water and nutrients. Online soil survey data (<http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>) can provide much useful information on soil drainage, bulk density and other soil properties and is a good starting point in determining whether soils are well-suited for grape production or need some remedial action.

Finally, soils should only be moderately fertile. Excessively fertile soils can lead to lush growth that doesn't properly mature and harden as well as lead to problems with cropping and fruit quality.



*In the photos above, the soil on the top is an example of a well-drained soil in the Missouri River Valley area. Note the brown color and lack of any apparent layers. This is a deep soil with no restrictive layers. The example on the bottom shows poorly drained soil in the Ozark Mountain area of Southwest Missouri. Note the mottled yellow coloration. Mottled yellow or gray colors in the soil are an indication of poor aeration in the soil, which is an indication of poor drainage.*

Soil profile				
Issue	Category 4	Category 3	Category 2	Category 1
5. Is soil profile evaluated to identify location(s) of hardpans and compaction?	Soil pits are dug at various sites in vineyard, and the soil profile is evaluated.	A soil pit is dug at a single location in the vineyard, and the soil profile is evaluated.	Soil information is determined by use of printed or online soil maps.	No attempt has been made to evaluate soil characteristics.
<b>Notes:</b> Soil pits reveal the different levels, or horizons, of the soil and are the best method of determining soil quality as well as identifying any restrictive layers in the soil.				

Soil drainage				
Issue	Category 4	Category 3	Category 2	Category 1
6. Do vineyard soils have good internal drainage?	Soils are naturally well-drained.	Soils are naturally moderately well-drained.	Soils are poorly drained but steps were taken to improve drainage.	Soils are poorly drained and steps have not been taken to improve drainage.
<p><b>Notes:</b> Poorly-drained soils can be improved by the installation of drainage lines. This is best done by professionals before planting the vineyard. It is critical to install the lines at the appropriate depth and with adequate inclination to provide proper drainage of excess water in the soil. Another option is to build raised planting mounds by moving topsoil from the row middle area and forming mounds in the vine row. Mounding can provide a greater volume of usable soil for the vine roots to exploit but can dry quickly. If mounds are used, drip irrigation should be installed and soil moisture status monitored closely.</p>				

Root development				
Issue	Category 4	Category 3	Category 2	Category 1
7. Do vineyard soils allow optimum root development?	Soils are 3 to 6 ft deep and have a low bulk density (< 1.6 g/cm <sup>3</sup> ) with drip irrigation.	Very deep soils (> 6 ft) in areas with low summer rainfall with drip irrigation. <b>Or</b> Soils are shallow (1.5 to 3 ft) with a low bulk density.	Very deep soils (> 6 ft) in areas with low summer rainfall but not irrigated. <b>Or</b> Soils are shallow (1.5 to 3 ft) with a high bulk density corrected by subsoiling prior to planting.	Very deep soils (> 6 ft) which lead to excessive <b>vine size</b> in areas with high summer rainfall. <b>Or</b> Shallow soils less than 3 ft deep with a high bulk density.
<p><b>Notes:</b></p>				

## III. SITE PREPARATION

Proper preparation of the vineyard site and installation of the vineyard is essential for efficient establishment and profitable operation. In many cases, site preparation and installation errors are difficult to correct, as the presence of planted vines greatly complicates or prohibits many operations. The history of the site has a strong influence on the amount of time and resources required to properly prepare a vineyard site. Sites previously farmed to row crops or managed pasture can often be prepared quite rapidly — occasionally in less than 6 months under ideal conditions. Woodlands, rocky sites, or previously unmanaged sites are typically more difficult to prepare and may require much more time to prepare properly.

Site clearing				
Issue	Category 4	Category 3	Category 2	Category 1
8. Has vineyard site been cleared of all obstructions that might interfere with grape growth and soil quality?	Site was cleared of trees. <b>And</b> A subsoiler used to remove large roots. <b>And</b> At least a year was taken to adjust soil pH and nutrient levels, remove perennial weeds, and build up soil organic matter before planting vines.	Site was cleared of trees. <b>And</b> A subsoiler used to remove large roots. <b>And</b> Adjust soil pH and nutrient levels prior to planting vines.	Site was cleared of trees. <b>And</b> A subsoiler used to remove large roots. <b>And</b> Plant vines.	Site was cleared of trees and stumps. <b>And</b> Plant vines soon after clearing.
<p><b>Notes:</b> For sites that were previously in timber or featured a rocky soil surface, site clearing is a significant undertaking, requiring up to 24 months of preparation time. The first step is to remove any trees or woody brush from the site. For heavily wooded sites, this commonly requires the use of a large bulldozer or excavator. It's wise to also remove trees that impede airflow through the site or prevent cold air from drifting to lower elevations, as well as any wild grapevines growing within 50 to 100 yards of the plot.</p> <p>After removing trees, the next step is to remove as many large rocks and tree roots from the site as possible, as both items complicate tillage and installation operations. The latter pose an additional risk in that they can harbor root-damaging pathogens and toxins. Subsoilers and chisel plows are both very helpful in bringing these items to the surface. All roots measuring 1.5" in diameter or greater should be removed from the site.</p>				

### III. SITE PREPARATION

Soil analysis				
Issue	Category 4	Category 3	Category 2	Category 1
9. Have soil samples been collected to determine possible lime and nutrient needs (P, K, B, Mn, Zn, Ca, Mg)?	Soil samples were collected from several areas around the vineyard based on changing soil types, cultivars, rootstocks, etc. Lime and nutrients were incorporated in soil according to soil lab recommendations.	Soil samples were collected from several areas around the vineyard. <b>But</b> No attention was given to differences in soil types, cultivars, rootstocks, etc. Lime and nutrients were incorporated in soil according to soil lab recommendations.	A soil analysis was performed but no lime or nutrient incorporation was done <b>Or</b> No soil analysis was performed but a given amount of lime was broadcast based on a 'best guess.'	No soil analysis was done prior to planting nor was lime or other mineral nutrients incorporated into the soil prior to planting.
<b>Notes:</b>				

Organic matter				
Issue	Category 4	Category 3	Category 2	Category 1
10. Is more organic matter needed to improve soil health and water holding capacity?	Soil has naturally high (> 2.5 but < 3%) organic matter content.	Soil has naturally low to moderate organic matter content. <b>And</b> High biomass cover crops were grown for a year prior to planting and disked into the soil to increase soil organic matter.		Soil has naturally low to moderate organic matter content. <b>And</b> No cover crops were grown prior to planting.
<b>Notes:</b>				

### III. SITE PREPARATION

Soil erosion				
Issue	Category 4	Category 3	Category 2	Category 1
11. Have cover crops been planted to prevent soil erosion?	A perennial grass cover crop was established in the row middles to hold soil in place and to provide a surface capable of supporting traffic in the vineyard.	An annual grass cover crop was established in the row middles to hold soil in place and to provide a surface capable of supporting traffic in the vineyard.	No grass cover crop was established but resident vegetation was allowed to remain in the row middles.	No attempt was made to establish any cover crop.
<b>Notes:</b>				

Row orientation				
Issue	Category 4	Category 3	Category 2	Category 1
12. Are vineyard rows oriented to accommodate site layout and slope?	Vineyard rows run perpendicular to the main (across slope). <b>Or</b> Slope along rows is < 3%; hill slope is < 12%. <b>And</b> Direction of slope is uniform.	Vineyard rows run perpendicular to the main slope. <b>And</b> Slope along rows is < 6%; hill slope is < 12%. <b>And</b> Some side slopes present.	Vineyard rows are perpendicular to the main slope. <b>And</b> Substantial side slopes are present (slope direction is not uniform).	Vineyard rows run up and down the slope and slope is greater than 6%.
<b>Notes:</b> Selecting row orientation is a primary consideration of vineyard layout. Of all the factors that should impact row orientation decisions, minimizing soil erosion must receive the highest priority. For this reason, on all but the gentlest of slopes or non-erosive soils, rows should be oriented perpendicular to the prevailing slope. <b>Source:</b> "New York Guide to Sustainable Viticulture Practices" at <a href="http://www.vinebalance.com">www.vinebalance.com</a>				

## IV. SOIL AND VINE NUTRITION MANAGEMENT

A good nutrition program is essential for efficient and profitable vineyard management. Proper monitoring of vine nutritional status allows the grower to add nutrients in the correct amount to meet but not exceed vine requirements. Nutrients may be supplied by application of inorganic fertilizer, application of organic fertilizer, or use of leguminous cover crops. Nutrients can be broadcast, banded, injected through the drip irrigation system (fertigation), or sprayed on the foliage (foliar feeding).

Vine nutritional status can be estimated by soil or plant tissue analysis. Soil analysis has proven to be less reliable for determining vine nutritional status than plant tissue analysis. This is because soil analysis provides information on the nutrients found in the soil but does not tell us whether nutrients are being removed from the soil and utilized by grapevines. For this reason, soil samples need only be collected from mature vineyards every two or three years unless a soil amendment program is being used (soil pH modifications, gypsum application, etc.). Plant tissues used for analysis of nutrients in grapevines include the leaf petiole, leaf blade, fruit (analysis of juice), or dormant canes.

Petiole samples should be collected from uniform areas of the vineyard and should not represent more

than ten acres. If the vineyard is not uniform (different soil types, uneven irrigation, presence of soil pests, etc.) more samples should be taken and sent to the laboratory. A change in variety or rootstock within an otherwise uniform ten-acre block would require collection of more petiole samples.

The size of the sample should be approximately 100 petioles. Samples can be collected from a select group of vines (reference plot) or by using a consistent pattern across the uniform vineyard block such as sampling from every 10<sup>th</sup> vine in every fifth or 10<sup>th</sup> row depending on block size. It is critical that the sample be representative of the vineyard block. Also, sampling from the same vines each year allows the grower to discern seasonal trends in vine nutritional status which could be difficult to identify if the variability in sampling is large.

Petioles used for analysis should come from the youngest fully mature leaf near the shoot apex (shoot tip). The leaf blade should be removed immediately and discarded. Petioles are then placed in a clean, labeled paper bag (small lunch size). A record of all information regarding the sample should be retained by the grower to allow for sample identification and interpretation of results from the laboratory.

Petiole tissue analysis				
Issue	Category 4	Category 3	Category 2	Category 1
13. Is petiole analysis done on a regular basis?	A nutrition management plan is in place that includes petiole analysis done on all blocks every year.	Petiole analysis is done on most blocks every 1 to 2 years.	Petiole analysis done less frequently than 2 years or only when a problem appears.	No petiole analysis since the vineyard was planted.
<b>Notes:</b> We recommend petiole tissue analysis at <b>véraison</b> for native ( <i>Vitis labruscana</i> and Norton/Cynthiana) and hybrid cultivars and at bloom for <i>Vitis vinifera</i> cultivars. See the ICCVE website for petiole sampling protocols ( <a href="http://iccv.missouri.edu">http://iccv.missouri.edu</a> ).				



## IV. SOIL AND VINE NUTRITION MANAGEMENT

Soil analysis				
Issue	Category 4	Category 3	Category 2	Category 1
14. Is soil analysis used to monitor and maintain pH, nitrogen, macronutrients and micronutrients in range appropriate for each cultivar?	A nutrition management plan is in place that includes conducting soil analysis on all blocks every 3 years to manage pH, nitrogen, potassium, phosphorus and micronutrients.	Soil analysis is done on most blocks every 5 years.	A single soil analysis regardless of soil type differences for the entire vineyard is collected occasionally or only when a problem occurs.	No soil analysis since the vineyard was planted.
<p><b>Notes:</b> We recommend soil analysis for mature vineyards every three years for all blocks in the fall after harvest to manage nitrogen, micronutrients, potassium and phosphorus. The grower needs to determine if the pH is appropriate for each cultivar: 5.5 to 6.5 pH for native cultivars (<i>Vitis labruscana</i> and Norton/Cynthiana); and 6.0 to 7.0 pH for American hybrid, French-American hybrid and <i>V. vinifera</i> cultivars.</p>				

Nitrogen management				
Issue	Category 4	Category 3	Category 2	Category 1
15. How are the need, rate and timing for nitrogen fertilization determined and implemented?	N rate is based on leaf petiole analyses, soil organic matter and vine size. <b>And</b> The recommended rate of N is applied as a split application at fruit set and post harvest but not during dormancy.	N rate is based on leaf petiole analyses, soil organic matter and vine size. <b>And</b> The recommended rate of N is applied at one time, before budburst.	N application is based on leaf petiole analyses and vine size. <b>And</b> N is applied at one time, before budburst.	Even though vine size the previous year was more than adequate, N is applied every year when the vines are dormant. <b>Or</b> N rarely applied even though vine size was inadequate.
<p><b>Notes:</b></p>				

### How to take a soil sample:

From the perspective of nutrient availability, soil can be sampled any time of the year. Fall or winter sampling allows more time for planning and corrective fertilizer management. Use a soil coring device to penetrate 7 inches into the soil to collect sub-samples at 10 to 20 random locations in a vineyard block. Discard the organic duff on top of the soil core, remove the next 6 to 7 inches of the soil core and place it in a sampling bucket, and discard soil core below 6 to 7 inches. Mix these subsamples in the bucket. If samples are very wet, allow them to air dry for a day then take a subsample from the bucket to fill the soil sample analysis box. Fill in the separate sample information form or the form on the sample box including county name. Remember to request nutrient recommendations for grape. Mail to or drop the sample off at any County Cooperative Extension Office. This office will submit the sample to the appropriate State Soil Laboratory for analysis (listed below). Soil test results will be mailed back to the appropriate area agronomist or horticulturalist who will send you fertilizer recommendations for that grape block.

- Missouri Soil and Plant Diagnostic Services: <http://soilplantlab.missouri.edu/soil/soilsamples.aspx>;
- Arkansas Soil Testing and Research Laboratory: <http://aaes.uark.edu/soil.html>



## IV. SOIL AND VINE NUTRITION MANAGEMENT

Nitrogen source				
Issue	Category 4	Category 3	Category 2	Category 1
16. What is the method of N application?	N is provided strictly by organic sources and cover crops.	N is provided mainly through organic sources and cover crops. <b>But</b> Some synthetic N is applied as needed.	N is provided mainly through synthetic fertilizer but some by cover crops or organic matter.	N is provided by synthetic fertilizer.
<p><b>Notes:</b> Organic fertilizers are slower to release N, often have an unpredictable rate of release and are more dilute. If used long-term, they may improve the quantity and quality of soil organic matter, promote soil biodiversity and reduce leaching. It is more difficult to ascertain the exact rate of organic fertilizer to add given the unpredictable rate of N release. Use of split applications and supplementation with foliar N will allow tweaking of the N rate. Examples of common organic N fertilizers include peanut meal, soybean meal, feather meal and fish meal. Be sure to read the label on synthetic and organic N and nutrient sources or request a nutrient analysis.  <b>Modified from</b> "New York Guide to Sustainable Viticulture Practices" at <a href="http://vinebalance.com">http://vinebalance.com</a></p>				

Nitrogen application				
Issue	Category 4	Category 3	Category 2	Category 1
17. How is N fertilizer applied?	N is applied in several small doses via fertigation.	N is applied by both fertigation and soil surface application.	N is band applied by the vine row (soil surface or subsurface).	N is only broadcast applied to soil surface.
<p><b>Notes:</b></p>				

## IV. SOIL AND VINE NUTRITION MANAGEMENT

Macronutrients				
Issue	Category 4	Category 3	Category 2	Category 1
18. How are other macronutrients managed (P, Ca, Mg, K)?	Macronutrients are maintained at acceptable ranges based on soil and petiole analysis results. <b>And</b> Vineyard manager can identify deficiency and toxicity symptoms.	Macronutrients are maintained at acceptable ranges based on soil and petiole analysis results. <b>But</b> Vineyard manager cannot identify deficiency and toxicity symptoms.	Macronutrient levels are only adjusted when deficiencies occur.	A fixed amount of macronutrients are applied every year.
<b>Notes:</b>				

Micronutrients				
Issue	Category 4	Category 3	Category 2	Category 1
19. How are micronutrients managed (B, Mn, Zn)?	Micronutrients are maintained at acceptable ranges based on soil and petiole analysis results. <b>And</b> Vineyard manager can identify deficiency and toxicity symptoms.	Micronutrients are maintained at acceptable ranges based on soil and petiole analysis results. <b>But</b> Vineyard manager cannot identify deficiency and toxicity symptoms.	Micronutrient levels are only adjusted when deficiencies occur.	A fixed amount of micronutrients are applied every year.
<b>Notes:</b>				

## V. CULTIVARS AND ROOTSTOCKS

In determining what grape cultivars to grow, there are many factors to consider. In the greater Ozark Mountain Region, first consider location within the region. The region encompasses a large geographic area, from the Arkansas River Valley in the south to areas north of the Missouri River Valley. In the more southern areas of the region, where winter temperatures are milder, cultivars of all the different types of bunch grapes may be grown due to the decreased risk of winter injury. Moving north within the region or at higher elevations, low temperatures in winter will limit the type of bunch grape and the cultivars within each type that can be grown (Allen 2006). Check archived local weather data for average winter minimum temperatures to determine appropriate cultivars for that location.

Next, consider who will be the end user of the grape. If you are planning to make your own wine, then make cultivar decisions based on the type of wine you plan to produce and your ability to sell it. If you are growing grapes for sale, then you must also consider who is going to buy the grapes when you begin to harvest crops from your vineyard. Know what cultivars buyers look for and in what quantities they will want those cultivars. Unless you have a contract from a winery requesting a specific cultivar, it is better to grow cultivars that are being used by several potential buyers.

The cultivar should also be economical to produce. Cultivars that are poorly productive or that lose a large percentage of their crop annually to disease may not be profitable to produce unless they yield a very high price per ton.

**Vitis vinifera cultivars.** *V. vinifera* cultivars are susceptible to many pests and diseases, including, but not limited to, powdery mildew, downy mildew, phomopsis, black rot, various bunch rot diseases,

crown gall, viruses and grape phylloxera. Additionally, the climate of much of the eastern U.S. and the Ozark Mountain Region in particular, makes *V. vinifera* production a much riskier endeavor. Very cold winters, fluctuating temperatures in late winter and early spring increase the risk of freeze or frost damage, whereas hot summers and high humidity increase disease pressure. Some cultivars, however, have produced good quality crops here. Some efforts have been undertaken to evaluate some standard cultivars as well as lesser known cultivars, particularly those more adapted to hot summers.

**Native and hybrid cultivars.** Although the production of *V. vinifera* cultivars has been increasing in the eastern U.S. in the last several years, the hybrid and native cultivars are still the predominant cultivars utilized in the Ozark Mountain Region for several reasons. Native and hybrid cultivars can tolerate colder temperatures than *V. vinifera* cultivars, which can be damaged by 0° to -5° Fahrenheit temperatures and severely injured or killed by temperatures between -6 to -10° F. The hybrids, on the other hand, can tolerate temperatures as low as -10 to -20° F. Native cultivars can tolerate temperatures from about -15 to -25° F. Also,

while most *V. vinifera* cultivars are poorly fruitful from secondary buds, even when their primary buds or shoots are damaged by late frosts many hybrids are still likely to produce an economical crop because of their fruitful secondary buds. Another reason is their (at least partial) resistance to some of the common fungal diseases that plague grapes. The American and French-American hybrid cultivars generally have greater resistance to fungal pathogens than *V. vinifera* cultivars. As a group, these cultivars are less risky and more reliable to produce in the often harsh and erratic climate of the eastern U.S.

Cultivar selection				
Issue	Category 4	Category 3	Category 2	Category 1
20. Are cultivars appropriately selected for the area?	Cultivars are selected based on being adapted to the climate and soil of the geographic area of the vineyard.			Cultivars are selected on availability or preference for producing a specific type of wine.
<b>Notes:</b>				

## V. CULTIVARS AND ROOTSTOCKS

Virus-free				
Issue	Category 4	Category 3	Category 2	Category 1
21. Are chosen cultivars suitable for the vineyard and certified as virus-free?	Vines were tested and certified as virus-free. <b>And</b> Vines were appropriate for climate. <b>And</b> Cultivar was chosen after consulting with winery purchasing crop.	Vines were not tested for virus. <b>But</b> Vines were appropriate for climate. <b>And</b> Cultivar was chosen after consulting with winery purchasing crop.	Vines were not tested for virus. <b>But</b> Vines were appropriate for climate.	Vines were not tested for viruses and no nursery production history was known.
<p><b>Notes:</b> Currently, only vines of <i>V. vinifera</i> cultivars are available commercially certified as virus-free. However, efforts are underway through the National Clean Plant Network to begin producing certified virus-free vines of native and hybrid grape cultivars.</p> <p><b>Source:</b> National Grape Clean Plant Network (GCPN) online at <a href="http://groups.ucanr.org/ncpn/Grape_CPN/">http://groups.ucanr.org/ncpn/Grape_CPN/</a></p>				

Source of vines				
Issue	Category 4	Category 3	Category 2	Category 1
22. How were the vines acquired?	Vines were purchased from a reputable nursery that other growers and extension personnel have recommended.		Vines purchased from any nursery with desired vines available.	Vines propagated by grower from cuttings from local vineyard where the disease status is unknown.
<p><b>Notes:</b></p>				

## V. CULTIVARS AND ROOTSTOCKS

Rootstocks				
Issue	Category 4	Category 3	Category 2	Category 1
23. How were rootstocks chosen?	Rootstock chosen to resist soil pest (nematodes or grape phylloxera) and/or chemical or physical soil variability and/or modify scion <b>vigor</b> to achieve optimum wine quality.	Rootstock chosen to resist soil pest (nematodes or grape phylloxera).	Rootstock chosen solely because of availability.	Vines planted on own roots.
<b>Notes:</b> <i>Vitis vinifera</i> and certain hybrid cultivars such as Chardonel require grafting. In replant situations, all cultivars do require grafting.				

Hilling soil above grafts				
Issue	Category 4	Category 3	Category 2	Category 1
24. Were grafted cultivars hilled with soil to minimize winter injury?	For the first five years of growth, a grape hoe or disc was used to throw soil 6 to 8 inches over the graft union in the fall and removed soil from the graft after the last frost date in spring.	For the first couple years, a grape hoe or disc was used to throw soil over graft union in the fall and soil was removed from the graft after the last frost date in spring.	For the first couple years, a grape hoe or disc was used to throw soil over graft union in the fall.	No soil hilling was done.
<b>Notes:</b>				

## V. CULTIVARS AND ROOTSTOCKS

Disease resistance				
Issue	Category 4	Category 3	Category 2	Category 1
25. Are the cultivars disease-resistant?	Cultivar was chosen to resist plant disease so that fungicide applications are minimized.			Disease resistance was not considered in selecting cultivars.
<b>Notes:</b>				

Vine and soil maps				
Issue	Category 4	Category 3	Category 2	Category 1
26. Do accurate maps of vineyards and soil types exist?	Maps of each block are available that delineate acreage of each cultivar, rootstock type and different soil types. Maps are updated annually.	Maps of each block are available that delineate acreage of each cultivar, rootstock type and different soil types.	Maps of each block are available that delineate acreage of each cultivar.	No maps exist of vines planted or differences in soil type.
<b>Notes:</b>				

## VI. CANOPY MANAGEMENT

The grapevine canopy is the above-ground portion of the vine that consists of the shoot system, fruit, trunk, cordon and canes. The shoot system is the most alterable part of the vine and is comprised of leaves, petioles, shoot stems, shoot tips, lateral shoots and tendrils. Grapevine canopy management refers to a range of techniques used to create or alter the position or amount of leaf area or fruit within a given space or canopy volume. These practices are normally performed to improve **canopy microclimate**, particularly in the fruit zone.

The three fundamental aspects of canopy microclimate are light, temperature and humidity. Current conventional wisdom suggests that quality improves with increased cluster exposure. However, excessive exposure reduces quality. Generally, more light has been correlated with higher quality fruit, while increased fruit temperatures are detrimental to quality, especially in warm climates. Humidity is generally greater within dense canopies. If the canopy is open, however, slight breezes may have a ventilation effect that will reduce humidity. Humidity within the canopy can be an important factor influencing the establishment and growth of grape fungal diseases.

The primary goals of canopy management are to improve grape and wine quality, increase vine yield, reduce incidence of disease, decrease production costs and promote ease of mechanization. Canopy microclimate manipulations can be directly applied by winter pruning, which affects the future shoot location and density. Shoot thinning or leaf removal can be utilized to decrease the current density of shoots and leaves. Other manipulations include summer pruning or trimming to reduce shoot length and shoot positioning to alter where shoots are located within the canopy volume. Fruit thinning is a common practice used to

manipulate fruit location within the canopy, reach desired crop loads at harvest, and utilize photosynthetic energy during ripening. Trellis training systems also change canopy surface area and canopy density.

Training system				
Issue	Category 4	Category 3	Category 2	Category 1
27. Is trellis training system appropriate for the vine size in each block?	Trellis training system accommodates the vine size of your vines, providing an open canopy with moderate exposure of the fruit zone to light and air without requiring leaf removal.	Trellis training system accommodates the vine size of your vines, providing an open canopy with moderate exposure of the fruit zone to light and air but requires leaf removal.	Trellis training system reduces excessive canopy density, but shading of the fruit zone still occurs even with leaf removal.	Trellis training system does not compensate for excessive vine size; the fruit zone is very shaded and fruit composition negatively impacted. <b>Or</b> High inputs of labor for canopy management are required to maintain an open fruit zone. <b>Or</b> Provides more canopy space than the vine can fill due to inadequate vine size.
<b>Notes:</b> The vineyard is developed with soil type, vigor of variety and rootstock, and crop load goals in mind. It is recommended that a viticulture extension advisor or professional consultant be involved in this decision making process, as the best management practice to apply will require customization and extensive knowledge of the vineyard and site.				

### Shoot density and thinning

Issue	Category 4	Category 3	Category 2	Category 1
28. Have shoots been thinned so that they grow at a proper density?	A shoot density of 4 to 6 shoots per foot of canopy was achieved without extensive shoot thinning.	Where necessary, shoots were thinned to 4 to 6 shoots per foot of canopy. If possible, non-count shoots should be preferentially eliminated.	Shoot thinning was done but not to the recommended level.	Excessive shoot density exists but no shoot removal was performed, resulting in a dense shaded canopy.

**Notes:** Shoot removal can be performed shortly after budburst. However, if shoot removal is performed before most buds have pushed, not all shoots will be visible. If shoots become longer than 15 inches, shoots become difficult to remove without tearing. Several shoot thinning methods have been established in commercial vineyards. Three common methods that have become more widely adopted include removing all shoots carrying no fruit (unless needed for renewal), removing all non-count shoots and retaining a certain number of shoots per linear length of canopy (generally 4 to 6 shoots/foot). Depending on the desired crop load of the vineyard, fruiting shoots may not need to be removed. For example, if the number of clusters per vine has been assessed prior to shoot thinning and the cluster count is estimated to be inadequate to meet the yield goal for the vineyard, then you should keep every shoot with a cluster.

### Shoot positioning

Issue	Category 4	Category 3	Category 2	Category 1
29. Are shoots positioned to reduce shading?	Shoot positioning was done three times in the correct way for the trellis training system and timing was optimal (see notes).	Shoot positioning was done three times but without optimal timing.	Some shoot positioning was done (one to two times) to reduce shading.	No shoot positioning was performed, resulting in a densely shaded canopy.

**Notes:** Positioning of shoots requires the shoots to be forced in the direction intended for the trellis system. Shoots are separated, untangled and, depending on the trellis, tucked up between foliage wires or positioned down to hang from the cordon. For the vertical shoot positioned trellis (VSP), positioning shoots is generally required when shoots are 12 to 18 inches (2 weeks pre-bloom), 24 to 36 inches (fruit set), and 2 to 3 weeks after fruit set. In high-wire trellis systems, downward shoot positioning is performed when shoots are long and heavy enough to remain in place after positioning but before shoots and tendrils become intertwined and attached to adjacent shoots. This typically occurs when shoots are between 18 to 24 inches in length.



## VI. CANOPY MANAGEMENT

Leaf removal				
Issue	Category 4	Category 3	Category 2	Category 1
30. Are leaves removed as necessary for healthy clusters?	No leaf removal is necessary. The cluster zone is at least 50% exposed to light (clusters have some exposure to the canopy exterior) and allow free air movement.	Leaves around the clusters were removed shortly after bloom to improve light penetration and air ventilation of the clusters.	Leaf removal sometimes done or very lightly done to minimize costs. <b>Or</b> Leaf removal done on vines with inadequate shoot growth, resulting in sunburn or reduced sugar accumulation.	Appropriateness of leaf removal was not assessed.
<p><b>Notes:</b> Pulling leaves at the end of fruit set best establishes the beneficial effects of an open canopy and tends to be more beneficial than removal later in the season. Late leaf removal in warm climates can often cause sunburn on the fruit, as berries need time to acclimate to warm weather conditions. Three widely accepted methods include the following (in order of severity): removing basal leaves of shoots carrying fruit; removing leaves in the proximal fruit zone of the trellis system (12-inch window depending on the variability of the vineyard); and removing leaves of nodes below, adjacent and above the grape clusters. Generally, a more severe leaf pulling treatment may be required in more vigorous vineyards, where lighter treatments can be applied in less dense canopies that still require manipulation. Pulling leaves on both sides of the canopy can be detrimental to fruit quality as pulling leaves on the afternoon sun side of the canopy can lead to excessively high berry temperatures due to direct sun exposure. Therefore, pulling leaves on the west side of north/south row orientations should be avoided if clusters will receive direct sun exposure during the warmest periods of the day.</p>				

Balanced vine growth				
Issue	Category 4	Category 3	Category 2	Category 1
31. Are vines maintained for balanced growth?	Pruning, crop load management, irrigation and cover crop are successfully adjusted to keep vines in balance (see notes).	Growth stops around véraison, but leaves are large and shoots are longer than 54 inches or 22 nodes.	Vines are too vigorous, but growth is greatly slowed after the beginning of véraison.	Vines are too vigorous and strong growth continues after véraison; or vines are very weak, and many shoots are shorter than 36 inches or 18 nodes.
<p><b>Notes: Balanced vine</b> growth is the goal for creating high quality fruit and exceptional wines. Partridge (1925a-c) and Dry et al. (2005) stated that a balanced vine was a natural balance between vegetative growth or canopy and fruit yield. If vines are balanced (due to proper trellis, spacing, cover crop, irrigation and fertilization), then shoot positioning, shoot removal, leaf removal etc. are unnecessary. Shoot tips have stopped growing by véraison; shoots are 36 to 54 inches long; and 50% of the fruit is visible. Nearly all clusters should be visible from the canopy exterior. The fruit should see some sunlight during the day, but not directly for long periods of time. Exterior leaves make up 80 to 100% of the leaves; 25% gaps in the canopy; leaves are functional through harvest (leaves are not yellow or beginning to senesce); lateral shoots are rare; leaves are layered between one and two leaves deep; 20 to 22 nodes per cane, or 12 “functional” leaves per cluster; four to five shoots per foot of cordon.</p>				

Yield to pruning ratio				
Issue	Category 4	Category 3	Category 2	Category 1
32. Is the yield to pruning weight ratio ( <b>Ravaz Index</b> ) monitored?	Yield to pruning weight ratio is monitored. <b>And</b> Adjustments are made to maintain the ratio range from 4 to 10 by crop load adjustment, trellis retrofitting, differential pruning of dormant vines and irrigation management.	Yield to pruning weight ratio is monitored. <b>And</b> An attempt is made to reach the ratio range from 4 to 10 by irrigation management.	Yield to pruning weight ratio is monitored.	Yield to pruning weight ratio is not monitored.
<p><b>Notes:</b> Generally, a 4 to 10 ratio is a good range in regards to maintaining balanced vines. However, a 5 to 8 ratio may be a more accurate range for balance, depending on the cultivar and trellis system. Use a spring scale to measure and record the weight of all the live, mature one-year-old wood pruned from the vine.</p>				

Canopy microclimate				
Issue	Category 4	Category 3	Category 2	Category 1
33. Is the canopy microclimate and shoot-tip length carefully monitored?	The canopy microclimate and shoot-tip length is monitored and recorded by an objective method (see notes) at various points throughout the growing season and corrective action is taken as needed.	The canopy microclimate and shoot-tip length is monitored by an objective method at various points throughout the growing season.	The canopy microclimate and shoot-tip length is monitored by casual observation.	The canopy microclimate and shoot-tip length is not monitored.
<p><b>Notes:</b> Some canopy microclimate monitoring methods include <b>point quadrat analysis</b> to assess foliage density, visual rating of canopy characteristics and measurement of photosynthetically active radiation in the fruit zones. See Smart and Robinson (1991) for further details.</p>				

## VII. CROP LOAD MANAGEMENT

Thin crop				
Issue	Category 4	Category 3	Category 2	Category 1
34. What are the methods and timing of crop thinning?	Cluster thinning is done at fruit set and is based on shoot length.		Cluster thinning is not done to reduce crop load. <b>But</b> Clusters lagging in maturity are removed at véraison.	Cluster thinning is not done.
<p><b>Notes:</b> Cluster thinning is the removal of excess fruit clusters to help manage crop load and prevent overcropping. Fruit cluster thinning can be done at any time after fruit set; to get the most benefit from cluster thinning, however, it should be done at fruit set. Small-clustered cultivars such as Vignoles or Norton are generally not cluster-thinned unless they are young and still undergoing canopy development. With moderate- to large-clustered cultivars it is recommended to follow the <b>2-1-None rule</b>: At fruit set, if the shoots are greater than 24 inches in length, <b>retain 2 clusters</b>. If shoots are between 12 and 24 inches in length, <b>retain 1 cluster</b>. If they are less than 12 inches in length, <b>retain no clusters (None)</b>.</p>				

Estimating yield				
Issue	Category 4	Category 3	Category 2	Category 1
35. How are yields estimated?	Yield estimates are determined by counting clusters on several representative vines using historic cluster weight data from the block.	Yield estimates are determined by counting clusters on several representative vines but records of historic cluster weight data by block are not kept.	Yield estimates are determined by visual assessment of crop weight per vine.	Yield estimation is not done.
<p><b>Notes:</b> Yield is assessed by counting the average number of clusters present per vine on a representative sample of vines. In blocks with uniform vine size a sample population of approximately 20 vines should generate fairly accurate results. If the vines are non-uniform, however, the sample population should be increased to perhaps 30 to 40 vines, or the block divided into homogenous sample areas to improve accuracy. Representative vines may be selected at random, or through a sequential selection process (every 20<sup>th</sup> vine, for example). While it's true that cluster weights for a given variety will vary annually, they remain an efficient method of estimating potential yield. Long-term records collected from individual vineyard blocks over time improve accuracy of this estimation strategy, and thus, provide the rationale for measuring cluster weights (by cultivar) at harvest every year.</p>				

## VII. CROP LOAD MANAGEMENT

Appropriate yield				
Issue	Category 4	Category 3	Category 2	Category 1
36. Is yield appropriate for cultivar and vine size?	Yield per vine is managed to achieve sustainable levels of high quality fruit annually based on vine capacity.		Yield is adjusted to a given number of clusters per vine annually.	Goal is to maximize yield per vine.
<p><b>Notes:</b> Appropriate yield per vine is determined by vine size or capacity and maintained with balanced pruning, where the number of nodes retained is based on vine pruning weight. At dormant pruning, the weight of one-year-old wood removed from a vine is collected and a pruning formula specific for the cultivar is applied to determine the number of nodes to retain. For native cultivars, balanced pruning alone may achieve optimum crop load. For highly fruitful hybrid cultivars, balanced pruning must be augmented by thinning excessive shoots and clusters.</p>				

Block profitability				
Issue	Category 4	Category 3	Category 2	Category 1
37. Are yield records kept by block to determine profitability?	Records are kept of yield, crop value, cost of labor and other inputs and reviewed to determine profitability.	Records are kept of yield, crop value, cost of labor and other inputs but profitability not determined.	Records are kept of yield and crop value but profitability not determined.	No records are kept by block.
<p><b>Notes:</b></p>				

## VIII. FERTILIZER STORAGE

### Fertilizer storage, safety and security

Issue	Category 4	Category 3	Category 2	Category 1
38. Are fertilizers properly stored and secured for safety purposes?	Fertilizer is stored in a locked building and periodically inventoried.	Fertilizer is stored in a locked building.	Fertilizer is stored in unlocked building and kept out of the rain.	Fertilizer is stored in an open shed.
<b>Notes:</b> Improperly stored and secured fertilizer could spill into ground water and soil or be stolen for possible use in terrorist activities.				

### Fertilizer runoff or leaching

Issue	Category 4	Category 3	Category 2	Category 1
39. Can fertilizer move into nearby water body or well?	Fertilizer is stored in a locked building on pallets on a concrete slab away from ponds, water wells or flood plains of flowing streams.	Fertilizer is stored on concrete slab away from ponds, water wells or flood plains of flowing streams.	Fertilizer is stored on concrete slab near ponds, water wells or flood plains of flowing streams.	Fertilizer is stored on ground or pallets near ponds, water wells or flood plains of flowing streams.
<b>Notes:</b>				

Type of irrigation				
Issue	Category 4	Category 3	Category 2	Category 1
40. What type of irrigation is used?	Professionally engineered and installed drip irrigation system with backflow prevention, pressure compensating emitters and fertigation/chemigation capability.	Basic drip irrigation system with backflow prevention, but no fertigation/chemigation capability.	Overhead sprinkler system without backflow prevention.	No irrigation is installed.
<b>Notes:</b>				

Flow meter				
Issue	Category 4	Category 3	Category 2	Category 1
41. Is water usage recorded by a flow meter?	Irrigation water use is determined by flow meter and records are kept by block.	Irrigation water use is determined by flow meter but records are not kept.		No flow meter is used while irrigating.
<b>Notes:</b>				

Water holding capacity				
Issue	Category 4	Category 3	Category 2	Category 1
42. What is the soil's water holding capacity?	Soil water holding capacity has been determined from soil survey information. <b>And</b> This information is used to determine irrigation initiation and irrigation scheduling.	Soil water holding capacity, annual rainfall and cover crop water use is known. <b>And</b> This information is used for information scheduling.	Grower knows soil water holding capacity but does not understand how it relates to vineyard soil type and irrigation program.	The soil water holding capacity has not been determined.
<b>Notes: Modified from</b> "Lodi Winegrowers' Workbook."				

Scheduling irrigation				
Issue	Category 4	Category 3	Category 2	Category 1
43. How are irrigation needs determined?	Multiple soil moisture sensors in each block measure daily changes in soil moisture and make decision to turn on trickle irrigation to monitoring soil moisture and maintain soil moisture at or below 40 kPa (the highest value before you see water stress). <b>Or</b> Vine leaf water potential is measured to assess vine water stress and determine irrigation timing when threshold $\geq -12$ bars.	Irrigation is run on a regular basis regardless of soil moisture level or apparent plant water stress.	Water is applied when plants appear water stressed.	No irrigation system, so water cannot be applied even if plants appear water stressed.
<b>Notes:</b>				

## Irrigation water destination

Issue	Category 4	Category 3	Category 2	Category 1
44. Does irrigation water move off-site?	Drip irrigation slowly lets water soak into soil around each vine and is turned off automatically when soil moisture sensor drops below value of 30 kPa.	Drip irrigation slowly lets water soak into soil around each vine.	Irrigation water moves down the rows, causing erosion and/or exits vineyard.	No irrigation is used.

**Notes:**

## Irrigation system maintenance

Issue	Category 4	Category 3	Category 2	Category 1
45. Is irrigation system regularly maintained?	After system components prove to be functional at start of season, system is inspected for line leaks and clogged emitters during each irrigation session.	After system components prove to be functional at start of season, system is inspected for monthly for line leaks and clogged emitters.	System components are checked at start of each season: filters, pressure gauges, valves, drip lines, emitters and emitter distribution rate uniformity.	No system maintenance is performed.

**Notes:**



Although weeds rarely reduce grape yields to the same extent that diseases and insects can, there are long-term impacts associated with weeds. By competing for nutrients, water and light, weeds reduce both the quantity and quality of the grapes harvested. In addition, robbing vines of sufficient resources also weakens vines and renders them more sensitive to diseases, drought and cold temperatures. In some cases, air circulation is more restricted with weeds growing under vines, which enhances the severity of diseases that benefit from longer wetting periods on vegetation. Proliferation of climbing perennials such as honeyvine milkweed (*Ampelamus albidus*) and others can interfere with grape harvest, while invasion of white clover and other legumes can encourage deer browsing.

The design of approaches to weed control in grapes depends first upon proper identification; selection of tillage or herbicide practices starts with plant identification. Weeds fall into one of three life cycles: annuals (winter or summer), biennials or perennials. Among these, plants can be classified as dicots (broadleaves) or monocots (grasses, sedges). Growers are urged to use online and published resources (*Weeds of the Northeast* or *Weeds of the South*, for example) for weed identification purposes. In addition, experts from industry or university extension are available to assist with identification.

**Herbicides.** There are a number of techniques for managing weeds in vineyards, but using herbicides is one of the most widely used methods. Several terms are important relative to herbicides. In the broadest sense, herbicides are either selective (affect some plant species with minimal or no influence on others) or non-selective (will injure all plants contacted). Also, herbicides can be contact (only injure plant tissue that is treated with herbicides) or systemic (herbicide affects the tissue that is contacted as well as other tissue at some distance

above or below ground). Finally, some herbicides are only effective on treated weeds or continue to provide weed control for some period of time (residual). Prior to use, growers must be aware that a number of herbicides are restricted use pesticides, and their purchase and use requires a pesticide applicator license in the state that applications will be made.

A number of herbicides can be used on established vines, which are loosely defined as plants growing in their second or third season. Herbicide use on newly planted vines can cause more extensive plant injury, especially if the herbicides exhibit residual activity and are absorbed by feeder roots. Consult all herbicide **labels** prior to use in order to determine proper protective equipment for application as well as identification of use rates, intended target species, recommendations of surfactants, and other restrictions. Any use of herbicides not labeled for use on grapes can result in sizable fines, confiscation, and destruction of all crops harvested from treated plants. The applicator and holder of the pesticide applicator license must ensure compliance with herbicide label guidelines and federal/state environmental laws.

However, the extensive use of herbicides can lead to selection for weeds resistant to herbicides, or populations with tolerance to herbicides. Therefore, growers are urged to rotate herbicide use based upon how the herbicides kill plants (mode of action), and use more than one herbicide (i.e. herbicides with different modes of action). No single herbicide program should be used continuously over multiple sources. The selection of herbicide-resistant weeds can result in long-term consequences for not controlling specific weed species with that herbicide. For additional information, go online to <http://www.weedscience.com> or ask your university extension representatives.

Growers must also be aware of herbicides that can leach through the soil to groundwater sources, or runoff with soil into surface waters. In June 1996, the EPA published the proposed "Pesticides and Ground Water State Management Plan." Through the development and use of State and Tribal Pesticide Management Plans (PMPs), the EPA proposed to restrict the use of certain pesticides by providing states with the flexibility to protect groundwater in the most appropriate way for local conditions. The EPA designated the triazine herbicides atrazine, simazine, cyanazine, and the acetanilide herbicides alachlor and metolachlor as the first five pesticides that would require a Specific Pesticide Management Plan (SPMP). The EPA determined that without proper management, these groups of herbicides posed a significant risk for groundwater contamination.

The most vulnerable areas of Missouri, such as the southeastern lowlands (Bootheel) and along major rivers and streams, are characterized by permeable surficial and sub-surface materials, a shallow water table (within 20 feet of the soil surface), and intense row-crop agriculture. These factors are conducive for migration of contaminants into the groundwater (<http://www.plantboard.org/groundwater/GWWebPages/Index.htm>).

Between 1992 and 2003, various monitoring programs in Arkansas focused on the occurrence of pesticide contamination in the alluvial aquifer underlying the extensive farmlands of the Arkansas Delta. Since the inception of the groundwater sampling program in 2003, the Arkansas State Plant Board has sampled 242 wells in 26 different counties with 38 wells testing positive for pesticides. Results can be viewed online at <http://dnr.mo.gov/ENV/wrc/docs/Pesticidefinalreport.pdf>.

**Cultivation.** Mechanical or hand-held cultivation can also be used effectively for weed control. Cultivation serves to break off, bury or uproot small weeds, and is most effective under moderately dry conditions to encourage desiccation of weeds. Numerous types of mechanized equipment are available for removing weeds. Important considerations for cultivation include the type of soil and soil slope. This will help determine the extent of erosion, which can be extensive on the sloped soils where grapes are often produced. A good rule of thumb is that cultivation equipment should not be within 2 inches of the trunk to avoid vine damage, and not greater than 2 inches deep, as this could damage feeder roots of the grapes. Cultivation is most effective on annuals or small biennials, as damaging these weeds can result in plant death. However, many perennials are propagated vegetatively, and cultivation can serve to induce greater shoot emergence of plants.

Mowing is another form of mechanical weed control and can be effective for managing seed production of weeds within the drive row. Note, however, that some plants can produce viable seed five days after flowers fully open (e.g. dandelion). Also, as days get shorter (after summer equinox), annual plants begin to flower and produce seeds, with seed production greatest in August and September. Therefore, some mowing may be necessary for seedhead suppression, despite the lack of tall vegetation in the drive row. For grasses maintained between vines, top growth should not be cut below a height that weakens plants. Excessive mowing can reduce shoot and root growth; a lack of sufficient leaves will not allow proper photosynthesis to re-build shoots and roots. The proper mowing height varies between grass species.

**Mulches.** Mulches are also used to manage weeds under grape vines, but a number of factors should

be considered before implementing mulches on a broad scale. First, some mulches (other plant residues introduced) can serve as a source for introducing additional weeds. Synthetic mulches (plastic) can raise the soil temperature beneath grape vines, stimulating plants to initiate seasonal growth at a time that could render plants sensitive to frost. When using plastic mulches, be sure the plastic is black (restricts sunlight to limit weed growth beneath the plastic) and of sufficient thickness (minimum of 4 mil is recommended). The use of wood-based mulches can be effective if they are 4 to 6 inches thick and allow the trunk to breathe. Note that wood-based mulches are degraded by soil microorganisms; a lack of sufficient soil nitrogen can

lead to an imbalance of the C:N ratio. Ultimately, additional nitrogen may be necessary to prevent severe deficiencies. Note that annual and biennial weed species are most sensitive to mulches; perennial weeds can penetrate mulches and are often poorly controlled.

The most effective weed management systems result from an integration of multiple tactics.

Weed identification				
Issue	Category 4	Category 3	Category 2	Category 1
46. What resources are used to identify weeds in the vineyard?	Vineyard manager knows the common names of all grass, sedge and broadleaf weeds in the vineyards, including those that compete with vines. <b>And</b> Resources (books and websites) are available to identify new or unknown weeds. <b>And</b> Whenever a new weed is found in the vineyard, grower takes immediate action to identify it.	The common names are known for all the major grass and broadleaf weeds, including those that compete with vines. <b>And</b> Books or websites on weed identification are regularly used to help with weed identification.	About 5 species in the vineyard have been a problem for ten years or more. <b>But</b> Grower does not know the weeds most competitive with grapes.	Vineyard manager depends on professionals in industry and academics as well looking at books or websites to identify weeds.
<b>Notes:</b> Identification of weeds is the first and most important step in designing appropriate weed management practices. Many weeds change significantly in appearance during their life cycle, but many free websites are available to view pictures of weeds.				

Weed distribution				
Issue	Category 4	Category 3	Category 2	Category 1
47. What is the distribution of weeds in vineyard blocks?	<p>Grower knows which rows in the vineyard contain each problem weed species.</p> <p><b>And</b> A written survey map is constructed at least every 2 years to track changes in weed populations.</p>	<p>Grower can categorize each known weed species present as rare or common and explain the areas of the vineyard where they are located.</p>	<p>Grower can explain the areas of the vineyard where each known weed species is located.</p>	<p>If a weed is present in the vineyard, grower assumes the species is widely distributed.</p>
<p><b>Notes:</b> Weed species can be introduced and spread throughout vineyards by equipment, soil and natural means (water, wind, animals). Control of new weed problems can only be effective if the weed locations are known. Land geography can result in weeds being a problem in only specific areas in a vineyard; weather patterns can lead to some weeds being widespread in some years and almost absent in others.</p>				

Weeds in drive row				
Issue	Category 4	Category 3	Category 2	Category 1
48. How is the drive row between grapes managed?	<p>Grower knows the erosion potential of the vineyard and plants appropriate legumes and grasses.</p> <p><b>And</b> Nutrients and pest management practices are used to maintain permanent ground covers.</p> <p><b>And</b> Row middles are mowed to manage permanent ground covers and prevent weed seed production.</p>	<p>A legume or grass is planted in row middles and mowed to a specific height.</p>	<p>There is no preferred plant species; grower simply mows whatever is there to a specific height.</p>	<p>There is no strategy to manage weeds in the drive row.</p>
<p><b>Notes:</b> Some management of vegetation between row middles is needed to prevent seed production for important weed species. Row middles can be used to grow vegetation that fixes nitrogen (legumes) for grapes or builds soil organic matter. A total lack of vegetation may allow soil, nutrients and pesticides to move off-site and contaminate nearby bodies of water.</p>				

Weed management tactics				
Issue	Category 4	Category 3	Category 2	Category 1
49. Are non-chemical weed management tactics used?	Herbicides, mowing, mulches and cultivation are integrated into a system that rotates to maintain acceptable levels of weed control. <b>And</b> Hand labor or spot spraying are used to control small or isolated populations of weeds.	Herbicide use is carefully incorporated with mowing for weed management of undesirable species in row middles; non-selective herbicides are rotated and used underneath the vines. <b>And</b> Mulches or cultivation equipment is used beneath vines to control small weeds.	Herbicides are selected based upon the undesirable species present in the vineyard; mowing is used in row middles when vegetation reaches an undesirable height.	Only herbicides are applied, and the decision to apply an herbicide is made based upon the cheapest material that provides control of the widest spectrum.
<b>Notes:</b> Although herbicide practices are an effective method of weed management, crop damage or selection of herbicide-resistant weeds is a real risk. Best management practices should include multiple approaches that are integrated into a system that is structured to control the weeds present in a vineyard.				

## Weed management decisions

Issue	Category 4	Category 3	Category 2	Category 1
50. What determines weed control tactics and herbicide rates?	<p>All available methods to learn about weed control are viewed or consulted (personnel from industry or academia).</p> <p><b>And</b> Weeds are scouted in each vineyard at least one time per year.</p> <p><b>And</b> Weed control tactics and herbicide rates are decided and implemented depending upon the undesirable weeds present.</p> <p><b>And</b> The sensitivity of the grape cultivar to each herbicide and rate is known.</p> <p><b>And</b> Herbicide programs are rotated to avoid selection of resistant weeds.</p>	<p>Grower scouts the vineyard and uses written and web-supported information to design weed control tactics.</p> <p><b>And</b> Herbicide labels are reviewed to identify the right rates and necessary surfactants.</p> <p><b>And</b> Continual use of the same herbicide program is avoided to prevent selection of resistant weeds.</p>	<p>Grower consults with industry or academic professionals and depends on their advice.</p> <p><b>And</b> Herbicide labels are reviewed to identify the correct rates.</p>	<p>Someone once provided this information, and the same tactics and herbicide rates from years ago are used.</p>

**Notes:** Forms of equipment and herbicides (and rates) for weed control in vineyards can change frequently. It is important to keep up-to-date on recommendations. With herbicides, spray target weeds at the right size and with the right rate to optimize weed control.

**Herbicide runoff and leaching**

Issue	Category 4	Category 3	Category 2	Category 1
<p>51. Are herbicides applied that may run off or leach into groundwater?</p>	<p>Unless it cannot be avoided because of the weeds infesting a vineyard, herbicides that could contaminate the groundwater are not used.  <b>And</b>                      If herbicides that could contaminate the environment are used, use rates are limited or proper living plants or filter strips are in place to restrict herbicide movement.  <b>And</b>                      It is known if the vineyard covers a <b>groundwater protection area (GWPA)</b>.</p>	<p>A list of use precautions for surface and groundwater contamination has been made for each herbicide used on the vineyards.  <b>And</b>                      Use of herbicides such as simazine, diuron, and norflurazon is limited to every second or third year.  <b>And</b>                      It is known if the vineyard covers a GWPA.</p>	<p>Grower looks at the herbicide label and applies the amount for the vineyard's soil type; the precautions about using herbicides away from surface waters and avoiding use on soils subject to leaching are carefully considered.  <b>And</b>                      It is known if the vineyard covers a GWPA.</p>	<p>It's assumed if an herbicide is labeled for vineyards, runoff and leaching should not be a concern.</p>

**Notes:** Herbicide labels must contain information that describes all environmental precautions for an herbicide. Growers who do not abide by these restrictions are still subject to all penalties associated with contaminating the environment. If you have a pesticide applicator license, you are also responsible for all the actions of individuals that apply pesticides under your supervision.

Herbicide mode of action				
Issue	Category 4	Category 3	Category 2	Category 1
52. Are herbicide formulations rotated with different modes of action to delay development of resistant weeds?	<p>Grower knows the weeds in home state with known resistance to herbicides and whether or not those weed species are present in the vineyard.</p> <p><b>And</b> Use of herbicides is consistently rotated based upon mode of action.</p> <p><b>And</b> Non-chemical techniques are integrated with herbicide use to further minimize selection for resistant weeds.</p>	<p>For each herbicide labeled for use in vineyards, the mode of action is known.</p> <p><b>And</b> Multiple herbicides with different modes of action are used throughout the year.</p>	<p>Grower is not aware of how herbicides work in plants, but consistently uses 2 to 4 different herbicides to control unwanted weeds.</p>	<p>Once an herbicide practice is found that works, this is used repeatedly until the program does not work anymore.</p>
<p><b>Notes:</b> Websites that describe herbicide-resistant weeds are available (<a href="http://www.weedscience.com">http://www.weedscience.com</a>) and should be consulted. The selection of herbicide-resistant weeds is a serious matter and once a grower has resistance, use of an herbicide to control that weed species is effectively lost. In some situations, an herbicide-resistant weed can move into a vineyard from a nearby field and become a major problem, even if the vineyard manager never used an herbicide that the weed species has developed resistance against.</p>				

Pre-emergence herbicides				
Issue	Category 4	Category 3	Category 2	Category 1
53. Are pre-emergence herbicides applied to maximize weed control?	<p>Grower knows the types of weed species present in the vineyard and their sensitivity to herbicides.</p> <p><b>And</b> Pre-emergence herbicides are used as part of an integrated system for weed control in vineyards.</p> <p><b>And</b> The potential for leaching and runoff are known for each pre-emergence herbicide.</p>	<p>Herbicide programs are carefully planned depending upon the weed species that will be emerging in the vineyard.</p> <p><b>And</b> Pre-emergence herbicides are used to minimize selection of herbicide resistance following strict use of post-emergence herbicides.</p>	<p>The most cost-effective herbicides possible are applied to control weeds.</p> <p><b>And</b> If pre-emergence herbicides will control those weeds, those products are applied.</p>	<p>Grower only applies post-emergence herbicides to treat identifiable weeds using herbicides that control those species.</p>
<p><b>Notes:</b> Pre-emergence herbicides are effective tools to control constantly emerging weeds over a significant part of the growing season. Although pre-emergence herbicides are more expensive, they allow growers time to accomplish other vineyard practices besides repeated cultivation or application of non-residual, post-emergence herbicides. However, some damage to grapes can occur with the use of pre-emergence herbicides, so growers should carefully follow all labels.</p>				



Spot spraying weeds				
Issue	Category 4	Category 3	Category 2	Category 1
54. Are herbicides spot sprayed to help manage weeds?	<p>Tillage and broadcast applications of pre- and post-emergence herbicides are used early in the growing season to control weeds.</p> <p><b>And</b> Spot spraying is done to manage difficult to control weeds, weeds observed for the first time in vineyards or weeds that escape other control practices.</p>	<p>Broadcast applications of pre-emergence herbicides are made to target widely distributed weeds.</p> <p><b>And</b> Post-emergence herbicides are applied as spot sprays where new weeds are seen.</p>	<p>All herbicides are spot sprayed on areas where weeds are most dense in population.</p>	<p>It is more cost-effective to apply herbicides to all target areas in a vineyard.</p>
<p><b>Notes:</b> Spot spraying can be an effective means to reduce total herbicide load into the environment and also save on weed control costs. Be sure that application rates do not exceed those described on the label for a given area of land.</p>				

## XI. PEST MANAGEMENT (PM)

Insect pest management is a season-long management strategy that involves periodic scouting of a crop to detect pest presence and to estimate pest population levels. The presence of insects detected by crop scouting enables a pest manager or grower to justify using and to aid timing the use of one or more pest management tactics. These tactics are used in an ecologically compatible manner to maintain the pest population below the **economic injury level (EIL)** or the number of insect pests per sample unit that cause economic loss of yield without eliminating the pest (tolerate sub economic levels of a pest). This approach attempts to conserve environmental quality, enhance habitat to support natural enemies and achieve sustainable farm production for present and future generations. In addition, a successful pest manager is always motivated to review and implement the current recommended best management strategies and tactics presented in this section. Continuing education programs provide growers the opportunities to learn about the biology and management tactics for both native and introduced pests such as the Japanese beetle.

### Foundational knowledge used in insect pest management:

- Be able to identify each pest species and the type of damage it causes.
- Knowledge of the seasonal biology, alternative hosts, **attractants** and behavior of each insect pest and its natural enemies in relation to the seasonal phenology of the crop.
- Population dynamics of each pest species or how fast a population increases over time.
- Sample as needed to estimate the number of a specific pest insect per sample unit.
- Sampling information alerts the pest manager as to when the pest population reaches the **economic threshold (ET)** = number of insects per sample

that justifies pest manager in making a decision to use a tactic that will keep the pest population from increasing to the EIL.

### Tactics used in grape pest management to maintain insect pests below the EIL:

- **Host resistance**, e.g., graft susceptible scions of *V. vinifera* cultivars and hybrids on grape phylloxera-resistant rootstocks or plant cultivars that resist foliar grape phylloxera
- **Modifying environment in and around the vineyard**, e.g., remove wild grapes and ground debris in adjacent woods and remaining clusters on commercial vines after harvest to lessen buildup of a fall population of grape berry moths, reduce overwintering survival, add nectar sources for natural enemies, change to a non-grass cover crop in drive rows and around vineyard to reduce survival of Japanese beetle larvae
- **Impact pest reproductive capacity**, e.g., **mating disruption** of grape root borer and grape berry moth or mass trapping grape root borer males
- **Exclude pests**, e.g., remove grape berry moth infested fruit after harvest, keep harvest bins free of grape berry moth overwintering larvae, net vines to prevent bird feeding, cover vines with finer mesh net to prevent Japanese beetle foliar feeding and green June beetle fruit feeding
- **Natural enemies**, e.g., introduce ground cover that supports natural enemies of grape berry moth, grape scale, aphids and leafhoppers or to apply to soil via irrigation nematodes and its pathogenic bacteria that infest, infect and kill grape root borer larvae in roots
- **Insecticides**, e.g., conduct scouting to justify use of (exceed EIL) and aid timing of applications of various types of insecticides:
  - Biopesticides are types of insecticides derived from the earth, e.g., oils to smother insects or eggs;

kaolin clay (Surround) to white-wash vines to lessen insect attack by Japanese beetles and grape phylloxera; or from natural toxins derived from plants (pyrethrin or neem seed oil) or a soil bacteria (Spinosad)

– Microbials are formulations derived from pathogens, e.g. *Bacillus thuringiensis* (Bt) bacteria used against grape berry moth

– Synthetic insecticide formulations that kill grape insect pests

See recommended insecticides, biopesticides and other recommended tactics listed in state or regional spray guides.

### Insect pest management (PM) strategies. Use knowledge with PM tactics to prevent crop losses and maintain species at non-pest levels:

- Do nothing (**non-pest**)
- Wait-and-see then dampen population peak occasionally (**occasional pest**)
- Scout when protocol recommends it and use PM tactics as needed to dampen population (**perennial pest**)
- Scout when protocol recommends it and use appropriate management tactics to dampen population (**severe pest**)
- Reduce host susceptibility to the pest, usually by maintaining plant health by proper nutrition
- Combine 2 or more tactics (multiple tactics are more sustainable than one)

### Management tactics to reduce pest population:

- Grow resistant cultivars so host does not supply resources for pest survival and buildup
- Optimize nutrients (fertilizer) and water via irrigation to improve host vigor and self-defense
- Till field to remove pest resources
- Use mating disruption to decrease mating and

## XI. PEST MANAGEMENT (PM)

- laying of fertile eggs
- Mass trapping to reduce local pest population
- Fencing and netting to prevent damage by deer, birds, green June beetles and Japanese beetles
- Remove pest overwintering habitat such as ground cover in adjacent woods or keep grass in vineyard mowed low
- Conserve or enhance habitat to support natural enemies by allowing some non-competitive flowering ground cover plants
- Apply natural enemies such as pathogenic nematodes against grape root borer larvae
- Apply biopesticides, microbials, Insect Growth Regulators (IGRs), synthetic insecticides

### Management of Perennial and Severe Pests (key pests):

- Strategy is to combine management tactics to reduce the population
- Apply perimeter insecticide sprays against first generation grape berry moth
- As a last resort, scout for pest and apply a well-timed selective insecticide

### Pest damage, common name, description and scouting

Pest damage	Arthropod common name	Arthropod description	When and how to scout
Scale on trunk or cane	Grape scale	<b>Adult</b> , <math>\lt; 1/16\text{''}</math>, bark color to gray; <b>Crawler</b> , <math>\lt; 1/16\text{''}</math>, legs, yellow	<b>Pruning</b> — flag scale-infested vines; <b>1 May to 1 June</b> — if crawlers under scale cover or on sticky tape on infested cane = spray vines
Hollowed out bud	Climbing cutworms or Grape flea beetle	<b>Caterpillar</b> , 1-1/4", brown, dark; <b>Beetle</b> , 1/8", black	<b>Bud swell</b> — check 100 buds for cutworm (night) or beetle (day) feeding = spray if > 1% damage
Purple area around holes in berries	Grape berry moth	<b>Moth</b> , 3/8", gray band at wing base; <b>Caterpillar</b> , 1/2", yellow-green to brown, amber head	<b>1 April</b> — set traps along woods, after first trap catch accumulate <b>DD</b> , check for cluster damage at 400-800, 1300-1700, > 2200 <b>DD</b> ; spray if > 1% damaged clusters
Galls on leaves	Grape phylloxera	<b>Adult</b> , 1/32", yellow, legless; <b>Crawler</b> , 1/32", yellow, 6 legs	<b>1 to 30 May</b> — apply foliar spray only to susceptible cultivars when crawlers appear in mature stem mother galls on first to third leaves at shoot base
White spots on leaves of susceptible cultivars	Grape leafhopper	<b>Adult</b> , 1/8", orange-yellow, wings; <b>Nymph</b> , white to yellow, wingless	<b>May on</b> — check 100 leaves for nymphs = spray if > 10 nymphs per leaf (nymphs are most susceptible to insecticide)
Tunneling in roots and plant vigor declining or vine dead	Grape root borer	<b>Moth</b> , 1", tan to brown, 4 thin hairs on tip of abdomen; <b>Caterpillar</b> , 1-1/2", white, legs	<b>15 June to September</b> — check monthly for pupal skins on soil by 100 vines per vineyard and use traps to detect moths
Skeletonized leaves or damaged ripe berries	Japanese beetle Green June beetle	<b>Adult</b> , 1/2", brown wing covers, white spots on sides of abdomen; <b>Adult</b> , 1", green wing covers	<b>15 June to late July</b> — watch for beetles defoliating susceptible vines or feeding on clusters in July

## Insect pest identification



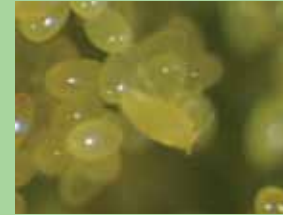
Grape berry moth larva



Climbing cutworm



Grape root borer adult



Grape phylloxera eggs and crawler (red eyes, legs and antennae) on inside of leaf gall



Grape flea beetle adult



Grape berry moth adult



Japanese beetle adults



Green June beetle adult



Grape scale female removed from scale cover (white box in lower right)



Rose chafers feeding on leaf

## Insect pest damage identification



Grape phylloxera root galls



Grape phylloxera stem mother galls on first to third expanded leaves



Grape berry moth larva infested berry



Grape root borer larva tunneling in root



Climbing cutworm or grape flea beetle hollowed out bud



Japanese beetle adult feeding on foliage and damage



Grape phylloxera galled leaves



Green June beetle adults group feeding on berries

### Pest management

Pest and damage identification				
Issue	Category 4	Category 3	Category 2	Category 1
55. What resources are used to identify insect pests and corresponding damage in the vineyard?	Vineyard manager and workers can identify insect pests and damage symptoms and know which cultivars are susceptible to each pest.	Vineyard manager can identify insect pests and damage symptoms but workers use posted color photo fact sheets.	Only the vineyard manager can identify cause of fruit or foliar damage.	No one can identify the major insect pests or damage that each causes.
<p><b>Notes:</b> The pest management presentation and handout from the Missouri Grape Production Short Course (offered by ICCVE) is available online under "Current Information and Talks" at <a href="http://comp.uark.edu/~dtjohnso">http://comp.uark.edu/~dtjohnso</a>. These materials describe pest biology, cultivars susceptible to pest attack, sampling methods, and tactics to keep the pest population below economically damaging levels. Grape insect pest management relies on the ability of growers and workers to identify each pest species, the stage causing the damage and the symptoms of damage (see previous pages of pictures).</p>				

Pest sampling				
Issue	Category 4	Category 3	Category 2	Category 1
56. Is the vineyard sampled for presence of insect pests and/or damage?	Grower or trained worker follows a season-long sampling protocol and damage assessment based on pest biology and available degree-day models and keeps written records by block/cultivar sampled.	Grower or trained worker follows a season-long sampling protocol based on grape phenology and periodically inspects grapevines for pest damage to fruit and foliage.	Grower or worker periodically inspects grapevines to assess pest damage to fruit and foliage.	No one monitors for insect pests or assesses damage of fruit or foliage.
<p><b>Notes:</b> Use the Pest Scouting Form for Arkansas/Missouri/Oklahoma/Kansas Vineyards on page 47.</p>				

### Sampling and economic thresholds

Issue	Category 4	Category 3	Category 2	Category 1
57. Do sampling and economic threshold-based decision-making protocols justify insecticide applications?	Use sampling protocol and economic threshold values of 1% bud damage (climbing cutworms or adult flea beetles) or 1% cluster damage (grape berry moth larvae) to justify and improve timing of insecticide application.	Follows sampling protocol for pest insects to improve timing of insecticide applications.	Apply insecticide any time an insect is detected in the vineyard.	No sampling for insects and applies insecticides on a calendar schedule.
<b>Notes:</b>				





## XI. PEST MANAGEMENT (PM)

Grape phylloxera management				
Issue	Category 4	Category 3	Category 2	Category 1
58. Is grape phylloxera management used to minimize damage to leaves and/or roots?	Cultivars susceptible to root phylloxera are grafted on resistant rootstock. Grower plants cultivars susceptible to foliar phylloxera. In May, sample weekly for foliar phylloxera crawlers in order to time insecticide sprays to prevent damaging levels of leaf galling. Assesses and records phylloxera foliar gall damage by block in late summer.	Grower or trained worker monitors in May for grape phylloxera, treat with insecticide and assesses foliar gall damage in late summer.	Grower or trained worker monitors for grape phylloxera and assesses damage periodically.	Grower does not monitor for or treat for root or foliar grape phylloxera and grows susceptible cultivar vines on own roots.
<b>Notes:</b>				

Grape scale management				
Issue	Category 4	Category 3	Category 2	Category 1
59. Is grape scale damage prevented by applying spot sprays?	Dormant oil is applied only to scale-infested blocks, focusing sprays to flagged scale-infested vines. In May, weekly inspections are conducted for crawler activity to time a scale crawler insecticide application.	A dormant oil spray and a bloom insecticide spray is applied to full vineyard for scale control.		Oil or summer insecticides are not applied to vines for scale control.
<b>Notes:</b>				

## XI. PEST MANAGEMENT (PM)

Grape berry moth				
Issue	Category 4	Category 3	Category 2	Category 1
60. Are grape berry moth infestations controlled with spot spray insecticides?	Vineyard is sprayed in May, only if <b>pheromone</b> traps catch moths and clusters in perimeter row are damaged by grape berry moth larvae; then perimeter rows are treated with insecticide spray. Sprays against later generations are applied to the full vineyard only if berry damage by grape berry moth larvae is detected.	Insecticide applications are applied to the full vineyard when grape berry moths are detected in May and during later generations.	Insecticide applications are applied to the full vineyard on calendar basis all season long, starting at bloom.	No grape berry moth sprays are applied.
<b>Notes:</b>				

Reduced-risk pesticides				
Issue	Category 4	Category 3	Category 2	Category 1
61. Are reduced-risk biopesticides or organic-approved compounds applied to manage pests?	Reduced-risk biopesticides or organic insecticides are always used to manage insect pests.	If economical or available, reduced-risk pesticides are applied to manage pests.	Only synthetic insecticides are applied to manage pests.	No insecticides are applied against pests.
<b>Notes:</b> The OMRI list of compounds is available on the web ATTRA – National Sustainable Agriculture Information Service at <a href="http://attra.org/attra-pub/biorationals/biorationals_main_srch.php">http://attra.org/attra-pub/biorationals/biorationals_main_srch.php</a> . Bt or pheromone-based mating disruption dispensers are used against grape berry moth or Surround kaolin clay to protect against Japanese beetles or grape phylloxera.				

Disease management is the attempt to prevent or eliminate disease damage caused by pathogens, including fungi, bacteria and viruses. Pathogenic diseases occur when the three corners of the **disease triangle** (below right) are present together: a susceptible host, a virulent pathogen and environment conditions favorable for pathogen growth leading to disease.

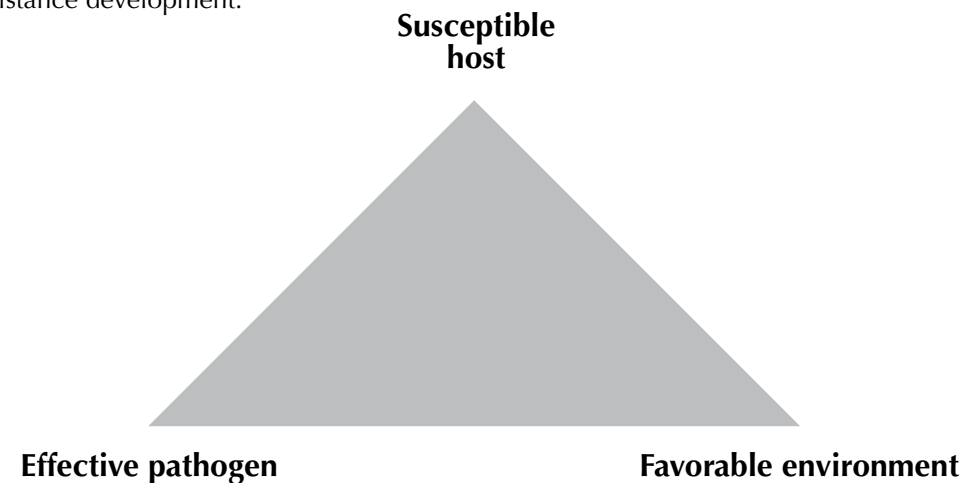
**Disease management strategies center on affecting one of these components of the triangle:**

- Select sites that offer full exposure to sunlight and air movement (environment)
- Remove alternate hosts of pathogens (pathogen)
- Select cultivars with resistance to one or more diseases (host)
- Practice sanitation by removing diseased clusters, mummified berries, diseased or dead wood (pathogen)
- Use proper canopy management practices to create a more open canopy, particularly in the fruiting zone (environment)
- Follow a proper spray program (pathogen)

To properly design and execute a disease management program, a vineyard manager must first be able to identify the common disease organisms and their damage, know at what time of the season these organisms are active, and know what environmental conditions favor infection and disease development. But there is more to it than that. The vineyard manager must also know what chemical compounds are labeled for each pathogen and what level of effectiveness each has against various disease organisms. For example, a fungicide may provide excellent activity against downy mildew and be totally ineffective against powdery mildew, or it may provide very good protection against phomopsis and only moderate protection against black rot. Also be aware of re-entry intervals, the periods

between the time various pesticides are applied and when workers can safely return to the field, and of pre-harvest intervals, the time between the last application of a pesticide and when the crop can safely (and legally) be harvested.

Another factor to consider in planning the disease management program is the potential for the development of resistance by disease organisms to the materials and how to reduce that risk. Many of the more effective materials, such as the sterol inhibitor (SI) and strobilurin classes of fungicides are at a high risk for the development of resistance, especially by disease organisms that have several generations during the season. Resistance development has been documented for the diseases powdery mildew and downy mildew in vineyards in other regions of the U.S. Alternating fungicides with different modes of action, tank mixing more at risk materials with low risk materials to cover a broader spectrum of the disease organism population, and using full rates of more at risk materials to kill a larger percentage of the disease organism population are strategies to incorporate into the disease management program to reduce the risk of resistance development.



### Disease identification



Bitter rot fruit infection



Black rot foliar lesion



Downy mildew  
on upper side of leaf



Eutypa dieback on cane



Sour rot fruit infection



Black rot fruit infection



Crown gall on trunk base



Phomopsis foliar lesions



Downy mildew  
on underside of leaf



Anthracnose on berries

### Disease identification (continued)



Powdery mildew  
on upper leaf



Ripe rot fruit infection



Powdery mildew on fruit



Phomopsis lesions on shoot



Virus on leaves



Anthracnose foliar infection

## XII. DISEASE MANAGEMENT

Disease identification				
Issue	Category 4	Category 3	Category 2	Category 1
62. What resources are used to identify common diseases of the Ozark Region?	Vineyard manager and workers can identify diseases and damage signs and know which cultivars are susceptible to each.	Vineyard manager can identify disease and damage signs, but workers use posted color photo fact sheets.	Only the vineyard manager can identify cause of fruit or foliar disease damage.	No one can identify the major diseases.
<p><b>Notes:</b> The ability to properly identify which diseases are causing damage in the vineyard is critical in determining control measures. Not all fungicides are effective against any one disease and of those that are effective, the level of effectiveness can vary. Routinely spraying one or two fungicides for the duration of the growing season may control some diseases but not others.</p>				

Disease monitoring and records				
Issue	Category 4	Category 3	Category 2	Category 1
63. How are vineyard diseases monitored?	Grower or a trained worker monitors for diseases and assesses damage weekly or at key phenological periods throughout the season, and also keeps written scouting records by block.	Grower or a trained worker monitors for diseases and assesses damage periodically, and also keeps scouting records.	Grower or a trained worker monitors for diseases and assesses damage irregularly, but does not keep records.	Grower rarely or never monitors for diseases or assesses damage.
<p><b>Notes:</b> Scouting for the presence of diseases is also an important part of a disease management program. While several diseases can potentially infect area vineyards every year, due to variations in weather conditions from season to season, infections by different disease organisms vary in the level of incidence and severity from season to season and at different times during the season. Routinely spraying for a disease that is not causing problems is a waste of chemical, a waste of money and increases environmental contamination.</p>				

## XII. DISEASE MANAGEMENT

Pruning and sanitation				
Issue	Category 4	Category 3	Category 2	Category 1
64. How are mummified berries, dead spurs and canes removed?	Dead spurs and canes, and mummified berries are removed at pruning to reduce overwintering disease inoculums and disposed of away from the vineyard.	Dead spurs and canes, and mummified berries are removed at pruning to reduce overwintering disease inoculums, but are dropped to the ground and not disposed of.	No effort is made to identify and remove dead canes or spurs, but mummified berries are removed at pruning.	No effort is made to identify and remove dead canes or spurs or mummified berries.
<p><b>Notes:</b> Dead or scabby spurs and canes can be overwintering sites for phomopsis. Mummified berries left on the vine can harbor spores for black rot or phomopsis and can be a significant source of inoculum for disease infections the following season. Removing and disposing of dead or scabby canes and spurs and mummified berries outside of the vineyard can significantly reduce the amount of overwintering inoculum in the vineyard.</p>				

Pruning and canker diseases				
Issue	Category 4	Category 3	Category 2	Category 1
65. How are pruning cuts made to remove old spurs, cordons or trunks?	Large pruning cuts such as the removal of old spurs, cordons or trunks are made after budburst when the vines are actively growing to reduce the risk of canker diseases.	Removal of old cordons or trunks are made after budburst when the vines are actively growing to reduce the risk of canker diseases, but old spurs are removed during normal pruning operations.		All pruning cuts, regardless of size, are made during normal pruning operations.
<p><b>Notes:</b> Large pruning wounds are more likely to be colonized by spores of canker diseases than small pruning wounds. When they are made during the dormant pruning period, these wounds remain open to colonization for a longer period of time.</p>				

## XII. DISEASE MANAGEMENT

Dormant sprays				
Issue	Category 4	Category 3	Category 2	Category 1
66. How is lime sulfur applied for controlling anthracnose?	Dormant applications of lime sulfur are made in blocks of very susceptible cultivars or where anthracnose has been a problem in previous seasons.	Lime sulfur is only applied to blocks where anthracnose has been a problem in previous seasons.		Lime sulfur is not applied even in blocks where anthracnose has been a problem in previous seasons.
<p><b>Notes:</b> Anthracnose is problematic in many Ozark Mountain area vineyards in wet seasons and in vineyards of Norton/Cynthiana that follow a low- or no-spray program. A late dormant season application of lime sulfur is the most effective control method for anthracnose as most other fungicide materials are only slightly or moderately effective against the disease.</p>				

Fungicide timing				
Issue	Category 4	Category 3	Category 2	Category 1
67. When are fungicides applied to the vineyard?	Grower or trained workers use weather data logger and local weather forecasts of temperature, hours of leaf wetness, inches of rain and % RH to run disease prediction models to better time fungicide applications.	Grower or trained workers apply fungicide before forecasted rains or long periods of high relative humidity and/or leaf wetness.	Grower or workers apply fungicide when signs of disease appear in the vineyard.	Fungicides are applied on a calendar-based schedule.
<p><b>Notes:</b></p>				



Fungicide resistance management				
Issue	Category 4	Category 3	Category 2	Category 1
68. How is the fungicide spray program designed to reduce the risk of resistance development?	<p>The fungicide spray program is designed using alternating applications of at-risk fungicides with different modes of action to reduce the buildup of fungi populations with high levels of resistance to a particular class of chemicals.</p> <p><b>Or</b></p> <p>At risk fungicides are tank mixed with materials that have a low risk of resistance development to reduce the buildup of resistant fungi populations.</p>		At risk fungicides are tank mixed with materials that have a low risk of resistance development to prevent the buildup of resistant fungi populations but the same materials are used with little rotation.	Just a few fungicides are used repeatedly throughout the growing season.
<p><b>Notes:</b> Materials such as the sterol inhibitor (SI) fungicides (i.e., Rally, Bayleton, Elite) and the strobilurins (i.e., Abound, Sovran, Flint, Cabrio) are highly at risk for the development of resistance by disease organisms and resistance by powdery mildew (SI) and downy mildew (strobilurins) have already been reported in other areas. Relying on only one material or materials with the same mode of action increases selection pressure on the disease population for resistant fungi to survive and reproduce, resulting in a disease resistance to that class of materials. Alternating sprays with materials having a different mode of action or combining them with materials that are at a low risk of resistance development can reduce the risk of resistance development by killing a larger percentage of the disease population.</p>				

Canopy management for disease management				
Issue	Category 4	Category 3	Category 2	Category 1
69. How is canopy management used to reduce disease pressure?	Canopy management practices (shoot thinning, shoot positioning, leaf removal, hedging) that result in a canopy more open to light penetration and air movement within the canopy to reduce conditions that favor disease development are followed. (See section on <b>Canopy Management</b> .)	Some canopy management practices that can reduce disease pressure within the canopy are performed annually while others are seldom utilized.	Canopy management practices that improve the environment within the canopy are practiced only on highly disease-prone cultivars.	Canopy management practices are not utilized to modify the environment within the canopy to reduce disease pressure.
<b>Notes:</b>				

## XII. DISEASE MANAGEMENT

Virus management				
Issue	Category 4	Category 3	Category 2	Category 1
70. Are virus-infected vines properly identified and managed?	The vineyard manager can identify symptoms of virus and virus-infected vines are immediately removed when identified. If the vineyard block must be removed, as much root system as possible is removed and the block is left fallow for a minimum of three years or the vineyard is replanted using vines grafted to a resistant rootstock.	The vineyard manager can identify symptoms of virus and virus-infected vines are immediately removed. If the vineyard block is removed, the site is fallowed for less than three years and/or vines are replaced with ungrafted material.	The vineyard manager cannot identify virus-infected vines and dead symptomatic vines are replaced with ungrafted vines.	The vineyard manager cannot identify virus-infected vines, and therefore nothing is done even if the block performs poorly or is nonproductive.
<b>Notes:</b>				

Crown gall management				
Issue	Category 4	Category 3	Category 2	Category 1
71. Are crown gall-infected vines properly identified and managed?	The vineyard manager can identify crown gall. Vines or portions of vines affected by crown gall are removed or replaced. If vineyard blocks affected by crown gall are removed, they are fallowed for at least three years before replanting.			The vineyard manager cannot identify crown gall and vines, or portions of vines displaying symptoms are not removed or replaced.
<b>Notes:</b> <i>Agrobacterium vitis</i> , the bacterium that causes grapevine crown gall, can survive in the soil for several years on decomposing vine roots. When renovating a vineyard block where crown gall has been a severe problem, as much of the root system as possible should be removed along with the vines. The field should be sown to a grass or grain crop and left fallow for at least three years to allow the bacteria population to decline.				

## XIII. PESTICIDES AND SAFETY

### Restricted use pesticides (RUP)

Issue	Category 4	Category 3	Category 2	Category 1
72. Does a holder of a certified pesticide applicator license manage <b>restricted use pesticides (RUP)</b> ?	Certified person purchases and supervises application of RUP. Workers have knowledge of pesticide use, and safety information on MSDS sheets and RUP label.	Certified person purchases and supervises application of RUP.	Certified person purchases and applies RUP.	No one is certified to purchase or apply RUPs.

**Notes: MSDS (material safety data sheet)** contains information to aid in product stewardship and workplace safety. It is intended to provide workers and emergency personnel with procedures for handling or working with that substance in a safe manner, and includes information such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment and spill-handling procedures (See Wikipedia online at [http://en.wikipedia.org/wiki/Material\\_safety\\_data\\_sheet](http://en.wikipedia.org/wiki/Material_safety_data_sheet)).

### Read label, MSDS and safety

Issue	Category 4	Category 3	Category 2	Category 1
73. Who handles safety information from the pesticide label and MSDS?	Supervisor and applicators know where the MSDS sheets are located, follow the label for labeled pests, wear required <b>PPE</b> and honor the REI and PHI.	Supervisor and applicators know where the MSDS sheets are located and follow the label for labeled pests.	Only the supervisor has read the label and MSDS but has informed farm workers where MSDS sheets are located.	No one has read the label or the MSDS sheets.

**Notes:** The pesticide label contains information about **active ingredients**, trade names, whether formulation is restricted use pesticide (RUP), personal protective equipment (PPE), pre-harvest interval (PHI), re-entry interval (REI), and EPA approval so manufacturer can produce and sell this pesticide formulation for use as labeled for specified commodities, pests, disease causing agents, weeds or rodents.

## XIII. PESTICIDES AND SAFETY

### Awareness of poison centers

Issue	Category 4	Category 3	Category 2	Category 1
74. Where are the poison center contact phone numbers located?	All emergency numbers (911 or sheriff, fire or emergency services department, agriculture poison center) are posted in the pesticide mixing and loading area and pesticide storage area.			No one is aware of the location of these emergency and poison center numbers.
<b>Notes:</b>				

### Pesticide safety

Issue	Category 4	Category 3	Category 2	Category 1
75. Are pesticides safely loaded and mixed?	Pesticide spill containment methods are used. Mixing and loading are done >150 ft from wells and 800 ft from public wells with approved storage, water well factors and protective site features.			Pesticides are loaded at same spot in the field year after year without spill containment methods.
<b>Notes:</b>				

## XIII. PESTICIDES AND SAFETY

Applicator cleanup				
Issue	Category 4	Category 3	Category 2	Category 1
76. Is a shower facility and locker available for pesticide applicator(s)?	A changing area (locker), sink, bathroom and emergency safety shower are present and maintained near the pesticide mixing area.	A sink, bathroom and emergency safety shower are present and maintained near the pesticide mixing area.	A sink and bathroom are provided to rinse off after applying pesticides.	A hose is available to rinse off after applying pesticides.
<b>Notes:</b>				

Spill kit				
Issue	Category 4	Category 3	Category 2	Category 1
77. Is a spill kit available?	Spill kit is present in pesticide mixing and loading area, and the applicator is trained how to use it.			A spill kit is not available.
<b>Notes:</b>				

## XIV. PESTICIDE APPLICATION

Pesticide coverage				
Issue	Category 4	Category 3	Category 2	Category 1
78. What methods are used to ensure good pesticide coverage?	Reduced canopy density and opened canopy by proper shoot removal, shoot positioning and leaf removal as appropriate for cultivar and training system.	Reduced canopy density and opened canopy by shoot removal and shoot positioning as appropriate for cultivar and training system.	Reduced canopy density by shoot removal as appropriate for cultivar and training system.	Dense canopy and minimal canopy manipulation.
<b>Notes:</b>				

Pesticide records and drift				
Issue	Category 4	Category 3	Category 2	Category 1
79. How detailed are pesticide application records?	A spray record notebook is filled out for each vineyard block; the notebook includes application date, pesticide, rate, target pest/disease/weed, and (for drift liability prevention) records wind speed and wind direction before, during and immediately after spraying a block.	A spray record notebook is filled out for each vineyard block; the notebook includes application date, pesticide, rate and target pest/disease/weed.	A spray record notebook is filled out for each vineyard block; the notebook includes application date and pesticide applied.	No records are kept except for receipts of pesticides used each season.
<b>Notes:</b>				

## XV. PESTICIDE EQUIPMENT

Foliage sprayer calibration				
Issue	Category 4	Category 3	Category 2	Category 1
80. Is foliage sprayer properly maintained?	Adjust sprayer gallonage per acre during the season as canopy increases in surface area and repair leaking hoses and tank as needed.	Annually calibrate sprayer and repair leaking hoses and tank as needed.	Repair leaking hoses and tank as needed.	Not properly maintained or calibrated.
<b>Notes:</b>				

Herbicide sprayer calibration				
Issue	Category 4	Category 3	Category 2	Category 1
81. Is herbicide sprayer properly maintained?	Before each application, sprayer is calibrated and leaking hoses and tanks are repaired.	Sprayer is calibrated and leaking hoses and tanks are repaired annually.	Leaking hoses and tanks are repaired as needed.	Herbicide sprayer is not properly maintained or calibrated.
<b>Notes:</b>				

Spray drift				
Issue	Category 4	Category 3	Category 2	Category 1
82. Are pesticides applied in a manner to reduce spray drift?	Vineyard manager uses drift hoods, follows drift minimization plan and does not spray when winds exceed 7 mph.			Pesticide drift has not been considered as a problem.
<b>Notes:</b>				



## XV. PESTICIDE EQUIPMENT

### Leftover pesticide and rinsate

Issue	Category 4	Category 3	Category 2	Category 1
83. What is done with leftover pesticide in tank and rinsate?	Leftover pesticide and rinsate are drained into a storage container which will be picked up by toxic waste company.			Leftover pesticide and rinsate are dispensed on ground.
<b>Notes:</b>				

### Empty container disposal

Issue	Category 4	Category 3	Category 2	Category 1
84. What is the procedure for disposing of empty pesticide containers?	Bags and triple-rinsed containers are punctured, returned to dealer, recycled or taken to licensed landfill.			Burning or burial of containers on farm.
<b>Notes:</b>				

## XVI. EVALUATION SHEETS

### I. Site Selection

Issue	Page no.	Category				NR
		4	3	2	1	
1. Is vineyard located on a site with higher elevation?	7					
2. Does vineyard site have a slope to discourage erosion?	7					
3. Does vineyard site encourage good air drainage?	8					
4. Does vineyard site allow for good air movement for rapid drying and lower humidity?	8					

### II. Soils

Issue	Page no.	Category				NR
		4	3	2	1	
5. Is soil profile evaluated to identify location(s) of hardpans and compaction?	9					
6. Do vineyard soils have good internal drainage?	10					
7. Do vineyard soils allow optimum root development?	10					

### III. Site Preparation

Issue	Page no.	Category				NR
		4	3	2	1	
8. Has vineyard site been cleared of all obstructions that might interfere with grape growth and soil quality?	11					
9. Have soil samples been collected to determine possible lime and nutrient needs (P, K, B, Mn, Zn, Ca, Mg)?	12					
10. Is more organic matter needed to improve soil health and water holding capacity?	12					
11. Have cover crops been planted to prevent soil erosion?	13					
12. Are vineyard rows oriented to accommodate site layout and slope?	13					

### IV. Soil and Vine Nutrition Management

Issue	Page no.	Category				NR
		4	3	2	1	
13. Is petiole analysis done on a regular basis?	14					
14. Is soil analysis used to monitor and maintain pH, nitrogen, macronutrients and micronutrients in range appropriate for each cultivar?	15					
15. How are the need, rate and timing for nitrogen fertilization determined and implemented?	15					
16. What is the method of N application?	16					
17. How is N fertilizer applied?	16					
18. How are other macronutrients managed (P, Ca, Mg, K)?	17					
19. How are micronutrients managed (B, Mn, Zn)?	17					

### V. Cultivars and Rootstocks

Issue	Page no.	Category				NR
		4	3	2	1	
20. Are cultivars appropriately selected for the area?	18					
21. Are chosen cultivars suitable for the vineyard and certified as virus-free?	19					
22. How were the vines acquired?	19					
23. How were rootstocks chosen?	20					
24. Were grafted cultivars hilled with soil to minimize winter injury?	20					
25. Are the cultivars disease-resistant?	21					
26. Do accurate maps of vineyards and soil types exist?	21					

## XVI. EVALUATION SHEETS

### VI. Canopy Management

Issue	Page no.	Category				NR
		4	3	2	1	
27. Is trellis training system appropriate for the vine size in each block?	22					
28. Have shoots been thinned so that they grow at a proper density?	23					
29. Are shoots positioned to reduce shading?	23					
30. Are leaves removed as necessary for healthy clusters?	24					
31. Are vines maintained for balanced growth?	24					
32. Is the yield to pruning weight ratio (Ravaz Index) monitored?	25					
33. Is the canopy microclimate and shoot-tip length carefully monitored?	25					

### VII. Crop Load Management

Issue	Page no.	Category				NR
		4	3	2	1	
34. What are the methods and timing of crop thinning?	26					
35. How are yields estimated?	26					
36. Is yield appropriate for cultivar and vine size?	27					
37. Are yield records kept by block to determine profitability?	27					

### VIII. Fertilizer Storage

Issue	Page no.	Category				NR
		4	3	2	1	
38. Are fertilizers properly stored and secured for safety purposes?	28					
39. Can fertilizer move into nearby water body or well?	28					

### IX. Irrigation

Issue	Page no.	Category				NR
		4	3	2	1	
40. What type of irrigation is used?	29					
41. Is water usage recorded by a flow meter?	29					
42. What is the soil's water holding capacity?	30					
43. How are irrigation needs determined?	30					
44. Does irrigation water move off-site?	31					
45. Is irrigation system regularly maintained?	31					

### X. Weed Management

Issue	Page no.	Category				NR
		4	3	2	1	
46. What resources are used to identify weeds in the vineyard?	33					
47. What is the distribution of weeds in vineyard blocks?	34					
48. How is the drive row between grapes managed?	34					
49. Are non-chemical weed management tactics used?	35					
50. What determines weed control tactics and herbicide rates?	36					
51. Are herbicides applied that may run off or leach into groundwater?	37					
52. Are herbicide formulations rotated with different modes of action to delay development of resistant weeds?	38					
53. Are pre-emergence herbicides applied to maximize weed control?	39					
54. Are herbicides spot sprayed to help manage weeds?	40					

### XI. Pest Management (PM)

Issue	Page no.	Category				NR
		4	3	2	1	
55. What resources are used to identify insect pests and corresponding damage in the vineyard?	45					
56. Is the vineyard sampled for presence of insect pests and/or damage?	45					
57. Do sampling and economic threshold-based decision-making protocols justify insecticide applications?	46					
58. Is grape phylloxera management used to minimize damage to leaves and/or roots?	48					
59. Is grape scale damage prevented by applying spot sprays?	48					
60. Are grape berry moth infestations controlled with spot spray insecticides?	49					
61. Are reduced-risk biopesticides or organic-approved compounds applied to manage pests?	49					

### XII. Disease Management

Issue	Page no.	Category				NR
		4	3	2	1	
62. What resources are used to identify common diseases of the Ozark Region?	53					
63. How are vineyard diseases monitored?	53					
64. How are mummified berries, dead spurs and canes removed?	54					
65. How are pruning cuts made to remove old spurs, cordons or trunks?	54					
66. How is lime sulfur applied for controlling anthracnose?	55					
67. When are fungicides applied to the vineyard?	55					
68. How is the fungicide spray program designed to reduce the risk of resistance development?	56					
69. How is canopy management used to reduce disease pressure?	57					
70. Are virus-infected vines properly identified and managed?	58					
71. Are crown gall-infected vines properly identified and managed?	58					

## XVI. EVALUATION SHEETS

### XIII. Pesticides and Safety

Issue	Page no.	Category				NR
		4	3	2	1	
72. Does a holder of a certified pesticide applicator license manage restricted use pesticides (RUP)?	59					
73. Who handles safety information from the pesticide label and MSDS?	59					
74. Where are the poison center contact phone numbers located?	60					
75. Are pesticides safely loaded and mixed?	60					
76. Is a shower facility and locker available for pesticide applicator(s)?	61					
77. Is a spill kit available?	61					

### XIV. Pesticide Application

Issue	Page no.	Category				NR
		4	3	2	1	
78. What methods are used to ensure good pesticide coverage?	62					
79. How detailed are pesticide application records?	62					

### XV. Pesticide Equipment

Issue	Page no.	Category				NR
		4	3	2	1	
80. Is foliage sprayer properly maintained?	63					
81. Is herbicide sprayer properly maintained?	63					
82. Are pesticides applied in a manner to reduce spray drift?	63					
83. What is done with leftover pesticide in tank and rinsate?	64					
84. What is the procedure for disposing of empty pesticide containers?	64					

# ACTION PLAN

Worksheet topic	Issue number	Area of concern	Plan of action	Timetable for action



# ACTION PLAN

Worksheet topic	Issue number	Area of concern	Plan of action	Timetable for action

- Allen, A. 2006. Winegrape cultivars for the Ozark Mountain region. In Missouri grape production short course. Institute for Continental Climate, Viticulture and Enology, University of Missouri.
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## SUGGESTED RESOURCES

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### Arkansas:

Arkansas Fruit IPM. Online at <http://comp.uark.edu/~dtjohnso/>

Missouri/Arkansas Vineyard and Pest Management News. [http://comp.uark.edu/~dtjohnso/MO\\_AR\\_Grape\\_News\\_21\\_May\\_10.pdf](http://comp.uark.edu/~dtjohnso/MO_AR_Grape_News_21_May_10.pdf)

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Weed ID guide. University of Missouri Weed Science Program. <http://weedid.missouri.edu/index.cfm>

**Great Lakes IPM, Inc.;** 10220 Church Rd NE, Vestaburg, MI 48891; Phone: 800-235-0285; Fax: 517-268-5311; Online at <http://www.greatlakesipm.com>

**Gempler's;** P.O. Box 270, Mt. Horeb, WI 53572; Phone: 800-272-7672; Fax: 800-551-1128; Online at <http://www.gemplers.com/>

**Forestry Suppliers, Inc.;** P.O. Box 8397, Jackson, MS 39284-8397; Phone: 800-752-8460; Online Catalog at <http://www.forestry-suppliers.com/icat/GB09/t1.asp>

## GLOSSARY

**Active ingredient (A.I.)** — the chemical or substance component of a pesticide product that can kill, repel, attract, mitigate or control a pest or that acts as a plant growth regulator, desiccant or nitrogen stabilizer (Source: <http://www.epa.gov/pesticides/glossary/index.html>)

**Attractants** — traps of different colors or shapes with or without a chemical (pheromone or kairomone) that lures and captures insects

**Balanced vine** — a natural balance between vegetative growth or canopy size and fruit yield (Partridge 1925a-c and Dry et al. 2005)

**Biopesticide** — certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals that are often less toxic, decompose quickly and are less polluting than synthetic pesticides. These include repellents or insecticides like kaolin clay (Surround), Spinosad (Entrust, SpinTor); an insect bacteria *Bacillus thuringiensis* (Bt; Biobit, Deliver, Dipel, Javelin), an insect fungus *Beauveria bassiana* (Mycotrol-O, Naturalis-L), and plant extracts – Azadirachtin (Aza-Direct, Neemix), and pyrethrin (PyGanic). There are fungicides like Sulfur (Ben-Sul, Micro Sulf), Potassium bicarbonate (Kaligreen, MilStop), a plant bacteria called *Bacillus subtilis* (Bs; Serenade, Rhapsody), and plant oils – Rosemary Oil (Sporan EC)

and Azadirachtin (Agroneem, Trilogy) (Sources: EPA; <http://www.epa.gov/opp00001/biopesticides/whatarebiopesticides.htm>; ATTRA: <http://attra.ncat.org/attra-pub/biorationals/index.php>)

**Canopy microclimate** — the climate within and immediately surrounding a grapevine canopy

**Carrying capacity (CC)** — maximum number of a species that the environment will sustain

**DAT** — days after treatment

**Degree-day (DD)** — average daily temperature — base temperature of insect; e.g. 47.1°F for grape berry moth and 43°F for grape phylloxera

**Disease triangle** — for a disease to develop it requires three factors to be present: 1) a favorable environment that supports growth of 2) a virulent pathogen on or into 3) a susceptible cultivar; reducing or eliminating one or more of these factors results in disease management

**Economic Injury Level (EIL)** — lowest pest population that will cause economic crop yield damage

**Economic Threshold (ET)** — pest density that alerts grower it is time to use tactic to prevent pest reaching EIL

**General Equilibrium Position (GEP)** — average long-term species population density in absence of environmental change

**Groundwater Protection Area (GWPA)** —

geographically defined areas that are vulnerable to pesticide contamination by leaching or runoff. GWPAs include all existing pesticide management zones (PMZs), plus other areas based on specified soil types, and a depth to groundwater of 70 ft or less.

**Kairomone** — a chemical produced by one animal or plant species (potential food resource) that benefits another animal or plant species (parasitoid or predator or herbivore) by eliciting the latter to follow the odor plume to the potential food resource (kairomones released by beetle damaged grape leaves or fruit attract Japanese beetles or green June beetles, respectively)

**Key pest** — a species that causes economic damage to the harvested fruit of a high value crop like grapes

**Label** — the Federal Insecticide, Fungicide and Rodenticide Act (“FIFRA”) and its implementing regulations describe the format of information in a pesticide label including restricted use or not, trade name, amount of active ingredient, manufacturer, precautions, hazards to humans and livestock, environmental hazards, signal words (caution, warning, danger, danger-poison), first aid instructions, PPE, what product controls, how and when to use it, rates per acre, storage and disposal

(CDMS agro-chemical pesticide labels: <http://www.cdms.net/LabelsMsd/LMDefault.aspx>)

**Mating disruption** — to saturate air inside and above a vineyard with dispensers or puffers of sex pheromone to so that male moths cannot find females which greatly reduces mating, laying of fertile eggs and hatch of very few larvae

**Minimum risk pesticides** — government list of pesticides posing little or no risk  
(List available at 40 CFR 152.25(g) conditions for minimum risk exemption: [http://www.epa.gov/opbhpdp1/biopesticides/regtools/25b\\_list.htm](http://www.epa.gov/opbhpdp1/biopesticides/regtools/25b_list.htm); EPA Pesticide Registration Notice 2000-6: [http://epa.gov/opppmsd1/PR\\_Notices/pr2000-6.pdf](http://epa.gov/opppmsd1/PR_Notices/pr2000-6.pdf))

**MSDS** — material safety data sheet for each chemical or pesticide includes: emergency numbers, first aid measures, hazards, toxicity to humans and other organisms, handling and storage, solubility, PPE, ecological concerns  
(CDMS database has MSDS at <http://www.cdms.net/LabelsMsds/LMDefault.aspx>)

**NIOSH** — National Institute for Occupational Safety and Health

**Non-pest** — an insect species that rarely occurs at population level that exceeds the EIL, so you follow the strategy: “Do Nothing”

**Occasional pest** — in some years, an insect species population level increases and exceeds the EIL, so you follow the strategy: “Do Nothing and Keep Scouting in case population exceeds EIL”

**Perennial pest** — each year the population of this insect species increases and exceeds the EIL, so you follow the strategy: “Scout and Use Tactics as Needed to Dampen Population”

**PPE** — Personal protective equipment — each EPA pesticide label and MSDS describes the minimum protective equipment: coveralls, long sleeve shirt, long pants, shoes or waterproof boots, socks, waterproof clothing, head covering, chemical goggles or shielded safety glasses, type of NIOSH-approved respirator and

chemical resistant gloves, and to keep and wash PPE clothing separately from other laundry

**Pesticide** — (1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant, and (3) any nitrogen stabilizer  
(Source: FIFRA: [http://epa.gov/opppmsd1/PR\\_Notices/pr2000-6.pdf](http://epa.gov/opppmsd1/PR_Notices/pr2000-6.pdf))

**Pheromone** — a chemical produced by one species that attracts a mate (grape berry moth and grape root borer) or causes an aggregation of that species

**Point quadrat analysis** — a measurement of canopy density derived by noting the number of leaf and fruit contacts with a rod inserted perpendicular into the vine canopy (number of leaf layers in a canopy ideally is less than two)

**Ravaz Index** — a ratio of crop weight to pruning weight for a vine

**Restricted use pesticide (RUP)** — compounds with relatively high degree of potential human and/or environmental hazard can only be purchased by a person with a RUP applicator license and that licensed person can supervise others to apply an RUP

**Severe pest** — if you do not implement a tactic, the population of this insect species will remain above the EIL, so you follow the strategy: “Always Scout and Use Tactics to Dampen Population”

**Sustainability** — a total-farm philosophy emphasizing the use of farm management practices that minimize impact on the environment, are economically feasible, and address needs and interests of the community (Dlott et al. 2002)

**Véraison** — stage of fruit development when the berries begin rapid final maturation, begin to change berry color and soften

**Vigor** — rate of shoot growth

**Vine size** — the weight of one-year-old cane prunings is

a measure of vine capacity

**Weed** — a plant that is growing in an undesired place and is affecting crop plant health and productivity by using limited nutrients and water provided to the crop plant

