I. Cover page

A. **Date:** August 15, 2012
B. **Title of Project:** Learning pathways for sustainable vineyard and winery management
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Learning pathways for sustainable vineyard and winery management

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"As agriculture is highly knowledge intensive and institutionally determined, what is the effectiveness of different novel extension strategies and how best can they be set up to facilitate institutional change and technical innovation with the aim of ensuring that the widest number of farmers are reached and engaged?"

- Pretty et al, "The top 100 questions of importance to the future of global agriculture." 2010:229

II. Objectives

II.a. Science: The first objective of this UC SAREP funded study was to advance understanding the role social learning among agri-food system practitioners and outreach professionals play in fostering knowledge about sustainable production. We used network analysis methods to empirically study the social networks of knowledge sharing among agri-food practitioners and outreach professionals. The results of this study have implications for integrating social learning principals into the design and evaluation of outreach and education programs, in particular programs offered by the Lodi Winegrape Commission to Lodi winegrape growers and winery managers.

II.b. Action: The second objective of this study was to provide empirical background to strengthen a 2011 Western SAREP grant application to fund a sustainability-oriented outreach and education program designed around principals of social learning. The empirical background was generated and the grant application submitted, but was not awarded funding. However, we strive to put science into action by communicating our findings directly to the Lodi Winegrape Commission.

III. Summary

In California's viticulture and wine sector, *sustainability partnerships*[1] have played a key role in supporting sustainable agriculture through outreach and education programs that provide practitioners opportunities for building knowledge about environmentally, economically, and socially viable practices (Broome and Warner 2008). The Lodi Winegrape Commission (LWC) is one such sustainability partnership (Klonsky, Zalom, Chandler, Ohmart, Elmore, and Tourte 1998), and is the collaborator to this project. Qualitative research has argued that knowledge about sustainable agriculture is best fostered through a joint process of experiential and social learning (Pretty and Chambers 2003; Warner 2007). *Experiential learning* is "learning by doing" (Kolb 1984), and *social learning* is "learning from others" (Lave and Wenger 1991). In this study we used quantitative methods to compare three *learning pathways* associated with the adoption of sustainability practices: experiential, social, and *formal learning* or "learning from expert texts" (van Kerkhoff and Lebel 2006). Our results have strong implications for the design and evaluation of agri-food outreach and education programs in Lodi's viticulture and wine sector, and beyond.

[1] A sustainability partnership is defined as an intentional multi-year relationship between at least growers, a grower's organization, and one or more scientists to extend knowledge about agricultural sustainability through applied science and practical application. We adapted Warner's definition of an agroecological partnership (2007: 67) to better suit the broad set goals the concept of sustainability covers.

This UC SAREP funded study complements a National Science Foundation (NSF) funded study that used surveys of California winegrape growers to inquire about adoption of sustainability practices and the effectiveness of sustainability partnerships (Hoffman, Lubell, and Hillis 2012). The UC SAREP grant funded the design and administration of a winery manager version of the survey. We report results from both surveys to achieve a system-level perspective.

In this report we focus on four analyses. First, growers and winery managers report having adopted a range of codified sustainability practices. The question of which learning pathways best support further adoption of these practices motivates this study. Second, practitioners rate experiential and social learning pathways as more useful for gaining knowledge about vineyard or winery management than formal learning. Third, given the importance of social learning, we used network analysis (Knoke and Yang 2008) to study the *knowledge networks* among growers, winery managers, and outreach professionals. We found individuals who are both practitioners and outreach professionals to be the most prominent senders and receivers of knowledge, and are therefore important "knowledge brokers". Finally, we test the hypotheses that a) participation in outreach and education activities have a positive association with practitioners' centrality in the knowledge network, which in turn b) has a positive association with practitioner adoption of sustainability practices. Among growers we found positive and significant relationships across our three variables of participation, centrality, and adoption. Among winery managers we found evidence suggesting that participation in outreach and education activities help build their knowledge network, but no evidence that network centrality translates into adoption of sustainability practices.

IV. Specific Results

IV.a. Methodology

The data used in our analyses were collected with two surveys. The first was a mail survey of Lodi winegrape growers delivered during 2010-2011. The grower sample was created from winegrape pesticide use reports accessed from Agriculture Commissioner Offices in Sacramento and San Joaquin counties. The grower survey collected a total of 210 responses with an overall response rate of 49%. The second survey (funded by UC SAREP) was an Internet survey of Lodi winery managers delivered during 2012. The sample was created from resources provided by the LWC. When possible, we supplemented the LWC sample with Internet searches of publicly available information. The winery manager survey collected a total of 52 responses with an overall response rate of 64%. Delivery of both mail surveys followed the Dillman method (Dillman 2007), beginning with an invitation letter, followed by a first survey, a reminder, a second survey, a second reminder, and a final reminder. All non-respondents were contacted by telephone. Response rates were calculated using AAPOR guidelines (AAPOR 2009). The complete grower and winery surveys can be accessed online.

IV.b. Adoption of sustainability practices

We found that the percent of growers having adopted any given sustainability practice varies widely from less than 10% (release beneficial predators or parasites) to 93% (rely on visual observations to determine irrigation timing). The percent of winery managers having adopted any given practice varies from 0% (written monitoring records of total carbon footprint kept & reviewed) to 93% (used barrels are recycled, sold, or reused).

Disease management was the most frequently adopted vineyard practice category (70%). Wine quality was the most frequently adopted winery practice category (77%). It is interesting to note that the most frequently adopted practice categories have the most direct economic benefit to the vineyard or winery enterprise. Individual practices and practice categories with low rates of adoption deserve scrutiny in terms of their a) relevance to vineyard or winery management, and b) the relationship between practitioner perception of the economic and environmental costs and benefits of adoption (Lubell, Hillis, and Hoffman 2010; Lubell, Hillis, and Hoffman 2011).

Survey respondents were asked to report their adoption of vineyard and winery sustainability practices. Sustainability practices are defined as vineyard and winery practices included in the California Sustainable Winegrowing Alliance's *Code of Sustainable Winegrowing Practices Workbook* (Dlott, Ohmart, Garn, Birdseye, and Ross 2006) and the Lodi Winegrape Commission's *Lodi Winegrowers' Workbook* (Ohmart and Matthiasson 2000). With the help of an advisory committee made up of growers, winery managers, and industry experts, a representative sample of practices was selected.

Table 1 reports the percent of respondents who reported having adopted 44 viticulture sustainability practice and 41 winery sustainability practices. The practices are grouped by category and sorted by decreasing adoption rate. The practice groups are sorted in decreasing order by average adoption rate across all practices within each group. The top ten most adopted practices are labeled.

IV.c. Usefulness of learning pathways and information resources

Both growers and winery managers rated experiential and social learning pathways as more useful than formal pathways. Our interpretation of these results is that learning about vineyard and winery management may be driven first by experiential and social learning, and second by formal learning. In other words, practitioners learn best through involvement in the "hands on" practice of growing winegrapes and winemaking itself, and by engaging in a knowledge sharing network of other practitioners and outreach professionals. Our analyses shows social learning to be slightly more useful than experiential learning for growers, while experiential learning is slightly more useful than social learning for winery managers. Formal learning plays an important albeit less prominent role in the learning process.

Survey respondents were asked to rate the usefulness of an exhaustive list of relevant information resources on a scale of 1 to 3, with "not useful" equaling a value of 1, "somewhat useful" equaling 2, and "very useful" equaling 3. The individual information resources were classified into three learning pathways: experiential, social, or formal.

Table 2 reports the mean and modal usefulness score for each learning pathway. In general, the average usefulness scores for experiential and social learning reported by growers (2.56 and 2.57 respectively) and winery managers (2.46 and 2.33) were higher than the scores for formal learning reported by growers (2.29) and winery managers (2.08). The modal usefulness scores for experiential and social learning was 3 ("very useful") while the modal score for formal was 2 ("somewhat useful"). Table 2 also reports the percentage of practitioners that selected each usefulness rating (not, somewhat, or very useful) for each learning pathway overall.

Table 1

Adoption of vineyard and winery sustainability practices:
Sysrtainability practices by percent of practitioners who reported having adopted each practice

	Vineyard practices (*n*=44)	%		Winery practice (*n*=41)	%
Disease management 0.70	Manage pruning decisions for timing and sanitation (2)	0.850	Wine quality 0.77	Regularly expand knowledge about wine quality (2-4)	0.873
	Remove diseased wood and fruit and clean burms (3)	0.825		Winery personnel trained in wine quality related practices (2-4)	0.873
	Remove infected vines (4)	0.777		Regularly communicate with grower about winegrape quality (5)	0.857
	Leaf pulling (5)	0.719		Monitoring records for tracking wine quality kept & reviewed (6)	0.821
	Irrigation management to reduce disease (9)	0.619		Regularly taste winegrapes with grower for maturity & quality (8)	0.786
	Computer disease forecasting model	0.328		Develop & implement written wine quality plan	0.404
Weed management 0.50	Written monitoring records and need-based spraying (10)	0.618	Waste reduction/ management 0.60	Used barrels recycled, sold, or reused (1)	0.927
	Reduced herbicide application rates	0.597		Used glass, cardboard, paper, and plastic recycled (2-4)	0.873
	Shielded sprayer to minimize drift	0.480		Pomace & lees integrated into vineyards or landscape (9)	0.764
	Narrow width of treated strip	0.453		Winery personnel trained in solid waste reduction & management	0.527
	Mechanical weed management	0.453		Develop & implement written plan to reduce, reuse, and recycle	0.345
	Use only contact herbicides/no pre-emergents	0.373		Written monitoring records of solid waste generated kept & reviewed	0.145
Insect and mite management 0.42	Dust reduction on roads (6)	0.705	Human resource 0.50	Fund enhancement of employees workplace skills	0.679
	Reduced pesticide application rates (8)	0.638		Regularly conduct personnel safety & training meetings	0.611
	Written monitoring records for pests	0.540		Offer employees incentives for meeting performance goals	0.547
	Dust reduction with cover crops	0.515		Implemen system to evaluate temployee performance	0.528
	Cover crops for natural pest refuge	0.515		Provide employee benefits such as health insurance	0.490
	Spot spray vs. entire field treatment	0.505		Implement system to evaluate performance of winery managers	0.415
	Written monitoring records of natural predators	0.203		Develop & implement a written human resource policy	0.389
	Pheromones for pest mating disruption	0.102		Develop plan for generational transition of winery	0.382
	Release beneficial predators or parasites	0.064			
Water and soil management 0.36	Rely on visual observations to determine irrigation timing (1)	0.928	Environmentally preferred purchasing 0.42	Products and services from locally owned business (7)	0.818
	Soil test for nutrient content (7)	0.702		Cleaning products that are safe for the environment & humans (10)	0.745
	Soil moisture tests to track water availability	0.405		Environmentally friendly packaging supplies	0.528
	Regulated deficit irrigation methods	0.396		Low volume and weight bottles	0.426
	ET-based methods to determine irrigation timing	0.258		Winery personnel trained in environmentally preferred purchasing	0.226
	Use of vegetative filter strips to reduce runoff into water	0.244		Develop & implement a written policy for environmental purchasing	0.127
	Measure plant water stress	0.186		Barrels made from eco-certified oak	0.074
	Mapping for soil water holding capacity	0.160	Water conservation /quality 0.35	Landscape irrigation with conservation techniques & technology	0.556
	Written erosion control plan	0.152		Winery personnel trained in water conservation & quality practices	0.481
	Diversion structures to control water flow	0.090		Cleaning water applied with water conserving technologies	0.463
				Develop & implement written water conservation plan	0.218
Other vineyard & operation management 0.35	Mechanical methods for major viticultural activities	0.692		Written monitoring records of water use kept and reviewed	0.273
	Vineyard management to achieve "vine balance"	0.665		Employ water use metric to track and evaluate water use efficiency	0.091
	Owl box & bird of prey perches	0.626			
	Use of compost in vineyards	0.383	Energy use/efficiency 0.22	Use energy efficient equipment	0.600
	Written monitoring records of energy use kept & reviewed	0.363		Winery personnel are trained in energy efficiency practices	0.473
	Disposal of removed vines other than burning	0.350		Written monitoring records of energy use kept & reviewed	0.196
	Develop a written company "sustainability" plan	0.288		Use energy efficient vehicle technology	0.179
	Third-party "sustainable" or "green" certification	0.288		Use renewable energy sources	0.143
	Develop & implement a written human resource policy	0.255		Develop & implement written energy use conservation plan	0.125
	Develop plan for generational transition of winery	0.202		Employ energy use metric to evaluate energy use efficiency	0.018
	Monitor and record canopy microclimate	0.171		Written monitoring records of total carbon footprint kept & reviewed	0.000
	Alternative fuels i.e. bio-diesel & natural gas	0.103			
	Alternative electricity sources i.e. wind & solar	0.090			

Table 2

Usefulness of learning pathways:
A) Mean usefulness score
B) Learning pathways by mean percent of individual learning resource rated as "very", "somewhat", and "not useful"

		Experiential		Social		Formal	
		Grower	Winery	Grower	Winery	Grower	Winery
A)	Average usefulness score (modal category*)	2.552 (3)	2.463 (3)	2.57 (3)	2.325 (3)	2.293 (2)	2.081 (2)
B)	"Very useful"	0.429	0.518	0.526	0.361	0.308	0.212
	"Somewhat useful"	0.291	0.388	0.301	0.432	0.410	0.457
	"Not useful"	0.029	0.067	0.033	0.078	0.076	0.147

*Usefulness scores: "Very useful"=3, "Somewhat useful"=2, "Not useful"=1

A majority of winery managers (52%) rated experiential learning resources as “very useful”. The pattern is slightly different for social learning resources. A majority of growers (43%) rated social learning resources as “somewhat useful”, while a majority of winery managers (53%) rated social learning resources as “very useful”.

Table 3 expands each learning pathway to provide a breakdown of the percent of growers and winery managers who ranked each individual information resource as being “very useful”. The resources are grouped by learning pathway and sorted in decreasing order of percent. The learning pathway groups are sorted in decreasing order of average usefulness score. The top ten individual learning resources are labeled. For both growers and winery managers, observations of their own vineyard or wine were the most important learning resource, with 82% of growers and 90% of winery managers rating the resources as “very useful”.

Table 3

Usefulness of individual learning resource:
Individual learning resources by percent of practitioners who rated them as "very useful"

	Vineyard learning resource (top ten rank) (n=20)	% "Very useful"
Social	Pest Control Advisors (2)	0.729
Social	County Farm Advisor (4)	0.583
Social	Winery personnel (6)	0.563
Social	Other winegrape growers (not family) (5)	0.557
Social	Field crew (7)	0.540
Social	Other winegrape growers (family)	0.387
Social	Viticulture consultant	0.315
Experiential	Observations of own vineyard (1)	0.816
Experiential	Trial and error with practices (3)	0.588
Experiential	Observations of others' vineyards (8)	0.529
Experiential	Written records of inputs & performance	0.401
Experiential	Field trial conducted in own vineyards	0.345
Experiential	Field trial conductediny others' vineyards	0.297
Formal	University publications (9)	0.442
Formal	Viticulture textbooks and reference books (10)	0.402
Formal	Internet resources	0.375
Formal	Trade journals	0.338
Formal	"Lodi Winegrowers Workbook"	0.325
Formal	Newspapers	0.146
Formal	"Code of Sustainable Winegrowing Workbook"	0.124

	Winery learning resource (top ten rank) (n=26)	% "Very useful"
Experiential	Observations of your own wine (1)	0.901
Experiential	Experiments conducted in your own winery (2)	0.638
Experiential	Observations of other winery’s practices (4)	0.537
Experiential	Trial and error with winery practices (6)	0.488
Experiential	Evaluation of written records (9)	0.420
Experiential	Experiments conducted in other wineries	0.338
Experiential	Formal education	0.309
Social	Winery managers or personnel from own winery (3)	0.556
Social	Wine making consultant (5)	0.500
Social	Winery managers or personnel from other wineries (7)	0.476
Social	Wine lab technician	0.366
Social	Winery supplier representative or salesperson	0.268
Social	Wine business consultant	0.259
Social	Family members	0.256
Social	Wine distributor or broker	0.207
Formal	"Wine Business Monthly" (8)	0.444
Formal	Internet resources (10)	0.410
Formal	"Practical Winery and Vineyard"	0.361
Formal	Textbooks or other reference books	0.313
Formal	"Wines and Vines"	0.309
Formal	University research publications	0.185
Formal	"Code of Sustainable Winegrowing Workbook"	0.086
Formal	Industry blogs	0.072
Formal	Newspapers	0.062
Formal	Social media such as Twitter or YouTube	0.049
Formal	"American Vineyard"	0.038

IV.d. Position in the knowledge network

Practitioners’ position in the social network of knowledge sharing can affect their ability to access and spread information about vineyard and winery management. In the grower and winery networks we found individuals who are both practitioners and outreach professionals to be best positioned to access and spread knowledge about vineyard or winery management. Their professional experience as “experts” and their practical

experience as growers or winery managers mean that they are likely some of the richest resources of knowledge. By virtue of their relatively high number of knowledge sharing relationships it is likely that these individuals are the best candidates for facilitating social learning across the boundaries of science, industry, and practice.

We calculated practitioners' *centrality* in the network, thereby quantifying their potential to broker knowledge. In the most general sense, centrality is an empirical measurement of how many knowledge sharing relationships a practitioner has and how connected that practitioner is to the rest of the network (Wasserman and Faust 1994: 172). Individuals who are most central have the greatest potential to be aware of others' opinions and insights about management approaches and specific practices because they are in communication with many others, and are therefore "in the know". They may also be able to rapidly spread information through the entire network because they are connected to others who themselves are connected to many others.

Survey respondents were asked to provide the names of up to four other practitioners and outreach professionals who they communicate with for advice about vineyard or winery management. Viticulture outreach professionals included independent Pest Control Advisors, company Pest Control Advisors, farm supply/input sales representatives, winery grower representatives, vineyard management contractors, labor contractors, viticulture consultants, and Cooperative Extension Farm Advisors. Winery outreach professionals included winery supply/input sales representatives, winemaking consultants, wine business and marketing consultants, wine broker/distributer/importer, and wine laboratory technicians.

Figure 1: Grower network

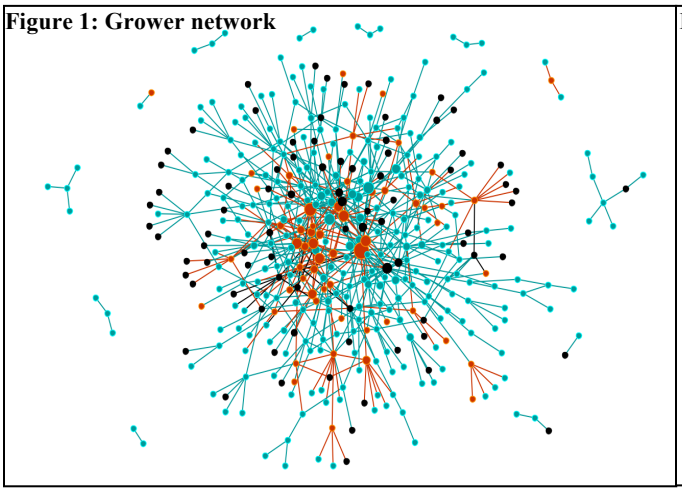

Figure 2: Winery manager network

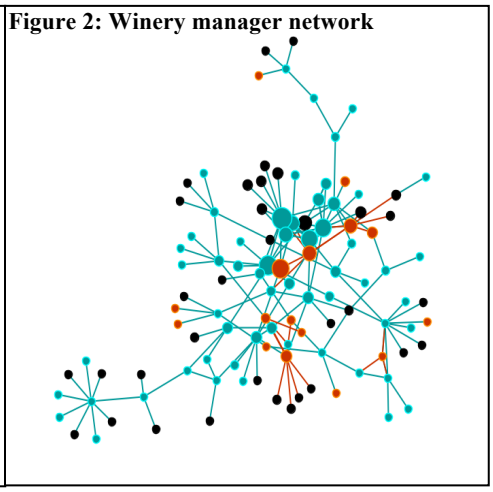

Figure 1 visualizes the grower knowledge network and **Figure 2** the winery knowledge network. Nodes represent individuals and ties represent knowledge sharing relationships. Nodes are color coded: **aqua** colored nodes represent individuals who are exclusively practitioners (growers or winery managers), **black** colored nodes individuals who are exclusively outreach professionals (viticulture or winery), and **orange** colored nodes individuals who are both practitioners and outreach professionals. Nodes are scaled by centrality, with larger centrality measures represented by larger diameter nodes.

Visual inspection of the network yields cursory insight into which individuals and groups are best positioned to broker knowledge. Nodes that have higher centrality measures are located closer to the center of the network diagram. Individuals who are both practitioners and outreach professionals (orange) clearly tend toward the center of both networks. The patterning of those who are exclusively outreach professionals and exclusively practitioners is more difficult to discern thorough visual analysis. The centrality measures of nodes provide more conclusive insight.

Table 4

Network centrality:
Actor categories by mean total degree centrality

	Viticulture network		Winery network
	Mean total degree centrality		Mean total degree centrality
Both	6.38	Both	3.50
Practitioner	2.79	Practitioner	2.16
Outreach	2.34	Outreach	1.23

Table 4 reports average centrality measures of the three categories of individuals in both networks. We report *total degree centrality* (Wasserman and Faust 1994: 172), which is simply the count of ties associated with each node[2]. Total degree centrality simply represents the number of knowledge sharing relationships each individual reported having. On average, individuals who were both growers and viticulture outreach professionals reported 6.38 knowledge-sharing relationships, 2.28 times higher than growers and 2.73 times higher than viticulture outreach professionals. On average, individuals who are both winery managers and outreach professionals reported 3.50 relationships, 2.85 times higher than winery outreach professionals and 1.62 times higher than winery managers.

IV.e. Relationships between outreach and education, centrality, and practice adoption
Finally, we looked at the relationships between a) practitioners' participation in outreach and education activities and centrality in the knowledge network, and b) the relationship between practitioners' centrality in the network and adoption of sustainability practices. In light of past research, which argued that outreach and education activities play a key role in extending adoption of sustainability practices through social learning (Warner 2007), we expected to find positive relationships between our variables. In general, we found support for existing outreach and education activities as instruments for extending sustainable agriculture through social learning among growers. Additionally, we found results suggesting that outreach and education activities provide winery managers opportunities to build their knowledge network. However, we find no evidence to suggest that social learning is playing a role in extending winery sustainability practices.

Survey respondents were asked to report their participation in various outreach and education activities offered by the LWC and other relevant institutions. Outreach and education activities in the grower survey included attended field meetings, attended informational lectures, read LWC newsletter, talked with LWC staff, completed the Lodi Rules for Sustainable Winegrowing certification program, completed the *Lodi Winegrowers' Workbook* sustainability self-assessment, attended *Lodi Winegrowers'*

[2] We reported total degree centrality because it is an intuitive measure of centrality and much easier to interpret in real-world terms than others. While total degree centrality does not reflect an individual's connectedness in real social networks as well as well as other measures, we found it to be highly correlated (grower network: r=0.830, p=0.000, winery network: r=0.703, p=0.000), and is thus qualitatively similar.

Workbook workshop, accessed LWC internet resources, attended the local viticulture industry fair, and completed the *Code of Sustainable Winegrape growing* sustainability self-assessment. Outreach and education activities in the winery survey included talked with LWC staff, attended educational workshops, read electronic LWC newsletter, read paper LWC newsletter, accessed LWC internet resources, visited LWC office, completed Certified California Sustainable Winegrowing certification for wineries, and completed the *Code of Sustainable Winegrape growing* sustainability self-assessment for wineries. The other variables used, network centrality and adoption of sustainability practices have been previously introduced.

Table 5 reports the pairwise correlation results of the three variables from growers and winery managers: the percent of outreach and education activities respondents reported having participated in, individual respondents centrality in their respective networks, and the percent of sustainability practices respondents reported having adopted.

Among growers, we found moderate positive and significant associations between participation and centrality (r=0.412 p=0.000), and between centrality and adoption (r=0.317 p=0.000). We interpret these results as supportive of the arguments that a) outreach and education programs play a role in building growers' knowledge networks, and b) social learning is an effective learning pathway for supporting the adoption of sustainability practices among growers. However, we also find a strong positive and significant association between participation and adoption (r=0.642 p=0.000), indicating that social learning may not be the only learning pathway at work on practice adoption.

Table 5

Correlation among participation in outreach and education activities, network centrality, and adoption of sustainability practices

		Grower		
		1	2	3
1	Participation	-	-	-
2	Centrality	0.412***	-	-
3	Adoption	0.642***	0.317***	-
		Winery		
		1	2	3
1	Participation	-	-	-
2	Centrality	0.311**	-	-
3	Adoption	-0.125	0.007	-

*p= 0.10 **p =0.05 ***p =0.001

Among winery managers, we found a moderate positive and significant association between participation and centrality (r=0.311 p=0.018). This finding suggests that existing outreach and education activities may be effective instruments for growing winery managers' knowledge sharing networks. However, the lack of association between centrality and adoption and participation and adoption suggest that sustainability partnerships are ineffective at supporting the adoption of winery sustainability practices either through social or other learning pathways.

Based on communication with our advisory committee and our experience in the viticulture and wine sector, we interpret this result as consequence of two factors. First, the LWC's winery outreach and education activities have heretofore focused on winery establishment practices, not sustainability practices. Lodi's wine industry is relatively young, and the knowledge development around basic winery establishment has taken priority. Second, only one learning resource, the California Sustainable Winegrowing Alliance's *Code of Sustainable Winegrowing Workbook*, promoted winery sustainability oriented practices. This resource is a formal learning pathway and was ranked as "very useful" by 12% of winery managers. Over time, we predict winery sustainability

practices to become increasingly adopted once Lodi wineries become more established, but only if the LWC integrates winery sustainability practices into their outreach and education programs. This prediction is based on our findings that sustainability-oriented outreach and education programs are effective at encouraging practice adoption.

V. Potential Benefits and Impacts on Agriculture Systems

In a paper discussing the top 100 questions relevant to global agricultural sustainability, Pretty and colleagues included the following: "As agriculture is highly knowledge intensive and institutionally determined, what is the effectiveness of different novel extension strategies and how best can they be set up to facilitate institutional change and technical innovation with the aim of ensuring that the widest number of farmers are reached and engaged?" (2010: 229). Continuing the LWC's tradition of providing innovative outreach and education to growers and winery managers will require a) extending sustainability-oriented outreach and education to practitioners in all aspects of the agri-food system, and b) pushing the envelope on program designed through the use of new strategies such as experiential and social learning.

First and foremost, our results here, and elsewhere, make a convincing case for continuing and expanding support of local sustainability partnerships as the outreach and education programs they provide have been largely effective at supporting grower adoption of sustainability practices (Hillis, Hoffman, and Lubell 2010; Hillis, Lubell, and Hoffman 2011a; Hillis, Lubell, and Hoffman 2011b; Shaw, Lubell, and Ohmart 2011). Extending this sustainability-oriented outreach to winery managers, as well as growers, is a natural next step to address sustainability at the system-level.

Based on our analyses, we make recommendations for sustainability partnerships to capitalize on the experiential and social nature of learning. Specific recommendations for program innovation are below.

1. **Experiential learning**: Beyond the learning that naturally comes from the process of vineyard and winery management, experiential learning can be accelerated through heuristics. Here we identify three heuristics that are well suited for supporting experiential learning.

- **Encourage practitioner use of sustainability self-assessment workbooks.** Sustainability self-assessment workbooks such as the *Lodi Winegrowers' Workbook* and the *Code for Sustainable Winegrowing Practices Workbook* provide growers and winery managers with a refined framework for assessing practices, evaluating management strategies, identifying areas of concern, and formulating plans for improvement. As one Lodi grower put it, using workbooks is like "… going back to school for farming" (Hoffman 2011). Our results show 22% of growers and 10% of winery managers are currently using workbooks.
- **Encourage the practice of written recordkeeping and goal setting.** Along with the use of workbooks, the practice of written record keeping and goal setting has high potential for heightening practitioners' awareness of their operation. Written records can serve as empirical bases for on-the-ground decision-making and written plans serve as strategic bases for big-picture decision making. Our results show that 31% of winery managers 32% of growers already employ written records and management plans.

- **Partner with industry and academic scientists to facilitate on-farm or in-winery experiments.** Gaining first hand experience in the process of experimentation with innovative technologies or strategies has high potential for forging new knowledge. Our results show that 35% of growers and 64% of winery managers report such experiments as "very useful" for learning about management. Moreover, this recommendation has an added benefit of social learning by building relationships between practitioners and outreach professionals.

2. **Social learning:** We suggest sustainability partnerships actively cultivate social learning among practitioners and outreach professionals, rather than merely acting as broadcasters of information.

- **Form alliances with knowledge brokers.** Those individuals who are both practitioners and outreach professionals ought to be considered key allies in outreach and education efforts. Their deep knowledge means that they are valuable advisers and their strong connection to the rest of the network means that they are positioned to a) be aware of practitioners needs and challenges, b) to rapidly spread knowledge, and c) are likely able to effectively communicate across the boundaries of science, industry, and practice.
- **Institutionalize knowledge brokerage.** We recommend that the job descriptions of outreach professionals, especially those responsible for administering outreach and education programs, be broadened to include the work of leveraging the network to maximize the benefits of social learning. Cultivating social learning may be as simple as introducing those who have answers to those who have questions. Such is the work of effective knowledge brokerage.
- **Facilitate opportunities for building knowledge sharing relationships.** Outreach and education activities that provide opportunities for practitioners and outreach professionals to engage in conversation and share insights may increase the chances of building short- and long-term knowledge sharing relationships. Employ discussion format meetings as opposed to lecture format meetings. A number of similar activities are already employed by sustainability partnerships including field meetings, workshops, and lectures. Our results show that 69% of growers and 75% of winery managers are currently taking advantage of such activities.

VI. Dissemination of findings

These results and recommendations will be disseminated to the LWC and the broader agricultural community through four means. First, the Principal Investigator will communicate the results directly to the LWC through a) sharing this report and b) presenting the findings to the LWC staff and Research and Education Committee. Second, a version of this report will be submitted for publication to viticulture and wine industry journal. Third, a version of this report will be broadly distributed to academics and policy-makers through the UC Davis Center For Environmental Policy and Behavior's research distribution list and blog. Fourth, after further analysis, this study will constitute a portion of the Principal Investigator's Ph.D. dissertation, which will have a wide academic and industry audience. The Principal Investigator intends to present these findings at the 2012 Green Wine Summit.

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