Through the grapevine: In search of a rhetoric of industry-oriented science communication

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Abstract

Rhetorical features of industry-oriented science communication texts structure meetings between science and industry communities and, consequently, structure research-industry relationships. Industry-oriented science communication, however, remains dominated by metaphors of technology transfer and research utilization which continue to enact deficit model paradigms by drawing on essentially positivist constructions of scientific knowledge. In so doing, these models limit the capacity for science communication texts to make research relevant to industry practice and to facilitate research-industry collaboration as multidirectional knowledge sharing. Better metaphors for more relevant and more collaborative communication can, I argue, be found in material semiotic paradigms which would have science communicators align and overlap the multiply practiced worlds of science and industry instead of transferring acontextual, would-be universal knowledge to deeply emplaced sites of utilization. In interviews with and surveys of winemakers and growers in Washington State and New Zealand, I find that technology transfer paradigms configure wine industry members' interactions with research in ways which systematically eliminate moments in which this public participates in scientific processes. Winemakers and growers generally value and seek out scientific information, but also tend to perceive scientific and industry knowledge as complementary, with industry knowledge having the epistemic authority to judge new scientific findings. Textual analyses of research dissemination in these two settings outline science

communication texts which limit valid knowledge to scientific knowledge alone, manifestly ignoring industry knowledge and the context-dependency of knowledge-making practices for industry use. These texts construct research practices as above and distant from the world of winemaker and grower practices rather than making scientific and industry practices adjacent and proximal. Material semiotic paradigms would in contrast have science communicators align and overlap the multiply practiced worlds of science and industry. Instead of transferring acontextual knowledge to sites of utilization, science communication would make it possible for industry readers to locate scientific knowledge practices with respect to their own practices, making science relevant to industry by drawing relationships amongst them. A collaborative rhetoric of industry-oriented science communication would, therefore, communicate scientific research as locatable practice in the context of its generation, recognizing the meaning-making practices of industry audiences and their potential contribution to the iterative process of creating applied scientific claims valid in both scientific and industry spaces.

Acknowledgments

The best part of situating one's research in the wine industry – better even than occasionally needing to taste wine for research purposes – is talking with winemakers and winegrowers. Any number of other industry communities are surely also full of perfectly lovely individuals. I nevertheless feel the need to assert the delightful uniqueness of wine people, if only out of loyalty. It is in some part an accident of history that Western culture has developed a more robust culture of appreciation around wine than around any other comestible. We could have discovered nuance and developed highly stratified quality markers for lentils or jam, though something should be said for the special, unpredictably *alive* qualities of foods produced via human collaboration with microbes. But our reverence for wine is, in another sense, also no accident at all. What other food is solidly nourishing and affably intoxicating, an aid to enjoying a good meal as much as enjoying a good conversation, expression of its place and people, ordinary and sublime? Bread, beer, and cheese may come close, but nothing is quite the same as wine. And for better or worse, wine people know it.

Winemakers – and members of the wine industry more generally – are an unusually passionate, unusually opinionated, diverse bunch of professionals. During my fieldwork I conducted interviews in fine art-laden tasting rooms while gazing out at showy views and in garages while perched on wooden shop stools, in rocking chairs on front porches and in anonymously modern conference rooms. My audio recordings are variously muddled by the

background noise of clucking chickens, the buzz of forklifts, and the enthusiastic greetings of winery dogs. And – clichéd but still true – people tend to pour stories as they pour their wine. It's rare to meet a winemaker or vineyard manager who's really unhappy at the job.

My approaches toward science communication, in the wine industry and in general, are colored by my desire to preserve all of these possibilities, including every bit of the idiosyncrasy and sometimes even cantankerousness of the men and women behind them. Even if I sometimes pretend that my motivations have to do with justice, or economics, or logic, the truth is that I'm fundamentally selfish. I like the diversity of wine and wine industry wisdom, and I want to see both thrive.

I leave these studies, however, with my great appreciation for wine and winemakers and growers mitigated by the structures this industry supports. Wine is a tool for appreciating beauty and cultivating joy that should not be limited to the higher social classes. Much as ordinary table wine has been and continues to be an ordinary part of middle- and even working-class life, the New World wine industry has become a playground for the wealthy. Many wineries operate in the name of executives or physicians – overwhelmingly white men – as a more interactive alternative to the conventional investment property or summer home. Many more are made possible by the investment of multi-generational land-owning families who enjoy a kind of security increasingly rare for today's transient workers.

Some part of me feels guilty that I've spent so much time and effort embellishing an industry that celebrates with white tie and caviar when I could have been, say, studying industry-oriented science communication in Sri Lankan rubber plantations. I hope that some of the ideas I develop may at some point apply to science communication concerns in such places where power inequalities are far more drastic and dangerous than between scientists and winemakers. I also hope that I have helped to present wine as something *other* than a luxury good, a tool for understanding science, a tool for preserving and sharing cultural values, and a tool for creating joy.

The fieldwork in Washington State and New Zealand that contributed to this thesis was funded by the Washington State University Viticulture and Enology Extension and by the New Zealand Sustainability Dashboard Project, respectively. I thank Dr. Thomas Henick-Kling at Washington State University and numerous members of the Dashboard Project for helping to facilitate my research. I also acknowledge the generosity of New Zealand Winegrowers in providing me with access to members-only resources for the analyses in chapter six.

In addition to the many wine industry members who have shown me their irreplaceable hospitality, I owe thanks to:

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Katharine, for feedback in particular on chapter one, and Fabien, for assistance in particular with chapter four and for ensuring that my sense of humor never had a chance to get lazy.

The several people who have kindly listened to me rattle on about industry-oriented science communication and reflected thoughts back at me, including Dr. Annemarie Mol and other participants in the 2015 Agri-food meeting in Queenstown.

Reviewers and editors at the *Journal of Wine Research*, the *Journal of Extension*, and especially at *Written Communication*, whose feedback has substantially improved the chapters published in those journals.

Sue and Steve, who saved my running afoul of many potential hazards of living in New Zealand, including being friendless.

My parents, who ensured that I left childhood with a robust appreciation for wine and perseverance.

The birds surrounding my little house by the bay – especially the kereru, tui, bell birds, pukeko, oyster catchers, and even the great black-backed and red-billed gulls – for providing the soundtrack to my writing and a constant, welcome source of company.

Geoff, my first and best editor.

How to use this thesis

This thesis is comprised of four central chapters published or submitted for publication, preceded by a theoretical introduction and general explanation of methods and followed by a conclusion recapitulating and synthesizing my findings in aggregate. Each of these chapters is introduced by a brief preface that locates its position in the thesis as a whole. The reader will find additional procedural information about study materials in the appendices. Also appended is a supplemental publication prepared for a science communication practitioner audience (*Journal of Extension*, which serves the American extension community). Published/in press chapters are reproduced here in their full and final pre-print form with the permission of the publishers. I have been personally responsible for conducting all research contained herein, including designing and planning projects, sourcing independent funding, collecting and analyzing data, and writing. All publications associated with this thesis are single-authored with the exception of chapter three, co-authored with Professor Lloyd Davis, who contributed editorial comments (roughly five percent of total revising and editing efforts) to late drafts of the manuscript.

I ask the reader to keep in mind that each chapter was submitted for publication shortly after the work of that chapter was completed, and that those chapters are presented here in their published/submitted form without additional revision. The reader may therefore find some minor repetition among chapters. Furthermore, my ways of thinking about my study, the wine industry, and science communication have shifted significantly between the point at which I submitted what is now chapter three (October 2014) and the point at which I submit this thesis (April 2016). Consequently, the main content chapters trace a trajectory toward the theoretical framework presented in the introduction.

Table 0.1 – Summary of publications contributing to this thesis

Chapter 1 – Introduction		
Chapter 2 – Overview of methods		
Chapter 3 – Wine Science in the Wild West: Information-seeking behaviors and attitudes among Washington State winemakers and growers		
Journal of Wine Research	**Published online 18 Sep 2015**	**Vol 26(4), 270-286**
Chapter 4 – More than transfer: Research utilization as post-dissemination review		
	Under review	
Chapter 5 – Constructing relationships between science and practice in the written science communication of the Washington State wine industry		
Written Communication	**Published online 23 Mar 2016**	**Vol 33(2), 184-215**
Chapter 6 – Enacting multiple audiences: Science communication texts and research-industry relationships in the New Zealand wine industry		
Science Communication	**Published online 23 Nov 2016**	**Vol 38(6), 724-745**
Chapter 7 – Conclusion		
Appendix A – Extension resource use amongst Washington State winemakers and growers: A case for focusing on relevance		
Journal of Extension	**Published online 29 Feb 2016**	**Vol 54(1), 1FEA2**

Chapter 1 – Introduction

Goals

In what follows, I suggest that we consider science communication to industry audiences as a unique category, that written science communication structures research-industry relationships, and that rhetorics of written science communication can facilitate more collaborative research-industry relations. At their most superficial level, my conclusions are familiar: collaborative science communication should involve recontextualizing science in terms of (industry) audience knowledge, respecting (industry) audience expertise, and acknowledging (industry) audience participation in the scientific process. The novelty of those suggestions lies in the theoretical ground on which they stand and, consequently, in the depth at which they apply. I have no interest in "engaging" industry publics (whatever, precisely, that means) or in convincing industry audiences to be more scientific, though this work may speak at times to those goals. I do not assume that science lies at the top or center and that other ways of knowing and doing are subordinate or secondary, nor that multidirectional science communication happens for the sake of supporting and advancing science alone. I locate science as one of multiple valid, local and limited ways of making knowledge that can and should work with other such systems of knowing. These assumptions cohere with societal goals for applying science to solve common problems in broadly interdisciplinary spaces. This grounding is, moreover, a logical extension of contemporary objectives of science communication to involve scientific and non-scientist communities in co-participation and democratic dialogue. Such efforts at participatory engagement inevitably devolve back to some version of "getting the public to know/do/support more science" if our theoretical models of scientific knowledge maintain the epistemic superiority of science as the discovery of objective knowledge and preclude making space for publics to contribute significantly to the knowledge-making process.

I argue for the value of studying industry-oriented science writing beyond content as a way to understand and manipulate research-industry relationships. I envision research-industry communication as a form of interdisciplinary communication between knowledge communities, whereby desirable relationships involve multidirectional knowledge sharing rather than one-way knowledge transfer. I suggest that material semiotics offers useful metaphors to replace "technology transfer" or "research utilization." Beginning from the perspective that work must be done to make research practices relevant to industry practices is useful in shifting the focus of assessing industry-oriented science communication from administrator-centric adoption to reader-centric relevance. I situate this study in the Washington State and New Zealand wine industries. Through studying science communication involved in those two settings I suggest rhetorical strategies for writing industry-oriented science as more relevant to industry and, simultaneously, more conducive to multidirectional research-industry knowledge sharing.

Material semiotics as developed through the work of Latour (1986, 1999; Latour & Woolgar, 1986), Law (1992, 2004, 2008; Law & Lien, 2012; Law & Singleton, 2000), Haraway (1988, 1991), and Mol (2003; de Laet & Mol, 2000) provides new metaphors for taking firm steps against the quiet slide back into the deficit model to which so much engagement-oriented science communication falls prey. It is, however, not essential to hold any sympathy with material semiotics to follow this study or its conclusions. I recognize that some portion of the audience for this thesis is likely to be unsympathetic to its theoretical grounding. Material semiotics recommends that we understand reality as constructed through practice: a thing becomes what it is through our interactions with it (Law & Lien, 2012; Mol, 2003). Consequently, unities can only be made out of multiply practiced realities through additional work to create those unities; stable assemblages that we commonly treat as single objects are the result of such work. The nature of those assemblages is then not inevitable. We can change what a thing is by practicing it differently.

Material semiotics is useful here because it highlights the necessity of *making* two sets of practices relevant to each other rather than assuming that knowledge generated through one set of practices can be transferred to another. Joining the metaphors of material semiotics and rhetoric of science suggests that writing science differently – because writing is a kind of practice – can make scientific research a thing more or less relevant to industry. A material semiotic perspective also insists on epistemically leveling scientific and industry knowledge, in contrast with the positivist argument that would privilege science above other ways of knowing about the world. This thesis is predicated on the assumption that the body of knowledge winemakers and growers develop through practical experience can and should contribute to constructing scientific claims as they address matters of industry practice.

Sympathy with this point – that science is not sole, superior, or universal knowledge, and that consequently the purpose of science communication cannot simply be to convince nondisciplinary (Fahnestock, 2008) audiences to like or believe or do more science – is a precursor to much of the argument put forth here. I would nevertheless offer that a pragmatic logical positivist might agree that behaving as though one's audience is comprised of knowledgeable professionals – even if you believe them to be ignorant and backwardly unscientific – is more effective in convincing them to listen to your science than transparently treating them as though they are ignorant and backward. If needs be, let my argument rest on that point: that treating other people and their differences with respect is a good way to encourage them to listen to you.

This introduction first maps out the relationships between this study and the disciplines from which it borrows. It then makes the case for why industry-oriented science communication should be thought of as a process of overlapping research and industry practices, constructing relationships between the two rather than transferring science to industry, and argues for the importance of rhetorical features of written communication in doing so. It concludes with a brief outline of the thesis as a whole.

Specific contributions

This thesis aims to make the following contributions to the scholarly literature:

- It is the first published investigation of wine industry practitioners' scientific information use from a co-constructive rather than an adoption-oriented perspective.
- It is the first published investigation of wine industry practitioners' scientific information use in the Washington State and New Zealand wine industries.
- It considers technology transfer as a science communication problem and suggests a revisioning of technology transfer paradigms through science communication concepts of extended expertise, participation, and their logical grounding in material semiotics.
- It addresses industry-oriented science communication as a unique rhetorical situation distinct from both peer-reviewed disciplinary science writing and popular science writing.
- It is, to the best of my knowledge, the first published study to consider improving industry-oriented science communication as collaboration by focusing on textual microprocesses.

Guide to the organization of this thesis

The remainder of this introduction outlines the theoretical and methodological framework uniting the chapters that follow and justifying the study as a whole. The subsequent four chapters describe the component parts of my two case studies, and the final chapter synthesizes findings from those studies. The four central chapters have been written as manuscripts for scholarly publication. Consequently, while I describe methods in overview and in their interrelations in chapter two, detailed methods for each segment of the study are located in their respective chapters. Also, in several cases appendices provide details included here in the interest of thoroughness but omitted for the sake of length in the original published/submitted manuscripts.

I ask the reader to keep in mind that each chapter was submitted for publication shortly after the work of that chapter was completed, and that those chapters are presented here in their published/submitted form (see Table 0.1) without additional revision. My ways of thinking about the study, the wine industry, and science communication have shifted significantly between the point at which I submitted what is now chapter three (October 2014) and the submission of the thesis (April 2016). Consequently, each chapter – and chapter three in particular – is not perfectly coherent with the theoretical framework presented in this introduction. In that respect, this thesis represents not so much as an end product as a trajectory.

Location in the literature

Table 1.1. Interdisciplinary location of this thesis*

	Industry as a public	Texts as rhetorical objects	Co-productive orientation
Science communication	No	No	Sometimes
Agricultural sociology	Yes	No	Sometimes
Rhetoric of science	Sometimes**	Yes	Sometimes
Technology transfer	Yes	No	No
Science and technology studies (STS)	Rarely	Rarely	Yes

*Generalizing from the dominant scholarly trends in these fields
**Rhetoric of science sometimes studies communication in science-industry partnerships, but rarely science communication *to* industry as a "public" or audience.

Science communication is a developing field, slowly consolidating a disciplinary center and still with fuzzy boundaries. This thesis lies closer to the boundaries than to the center. Science communication scholarship has historically concerned the most effective means of communicating scientific information to non-scientists – the public or publics in their various forms including the general lay population or "citizens" (reviewed in Riesch & Potter, 2014), decision-makers, and sometimes journalists – for purposes of general education and improving pro-science attitudes and actions (e.g., Borchelt, 2001; Davies, 2008; Edwards, 2004; Weigold, 2001). These studies have conventionally drawn their theoretical foundations from the positivist well, taking for granted that science is right, true, and valuable, and that the public needs or deserves to know about it (Kurath & Gisler, 2009; Palmer & Schibeci, 2014; Sturgis & Allum, 2004). Across the academy, the positivist well is becoming drier. An ever-increasing diversity of constructivist perspectives, notwithstanding the differences in their stances, all conclude in some way that scientific knowledge is socially constructed and therefore limited. Constructivist perspectives have begun to color science communication studies, with scholars asking more fundamental questions about science in society: *why* publics should know about science (e.g. Sturgis & Allum, 2004; Weigold, 2001), how publics can or should be involved in science (e.g. Quet, 2014; Whatmore & Landström, 2011), and what role public science communication occupies in social and political processes (e.g. Jaspal, Nerlich, & Koteyko, 2013; Walsh, 2015). The deficit model – variations on the theme that science has knowledge and the public is ignorant, but will agree with science once educated – has become everyone's favorite straw man against which they position their version of engagement, dialogue, or democracy (e.g. Mellor, Davies, & Bell, 2008; Smallman, 2016). However, science communication scholarship too rarely roots these new questions in new discussions of what science *is* (Wynne, 2008, 2014). Scholars ask questions about the place of science *in* society but continue to call, explicitly or not, on positivist assumptions that locate scientific knowledge *above* and *outside* of society. Consequently, many attempts at multidirectional knowledge sharing slide back toward the deficit model, where the rationale behind the enterprise remains that non-scientists suffer from science deficiency and need to know, agree with, and accept more science (Cook, Kesby, Fazey, & Spray, 2013; Kurian & Wright, 2010). In one sense, then, this study engages with science communication scholarship calling for more "engagement" with science, that is, for more and better points of contact between science and its publics (e.g., Davies, 2013; Michael, 2012; Rowe & Frewer, 2005). In another sense, it breaks with much of the engagement scholarship in science communication by being concerned not with whether the engaged public becomes more pro-scientific, but with whether useful connections are being made between scientific knowledge and other ways of knowing about the world.

Trends in science communication have also complicated the "public" in "public engagement." Publics are multiple and varied; they may already possess relevant knowledge; public listening and understanding is not equivalent to public agreeing and accepting; publics can and should have a voice in scientific conversations (Braun & Schultz, 2010; Marks, 2014; Mellor, Davies, & Bell, 2008; Miller, 2001; Stilgoe, Lock, & Wilsdon, 2014; Sturgis & Allum, 2004). This movement makes it possible to realize more detail in science communication audiences – the “them” we contrast against “us,” the communicators – which in turn allows us to make its members more real, to show them more respect, and to see how they act. The research presented here appeals to this splintering of publics by focusing on the unique characteristics of a splinter rarely addressed in science communication scholarship. Industry audiences are distinct both from scientists and from undifferentiated “lay audiences” with little if any specialized knowledge; industry practitioners certainly have specialized knowledge related to the performance of their profession, but are not insiders to the scientific community.

Industry members' ability to access and work with scientific knowledge is vital to the health of science, industry, and society at large. We assume that advances in scientific knowledge will improve industry work, and that those improvements will be passed on to consumers and users of industrial products. Those assumptions are embodied in the infrastructures built around funding and disseminating applied research. In the United States, science communication to agricultural industries, such as the wine industry studied here, has since the late nineteenth century been considered so important to national well-being as to merit a publicly funded agricultural “extension” service charged with that specific purpose.

Still, in schema describing the activities of science communication, industry groups remain conspicuously absent. Burns, O'Conner, and Stocklmayer (2003), offering a "contemporary definition of science communication" (p. 183), divide science communication "publics" into scientists, communicators, policy makers, and interested or disinterested members of the "general community" (p. 184); their outcomes for science communication involve understanding and appreciation, but not implementation as such. Kuehne and Olden (2015), suggesting areas of neglect in science communication, "have conceptualized the science media ecosystem" as scientists communicating to "the public," "managers/decision makers," and scientists in the same or other disciplines (p. 3585); industry members are, again, absent. Fahnestock's (2008) review of "the rhetoric of the natural sciences" (p. 175) includes a section addressing "nondisciplinary" audiences, but limits the discussion to scientists in other disciplines and readers of "various publications that are devoted to science" or "of mass media outlets" (p. 183). Industry groups are studied in terms of the "boundary-work" done between science and not-science (e.g. Hansen, 2011; Tuunainen, 2005) and potential "contamination" of scientific disinterest in the Mertonian sense by profit-motivated interests (e.g. Lawless & Williams, 2010; Tuunainen & Knuuttila, 2009; Mirowski & Horn, 2005) or problems of "asymmetrical convergence" (Smith-Doerr & Vardi, 2014; also Law & Akrich, 1994) in terms of their contribution to science policy (e.g. Simakova, 2012; Lave, Doyle, & Robertson, 2010). Scholars of the sociology of scientific knowledge (SSK) have outlined theoretical arguments for knowledge co-production among the "triple helix" of academia, industry, and government (Shinn, 2002;

see also Kleinman & Vallas, 2001; Vallas & Kleinman, 2008; Varma, 2000). But science communication scholarship largely ignores how science relates to industry communities as specific and unique publics or audiences for science dissemination. Wynne's (1992) exemplary case study of exchanges between nuclear physicists and Cumbrian shepherds – a specific professional audience – certainly involved industry-oriented science communication, but touched on the communication itself only incidentally in discussing social negotiations and public perceptions of “trust and credibility” (p. 281). The same general approach has been taken by subsequent science communication studies involving industry publics (e.g. Chilvers, 2013; Perlman, 2004; Suryanarayanan & Kleinman, 2012). Theories of science communication have continued to gloss over how theoretical considerations change in response to the exigencies presented by industry audiences.

Industry-oriented science communication as such is left as a concern for sub-disciplines in other scholarly traditions. Agricultural or “rural” sociology rose up alongside agricultural extension in response to the perceived need amongst government administrators and scientists for new techniques from the human sciences to persuade farmers[1] to follow scientifically supported practices (Röling, 1985; Ruttan, 1996). A critical tradition has in parallel rejected that “linear model” of transfer in favor of one or another co-constructive alternative (Noe et al., 2015). True to their sociological roots, these studies ask what “logics” or “institutions” describe farmers' uptake of new innovations (Leeuwis, 2004). Technology transfer studies have a similar object to describe, understand, and

[1] “Farmer” in the broadest sense of someone involved, usually professionally, in an agricultural enterprise.

improve the process of industry innovation, but a different disciplinary inflection: they study industries broadly rather than focusing on agriculture and stand in the lineage of business and organizational management scholarship (see, for example, the *Journal of Technology Transfer*). In that spirit of delivering products and value, recent reviews of "the evolving state-of-the-art in technology transfer research" (Bozeman, Rimes, & Youtie, 2015) continue to make the "transfer" of a product-oriented science their dominant metaphor for communication. Consequently, even as they suggest "participation" as means of improving product delivery through the research "pipeline" (Green, 2008), technology transfer paradigms conceptually preclude understanding science communication as a co-constructive process.

Science and technology studies (STS) also deals with relationships between science and industry. My theoretical orientation involving scientific co-construction, enactment in practice, and multiply practiced realities owe much to the STS camp, and in particular the material semiotics or actor-network theory of Law and Latour (e.g. Latour, 1999; Law, 1992, 2004) and the feminist practices of Mol (2003) and Haraway (1988, 1991). Though rhetorical methods are sometimes used in STS studies (e.g. Ashmore, Myers, & Potter, 1995; Bazerman, 1989; Myers, 1996; Woolgar, 1989), by placing texts as rhetorical objects at the center of my investigation, I align more closely with the traditions of writing studies and the "strong" rhetoric of science (e.g. Bazerman, 2000; Cecarelli, 2005; Fahnestock, 1989; Graham & Herndl, 2013; Herndl & Cutlip, 2013; Fahnestock, 1998; Myers, 1990; Myers, 1996).

As Graham and Herndl (2013) have observed, evidently from personal experience as well as in updating Ceccarelli's (2005) earlier literature review pointing to the same problem, rhetoric of science "engagement with interdisciplinary STS is not an unproblematic project. To be blunt, work by rhetoricians of science and technical communicators has not been well received by the larger STS community" (Graham & Herndl, 2013, p.105). While written texts are frequently implicated in STS concerns, and in science communication and technology transfer studies, internal features of the texts themselves are rarely a focal point. In much of STS, texts are *objects* in heterogeneously material-social networks (Law, 1992). In technology transfer paradigms, texts are *vehicles* for content. Science communication studies tend to extract content from texts, study the content, and discard their other functions. Rhetoric of science scholarship, in contrast, picks up those more-than-content features and shows them to be essential components of what texts do. Rhetoric of science has explored the more-than-content activities of the peer-reviewed research article, communication amongst scientific disciplines, and science "popularizations" (Fahnestock, 2004; Myers, 1990). Popular science communication, however, has been defined negatively as "not-disciplinary" (Myers, 2003), leaving industry-oriented science communication as a distinct third category out in the academic cold.

Bazerman (2000), Myers (1990), Shapin (1985), Gross (1996), Prelli (1989), and Latour and Woolgar (1989), among others, have all developed accounts of how rhetoric contributes to the production of scientific knowledge through disciplinary science writing.

Some rhetoricians of science (e.g. Alaimo, Bean, Langenhan, & Nichols, 2009; Bazerman, 2000) consider how informal science writing lies upstream of formal publications. Others, speaking of the relationship between peer-reviewed and popular science, argue against the idea of a stream at all in favor of a more complex and multidirectional network of communication (e.g., Fahnestock, 2004; Latour, 1999; Myers, 2003). Fahnestock (1989, 1998, 2004), Walsh (2010), Perrault (2013), and others have asked how popular science writing changes or preserves scientific meaning. And yet, even as rhetoric of science expands outward from the peer-reviewed scientific article, industry-oriented science rhetoric receives little attention. None of these accounts has addressed how other "downstream" or non-disciplinary forms of science writing contribute to scientific knowledge production, or whether or how the principles of disciplinary rhetoric apply to industry-oriented communication. Even as rhetoric of science studies subvert the illusion "that matters of fact are not man-made" (Myers, 1990, p. 23), they have largely permitted a different illusion to persist, that matters of fact are decided by scientific men and then transmitted to others in popularizations.

Recent work by Herndl and his collaborators has challenged those assumptions, questioning how interdisciplinary groups of researchers and industry practitioners make common understandings in conversations that juxtapose disparate discourses and epistemologies around common objects: classified air defense systems (Wilson & Herndl, 2007), pain (Graham & Herndl, 2013), or sustainable farming (Herndl et al., 2011), for example. Graham and Herndl's (2013) exploration of verbal blending of disparate discourses around pain management as a juxtaposition of multiple ontologies, in particular, resembles the theoretical framing of the study presented here; those authors and I both argue for the utility of applying STS-derived theories of material semiotics to rhetorical problems. While I share Graham and Herndl's (2013) approach to joining material semiotics and rhetoric of science, the present study questions the two-dimensional meeting of epistemically disparate communities in written communication rather than in spoken discourse.

This thesis thus sits in a gap at the edges of conventional public science communication oriented toward increasing public knowledge and altering public attitudes, conventional technology transfer oriented toward maximizing adoption and practical return from the research-industry pipeline, and conventional rhetoric of science studies oriented toward how meaning is made or preserved in peer-reviewed or popular science writing. I address industry practitioners as an important "third public" for science communication, distinct from both scientists and the general or lay public. I also ask what texts do*,* not as carriers of content but as strategic mediators of relationships, that is, as rhetoric – strategic language (Bazerman & Prior, 2003) – and discourse – language as social action (Fairclough, 1992). These are science communication questions in that they are fundamentally about sharing science with audiences outside the scientific disciplines. Moreover, these questions of how scientific and industry communities meet in written communication benefit from science communication scholarship and theories of public(s) participation developed therein.

1.2 Theoretical framework

To say anything about desirable relationships between scientific knowledge and industry practice, I must first say something about what science is and how science relates to the rest of the world. Working from the position that science is constructed in practice, with no special access to universal truth and therefore no inevitable authority over other knowledge systems, I argue that work can and should be done to make science relevant to industry and that the rhetoric of industry-oriented science communication is an essential part of that work. I conclude that relevance is a more appropriate lens than adoption for assessing industry-oriented science communication, and that creating relevant texts implies creating collaboration-building texts that work against one-way transfers of scientific knowledge. In framing this argument, I borrow from the material semiotics tradition in science and technology studies and from scholarship in rhetoric of science, joining them via discourse as the practice of language as social action, and applying the result to critique conventional paradigms of communicating science to industry.

Scientific knowledge is constructed in practice among many diverse actors

Many arguments have been advanced in support of scientific knowledge being created, not discovered (e.g. Bourdieu, 1975, 1990; Collins, 1975; Guba & Lincoln, 1989; Kuhn, 1962; Latour & Woolgar, 1986). Guba and Lincoln (1989), writing about assessment practices for a broad audience, catalogue an extensive list of “the variety of fields in which issue is being taken with scientific positivism and proposals for redirection are being made”

(p. 45). Their functional argument for why positivism is inappropriate grounds for evaluative studies also provides grounds for why positivism is inappropriate grounds for science communication.

Discarding positivism does mean, Guba and Lincoln (1989) acknowledge, giving up the comforting purposefulness of research that can arrive at objective truth, the control the trained researcher has in being the expert equipped to find that truth, and the efficiency of devising generalizable “interventions” (p. 46) that remain correct independent of changing contexts. Still, their list of advantages for adopting a constructivist perspective is longer. First, constructivist perspectives make valuing non-researcher stakeholder perspectives possible. Non-researcher stakeholders are knowledgeable people who will use the results of an investigation, who are vulnerable to “exploitation, disempowerment, and disenfranchisement” (p. 52) when decision-makers exert power over them without accounting for their perspectives, and who should therefore be meaningfully involved. Conventional positivist paradigms make no space for considering any perspectives other than that of the objectively accurate scientist/investigator because (so it goes) personal perspective is irrelevant to arriving at true conclusions. Relatedly, conventional positivism depicts the creative phases of science that occur in advance of formal hypothesis-testing as being essentially outside science and thereby ignores that a fundamental part of the scientific process is indubitably dependent on perspective and context. Conventional positivism deals with the mess of context by controlling it into non-existence and thereby creating statements valid in “other contextless situations” (Guba & Lincoln, 1989, p. 60) but incapable of accounting for the variety of contextual factors present in every real site of application. Conventional positivism presumes that facts are independent of values, but this assumption does not hold with the inescapable dependence of "fact" on appropriate context: facts only describe reality accurately in light of the theories on which they are predicated; they are not independently "real" (p. 64), but are value-bound and value-dependent. Facts and the fact-maker are not independent.

In short, assuming a positivist stance toward scientific knowledge – that scientific knowledge is objectively correct, generalizable, and value-neutral – subjugates non-scientist audiences, be they "citizens" or industry members, to the dominance of the unquestioned perspectives on which science is predicated. Stating that science is objective truth which non-scientist audiences should accept and with which non-scientist audiences should agree is effectively to state that the values of science are simply superior to the values of everyone else. This sort of ideological violence is wholly out of line with the tenets of contemporary science communication that we should treat non-scientist audiences with respect and as active parties who can and should participate in the knowledge-making activities that structure their experiences.

For understanding how science communication constructs relationships amongst science and industry, a particularly useful constructivist paradigm comes from Latour's description of science brought into being via the circulation of immutable mobiles through an actor-network (Latour, 1986, 1999). Latour, as a sociologist and philosopher of science, wanted to understand what made science special and found it unreasonable to imagine that scientific training makes scientists radically different, smarter people. Explaining the shift from prescientific to scientific society as essentially a human gain-of-function was, to his mind, too complicated; allowing the difference between science and not-science to remain an unquestioned dichotomy was too simple:

> All such dichotomous distinctions can be convincing only as long as they are enforced by a strong asymmetrical bias that treats the two sides of the divide or border very differently. As soon as this prejudice loses hold, cognitive abilities jump in all directions: sorcerers become Popperian falsificationists; scientists become naïve believers;...These quick reversals prove that the divide between prescientific and scientific culture is merely a border—like that between Tijuana and San Diego. It is enforced arbitrarily by police and bureaucrats, but it does not represent any natural boundary. (Latour, 1986, p. 2)

Law and other scholars of scientific knowledge would later respond that appealing to arbitrary cultural norms – to consciously share in values common to society – can be valid and valuable so long as we do not take the additional step of assuming those norms to be singular or inevitable. Latour, however, was still pursuing the quandary of how Western science has greater powers and further-reaching effects than earlier, evidently (to that frame of mind) more primitive knowledge systems:

> We have to steer a course that can lead us out of a simple relativism and, by positing a few, simple, empirically verifiable causes, can account for the enormous differences in effects that everyone knows are real. We need to keep the scale of the

> effects but seek more mundane explanations than that of a great divide in human consciousness. (Latour, 1986, p. 2)

The course he devised, through empirical observations of laboratory work and the movement of scientific knowledge through time and space, led to immutable mobiles.

Latour's (1986) immutable mobiles are the pivot point in scientific production. Through "inscription devices" (p. 7) – experimental apparatuses in their myriad forms, including the properly trained and configured scientist – scientists convert physical materials into statements. The conversion allows observations to be made into data, extracted from context and "mobilized:" able to be picked up, moved around and, most importantly, accumulated without change. An immutable mobile is, therefore, what an observable phenomenon becomes when flattened from three dimensions into a situationally independent two-dimensional set of parameters.

Scientific knowledge is consequently made, to greatly simplify Latour's explanation, in three operations. Appropriately flattened observable phenomena are lined up and compared. Generalizations[2] are made about the set. Those generalizations are offered up for evaluation and accepted into the body of valid scientific knowledge if they mobilize

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[2] I self-consciously use a passive construction here to highlight the word "generalizations" by making it the first word in the sentence. An alternative construction, "scientists can then make generalizations," emphasizes the agency of the human scientist in creating order from data. That construction emphasizes that the generalizations must be *made*, but also risks overemphasizing the freedom any individual scientist has in making. I prefer the passive construction not only for its service to the narrative continuity of the paragraph, but because it focuses attention on the movement of the generalization rather than how the generalization comes about. Had I followed the conventional preference for the active voice in service of readability I would have made a different decision; had I followed the scientific convention for the passive voice, I would have made this decision unself-consciously. Similar small rhetorical choices, often governed by rule or habit, become important to understanding how texts construct research-industry relationships in later portions of this thesis.

sufficient supporters amongst a sufficiently authoritative scientific community (Bourdieu, 1975; Latour, 1986; Latour & Woolgar, 1986). The first half of the process constructs what eventually becomes science through how scientists choose to simplify complex and situated phenomena and what their chosen inscription devices make it possible to observe and preserve. The second half of the process constructs what eventually becomes science through how the scientific community, as subject to politics and its own constellation of accumulated peculiarities as any community, chooses to ratify as valid scientific knowledge versus experimental error, outworn paradigm, or pseudoscience. Extending the process to a third component – albeit a "component" that pervades the previous two rather than being ordered after it – scientific knowledge is shaped not only by its physical modes of production inside the lab or by conversations in the scientific literature, but by how scientific interests "circulate" through their many wider entanglements with other elements of society. Ultimately, circulation through the many heterogeneous (human and non-human) "actors" of this tangled, non-linear "network" makes scientific knowledge (Latour, 1999). Understanding what science is follows from understanding what science does, which is largely about understanding where science goes.

Latour (1986) liked these "materialist" and "parsimonious" explanations via "writing and imaging craftsmanship" (p. 3), it seems, because they are modest and empirically derived. I like them because they are proximal and direct: they are the instruments through which scientists work; those instruments and that work can be manipulated. Science moves and acts through written texts; writing is a malleable process.

For much the same reason, I draw the guiding metaphors for this study not from Latour's actor-network theory alone, but from its development in the material semiotic tradition of feminist STS. I draw upon these metaphors not because they are timely (though they are), nor because I think them more correct than the alternatives (thinking them fundamentally superior would be hypocritical), but because they are useful to visualize and enable manipulating the relational effects of communication in which I am interested. By visualizing the relational effects of communication as a reality-constructing practice, material semiotic metaphors visualize a point of intervention through which research-industry relationships can be practiced differently.

The material semiotic tradition refocuses attention from what objects are to what (human and non-human) actors do, and in so doing redefines objects in terms of practices (de Laet & Mol, 2000; Law, 2004; Law & Lien, 2012; Mol, 2003). What we call objects are “assemblages” (Law, 2004; Mol, 2003; Star, 2010) or “networks that hold together for long enough to act in relation to something else” (Law, 2008, p. 632): sets of practices whose relations to one another are temporarily practiced in relatively stable, recognizable ways allowing us to treat that set of practices as a feature of reality. By changing our practices, therefore, we can change the nature of reality. Mol can ask what is a *good* way to practice disease (2003) or medical care (2008), and I can ask what is a *good* way to practice wine science. All three questions rest on normative definitions of “good:” as improving quality of life, as creating systems that treat people well (as Mol asks us to intuitively recognize by telling us stories of people who are content and people who are discontent), or as employing science to address larger social problems. In other words, material semiotics insists that we replace questions of what *is* with what would be *good to do*, simultaneously freeing us from the necessity of accepting things as they are and burdening us with the responsibility of imagining things as we want them to be. By changing our practices, we destabilize the assemblages out of which objects are made and open up the possibility of re-forming them in new ways.

Material semiotics thus responds against positivism in all its forms and, also, against classic social constructivism. Classic social constructivism replaces the universal, unchanging laws of nature with universal, unchanging laws of society (Law & Lien, 2012). In the European Middle Ages, the Christian God imposed order on reality. In the Enlightenment, the divine consciousness of Man replaced God. The (so-called; Shapin & Schaffer, 1985) scientific revolution replaced Man with Nature, and the contemporary era has been replacing Nature with Society. For the relativist, material semiotics is useful because it steps away entirely from the idea of universal orders emerging from any of these points and insists that the universe need not be coherent at all (an idea, as Law has observed on many occasions, which may be alien to Western traditions but has long been part of Eastern ones). The nature of reality can differ without conflicting, and multiple constructions can be valid without ordering one as the "real" world to the exclusion of others (Guba & Lincoln, 1989; Star, 2010).

I employ material semiotics not for its aid to relativism, but for its particular utility in studying written texts. Refocusing on practice steps away from the "irresolvable and unproductive” (Graham & Herndl, 2013, p. 110) debate over the relationship between linguistic representations and things as they really are because linguistic representations are also practices which construct realities. We can therefore ask how two texts differently practice reality rather than questioning which of two texts is a better representation of an external, fixed reality taken to somehow exist outside language. A material semiotic view of written texts is therefore compatible with a discursive view of language use as social practice (Fairclough, 1992; Foucault, 1969) and a rhetorical view of texts as having relational functions beyond content transmission[3] (Bakhtin, 1975/1981; Bazerman, 2013; Carey, 2009; Silverstein, 2004).

Refocusing on practice also permits stepping away from questions about text versus context and with which one the writing scholar should begin (a weak point in discourse analysis particularly attacked by Blommaert, 2005, and a perennial problem in writing studies highlighted, for example, in Bruffee's classic 1986 review). A material semiotic response to the text-context binary insists that the text both produces and is produced by its context: context is comprised of interconnected material practices, of which the text in question is one; by focusing on the practice, one need not begin with either the text or the context but may fold them together. The result may be messy. Law's (2004) treatment of social science research methods “divest[ed]” of “'singularity': the idea that indeed there are definite and limited sets of processes, single sets of processes, to be discovered if only you

[3] It is worth noting at this point that this study differs from the two other published studies of science communication to winemakers and wine growers (Boshoff, 2014; Hill et al., 2015) as well as from other studies of research utilization in science communication (e.g. Landry, Amara, & Lamari, 2001) because it does *not* focus on the efficacy of science communication texts as transmission devices.

lead a healthy research life" (p. 9) is entitled "After method: Mess in social science research." Law asserts that mess is essential to scholarly research because reality itself can be messy. Understanding, describing, and manipulating the messy, multiply practiced world means embracing its messiness and allowing for messy research practices, not imposing order in accord with any one predefined theory about the way things really are – or, rather, the way we insist they must be.

Law's exhortation to messiness poses two specific problems for writing research and for this thesis. The first is that scholarly Standard American English is ill-suited to talk about messy, fluid, assembled things. "Ordinary" words often need to be understood in multiple ways simultaneously, which can be confusing in light of some expectations for orderly scholarship. Star (2010), for example, observes that the "object" in her concept of the "boundary object" must be taken both in the "ordinary" as well as a technical sense as a thing which derives its objectivity from what people do with it rather than from some inherent property or quality: "So, a theory may be a powerful object" (p. 603; see also Carolan, 2013). Butler (1988), speaking of performative constructions of gender, speaks of "unfortunate grammar" and the desirability of "a vocabulary that resists the substance metaphysics of subject-verb formations and relies instead on an ontology of present participles" (p. 521). Material semiotic STS redefines and multiplies words frequently, to the mutual frustration of authors who feel compelled to bracket "ordinary" words in quotation marks and journal editors of the Order of the Strict Observance of APA who feel compelled to remove them. "We are in a sense," as Star (2010) observes, "stuck with using

Newtonian language for quantum phenomena" (p. 603). Dealing with this potential for confusion relies in trusting in the discursive formations (Foucault, 1969) on which terminology and citations call to recreate productive contexts for interpretation.[4]

The second is that material semiotic STS claims to be an essentially descriptive enterprise (Law, 2008, 2009), and here I wish to be both descriptive and prescriptive (a dual function which rhetoric of science studies embraces; see, for example, Bazerman, 2000; Gross, 1994; Herndl & Cutlip, 2013). Material semiotic STS advocates that because of the tight and messy ties between context and practice, theories must be developed in context (Law, 2009). Mol would have me follow winemakers through how they make and exchange knowledge, dispensing both with generalities and with scientists inclined to make them. I know this because Dr. Mol told me so when I was six months away from finishing this thesis (and thus, for better or worse, in no position to so dramatically recalculate my trajectory; A. Mol, personal communication, December 3, 2016), but also because STS theory never treads too far from its examples (Law, 2008, 2009; Mol, 2003, 2008). This thesis holds with this STS tradition insofar as it works through two case studies, which I offer not as representatives of any group but as useful for thinking about other cases. The thesis breaks with that same STS tradition in using case studies to reflect on an essentially structuralist view of language; I make claims about how language works in general where the STS mold would have me follow what any one written text does as it moves through places and amongst people. Latour (2005) exhorts, "follow the actors themselves" (p. 12).

[4]A strategy most important to this thesis in chapter four, thanks to a journal editor unsympathetic to the "ironic" quote and where, consequently, I may have enabled meanings that I had hoped to discourage.

My lead actors are the texts, and instead of following them through space I make the distinctively writing studies move of studying them as they sit in one place, exploiting their stillness to sit down with them and take them apart (Myers, 1990). In doing so, I would argue, I focus on the texts as practices by practicing the texts myself – in what I hope is a "well informed and sophisticated" and therefore valid way (Guba & Lincoln, 1989, p. 58) – rather than collecting many different individuals' textual practices and developing networks of social relations in my effort to order them.[5] While I begin with material semiotics, I end up in rhetoric of science, relying on properties of language and drawing on the work of rhetoricians and applied linguists – Bazerman, Myers, Hyland, Fahnestock, Herndl, and others.

Scientific knowledge is discursive

Latour hesitated to let texts themselves carry too much theoretical weight. He dismissed the "strategy of deflation" that would replace universal narratives with "sets of skills to produce images, and to read and write about them" as unreasonable, insisting that these might be "important *asides* of the scientific revolution...but they certainly cannot be sufficient causes. Certainly not" (Latour, 1986, p. 4). Latour may be speaking ironically, but here and elsewhere (e.g. Latour, 1996; Latour & Woolgar, 1986) his argument begins from the position that scientific knowledge production is social at its roots, effectively demoting texts to servants of the sociological tradition. In the absence of a stronger argument, I am

[5] Also useful, but not a goal I tackle here, in my efforts to think about the shape of a collaborative rhetoric of industry-oriented science rather than to conduct an assessment of a particular science communication program.

inclined to ascribe Latour's unsubstantiated dismissal of the rhetorical tradition as "a worse kind of mysticism" (p. 4) to his biases as a sociologist. Though texts were central to Latour and Woolgar's (1986) seminal ethnography of a physiology laboratory, he was more interested in the social processes surrounding text production than in internal features of the texts themselves. As a writing studies scholar, I am uninterested in making texts powerful outside their social contexts of production. However, written texts function on many levels beyond material object of exchange or neutral, transparent conveyors of content. They have many, complex, and changeable internal working parts that contribute to what the text means and what it does as a social object. Rather than "black box" (Latour, 1987) texts and treat them only as objects of exchange, texts and the details of their internal working parts deserve a more prominent place in studies of scientific knowledge and science in society.

Not all knowledge involved in scientific activities is constructed in writing. Scientific knowledge as a body of knowledge shared and ratified by the scientific community, however, *is* constructed in writing. The recent work of architect-turned-anthropologist Trevor Marchand (2003, 2010), for example, and other scholarship in social anthropology, asserts that knowledge has extralinguistic, embodied components communicated through movement or incommunicable altogether. Much like the builders Marchand studies, scientists perform craftwork involving embodied knowledge (Carolan, 2008; Haraway, 1988; Myers, 2008) outside what can be conveyed in scientific journal articles. During one of my summers as an undergraduate researcher in a bacterial genetics laboratory, I worked with a technician who had developed a protocol for extracting bacterial RNA in the days before this technology came conveniently packaged in a box with instructions resembling a boxed cake mix. Successful extraction, as Dan showed me while standing over the vortexer at his bench, depended on how the plastic Falcon tubes containing phenol and bacterial homogenate were mixed. When requests arrived from other labs, Dan tried to convert the necessary motions in words, but technicians hundreds or thousands of miles away were unable to convert those words back into successful motions. Eventually, Dan had to be shipped to those other laboratories to share his embodied knowledge in person. He was unable to make his technique travel outside the lab in words.

Dan could share his extralinguistic knowledge, but its range was limited; money and time allowed for shipping Dan to only so many places. For that knowledge to become the cake mix-style RNA extraction kit that has so successfully colonized bacterial genetics labs around the world, someone else's embodied tube-manipulating knowledge had to be converted into words able to be widely shared and communally validated. Dan's knowledge was properly craft knowledge, not scientific knowledge, if we define scientific knowledge as the body of statements ratified as scientific by the scientific community authorized to do so (Bazerman, 2000; Collins & Evans, 2002; Delamont & Atkinson, 2001; Lyne & Howe, 1990; Myers, 1990). While many different kinds of knowledge are involved in doing science, knowledge becomes scientific only when recognized as such by the authoritative scientific community (Bazerman, 2000; Bourdieu, 1975; Latour & Woolgar, 1986; Myers, 1990; Shapin & Schaffer, 1985; Zuckerman & Merton, 1971). And while British gentlemen once gathered to witness experiments at the Royal Society (Bazerman, 2000; Shapin &

Schaffer, 1985), the now-highly distributed scientific community exchanges and argues via scientific publications while initial community judgments have been formalized in pre-publication peer-review (Bazerman, 2000; Myers, 1990). Whether a claim persists as part of accepted scientific knowledge rests on its reception by and reproduction in subsequent publications. Publication in words is the necessary precondition to that scholarly conversation. The published form is the form in which a claim is later reproduced. No more essentially true scientific claim exists behind the text. How would anyone in the scientific community know what that essential claim is? The text is the claim. How science is written, indeed even at the level of specific words and turns of phrase (e.g. Baake, 2003; Bazerman, 2000; Fahnestock, 1989, 1998; Kopple, 2002; Myers, 1990; Walsh, 2010, 2015), is how scientific knowledge is shaped as a body of knowledge able to be ratified, shared, and perpetuated.

Written texts constitute the social spaces (Bazerman & Prior, 2005; Silverstein, 2004) in which negotiations occur about the value the scientific community will attribute to a claim, both before and after a claim is published, in the exchanges of pre-publication review and in how a claim is discussed and reproduced after its publication. Writing also constitutes the nature of the claim itself: the only claim that can be discussed and practiced is the claim that exists in shared language. There is no other claim. The same principle, that science is written, holds true for science communication to non-disciplinary communities. When the primary contact extradisciplinary communities have with science is via written texts – as is often the case (Dahl, 2015) – those texts constitute science in its extradisciplinary movements just as much as disciplinary publications constitute science for other scientists. An audience, disciplinary or otherwise, has only the text, not some fundamental scientific concept hidden behind the text. This is not at all to say that scientific claims are independent of the world outside the text. Claims are the product of sociomaterial networks such that the nature of possible claims is moored to extratextual physical and social practices; their scope of possibility is constrained (Latour, 1999; Law, 2004). But the claim – *as it exists as knowledge that can be discussed* – is made in the text.

Texts do not magically contain One True Meaning that can be unlocked with a pure heart and disciplined training. Writing can only (and must, inescapably) be made to mean something when it is read (Fish, 1980; Nystrand, 1989). A text can be read in many different ways, and while some readings may be more valid than others in light of a particular community's norms, none constitutes the essential or true *ur*-meaning of the text. Again, how would anyone know what this reader-independent meaning is? A reading is a product of the text and a reader; meaning is produced in front of the text, *between* the text and the reader (Fish, 1982; Roth, 2001). A reader cannot make any given text mean anything and everything (Nystrand, 1989); the range of available options is constrained by the properties of the text, the preexisting knowledge of the reader, and the many social influences surrounding the reader's knowledge: her education, the communities to which she belongs, what she knows about the author, where she found the text, the context in which she is reading it, and much else. Texts are always necessarily made and read within communities that predispose their meanings (Bakhtin, 1975/1981; Fish, 1982; Foucault, 1969). Making meaning with written texts is tied up in the same kind of sociomaterial tangle Latour (1999) described behind scientific knowledge; knowledge production in both cases is constrained by materials, but also by myriad non-linear social networks extending beyond the scientist or the reader.

A rhetorical theory of scientific knowledge – science is constructed through texts, which are meaningful through the interaction of text and reader – is therefore compatible with Latour's circulatory actor-network system and with material semiotics. Texts are part of scientific actor-networks and, in contemporary science, the main vehicle in which scientific knowledge circulates. Texts are not fixed objects but are themselves assemblages of meanings, each produced with the text by a reader with the involvement of yet other actor-networks. Making meaning with a written text is a situated practice. Readers perform a reading (Bazerman, 2003). Those readings need not all be coherent, but are different ways of practicing or performing the text in different settings out of which we create a unity to say "the text means X" by doing mental work to assemble and order those readings (Law & Lien, 2012).

Latour (1986) asks when we can reasonably expect changes in "writing and imaging procedures to make any difference at all in the way we argue, prove and believe" (p. 4). The writing scholar responds that changes in writing (in words or in images) are intrinsically, inescapably part of changes in arguing. The scientific community argues in language. Changes in writing change what knowledge is made and can be made through deliberations which produce additional texts. Changes in writing also affect the writer, and how the writer makes meaning with her own and other texts. Because the act of producing text is tied to thinking, writing changes the writer's ability to make meaning as a reader (Emig, 1977; McLeod, 1992; Vygotsky, 1989).

Changing writing therefore makes a difference in three ways. First, writing constitutes the material text with which a reader can make meaning. Second, writing shapes the writer as a performer of readings and an instrument for making meaning. Third, writing contributes to the sociomaterial networks through which social bodies of knowledge are constructed and which serve as the context for additional productions of texts and readings. Changing the rhetorical features of a text alters scientific knowledge production through a direct material effect, an indirect social effect, and a cognitive effect on an author who then again herself is an actor in the social contexts of scientific knowledge production.

The question is not whether writing makes a difference, but what kind of difference writing makes. Latour (1986) argues that writing is important insofar as it mobilizes supporters and aligns forces on the side of a particular argument. This straightforwardly persuasive simplification of textual functions was an adequate summary of the difference writing makes for Latour's war-modeled solution to how Western science has conquered the world. Unsimplifying texts, opening them up to understand how they construct relationships more complex than winners and losers, enables my search for a solution to how *not* to make war between science and the rest of the world. Latour wants to know how science compels. I want to know how science collaborates.

Discursive distinctions between scientific and industry knowledge

Here I would seem to arrive at a problem. I am interested in how written science communication texts relate science and industry and thereby facilitate or create space for knowledge-sharing and collaboration. And yet if scientific knowledge is constructed through socially dispersed networks, clear lines separating scientific knowledge from industry knowledge blur. Industry members are already, necessarily scientific collaborators; industry knowledge is already, necessarily tied up in producing scientific knowledge. When a vine pathologist conducts a study of new protectants against viral trunk disease and uses commercial vineyards as field test sites, her experimental results are altered by how vineyard managers have trained their vines and the fungicide regimens they employ, by how any given Mexican (in Washington State) or Vanuatuan (in New Zealand) labor team has pruned the vines, and by what varieties a wealthy doctor or fourth-generation landowner chose to plant. Conversations between the grower and the scientist further shape how the scientist draws her conclusions. Scientists devise experiments informed by industry problems, conversations with winemakers, and their experiences in the field. Scientific knowledge in turn becomes embedded in industry. Winemakers and growers pursuing job-related university degrees (as an increasing number do) take courses in microbiology, organic chemistry, and plant sciences. They consult science textbooks, read articles about new research, and attend workshops at which scientists present. Established scientific knowledge and new scientific research guides winemaker and grower decision-making and provides new ideas for practical trials in ways that are not easily traced. Scientific and industry knowledge circulate and mingle in the field, in the laboratory, and in administrative bodies which mediate interactions between the two communities.

Common sense interrupts this train of thought, as does the idea of discourse communities (reviewed in Porter, 1986). Even as scientific discourse "intersects" and mingles with other discourses, we can recognize categorical differences between scientists and winemakers/growers and the "primary discourse(s) of knowledge production among specialists" (Bazerman, 1998, p. 385); categorical differences are what make the terms themselves usable. Differences are easy to see in what scientists and winemakers do, the kinds of knowledge they require to do their jobs, and the kinds of knowledge they produce. Scientists make research papers. Winemakers make wine. Scientists are chiefly concerned with building scientific knowledge, earning grants, sustaining their laboratories, and building their reputations. Winemakers and growers are chiefly concerned with building organoleptically enjoyable objects, customer bases, profits, and (too) their reputations. Scientists' and winemakers' practices differ, and so do the communities through which they exchange and validate shared knowledge. Scientists and wine industry members interact and exchange knowledge, but remain different groups. And, importantly, the groups themselves employ this distinction: the many scientists, winemakers, and growers with whom I have spoken use these terms unproblematically.[6] Asking what role winemakers and

[6] Unproblematically in terms of the distinction amongst scientist, winemaker, and grower. A debate over what we should call people who tend vines perennially rumbles through the wine industry community with various arguments in favor of grape grower, wine grower, or *vigneron*, indicating different positions on what part the grower plays in a finished wine. "Winemaker" incurs less debate, notwithstanding the lengthy heckling I received from a commenter named "Isotope" about using "winemaker" as a human job title rather than attributing it to *Saccharomyces cerevisiae*, the workhorse yeast responsible for the physical work of fermenting grape sugar into alcohol, on *Palate Press* in 2010 (Szymanski, 2010). "Scientist," as a term or a title, seems to generate little debate in the wine community.

growers play in scientific research is, in this community, a sensible question.

Bakhtin gave such differences theoretical shape in his coneptualization of the discourse community. For Bakhtin (1975/1981, 1986), language is constructed not in individual words or texts but in interactions amongst language users. Statements – “utterances,” in Bakhtin's lexicon – are always, inevitably made in a social context which both constrains the possible nature of those utterances and provides a context for their interpretation. All texts imply the existence of preceding texts which make interpreting any one text possible. Together, sets of texts related by “actual social life and historical becoming create within an abstractly unitary national language [e.g., English] a multitude of bounded verbal-ideological belief systems” (1981, p. 288) representing “specific points of view on the world, forms for conceptualizing the world in words, specific worldviews, each characterized by its own objects, meanings, and values” (p. 292). These discourses include:

> a *professional* stratification of language, in the broad sense of the term “professional”: the language of the lawyer, the doctor, the businessman, the politician, the public education teacher and so forth...These languages differ from each other not only in their vocabularies; they involve specific forms for manifesting intentions, forms for making conceptualization and evaluation concrete. (Bakhtin, 1975/1981, p. 289)

Foucault (1969) elaborates on how these stratifications take shape (and therefore how they can be reshaped) via “discursive formations:” statements accumulate or sediment over time and form, in their relationships with historical moments and each other, networks of codependencies such that all statements exist within and are determined by an "enunciative network." Scientific and wine industry knowledge can be understood as the shared knowledge-making "discursive practices" (Foucault, 1969, p. 117) of discourse communities distinguished by their patterns of sedimentation over time and space. Discourse theory thus makes sense of drawing science-industry distinctions and forms a bridge between material semiotics and rhetoric of science studies in that discourse makes language social *practice* (Fairclough, 1992).

I could break those discourse communities down further. Scientists come from many sub-communities with different points of view, as do winemakers and growers. But resolving these communities at a higher power is not helpful for this analysis. My question is how science communication relates scientific and industry work as categories of contrastive practices. For these purposes, a scientific knowledge statement is distinguished in two ways: by its reference to the shared body of scientific expertise, and by discourse markers signifying that the speaker/author is speaking as a member of the scientific community. A wine industry knowledge statement is likewise distinguished by its reference to industry expertise and by discourse markers signifying the speaker/author's membership in the wine industry community. When the question is how science communication relates scientific research as one type of group of practices to industry work as another, however, whether knowledge belongs to a scientific or an industry discourse is the important question. For my purposes, a scientific knowledge statement is distinguished in two ways:

by its reference to the shared body of scientific expertise, and by discourse markers signifying that the speaker/author is speaking as a member of the scientific community. Those special characteristics of scientific discourse, in general and as they differ among disciplines, are a favorite topic in the rhetoric of science literature (e.g. Bazerman, 2000; Fahnestock, 1989, 1998; Gross, 1996; Kopple, 2002; Knorr Cetina, 1999; Myers, 1990; Prelli, 1989; Walsh, 2010; Yearley, 1981). A wine industry knowledge statement is likewise distinguished by its reference to industry expertise and by (much less thoroughly studied) discourse markers signifying the speaker's or author's membership in the wine industry community.

In practice, I can consider that scientists make scientific knowledge statements and industry members make industry knowledge statements because their rhetorical framing implicitly references these respective discourse communities. In theory, any individual could practice in both communities. Some wine industry members do play multiple roles crossing the scientist-winemaker/grower boundary; the occasional wine scientist also makes wine or grows grapes. Such individuals may at times speak as scientists and at times as winemakers, performing one role or the other via vocabulary, syntax, medium, and other markers. However, the same qualification applies to every scientist and winemaker inasmuch as they perform other roles outside their professional capacity. A bacterial geneticist is not making a scientific statement when she tells her daughter that it's bedtime; she may not even be making a scientific statement when she speculates about water on Mars or some other scientific phenomenon outside her specialty if she is not commenting from her professional expertise. Because my focus is expressly on professional communication, such boundary-crossing and alternate role-playing statements end up being insignificant: I am only examining statements that individuals make in their professional capacities.

All discourses construct bodies of shared knowledge by transforming complex, four-dimensional experiences situated in time and space into utterances with less detail that can be remembered and retold (Latour, 1986; Leeuwis, 2004; Noe et al., 2015). How details are characteristically lost or preserved determines how a discourse constructs reality, the unique patterns formed in its sedimentation, and what can be seen through it. Utterances in scientific and wine industry discourses may flatten the "same" experience in two different ways, constructing different pictures with different blind spots. These simplifying choices reproduce and consolidate their discursive institutions (Bahktin, 1988; Noe et al., 2015). Scientific utterances build more science but do not necessarily preserve the details considered important for enacting realities within an industry discourse, and vice-versa. Consequently, distinctions between scientific and industry knowledge become not only possible, but important. Scientific knowledge cannot simply be translated into industry discourse or vice-versa because the two discourses have systematically different affordances; they practice and pattern the world in systematically different ways.

A note on terminology: what I call "industry knowledge" (and, at other points in this thesis, "industry experiential knowledge") is similar to what other authors term "experiential," "anecdotal," "practical," and "indigenous" (in the sense of local; e.g.

Watson-Verran & Turnbull, 1995) knowledge. I prefer "industry knowledge" because that term avoids connoting that industry knowledge is inherently inferior to science, as "anecdotal" does (Moore & Stilgoe, 2009; Suryanarayanan & Kleinman, 2012). "Industry knowledge" avoids suggesting that scientific knowledge is not derived from practice, as "practical" does. It avoids contrasting scientific knowledge as Western knowledge against non-Western autochthonous knowledge systems historically presumed to be inferior in development studies, as "indigenous"[7] does (Sillitoe, 2007). "Industry knowledge" helpfully suggests the idea that (shared) knowledge is shaped by and dependent on a discourse community and highlights the contrast between the scientific and industry discourse communities. Importantly, "industry knowledge" also indicates that the world is not divided into scientific and non-scientific knowledge; "industry knowledge" is not defined negatively as all-that-is-not-science, but positively as the shared knowledge of a separate community.

Scientific knowledge is local, limited, and mutable

Several conclusions about the nature of scientific knowledge follow from these lines of thought (summarized in Table 1.2, below). First, science has no special claim to being the only or best way of knowing about the world; science is one set of many systems of knowledge practices. Second, science is shaped by the conditions of its production. Third,

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[7] Still, I think that what the cultural anthropology literature develops as indigenous knowledge is useful here. Thinking about winemaker/grower knowledge as "indigenous" emphasizes its place dependency, and that the distance between Western science and non-Western scientific knowledge systems is not always measured in degrees of latitude.

science is made (and can be made differently) through many practices in and outside of the lab. I hereby come to my starting position for talking about industry-oriented science communication. First, scientific knowledge is one way – more accurately, one set of ways – of knowing about the world, but not the only way. Second, the nature of scientific claims depends on how and where they were produced, and thus the contexts of scientific production matter to where and how scientific knowledge is useful as it moves to new locations. Third, because scientific knowledge is made in writing, scientific knowledge can be reshaped by altering writing practices.

Table 1.2 Implications of a material semiotic ontology for industry-oriented science communication

Nature of scientific production	**Implications for scientific knowledge in society**	**Implications for industry-oriented science communication**
Science is constructed in networks of practices in and outside the lab	Science is not the only or best way of practicing knowledge	Scientific knowledge should work with industry knowledge
	Science is shaped by the conditions of its production	How scientific knowledge can be usefully applied differs across new locations
	Science is constructed in practice, including (especially) writing	Altering textual rhetorics alters scientific knowledge

Research should be relevant to industry

Scientific knowledge and industry knowledge are both constructed in practice. While the practices of science – by scientists, directed at making scientific knowledge – and the practices of industry – by winemakers, growers, and their assistants, directed at making wine – brush up against one another, they are distinct. Industry-oriented science communication presumes to translate scientific practices into industry-friendly language and "transfer" (Rogers, 2003) them to locations where industry work occurs. If realities are constructed through practice, however, and if the world is multiply practiced with no predetermined "grounding order" (Law & Lien, 2012, p. 364), we have no reason to presume that such a transfer strategy is reasonable, practical, or good. No natural or inevitable relationship preexists between scientific and industry practices ordaining that the former are useful in making judgments about the latter.

Science cannot simply be picked up, moved out of context, and assumed to work (that is, to make useful predictions) in new locations. For scientific knowledge to be applicable to industry, additional practices must create relationships that align and overlap scientific and industry practices to make them mutually relevant. Depictions of scientific and industry practices[8] must "assemble contexts" and "hold them together in a mode that may be descriptive, explanatory, or predictive" (Law & Moser, 2012, p. 332); "ordering relations" must create order out of originally unordered practices (Law & Lien, 2012, p. 366). Such ordering happens in many ways. Insofar as scientific knowledge is constructed in writing and shared with industry in writing, however, the rhetorics of written texts are an essential mode of ordering research practices as relevant to industry.

We cannot simply assume that scientific research is relevant to industry practice. Scientific research must be *made* relevant to industry practice. Consequently, it becomes necessary to ask: is this a good thing to do? Should research be made relevant to industry?

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[8] Depictions which are themselves practices; describing descriptions of practices becomes endlessly recursive.

Arguments can be made for *not* working to relate research and industry practices. Forcing science to work for industry application risks turning scientists into industry contractors, using their specialized expertise to generate a product for industry consumption, and perhaps diverting scientific efforts away from incrementally accumulating scientific knowledge in the scholarly literature. This progression is already evident in New Zealand, where the director of New Zealand Winegrowers' research arm sees the successful endpoint of a research project not as publishing in the scholarly literature but as delivering an industry report; the reason to *also* publish in the peer-reviewed literature is to support the reputation of New Zealand, its research system and wine industry, and thus the national economy (personal communication, August 2014). Some industry members interviewed for this thesis would like to see research-industry ties weakened. In New Zealand, winemakers and growers spoke of "blue skies research" (a term I did not hear in Washington State, though some Americans shared the sentiment), supporting the idea that scientists should be free to explore whatever scientists want to explore, without obligations to produce anything of quantifiable economic value at the end of the day. They explained that they see such "basic" research[9] sometimes leading to unexpected discoveries of eventual unforeseen value, but also explicitly supported scientific knowledge-building for the sake of scientific knowledge-building alone.

[9] Distinctions between basic and applied research, both what they are and whether they exist, are contested (Hoffman, 2015). For the purposes of this study, I define basic science as the set of scientific claims which aim for validity only within the scientific community, in contrast with applied science, the set of scientific claims which also make bids for validity outside the scientific community. Basic and applied science will necessarily take different forms because scientific knowledge is constructed discursively, but those differences are constructed in their movements , not essential to their nature. The distinction is thus neither about the "*substance* of knowledge itself" nor a mere "*artifact*" of context (Hoffman, 2015, p. 243) but a discursive difference in orientation.

Most stakeholders, however, appear to see making science relevant to industry practice as a good thing. Vast and thoroughly entrenched social structures are, moreover, predicated on the assumption that scientific research will do useful industry work. I have alluded to some of those structures in the above discussion about distinguishing scientific and industry knowledges. Experimental, industry, and administrative structures already work as ordering practices structuring research-industry relevance. The United States agricultural extension system ties scientific research at land-grant universities to agricultural development. The New Zealand Winegrowers research arm coordinates goals, intellectual and financial resources, and research products jointly across research and industry groups. Wine industry publications with science columns, such as those discussed in chapter five, tell winemakers and growers that scientific research concerns their work. Research grant applications for the American Vineyard Foundation require "a description of how the research would address industry priorities" (Deitrick, 2016). Funding applications to New Zealand Winegrowers must address how a project will "protect NZ Wine's competitive advantage" or "support growth of NZ fine wine to markets, segments and consumers," and ask researchers to explain how "the information will be best up taken [sic] by the industry" (New Zealand Wine, 2016).

That these structures exist says nothing about whether they are good or should be perpetuated; one of the aims of exploring the rhetoric of these interactions is, indeed, to find ways to restructure them (Fuller, 1995).[10] However, unmaking these structures

[10] Fuller (1995) argues that sociological studies of science promised strategies to change scientific social orders, but have failed to deliver on that promise and have instead become caught up solely in describing things as they are, implying things as they must inevitably be: "Many of society's doors may be unlocked,

altogether would require enormous effort and might not be desirable in any case (Law & Lien, 2012; Singleton, 2012). Scientists speak of being motivated in their work by the idea of helping winemakers (detailed in chapter five). Winemakers and growers speak of how much they value knowing scientific principles, of deriving new ideas from new research, and even of simply enjoying reading about wine science (discussed in chapters three and four). Their testimony supports the worthwhileness of making science industry-relevant.

My argument is that if we practice science as relevant to industry, then we should do so thoroughly. Microrhetorical textual practices involved in research-industry infrastructure should cohere with the messages conveyed to scientists, industry members, and administrators by the kind of macro-level institutional rhetorics I have detailed above. Rather than interfere or disrupt for the sake of destabilizing these systems, exploring the rhetoric of research-industry interactions can interfere for the sake of reinforcing them. That said, interfering in scientific rhetorics does disrupt science. Aligning and overlapping research and industry through rhetorical practices changes the nature of science by changing how science is written. By practicing more collaborative and tightly mapped research-industry relationships, science becomes more an unexceptional knowledge tool in the world and less an exceptional knowledge system sequestered outside it. What science *is* changes. Actors involved in applied science and technology transfer have invited that change by reconfiguring science as a tool for solving the world's problems rather than a

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but social science discourages most from trying to turn the knobs" (111). He offers rhetoric of science as an alternative means to "a *knowing that* that [is] simultaneously a *knowing how*" (110). Fuller appears to disregard the work of feminist sociologists of science expressly working to "interfere with" things as they are (Singleton, 2012; Woolgar & Lezaun, 2013); his point is supported, however, by the degree to which they interfere through rhetorical means.

system for discovering and describing nature.

Carrying current research structures out to their logical ends indeed may lead decision-makers to conclude that this isn't the way we want to do science after all. To the extent that making textual microrhetorics and institutional macrorhetorics cohere works toward directing societal resources toward what societal priorities *claim* to be, that trajectory and the crisis to which it could lead are a good thing. Here, I am arbitrary. I arbitrarily value efficiency and coherency of motives. I say that it is good for society to synchronize its resources toward doing what institutional voices for applied science claim to be doing. I could just as easily argue that textual rhetorics should subvert the notion of applied science by practicing research findings as isolated scientific phenomena. However, for reasons I cannot clearly identify, I believe that the best route toward finding good ways to live involves making conscious and examined decisions rather than accidental ones, and in so doing to encourage our ostensible goals and strategies to cohere. Haraway (1988, 1991, 1997) , Mol (2008), Singleton (2012), and other feminist science studies scholars aver that coherence is not the only or always desirable option. Still, a multiply practiced world has space and use for many strategies.

Industry should have a collaborative relationship with science

The question to resolve, after establishing that science should be made relevant to industry by creating relationships amongst their respective practices, is what kind of relationships they should have. An answer to that question is implied by both the material semiotic ontology that reality is created in practice and the very premise that scientific research should be relevant to industry: scientific and industry communities should build knowledge collaboratively. Reality-as-constructed-in-practice implies that the sciences can be useful ways of practicing and ordering reality, but are not the only ways to do so. Constructing science as relevant to industry implies creating connections between their *respective* knowledge-making practices. Aligning and overlapping research and industry practices suggests, first, that neither takes precedence as the ideal or reference set; second, that scientists and science communicators need to know about industry practices; third, that industry knowledge can and should inform scientific practices and vice-versa. Scientific and industry knowledge become *mutually* relevant.

Science and industry should have a collaborative relationship: they should share knowledge for mutual benefit around common problems. This is not to say that scientists should become winemakers or that winemakers should become scientists, or that either group needs to know everything about the other. The division of labor between making scientific knowledge and making wine has obvious benefits. Nor is it to say that *all* science and industry work should be collaborative. Aligning some science and industry practices allows for the possibility of "basic" research that no one wishes to relate to practice, and of winemaking that no one wishes to be informed by science.

This particular vision of collaboration also differs from much of what is called collaboration in the science communication literature, in which scientific knowledge retains epistemic primacy and "citizens" are enrolled as a kind of distributed scientific instrument to collect data for scientists (Riesch & Potter, 2014. It is also distinct from "civic participation" (Braun & Schultz, 2010) in science, as often described in the STS literature, where participation is first about democratic engagements and sociopolitical processes, and second about creating more robust knowledge (Cook, Kesby, Fazey, & Spray, 2013; Irwin, Jensen, & Jones, 2012; Jasanoff, 2003b; Quet, 2014; Slocum, 2003). In this case, by collaboration, I mean not industry member participation as accessories in scientific work, but exchange amongst scientific and industry knowledge systems. Nothing is wrong with industry participation in science. Far from being a bad thing, indeed, much wine research depends on winemakers and growers providing data or materials from which data can be extracted (e.g. wine samples, vineyard rows, diseased grape leaves, etc.), often to the mutual benefit of scientist-director and industry-participant. Participation *in* science principally for the sake of advancing the aims of science, however, is something different than collaboration *with* science as a joining of multiple knowledge systems.

Beginning with an ontology that places science and other knowledge systems on epistemic par makes collaboration amongst knowledge systems possible. This thesis is, in effect, about exploring an inherently interdisciplinary rhetoric of science that writes science as one knowledge system among many, rather than a supreme knowledge system over and above others. Though contemporary science communication scholarship and practice largely espouses an inclusive, participatory ethos (reviewed in Smallman, 2016), continued implicit reference to a "presumptively entrenched scientistic normative baseline" (Wynne, 2014, p. 60) subverts attempts at meaningful non-scientist participation. The work presented here is an initial exploration into making space for meaningful participation via science communication predicated on a constructivist epistemology and conducted through a rhetoric of science that is not inherently scientistic.

My goal is not to convince scientists or science communicators who espouse science-dominant epistemologies that they are wrong about preferencing science over other forms of knowing. It is, rather, to point to the rhetorical (relational) features of written science communication texts, to point out that those features structure science-industry relationships, and to observe that texts will structure undesirable relationships in the absence of conscious attention to ensure that they do otherwise. Textual rhetorics are certainly not the only means by which relationships amongst science and its various publics are structured. Inasmuch as scientific knowledge is built in text and interacts with industry and other publics via texts, however, textual rhetorics are an important factor in those relationships. Textual rhetorics can work toward or against making science relevant to practice and science-industry collaboration, and yet they remain largely unexamined. My goal is to begin exploring rhetorics that avoid structuring undesirable relationships, and that are coherent with broader science communication goals and, more broadly still, with what contemporary society expects industry-oriented science to do. At present, neither STS in the material semiotic tradition nor science communication scholarship – and, arguably, not rhetoric of science scholarship – is attempting that reconciliation.

Science communication texts as more-than-content

To investigate how texts build science-industry relationships, it is not enough to observe what texts say; I must observe what texts *do* (Bazerman & Prior, 2003). Texts operate on many levels beyond what the simplifying moves of science communication content analyses typically suggest. They are, at one level, an object of exchange: I can hand you a magazine or email you a newsletter. They have content functions: I can say that the magazine article is about red blotch disease affecting Washington State merlot vines or about maximizing thiols in Marlborough sauvignon blanc. They have narrative value: we can identify characters (the merlot, or a Kiwi winemaker) and what happens to them. They have stylistic and grammatical features: an author's phrasing may facilitate understanding or hinder it, signify her membership in a particular community, or limit her likely readership. They have rhetorical features – techniques employed to relate author, audience, and medium to create meaning in the text – and social and political functions in how the text acts as a space for various actors to meet and how the text distributes power amongst those actors.

Texts are social spaces in which readers, authors, and other actors meet (Silverstein, 2004); “linguistic conventions help to generate a social world of science,” and analyzing textual features can “indicate how social structures are reproduced through language” (Hyland, 1997, p. 19). Texts, for example, indicate who belongs to their intended audience through their use of jargon (reviewed in Sharon & Baram-Tsabari, 2014). Authors may create a partnership with the reader by using the pronoun “we” (Mulderrig, 2012), or may impute a direct relationship between author and reader using “I” and “you.” They may set the reader at a distance by avoiding reader-referential pronouns altogether. Texts position themselves, their authors and messages with respect to other texts and discourse communities through their choice of topic or vocabulary, but also via phrase structure, sentence and text length, organization, use of graphics, use of references (Bazerman, 1984; Connors, 1998, 1999; Fahnestock, 1998; Garwood, 2013; Graves, 2014; Herndl et al., 2011; Hyland, 2010), metaphors (Baake, 2003; Ceccarelli, 2004), use of tenses (Liddicoat, 2004), and by taking a descriptive, exhortatory or evaluative stance (Fahnestock, 1998; Johnstone & Mando, 2015; Kopple, 2002; Walsh, 2010).

A basic premise of rhetoric studies is that none of these textual functions is independent of the others (Bazerman, 2013; Bazerman & Prior, 2003). Even changing the weight and glossiness of the magazine page or the font employed in the newsletter alters what the text means. Rhetorical functions are not independent of content; they are *more* than content. Changing the rhetoric of the text changes the nature of the scientific claim the text constructs. However, focusing on the claim alone ignores all of the other functions the text has as social practice.

The inappropriateness of technology transfer as a metaphor for science communication

The theoretical position I have outlined is far from being either new or radical, even if interest in textual rhetorics is marginalized in the current generation of science and technology studies (Graham & Herndl, 2013). Work I have referenced sits in the top few strata of sedimented scholarship moving toward multiply enacted ontologies and epistemic parity across philosophy, rhetoric, sociology, literature, anthropology, and gender and other critical cultural studies.[11] Bruffee reviewed constructivist approaches for composition studies in 1986; Guba and Lincoln, in 1989, articulated an extensive argument for a strong constructivist approach to evaluation. Nevertheless, socio-material-rhetorical strategies for locating science in the world contrast sharply with the "technology transfer" and "research utilization" paradigms that even today continue to pervade agricultural extension and innovation studies (see especially a recent review of the "state-of-the-art" by Bozeman, Rimes, & Youtie, 2015).

Historically, traditional technology transfer and agricultural extension models constructed a linear, unidirectional "pipeline" from scientists to end users (Green, 2008; critiqued in Henke, 2000; Ison & Russell, 2000; Warner, 2008). Technology transfer has followed the assumptions of the much-maligned deficit model: "'the public' is considered to have a low level of understanding which needs to be overcome in order to make what scientists consider to be 'rational' decisions" (Palmer & Schibeci, 2014). Users – routinely farmers or other agriculturalists – needed to be given scientific information to enable them to make good choices. When they failed to make those choices even after receiving scientific information, blame fell on the user's social conditions: a farmer's need to turn a faster profit, for example (e.g. Marzano, 2007), or the competing influence of contradictory information from other sources (e.g. Sillitoe, 2007), or interference from conflicting personal goals (e.g. Vanclay & Lawrence, 1994). These opposing social forces were

[11]Mol (2002) walks through philosophical and social underpinnings in particular in the subtext to her book *The Body Multiple.*

"barriers" to be overcome (Rogers, 2003).

Even as such unidirectional pipeline models have been criticized for limiting the agency of the end user, models invoked to replace them continue to confirm the fixed value of a knowledge product that exists as a transferable object in advance of the transfer process. Like their predecessors, those replacement models therefore also continue to consolidate power in the institutions creating the (scientific and technical) knowledge product; like their predecessors, they presume the legitimacy and superiority of that product. Bozeman, Rimes, and Youtie (2015), for example, offer a "revised contingent effectiveness model of technology transfer" that "in a nutshell...maintain[s] that the impacts of technology transfer can be understood in terms of who is doing the transfer, how they are doing it, what is being transferred and to whom" (p. 35). Their schema does not make space for questions about the *object* of the transfer, its validity, and the worthwhileness of transferring it. When Rogers (2002), who popularized the "diffusion of innovations" metaphor, expands the concept of research use to allow that "the receptor organization transforms the research-based technology into a product or service that can be sold in the marketplace," which "may create further problems for which the organization then seeks solutions from expert sources" (p. 327-328), the validity of the research-based knowledge object remains unquestioned despite the potential non-linearity of the process; users' contributions remain at the level of creating "a product or service" rather than the knowledge itself. These remain models of *technology transfer*: taking for granted that scientific/technical knowledge is a mobile product of fixed validity that can and should be exported to settings distant from the location of its production, where knowledge will remain valid, where implementing it will constitute an improvement, and thereby inherently assuming that scientific/technical knowledge is superior – more powerful, more useful – than whatever "local" practice preceded it.

A recent example of a similar model,[12] applied in a context relevant to this study, comes from Hill and coauthors' (2015) report to the Australian Grape and Wine Authority on "Adoption of grape and wine R&D outputs: Who, what, and why?" Working from a "scientistic normative baseline" (Wynne, 2014, p. 60) that increasing adoption of new scientifically-supported technologies is the desired outcome, the research team identified "adoption criteria" related to the efficiency with which an innovation was taken up by the wine growing community toward the goal of "achieving adoption outcomes" (p. 12). The strategy is a sensible one for identifying variables which may promote the use of beneficial practices derived from contemporary research. Even still, the report reflects a top-down communications assessment strategy designed to produce a better understanding of innovation markets – winemakers and growers – so that they can be more effectively persuaded to make choices that administrators have established are desirable in advance of the transfer process.

A collaborative approach to technology transfer as science communication for use, as Rogers (2002) puts it, demands a different approach: a model that allows for the possibility of users critiquing received knowledge claims *as knowledge claims*, of users

[12] Venkatesh & Davis's (2000) revised "Technology Acceptance Model (TAM2)" (Hill et al., 2015, p. 11). Though their emphases differ, the models developed both by Venkatesh & Davis and by Bozeman's group construct technology transfer as the movement of a knowledge product.

materially contributing to knowledge construction, and of information being a tool for practice rather than a fixed product of predetermined value. STS scholarship offers such alternatives via ethnographic descriptions of how research-based information is employed in specific settings. Introducing her edited collection on "knowledge and technology transfer or the travel of thoughts and things," for example, de Laet (2002), observes that "to acknowledge the depth, strength, and appropriateness of local expertise seems to be rule number one in the stories that follow" (p. 4). Star (1989) suggests that we value "robust" theories that exhibit the twin characteristics of plasticity and coherence: "Plasticity is the ability of the theory to adapt to different local circumstances to meet the heterogeneity of the local requirements of the system. Coherence means the capacity of the theory to incorporate many local circumstances and still remain a recognizable identity" (p. 21). Developing a similar idea, de Laet and Mol (2000) advocate for a "love" of "fluid" technologies (p. 225), an alternative to the "arid trope" (p. 251) of observing a technology *against* various external contexts; the fluid technology instead incorporates context so that the borders between technology and context become indistinct and unimportant. Robust or fluid technologies invite the possibility of user collaboration in co-constructing scientific knowledge by folding their own local knowledge practices together with scientifically supported practices in ways that add to the original claim. A good fluid technology demands the participation of multiple discourses. de Laet and Mol (2000) observed that "technology transfer" studies (p. 256), even in acknowledging the need for local adaptation, did not yet seem to have grasped the idea of a "fluid" technology whose borders variously shift to incorporate local knowledge and other elements of any given new setting (p. 256). Sixteen years later, that observation still appears valid.

Constructivist paradigms have seeped into agricultural extension scholarship (e.g. Ison & Russell, 2000; Warner, 2007, 2008). In both "technology transfer" studies and in science and technology studies approaches to extension communication, however, the object generally remains to understand the shape of social institutions to the neglect of attending to the shape of communication objects themselves (e.g. de Laet, 2002; Henke, 2000; Ison & Russell, 2000; Krzywoszynska, 2015; Leeuwis, 2004; Noe et al., 2015; Warner, 2007, 2008). Institutional macrorhetorics remain disconnected from textual microrhetorics because textual microrhetorics remain ignored. Despite the title *Communication for Rural Innovation,* Leeuwis (2004, updating earlier editions by van den Ban and Hawkins) – in what is likely the major English-language text on extension communication as collaboration as an alternative to persuasion – focuses largely on innovation and very little on communication. Leeuwis briefly discusses commonsense differences amongst media channels at the end of the book, but even here does not address how "change agents" might create messages for them. The operating assumption, of Leeuwis and of other innovation studies scholarship which ignores textual composition, appears to be that writing is self-explanatory once the goals for writing have been established. This assumption is opposed by extensive disciplinary studies of writers, writing, and the writing process throughout the past century (reviewed in Bazerman & Prior, 2003; McLeod, 1992; Russell, 2002). Texts fly under the sociological radar. So too, then, do rhetorical strategies as a set of tools for reshaping science communication institutions and relationships.

Replacing technology transfer and adoption with relevance

When industry-oriented science communication is assessed in technology transfer contexts, the outcome measure is usually adoption. Communication is “working” when industry adoption of a scientifically supported practice, as defined by the institution administrating the communication program, increases after a science communication tool has been deployed. Hill's (2015) study of adoption in the Australian wine industry is a good example of the standing policy assumption so common to agricultural extension studies: resources need to be poured into studying and solving problems, with “problems” understood to mean gaps between actual practice in the field and potential practice as enabled by scientific innovation (and as economically beneficial to the government who, standing behind such studies, is seeking to increase production value and thereby increase tax revenue). A similar set of paradigms revolves around “research utilization” (Beyer & Trice, 1982; Estabrooks, 1999; Larsen, 1980). Research utilization may be “instrumental” in directly identifiable ways, “conceptual” in affecting users' ways of thinking in less directly identifiable ways, or “symbolic” in helping users justify an action or belief (Beyer & Trice, 1982; applied in a wine industry setting by Boshoff, 2014). In all cases, “utilization” remains a desirable set of actions defined by categories restricted by the research paradigm.

Focusing on adoption or utilization consolidates power within the institution[13] conducting the assessment which, extending the perceived authority of science over non-scientific objects (Wynne, 2014), decides what practices are desirable to adopt or what research is worth using. This "'fix' mentality," what Ison and Russell (2000) have critically termed "first-order R&D" (p. 12), never allows for questioning how the problem to be addressed is defined in the first place. Research utilization paradigms assume that all stakeholders agree on the nature of a problem, presuppose that research should be used, define in advance what information is relevant, and impute its superior quality and natural authority over the information stakeholders already have (Guba & Lincoln, 1985; Knott & Wildavsky, 1980). The inscription devices through which evaluators flatten and mobilize users limit the responses users can make, or can be *seen* to make, to research. Roles for industry knowledge and participation are curtailed while the authoritative institutional perspective is perpetuated. Technology transfer transforms what could have been a knowledge exchange, an invitation to a dialogue, instead into a device for depositing users in boxes and converting users into numbers controlled by one set of voices only.

By defining successful communication as communication which increases adoption (or, more generally, acceptance), assessments of science communication interventions are unable to capture what Michael (2012) calls "overspilling:" audience engagement with

[13] The fascinating power dynamics at play amongst winemakers and winegrowers of various stripes, government agencies, industry organizations, scientists, and wine consumers are only indirectly part of this study. The omission is regrettable in that these dynamics are essential drivers behind rhetorical choices in what science is communicated, how, and why. Any practical program to intervene in wine science communication rhetorics will need to account for them. I have omitted them to retain my focus on textual rhetorics rather than implicating extratextual social structures, and in light of the sensitive political situation presented by the New Zealand wine industry.

science communication activities that falls outside the bounds of what organizers expected. Because overspills go unaccounted for by research utilization paradigms, these activities are literally made invisible. Overspilling participants, who might otherwise be called collaborative innovators, may even instead be labeled “non-adopters” who become the object of programs to increase their compliance. Michael urges public communicators of science never to be too busy with “what we're doing” to ignore what such “misbehaving” participants have to say (p. 528). His exhortation applies just as well to industry-oriented science communication. Assessing industry-oriented science communication by way of adoption functionally excludes the possibility of collaborative communication. In this sense, extension communicators, “change agents” (Leeuwis, 2004), and others interested in promoting research use amongst industry act counterproductively when they work to promote adoption of fixed scientific knowledge products in predefined ways. If their goal is indeed to help devise solutions to industry problems – rather than to encourage as many people as possible to agree with scientists – then assessments relying on adoption or research utilization hinder that goal by limiting the ways in which users can (be seen to) use research and how users can collaborate with scientific problem solving by critiquing, adding to, or otherwise manipulating research findings in practice.

Adoption is also incoherent at a theoretical level with models of knowledge that reject the natural superiority of science and, with it, the assumed value of adoption in terms predefined by administrators, the idea that scientific knowledge is a product which can be transferred to industry, and limitations on how industry knowledge can interact with scientific knowledge. In conventional paradigms, research utilization is a separate step occurring after scientific experts have produced a research outcome. Post-production, post-transfer, what to *do* with the claim is on the table but the validity of the claim is not. Scientists are assumed to be the experts who create scientific products for external use; because these products are scientific, they are good. Users are assumed to be outsiders with respect to the knowledge-building community. Constructivist paradigms counter the appropriateness of those assumptions by arguing that use, and communication facilitating use, participates in knowledge construction by adding to the practices we assemble that constitute the claim; expertise is practiced, exists with respect to many different domains of knowledge, and is therefore neither the sole property of scientists nor granted by authority of the scientific community (Carr, 2000; Dreyfus & Dreyfus, 2005).

Relevance provides an alternate conceptual lens for assessing how written science communication creates conditions in which multidirectional knowledge sharing can occur. Assessing relevance instead of adoption, in other words, makes it possible to ask how texts invite and allow for industry participation in collaboratively constructing applied scientific claims. To ask how a text makes scientific information relevant to its readers is to ask how a text makes it possible for readers to make connections between the text and themselves.

Defining relevance precisely has been difficult, even in the information sciences literature where attempts to do so are more common than in science communication or rhetoric of science scholarship. One review of research relevant to relevance actually encourages that relevance is an “intuitive notion” that “does not have to be explained; it is universally understood" (Saracevic, 2007, p. 1916). The same review (for the reviewer does also attempt to aid intuition) and others nevertheless describe relevance in terms of *relationships.* Relevance might be defined as a relationship "between an information object I and an information need N with the components of *Topic, User, Problem/Task, and Situation/Context*," (Huang & Soergel, 2013, p. 20, emphasis original), or, as Saracevic elaborates at length in an attempt to cover all the possible bases:

> Relevance always involves a relation between a P (or a number of Ps) and a Q (or a number of Qs) along some property R (or a number of Rs). Parts P and Q could be intangible objects (such as ideas, concepts, information) or tangible objects (such as documents, machines, processes) or a combination of both intangible and tangible objects (such as tasks, situations, responsibilities). Properties R (such as topicality, utility) provide a base and a context for establishing a relation, i.e. relation between Ps and Qs is considered as to relevance along properties R. These properties may be explicit or implicit, well-formulated or visceral, rational or not entirely so—on a continuum. Relevance is also considered as a measure of relatedness. (Saracevic, 2007, p. 1918).

Designing relevant science communication is a first step toward designing collaboration-facilitating science communication. To create relationships is to acknowledge the existence of the audience, the audience's world, and the audience's concerns. Drawing lines between industry practice and research practices forces research practices to be located in time and space, making science a situated (and therefore limited) set of practices rather than a series of decontextualized knowledge statements, and thereby opening up the possibility for productive multidirectional dialogue *amongst* situated knowledges. Reading science communication texts for relevance, therefore, means reading for how texts create relationships among science and industry practices, scientist and winemaker or winegrower. These textual analyses are described in more detail in the methods chapter which immediately follows and in chapters five and six.

The textual analyses I employ are expressly *not* about attempting to read science communication texts as would either an industry reader or a scientist in the same disciplinary community. Fuller (1995) has criticized rhetoric of science studies for reading science in ways completely alien to the actual, intended audience for a text. Fuller makes a good point for studies aiming to understand the cognitive effects of texts on their readers. This is, however, only one of many possible reasons for critical textual analysis. Rhetorical studies of science also ask how texts reflect and reproduce sociomaterial conditions beyond the individual reader, and about what strategies science texts use to persuade readers (e.g. Bazerman, 2000; Fahnestock, 2005; Myers, 1990; Woolgar, 1989). A constructivist evaluation (Guba & Lincoln, 1985) of how well science communication texts work and of stakeholders' concerns with them would have called for involving industry member-readers, scientists, other science communicators, and administrators in conversations about what texts do for them to construct a multifaceted portrait of textual performance. I am instead attempting to understand one set of functions – relational functions – of science communication texts in the Washington State and New Zealand wine industries – not to assess how well science communication texts perform in these settings – because properties of these cases make for useful reflection on other settings of science communication. I am attempting to understand something about the worlds the rhetorics of these texts create and, as a community insider/outsider, to generate valid readings but not general ones: valid in understanding and accounting for texts in context, but not general in terms of incorporating as many stakeholder perspectives as possible (Guba & Lincoln, 1985). Rather than attempting to conduct an evaluation and create a program of action for a specific setting, I aim to work in the direction of a heuristic, a tool for thinking about industry-oriented science communication.

The utility of this framework to science communication and public understanding of science

Industry "publics" of any kind, let alone winemakers and wine growers, are uncommon actors in science communication scholarship; the public in "public understanding of science and technology" is far more typically some group of lay citizens distinguished not by their acting in any kind of professional capacity but by geography or shared interests. Part of the object of this thesis is to address industry members as a unique public for science communication and to argue in favor of applying rhetoric of science and science communication concepts to such cases more commonly taken on in business innovation scholarship. However, a study of such a peculiar public can also speak usefully to science communication to more general audiences because industry publics are excellent examples of considerations less obvious but also important in these other settings. This study of wine industry science communication highlights that science communication can be for the sake of use beyond “awareness, enjoyment, interest, opinion-forming, and understanding” (Burns, O'Connor, & Stocklmayer, 2003, p. 183), and that reasonable public participation varies with the practices and expertise of the public in question. It explores the relationship between public engagement or participation and the nature and location of scientific knowledge. And it suggests the need to align textual microrhetorics with institutional macrorhetorics to avoid having the specific instruments through which science communication is carried out subvert the goals those instruments are ostensibly supposed to serve.

Historically, the enterprise of science communication has been predicated on the idea that some privileged people have a thing called science that they also have a mandate to share with other less privileged people for the improvement of the science-receivers and society at large (Mellor, Davies, & Bell, 2008; Perrault, 2013; Sturgis & Allum, 2004). In the decades since Durant and colleagues (1989) drew attention to how poorly British citizens scored when tested on basic scientific knowledge, “preoccupation with public ignorance” (Mellor, Davies, & Bell, 2008, p. 3) has faded in favor of a preoccupation with public engagement (reviewed in Smallman, 2016; see also the 2014 special issue of *Public Understanding of Science* on public engagement). Science communicators' mantra has shifted from “deficit to dialogue” (Smallman, 2016; Stilgoe, Lock, & Wilsdon, 2014). Rather than measuring and increasing public knowledge, contemporary science communication is likely to be about doing science together, about "engaging" the public in more "democratic" ways (e.g. Bickerstaff et al., 2010; Davies, 2013; Grand, Davies, Holliman, & Adams, 2015; Han & Stenhouse, 2015; Kurath & Gisler, 2009; Rowe & Frewer, 2005; Stilgoe, Lock, & Wilsdon, 2014). If science is a powerful discourse with "a claim to legitimate domination" (Bourdieu, 1990, p. 28), discussants of science in society are increasingly unlikely to accept that power and domination are reasonable measuring sticks for value, or that strength, power, or value should be defined solely from the perspective of the European, white, male landowner who comprised the audience for Newton's *Principia* or Darwin's *Origin*. Science communication, among many other critical activities in contemporary Western society, is seeking to bring marginalized perspectives back into the picture.

Simultaneously, the recent global climate (double-entendre intended) has provoked questions about whether following supposedly value-neutral science is our best route to long-term survival. While some continue to profess "promissory" science (as discussed in Goven & Pavone, 2015; Schyfter & Calvert, 2015; Wynne, 2014) as the route to salvation, others correlate widespread adoption of that public religion with our current envirosociopolitical pickle and argue instead that the power of science in the public sphere must be curtailed (Evans, Kotchetkova, & Langer, 2009; Perrault, 2013; Sillitoe, 2007). Once again, bringing alternative or outsider voices into dialogue with science is central to the program.

In short, my path through material semiotic and rhetorical theory has carried me to a destination at which much of contemporary science communication begins: science communication should be about dialogue and collaboration. The route I have taken to that conclusion, however, is germane to the forms science communication scholarship allows dialogue and collaboration to take. For publics merely to have a voice in conversations about science is insufficient if that voice is rendered ineffectual by consistent and inevitable subordination to scientific knowledge.

When audience participation appears in the science communication literature, the goal often remains increasing public awareness or acceptance of science (Stilgoe, Lock, & Wilsdon, 2014). “Engagement” with science can only be about improving the public and not about improving science so long as science is about discovering truth and the nature of that truth is predetermined and therefore inevitable (Cornwall & Campbell, 2012). Scientists will discover the truth on their own and indeed are the best-trained parties to do so; public participation is at best about an extra source of voluntary (and un-paid) semi-skilled labor, at worst about laypeople getting in the way (Riesch & Potter, 2014). Non-scientists might participate in science as a toddler “helps” her father bake cookies: the toddler is no doubt active in the process, but the point of the exercise is the toddler's education and father-daughter bonding, and dad may have to pluck bits of eggshell out of the mixing bowl along the way. Engagement is science public relations (Lee & VanDyke, 2015): increasing public understanding of scientific knowledge, engendering more positive public attitudes toward and acceptance of science, and persuading non-scientists to be more scientific in their daily choices. Efforts to reject the deficit model in favor of “science engagement" devolve back to the deficit model when communicators remains more interested in science public relations than in non-scientists' knowledge (Jasanoff, 2003a; Wynne, 2001; Wynne, 2006). The "more science" orientation and its marginalization of participant knowledge is both obvious and inevitable because the superiority of science is taken for granted.

Efforts to "engage" fail to reorder science-public power relations when they continue to reference the positivist foundations underpinning the original deficit model: that scientific knowledge is inherently superior knowledge and "the public" (no matter how more complicated and active that public has become) should have/know/do/appreciate more of it. Science is, structurally, a domineering (and, some would say, a menacing and oppressing) discourse: by claiming objectivity, science inherently "contains a claim to legitimate domination" (Bourdieu, 1990, p. 28); by presuming objectivity, scientific discourses assert the dominance of their subjective positioning (Haraway, 1988, 1991). But the argument for scientific objectivity derives from its claims being built from meta-observations, made by comparing many observations flattened and simplified into sameness, and therefore distanced from the performances of any one person in any one place. Aggregating many individual instances, science finds commonalities, reduces the weight of individual variance, and moves toward universals (Latour, 1986; Shapin, 2012). The argument in support of objectivity, however, falls apart with a change in resolution: someone must still be making the meta-observations; the observational process remains situated in a network of social actors, constraints, and possibilities; the knowledge claim is still constructed through the simplifying moves of one discourse and not another. Replacing claims to objectivity with an accumulation of practices, publics now have an appropriate and useful place in adding to the accumulation. Objectivity as the ideal, unchanging limit toward which scientific knowledge ineluctably progresses is replaced with an accumulation of subjectivities that participants can shape and move.

A call for collaboration is effectively a call to remake science as one of many "partial, locatable, critical knowledges sustaining the possibility of webs of connections" (Haraway, 1988, p. 584) rather than the best way of discovering reality (see also Guba & Lincoln, 1989). Such a call serves the democratic aims of contemporary science communication. Making science partial prevents the expansion of science from obliterating the public's alternate reality-ordering practices or, if you prefer, the public's point of view. Making science locatable allows disciplinary outsiders to identify where they stand in relation to science and how those two locations are related. Making science critical allows scientific knowledge to engage in dialogue with other perspectives in the community. Science communication scholarship invokes limited, locatable, critical science when it acknowledges the validity of non-scientific expertise and invites non-scientist participation as more than a superficial token designed only to further scientific ends. For science to be placed in and done with society rather than commanded over it, science cannot be global, universal, and inviolable.

This kind of epistemic pluralism need not invoke relativism and despair that we will never know anything at all. A constructivist pluralism indeed says the precise opposite, insisting on the value of many knowledge-making practices while relativism insists on the non-value of all of them. A constructivist pluralism moreover empowers stakeholders to change reality, not merely to accept it or to acquiesce to the unknown (Guba & Lincoln, 1989). Acknowledging public practices as meaning-making practices that can be related to science creates conditions that enable genuine, effective, empowering public collaboration with science, and not merely superficial participation in science. In acknowledging science as situated practice, it becomes possible for members of the public to draw lines between where they stand and where science is happening and to create some kind of order between the two. Science becomes more proximal, accessible, and relevant.

The difference between industry publics such as winemakers and winegrowers and the general, lay, or citizen publics more prevalent in the science communication literature lies in the nature of their practices, and thus of their discursive knowledges, and consequently in the kinds of relationships they are likely to draw between scientific practices and their own. Winemakers and wine scientists can realistically come to agree that both groups are doing things with wine. Neither accountants from Illinois nor nanoscientists are likely to agree that an accounts payable manager from Chicago does anything with nanoparticles, even if the accountant's daily life could be affected by nanoparticle use. The level at which the accountant's work and nanoscientific practices overlap is in science policy, the ingredients in her toothpaste and the health of her brother who works in an auto body shop. Her toothpaste choices may be part of the networks through which nanoparticle science circulates, but do not materially intersect with the core meaning-making practices of nanoscience. Much more direct overlaps are easy to create and desirable to strengthen between the winemaker and wine scientist.

Science communication for the sake of enjoyment (Fahnestock, 1998) or for awareness and understanding (Burns, O'Connor, & Stocklmayer, 2003) rather than use, does not need to overlap and align scientific and audience practices, or at least not in the same way. While writing this chapter, I read an article on the *Nature* news website about the discovery of venomous frogs for the sake of the story's novelty (the frogs are venomous, not poisonous, you see), but not because I expect that knowing about venomous frogs will help me write this thesis or in any other way augment my professional capacities. The only use I will make of this froggy phenomenon is sharing it with my husband in our daily "did you know" exchanges; the only overlaps the *Nature News* article needs to construct between amphibiology and the life of the reader are those enabling comprehension and feeding curiosity. I read about Pluto or proteomics as trivia; I read about pesticide residues in Pauillac as a tool for performing my profession. Rhetorical exigencies change when science communication is about knowing how to *do* something with science rather than "knowing about science" (Sturgis & Allum, 2004). In such cases, what Fahnestock (1998) describes as the classic and conventional epideictic voice of science popularizations – "their main purpose is to celebrate rather than validate" (p. 333) – or persuasive moves to develop a positive awareness of science (Burns, O'Connor, & Stockylmayer, 2003) become inappropriate. The mission of *applied* science communication, to industry audiences or otherwise, is to align (or make it possible to align) research practices with readers' practices such that scientists and readers are doing things with recognizably similar objects, and so that their practices become locatable with respect to each other, mutually relevant and informative.

Locating the science is important. Whether science communicators think about communicating “science” as fixed and pre-existing knowledge or about constructing science in communicating it, science communicators can only discuss how publics (of any sort) relate to science by simultaneously implicating the nature of science (Wynne, 2008). Science communication always implies a location for its object. Left implicit, science communicators risk misplacing it.

Outline

The four central chapters of this thesis – excluding this theoretical introduction, the overview of method that follows it, and the concluding summary – were written as a series of published or submitted-for-publication articles focused around the lines of exploration outlined above. These article-cum-chapters are all written for scholarly audiences in science communication, but for different audiences within science communication as an always-interdisciplinary and sometimes-diffuse field. Chapter three was written for a wine studies audience whose interest in science communication may be secondary to an interest in wine business, communications, agricultural extension, or wine science research; it presumes the most wine industry knowledge. Chapter four was written for a writing studies audience and connects writing studies methods and approaches to science communication's disciplinary need for a stronger focus on the text. Chapter five was written for an STS audience wherein theory development is a primary result of empirical case studies, and chapter six for a science communication audience interested in the confluence of science communication theory and practice. The conclusion addresses the same science communication audience and perhaps also the rhetoric of science community, recommending the value of rhetorical studies and specific rhetorical strategies to industry-oriented science communication. I see the boundaries between science communication, STS, and rhetoric of science as permeable and, I hope, increasingly unimportant as STS focuses on the practical "making and doing" outcomes of its theories (see, for example, the inaugural "making and doing" sessions of the 2015 annual meeting of the Society for Social Studies of Science), as science communication develops stronger theoretical groundings for its practical experiments, and as rhetoric of science continues to expand into active as well as descriptive modes.

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Chapter 2 – Overview of methods

This is a mixed-methods study guided by a modified grounded theory and built, imperfectly, on a material semiotic ontology. Employing material semiotics more thoroughly would have called for following one or a small handful of science communication texts to observe what the texts do as they move amongst people and settings; instead, I call on structural explanations of what language does in the rhetorical tradition. A material semiotic methodology also would have called for deriving the existence and nature of my key categories – scientific and industry knowledge, researchers, winemakers, growers, and so forth – from empirical data, and perhaps finding them to be different than how they are presented here, rather than assuming their existence from the outset. I have not made these moves in part because beginning with a priori categorizations allows me faster access to practical suggestions for science writing – a goal out of step with material semiotics but at home in rhetoric of science and science communication traditions. Much as I appreciate that "going faster" risks "simply repeating the old settlement" (Latour, 1999, p. 81), I also note that the material semiotics studies I cite, which begin with understanding the practiced nature of their realities of interest (e.g. Law & Lien, 2012; Mol, 2003; Woolgar & Lezaun, 2013), conclude by observing how multiplied realities alter attitudes toward knowledge-making without drawing implications for improving the practices they discuss. Because my interest lies in using the idea of practiced realities as a tool for thinking about how to improve industry-oriented science communication, I short-change describing the ways in which realities are practiced to make it possible to apply this general conceptual shift to practical outcomes.

Perhaps even more importantly, the categories I employ are themselves employed by the wine scientist and industry communities involved in this research. I adopt the wine industry's existing “punctualizations” (Law, 1992, p. 385): the networks so stabilized that they can be discussed as objects. These same categories are also used by my research participants, and I want to communicate with them about science communication, not argue with them about terminology (Mol & Law, 1994). Describing how these punctualizations – “scientist,” “researcher,” “winemaker,” “wine grower” – are constructed and contended by discursive networks would be useful in questioning how science communications allow or disallow various kinds of people, professions, wine styles, and winemaking identities. While, I plan to conduct such a study in the future, that exploration lies outside the scope of this investigation.

One tradition in mixed methods research defines mixed methods as a third “research paradigm” which finds (epistemologically squishy) middle ground between qualitative and quantitative approaches (Johnson, Onwuegbuzie, & Turner, 2007). I use mixed methods in the sense of using multiple complementary methods, assuming that each is limited and can thus enrich the other, rather than as an attempt to mediate between the expectations of qualitative and quantitative research. Problems described and discussed within single highly consensual discourse communities can sometimes be tackled using single agreed-upon gold standard methods: all parties with a valid claim to participate in building knowledge claims share the same standards for doing so. The same is not true for problems shared by communities with different standards or problems described within highly heterogeneous communities. In such boundary-crossing cases, no one method can be relied on to produce valid claims because no single set of tightly normed community standards applies (Bazerman, 2000). Interdisciplinary problems require mixed methods because no justification exists for prioritizing the results of any one method as “right” and the others as “wrong;” research must become a practice of taking multiple pictures into account rather than of finding (and then persuading others to accept) the correct picture. Selecting appropriate methods for messy, interdisciplinary problems is about matching methods to worlds and the kinds of realities we want to stabilize (Law, 2008). This outlook tends to reject the idea of replicating precise methodological schools because they (blindly) stabilize the same reality and miss finding and responding to difference (Haraway, 1991). The following approaches are grounded in a position of extended familiarity with scientific research and industry practice in the wine industry and a desire to see science communication align more tightly with the shared goals of that community.

I begin with semi-structured interviews of winemakers and growers concerning how they access and conceptualize the use of scientific information resources in their practice. These interviews allowed participants significant control over the direction of the conversation and allowed me to identify themes of interest and responses that I had not anticipated. Complementary surveys built on these interviews and served as a check against having missed any major approaches to scientific resources in my interview sample.

Surveys required that I control the direction of the conversation in advance, but enabled conversing with a much larger number of people in more diverse locations. Free-response survey items were particularly useful in checking that my interviews captured the scope of attitudes present in the larger population. Together, interviews and surveys provided one answer to the question: what kind of relationship exists between wine science and wine practice, and what role do written texts play in that relationship? Another, complementary answer to that question came from studying written science communication texts themselves. Textual analysis yielded more detail about what specific texts do, but was limited by the kinds of readings I can perform from my perspective as an industry insider-outsider. Finally, I synthesize my empirical data in light of previous work in rhetoric of science to suggest principles for purpose-driven rhetorical tools for industry-oriented science communication.

The remainder of this chapter explains my choice of general method and case studies. Details of how specific methods were employed are located in the content chapter to which they pertain.

Grounded theory

Broadly, grounded theory provides a useful guide in some specific ways for the kind of qualitative research I have attempted to undertake: data-centric without assuming a priori that specific preexisting theories or sets of classifications will pertain to these new data, iterative, self-reflective, and empirical. That said, I need to distance myself from other facets of grounded theory's foundations as quickly as possible.

Classical grounded theory assumes that a fixed and rigorous method can discover features of objective reality in a way wholly incompatible with contemporary STS and material semiotics. Glaser and Strauss (1965) “discovered” grounded theory as positivists aiming to justify the validity of qualitative research. Their grounded theory responded to what they saw as the prevailing argument in sociology in the mid-20th century that “qualitative research is a preliminary, exploratory effort to quantitative research since only quantitative research yields rigorously verified findings and hypotheses” (p. 5). Sociological theory development, they feared, was straying “embarrassingly” far from empirical observations (1967, p. vii). This sort of ungrounding is hardly a problem in science communication research or, for that matter, in rhetoric and writing studies. In science communication, greater dangers lie in applying preexisting questions and theories to new data in an effort to be scientific through standardized methodology, and in neglecting the role of the researcher(s) in coloring an investigation's parameters and analysis. These are concerns which grounded theory helps to address.

I defend my loose association with grounded theory, choosing what parts are useful to me and discarding the rest, in the spirit of grounded theory (and material semiotics) itself: assuming that any one established method will be valuable or appropriate to new, unique data imposes a regularized means of constructing the present reality that may not be productive. Unlike Glaser and Strauss, I do not imagine grounded theory as a means of making qualitative analysis reproducible (Glaser & Strauss, 1965). They emphasized "verification" and employed reflection more as a means to document and mitigate the subjective influence of the researcher than to increase her efficacy as a research tool. Qualitative investigations need not be replicable to be useful; indeed, replicability may work against local validity. A replicable investigation is an investigation that has been standardized such that the individual characteristics of the research setting are erased. Such "context-stripping" (Guba & Lincoln, 1989, p. 37) demands simplifying observations in ways that may be unhelpful in responding to complex questions (Guba & Lincoln, 1989; Law, 2004). The question is not whether research is subjective or objective, replicable or idiosyncratic, but where and how a knowledge claim is useful. Research is a knowledge-making (a reality-making) exercise that produces tools for thinking; those tools may, then, be picked up and used for thinking by other people in other places, understanding where they came from and how they came to be. Glaser (2002) has placed himself and his orthodox version of grounded theory firmly in the opposing camp, asserting that grounded theory produces a "product" that is "an abstraction from time, place and people that frees the researcher from the tyranny of normal distortion by humans trying to get an accurate description to solve the worrisome accuracy problem" (n.p.).

Elements of grounded theory I employ include avoiding determining codes or thematic categories in advance of the analysis, self-reflective "memoing" throughout the research process, and attempting to reflect on my position as a researcher as an important element of the study. I begin with areas of interest and exploratory directions rather than with testing hypotheses that functionally constrain what I can observe. I expect theory to be the product of empirical observation and employ “constant comparison” (Johnson, Onwuegbuzie, & Turner, 2007, p. 118) as a check against fidelity to the data.

Many grounded theory-based studies claim that themes and theories “emerge organically” from the text. This odd attribution is a pretense made to avoid saying that the researcher came up with the codes herself, a statement which seems to rub still-impersonal scholarly culture the wrong way. Coding is a product of a reading, the situated interaction between a reader and the text (Fish, 1982; Roth, 2001). I as a researcher, student, wine writer, wine consumer and oenophile, woman, and American citizen of European descent necessarily inform my readings with an idiosyncratic complement of knowledge and attitudes. For others to be able to map my research narrative to their own knowledge and context, I should reflect on the personal nature of my reading and aim to make some of those reflections transparent to my readers. I do not strictly apply a specific pattern of coding, such as the “open, axial, and selective” (Evans, 2013) triplet of Straussian grounded theory. While I follow the general “constant comparative” approach of iteratively defining and refining codes, I take it as the researcher's role in matching focus to purpose and method to worlds (Law, 2008) to select from amongst the many possible ways of reading, and to read purposefully without necessarily assuming any specific linear order to that reading.

I likewise eschew the wholesale ban classical grounded theory imposes on reading the literature until after identifying themes and building theories from my own data. While I agree that a researcher cannot avoid being influenced by the literature even if she does not self-consciously borrow from it, this is a feature, not a bug. Ideas for thinking with data inevitably come from the full spectrum of previous reading and other personal experiences. This starting material enables the range of new assemblies and connections a researcher can make. Reading broadly fuels the potential for many assemblies and augments creative thinking; this process of broad, generative reading, indeed, appears to be part of the premise of doctoral training. Avoiding reading the literature, rather than preventing my mind from being “contaminated” by the influence of other thinkers, asks me to assemble themes and theories that make sense in the context of my data *only* from those ideas that I gathered prior to the point at which I chose to begin this research. The prohibition creates an arbitrary and limiting distinction between older and new influences, making older influences acceptable and new ones anathema.

Remaining “grounded” in one's own data must instead involve consciously avoiding simply replicating categories from the literature, attempting to reflexively examine data and one's own assumptions, and reading broadly. Numerous others in science communication have described employing a version of grounded theory similarly, as a guide for qualitative reading and coding, without subscribing to the positivist assumptions of its classic form (e.g. Chilvers, 2008; Hinnant & Len-Rios, 2009; Luzón, 2013).

Interviews

I conducted semi-structured interviews to assay winemaker/grower uses of scientific information resources in a fashion giving interview participants extensive control over the discussion. These were conversations in the best and in the vast majority of cases. Though my predetermined list of questions (see Appendix B) focused the conversation, my interlocuters' participation as conversation partners rather than informants on a specified set of questions allowed them to suggest possibilities for winemaker/grower-research interactions that I had not imagined in advance. The various tangential references and stories we explored also added substantially to how I understood the lives, work, concerns, and interests of these wine industry members. Appendix B contains a list of topics around which interviews were structured, following the methodological lead of Brandt (2001), Hinnant and Len-Rios (2009), and Horst (2013).

Because interviews served to document the presence rather than the prevalence of characteristics in wine industry practitioner populations, interview samples did not need to be strictly representative. Attempting a representative sample would likely have been counterproductive in the sense that focusing on the most *prevalent* population segments could have overrepresented one or a few attitudes and practices to the exclusion of others. The degree to which my samples were or were not representative, moreover, is impossible to judge because of the absence of detailed demographic data for winemakers and/or growers in Washington State and in New Zealand.

Interviews were instead selected with maximum diversity in mind. Interview participants varied in age (by my conservative estimate) from early thirties to late sixties and in education from high-school diplomas and two-year degrees to doctorates and advanced professional degrees. Winemakers and growers were employed at wineries prestigious and plebian, owned locally and internationally by families and by corporations, with local and international reputations, and dispersed across the conventional-organic-biodynamic spectrum. Some owned their own businesses and some were employees. In keeping with the nature of the industry, they were predominantly male and overwhelmingly white, though I deliberately included women and people not native to the region. Informal estimates (Talev, 2014) count a dozen or so African-American winemakers working in the United States, and the number of non-White (chiefly Maori-descent) winemakers in New Zealand appears to be below ten (J. Burzynska, personal communication, October 4, 2015). I was able to interview only one non-white industry member.

Interviewing a small number of people surely meant not capturing the full spectrum of practitioner attitudes. However, interviews appeared to approach saturation both in Washington State and New Zealand: by my final interviews in each location, I could accurately anticipate most of my interviewee's responses, suggesting that I had gathered enough data to understand the population (Guest, Bunce, & Johnson, 2006; Mason, 2010). Multiple qualitative researchers have argued that the sample size necessary for any given study is governed by its objectives, and that the availability of additional data from complementary methods or topical expertise can support a smaller sample when the goal is developing a principled understanding rather than making specific predictions about future events (as reviewed in Mason, 2010). All of these conditions hold true for this study.

Most interviews were one to two hours long and a compromise between obtaining rich data and conversing long enough for interviewees to become comfortable, on the one hand, and sensitivity to interviewee's time constraints on the other. With few exceptions,[14] interviews were comfortable and relaxed conversations. Conversations often extended into informal vineyard or winery tours and sometimes into wine tastings. I nevertheless deliberately attempted to perform the role of "researcher" and not "wine writer" in all save two instances when a winemakers' familiarity with my other role made separating the two impossible. In these cases, the greatest observable impact on the data appeared to be that both winemakers described their beliefs about the functions of scientific literature as sympathetic with the position that I take publicly on my blog and in my articles – appreciative but critical, generally speaking. Their sympathetic attitude may have been a friendly gesture, but also appeared congruent with their public statements in social media and other published interviews. It is possible that winemakers and growers familiar with my public writing persona who tend to strongly disagree with or dislike my writing did not respond to my interview requests. In all these cases, it should be kept in mind that many winemakers – who, depending on the size and public image of their wineries, are often a highly visible public face of the brand – are experts at managing their public image.

Surveys

Surveys were designed to reach a larger number and wider range of winemakers and growers in the two case areas, particularly including industry members who work outside

[14] I conducted one interview in Washington State and one interview in New Zealand in which I felt uncomfortable, and in which I suspect the interviewee felt uncomfortable. One involved a participant who seemed uninterested in being interviewed (though she had volunteered to participate), the other an unanticipated time conflict with another and clearly more important meeting. Both interviewees' responses were terse, and these constituted by far my shortest interviews at 35 minutes and 15 minutes respectively.

the regions in which time and financial limitations made it practical to conduct interviews. Surveys (see Appendices C and D) canvassed topics similar to those addressed in interviews. A combination of multiple-choice and free-response questions allowed for understanding industry members' responses to specific, well-known information resources while also allowing for inclusion of resources or concerns missed in interviews. Survey response rates were low (approximately 17 percent in Washington State and 23 percent in New Zealand) in terms applied to general population surveys (Rindfuss et al., 2015) despite a recruitment strategy that involved two personalized emails and a third general reminder email. Still, responses in both Washington State and New Zealand came from a diverse body of industry members distributed across wine producing sub-regions, age, length of experience in the industry, and general and industry-specific educational background. Winemakers' and growers' attitudes toward the utility of scientific research in industry practice does not appear to correlate with any of these demographics, and it seems likely that responses were weighted toward winemakers and growers who hold strong feelings about scientific research with less representation from industry members who feel less invested in the subject. No attempt was made to follow up with non-responders; winemakers and growers are a notoriously difficult population to reach (New Zealand Winegrowers staff, personal communication, October, 2014) and my interests in maintaining cordial long-term relations with the survey populations outweighed my desire to gather every possible response. The survey nevertheless appears to have served its purpose by gleaning a variety of responses, confirming the value of information resources identified as important in interviewes, and making it possible to outline multiple different types of ways of responding to the role of scientific research in industry practice.

Textual analysis

Interviews and surveys generated context for the textual analyses which followed. These preliminary studies also made it possible to focus my corpora around the types of texts and the sources that interview and survey respondents described using most often. I attempted to read in keeping with what I learned in interviews and surveys with the understanding that texts and their contexts are reciprocally co-productive (discussed in more detail in chapters five and six). Reading these multiple data sets together without treating one as primary is my response to the criticism of critical discourse analysis that Blommaert's (2005) exemplifies: that critical discourse analysis is an excuse for researchers to coerce a text into proving what the researcher has already decided is true from context. If, however, texts and contexts are produced together rather than one preceding the other, then it makes sense for them also to be understood together rather than attempting to order a linear analysis accounting for each in turn.

I focus textual analyses at a rhetorical and discursive level, an approach Myers (1996) models at the junction of writing studies and science and technology studies, using the guiding principles of critical discourse analysis to identify microprocesses that enact relationships. “Microprocesses” is a term used across the social sciences and in business studies to describe individual interactions that aggregate to produce a larger-scale phenomenon. The term has, for example, been used to denote one-to-one interpersonal relationships participating in institutional change (Johnson, Smith, & Codling, 2000), counseling relationships (Altenstein, Tobias, & Grosse Holtforth, 2013), and intra-group interactions in the context of problem-solving capacity (Metiu & Rothbard, 2012). Bazerman (2004) uses “microprocesses” in a writing studies context to denote intratextual maneuvers that aggregate to construct or perform textual characteristics, a usage I adopt here.

Textual microprocesses overlap with rhetorical features, but speaking of microprocesses has several specific affordances. Rhetoric refers broadly to the innumerable strategies available to authors (or speakers, or communicators broadly) to construct their message in a particular context, or “an arguer's creative response to the constraints of a particular situation” (Fahnestock, 1989, p. 27). In science communication, nevertheless, rhetoric often denotes *classical* rhetoric, or the panel of strategies for public oratory developed by Aristotle and a handful of other ancient Greeks and Romans (Ashmore, Myers, & Potter, 1994). Microprocesses avoid aligning this study with that body of classically driven scholarship in a potentially misleading way. Rhetorical features are also not universally *intratextual*: the choice of medium or the timing of a message can, for example, be rhetorical. Microprocesses, though broad, are more specifically intratextual.

It remains true, however, that I read through a rhetorical lens in that I understand textual features to represent strategic choices mediating relationships. “Strategic” need not necessarily invoke agency on the part of the author acting as an individual; the individual author is not (necessarily) making the conscious and personal choice to structure relationships in her writing. I follow Fairclough (1992) in taking texts as the product of an individual acting simultaneously as an individual and as a group member, and Latour (1999) and Law (1992) in taking agency as a distributed property of a heterogeneous network without absolving individual actors (human or otherwise) of a personal role in enacting that network.

Critical discourse analysis

This study as a whole appeals to (some but not all of) the norms of grounded theory; similarly, the textual analysis portion of this study appeals to (some but not all of) the norms of critical discourse analysis (CDA) while acknowledging that some of its assumptions are out of line with the STS sensibilities that also underpin this study (Myers, 1996).[15] CDA was born out of critical linguistics in the 1970's (Wodak & Chilton, 2005) and has since been deployed and elaborated in discourse analysis and various social sciences. Here, I employ a rhetorically inflected CDA involving the critical inflection of CDA (Hucklin, Andrus, & Clary-Lemon, 2012) and the attention to specific textual strategies characteristic of rhetorical analysis.

Classical Aristotelian rhetoric reads texts as tools of persuasion. Classical rhetoric was also a function of the limited genres important to public Athenian oratory. Bazerman (2013) has suggested that an alternative understanding of rhetoric, more appropriate to

[15] Myers observes that critical discourse analysis and Latour's actor-network theory are mutually useful guides for doing rhetoric of science studies, even though they are technically theoretically incompatible.

contemporary usage, reads texts instead as manipulating “the symbolic landscape so as to change the field upon which others will act in order to assert my concerns, interests, contribution, or participation into the process or outcome” (p. 88). In this definition, textual rhetorics move out of the relatively narrow social roles described by an author persuading an audience and expand to include more varied ways in which authors and audiences relate. In calling my analysis both rhetorical and discursive, then, I refer to textual strategies shaping the field upon which authors and audiences meet. Elsewhere in the discourse analysis literature, CDA has been used in a similarly rhetorical fashion to analyze, for example, anti-piracy advertisements in South Africa (Kariithi, 2010) and nature-human depictions in Greek reserve exhibits (Stamou, Lefkaditou, Schizas, & Stamou, 2009) .

Useful elements of the CDA tradition include its treatment of authors as both individuals and discourse community members and its focus on how discourse enacts the power dynamics of social relationships (Tischer, Myer, Wodak, & Vetter, 2000). The space CDA provides for the communicative power of silence and absence, congruent with Law's (2004) valuation of manifest absence, is also apt for describing wine practitioners' place in wine science communication. I could be more precise by calling my analytical strategy a rhetorical discourse analysis informed by material semiotics, attending to strategic/rhetorical elements of texts as social action at the discourse community level and understanding texts as enactors in heterogeneous networks of which scientific knowledge (among other things) is an emergent property. I replace that long phrase with the much shorter “CDA” with the aforementioned caveat of seeing texts and contexts as mutually productive rather than reading texts *in* context as such.

Epistemological limitations

The first winemaker I interviewed in Washington State explained that when he evaluates new information, he compares it with his whole mental "database" of knowledge built out of first-hand experience, talking to neighbors, visiting colleagues in Spain and other assorted wine producing countries, and reading textbooks and extension newsletters. The new information needs to cohere, but to be useful it also needs to be something new, something a little bit surprising. My new data generated in the course of this study likewise need to cohere with my own mental database describing the probable limits of likely readings while allowing for surprise. The question is not whether to begin with text or context, but how to explore the two as mutually co-dependent. The answer is not to define one object as primary and to exclude the others as invalid, but to treat all information as data.

This study does not, then, "uncover facts," or "reveal truths," or otherwise dig a solid bit of reality out of the ground and polish it up for communal approbation and admiration. Its value cannot be extracted away from the conditions of its production. It is one picture of a set of fluid objects which became objects in the process of my constructing them. The study is a reading of scenarios or locations which change as a result of my observation (Kelly, 2014). Read alongside other readings so that one can provide new material for rereading and understanding the other, it should help to create a multivalent picture of the objects under consideration with different and fewer blind spots.

Rationale for case study selection

I situate my study in the wine industry and Washington State and New Zealand in particular in part to make use of my background with that industry which allows me to read wine science communication texts as an insider-outsider, and in part because the wine industry emphasizes producer individuality in a way felicitous to studying collaborative research-industry communication.

I have been interacting with the wine industry in various ways since childhood: first as a winery visitor and assistant to casual home winemaking, then as a reader of wine books, then taster, wine writer, wine microbiology researcher, now as a science communication researcher and writer, and always as a consumer. I became familiar with the wine-producing regions of eastern Washington while living near them for several years before moving to New Zealand. Living and studying in New Zealand has allowed me to become more familiar with the industry here. My extracurricular work as a wine writer brings me into regular contact with the primary peer-reviewed wine science literature, the trade literature, and winemakers. As a result, the way I read and understand the wine science literature is better-developed and closer to an "industry-insider" perspective than would be the case for any other industry.

Insider-outsiderness

These relationships I have with my research subject are germane to the data I gathered from my study participants and to how I conducted my analyses. I am outside the primary audience for the wine extension literature, not a wine producer and with no financial stakes in the wine business. But I am also inside the industry in having some degree of privileged access to its people, privileged knowledge of wine science – and, to a lesser extent, some practical knowledge of winemaking – and some sense of community belongingness. I know the jargon of the wine science literature, how it applies to practice, and what scientific language winemakers typically use in conversation. Most of my interview participants realized that we could conduct our interview in specialized industry and technical terms without interruptions for explanations that casual winery visitors would have required.

In the seemingly endless search for reflexivity, the social science literature is well-populated with discussions of the researcher as insider-outsider. These observe that the researcher's role is always relational and performative, and that the affordances and constraints of a researcher's positionality benefit from examination in the interest of making the nature and value of the research transparent both to the researcher and to future readers (Gair, 2012; Kelly, 2014; McDonough & McDonough, 2001; Milligan, 2016; Ochieng, 2010; Tang, 2007). Milligan (2016), as a white woman conducting research amongst black men in the rural Kenyan educational system, found that she "represented a number of different identities" (p. 2) which she could to some extent manipulate. Her conclusion was that qualitative researchers can take deliberate action to alter their insider or outsiderness. I have in my own research come to similar conclusions.

In brief, I aimed to play the part of well-informed independent wine researcher, but played up student naïvety or wine writing experience as doing so facilitated smooth and open conversations. Because some interview participants were more comfortable with one or another role, my information-gathering was eased by being able to transition between these multiple roles. My initial email contact with prospective interviewees involved "active choices" (Milligan, 2016, p. 241) to present as a researcher independent from industry bodies, publications, and funding agencies, stating no affiliation other than with the University of Otago and downplaying my alternate identity as a wine writer. I wanted to make the purpose of my visit clear, but also to remain as distant as possible from the complex power moves that can accompany wine industry public relations. In interviews, I exploited the flexibility of my positioning to let winemakers know that I had some insider knowledge about the technical side of the industry while still being outsider enough to warrant asking questions about their everyday work. As a result, conversation could focus on information resource use without lengthy clarifications about the technical content of those resources. Winemakers also seemed comfortable speaking outside the polished narratives delivered to consumers or wine journalists, and sometimes quite openly spoke to me as being a neutral party outside local political dynamics. While I was no doubt still on the receiving end of image-motivated mitigations, moments of guarded storytelling seemed to contrast with the majority of instances in which interviewees spoke with me casually, sometimes explicitly marking a statement as standing against or outside the winery's formal brand story.

Several interviewees in New Zealand appeared to treat me as a safe space of sorts for airing opinions that they had been unable or unwilling to speak elsewhere, or which they said had been expressed to but actively ignored by industry decision-makers. As a consequence, my data may appear more radical or may reflect more dissatisfaction than narratives collected by representatives of industry organizations with known stakes in the political games of a highly relationship-oriented industry. Because my primary interest in these interviews was to understand information resource use – which, while hardly apolitical, never appeared to be an especially sensitive topic – I did not transcribe or analyze interviews with a level of detail that might have allowed for identifying more and less guarded speech. In the interest of not compounding multiple levels of erroneous assumptions, my analysis assumed that all transcript data were of equal quality.

The wine industry as a case of industry-oriented science communication

Research-industry relationships are only interesting if we believe that research and industry should have a meaningful relationship in the first place. In the wine industry, one could not survive without the other. Enology and viticulture, the study of winemaking and grape growing, respectively, exist because of the wine industry on two levels. The industry provides researchers with meaningful questions and problems; without working vineyard and winery contexts after which to model experiments, researchers would lack direction in conducting experiments that relate to the extra-scientific world in meaningful ways.

Industry also directly and indirectly funds research: industry organizations support research with levy monies, sponsor scholarships for students studying viticulture and enology, provide grants for specific research projects, and support university departments of viticulture and enology with endowed chairs and other direct support (see, for example, the recently christened Ste. Michelle Wine Science Center at the Tri-Cities campus of Washington State University and the Bronco Wine Company Viticulture Research Chair at Fresno State University in California). Scientific researchers consult on industry projects, some scientists have spent time working in wineries or vineyards, and researchers sometimes transition to roles in commercial viticulture or winemaking.

The contemporary wine industry is equally dependent on research. Wine has been made for millennia (Cavalieri et al., 2003). Some contemporary winemakers continue in their trade with millennia-old technology. By far the vast majority of today's wine, however, benefits from the work of scientists conducted over the past 300 years. Moreover, the shape of the contemporary industry is itself the product of 20th century technology making it possible to produce wine in bulk lots and distribute it for global consumption. Advances in microbiology reduce the risk of unsuccessful fermentations, making it practical to ferment in larger volumes. Microbiology and chemistry together have devised techniques to dramatically reduce the chance that stray yeast or bacteria or a chemical fault will spoil a bottle by the time a consumer pours it out for dinner guests. Revolutionary changes in plant sciences make it possible to grow grapes in climates deemed completely unsuited for fine viticulture even a generation or two ago, and to maximize yields within acceptable quality parameters, together making for a plentiful and inexpensive global wine supply. Sweet wines once were difficult and costly to produce, reserved for nobility and the wealthy. Now, the ability to make sweet wines inexpensively and with a near non-existent risk of spoilage has expanded the range of products on the market and the range of consumers interested in drinking them. Wines have become sweeter, higher in alcohol, and dramatically less prone to technical faults. Never before has such high-quality wine – wine that has not turned to vinegar, been watered down, or been adulterated by the merchant to cover up spoilage – been available to so many people, thanks to the partnership between scientific research and industry practice.

The same can be said of other agricultural industries, which is important in considering how the findings of this study might be used beyond the wine sector. Many fruits are grown cheaply in large quantities and stored for year-round consumption in ways that were impossible a century ago, thanks to ongoing research in plant and food sciences. Agricultural systems in general are particularly fertile settings for observing how scientific knowledges are embodied in practice (Arce & Fisher, 2007). When academic professionalization, modern agrochemical development, federal funding for tertiary education, and a push for increased food production collided in the late 19th century, newly professionalizing agricultural scientists established their positions by constructing farmers' problems as scientific problems that they were well-equipped to solve (Danbom,1986; Suryanarayanan & Kleinman, 2012; McDowell, 2001). American land-grant universities were created with a mandate to teach agricultural skills but, as universities, they obviously needed to teach science and not merely pedestrian trades (Cash, 2001). Gradually, successful farming became a product of specialized scientific knowledge systematically applied, not the outward sign of a farmer's good “character” (Marcus, 1988, p. 9). 20th century agricultural science developed as melded basic and applied science (Clarke, 1998) with widely assumed authority over agricultural practice until the anti-agrochemical revolutions of the 1970s brought it into question (Warner, 2008). The fallout of that questioning is visible in the overwhelming folding-in of social and ecological interests into agricultural sciences under the umbrella of “sustainability,” including notable farmer-led initiatives; still, their rise has by no means meant the fall of agricultural extension (Pence & Grieshop, 2001; Warner, 2008). Institutionalized agricultural science communication continues to focus largely on technology transfer (Warner, 2008) while treading the difficult line between telling farmers what to do and allowing farmers to initiate voluntary change amongst themselves.

Unlike many other agricultural sectors whose histories have been tangled up in agricultural extension, however, wine is not traded as a uniformly graded commodity. Wine's diversity and value as a culture and a lifestyle make the wine industry particularly useful for studying research-industry communication. In commodity industries, individual producers appeal to a set of agreed-upon standards, competing to be the best at following established guidelines or finding new and improved ways to meet established goals (Legun, 2011). New World[16] wine regions, in contrast, operate with minimal if any quality

[16] Wine's “New World” is typically defined as wine producing countries outside of Europe, in contrast with the European “Old World.” The Old World/New World distinction is troublesome on multiple accounts. Some “New World” regions – Argentina is perhaps the best example – have centuries-old winemaking

regulation. In terms of wine quality and even in terms of business model, every producer may in theory be working toward something unique. Indeed, it could be argued that their marketing efforts try to assert exactly that case (Easingwood, Lockshin, & Spawton, 2011; Mora & Livat, 2013). Winemakers and growers are not compelled to follow scientifically supported recommendations either by law or by market pressures, and they tend to develop extensive expertise through trial and error in developing their own styles. Wine producer value systems are diverse and the industry rewards experimentation and innovation.

Consequently, interactions between wine science communication and producer knowledge should be easier to observe than they are in systems forced to be more homogeneous by commodity regulation systems. When producers survive by finding "points of difference" (Beverland & Luxton, 2005; Dawson, Fountain, & Cohen, 2011) and arguing their uniqueness to consumers (Mora & Livat, 2013), they have an incentive for trying new things. When not everyone shares definitions of "good wine" and "good winemaking" (see, in particular, chapter three) it becomes easier to see how science communication tools support one definition at the expense of others, perhaps with unintentional consequences. Winemakers also tend to be well-educated, accustomed to being in the public eye, and have often chosen their careers out of a personal passion that drives being outspoken about them. When industry members are highly opinionated, loud,

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traditions, but are classed as New World because of physical, political, and cultural geographies. The dichotomy also imagines false similarities amongst regions with very different production systems, and it essentially ignores increasingly significant wine production in the "Third World" (Banks & Overton, 2010). Nevertheless, the distinction is widely used for generalizing about differences between the highly regulated "Old World," where the grapes and techniques permissible in winemaking is a legal matter, and the "New World," where such regulations are virtually nonexistent. Alternatives to the two-world classification have not yet been put into general use, and doing so is beyond the scope of this discussion.

and visible, it becomes easier to see how science communication accounts or fails to account for their voices. Wine marketing narratives depict winemakers as expressive, even artistic, and deeply and personally connected to their products (Mora & Livat, 2013; Scott Morton & Podolny, 2002; Sexton, 2013). The wine industry thus highlights a point often clouded in other science communication contexts: by affecting how winemakers and growers perceive the role of science in their practices, science communicators apply pressure to change the kinds of wine they make and the stories they tell through and about those wines. Using science communication to suggest how they should use scientific research, at least to the extent that science communication succeeds at its aims, changes the options we have at the local wine shop. If science communication is construed as being about conveying accurate research-based information without seeing how it re-orders value systems, its effects on the latter may be unseen and inadvertent.

The Washington State and New Zealand wine industries

The Washington State and New Zealand wine industries represent two extremes along a spectrum of ways of structuring institutions responsible for wine science communication. Both regions are located in winemaking's "New World," defined negatively as wine producing regions outside the European "Old World." In the New World, winemaking styles are governed by preference and the market, not law, and winemakers and growers are largely free to make their own choices about whether and how to employ science. This environment contrasts with many highly regulated Old World regions where legislation defines allowable winemaking practices and permits, requires, or prohibits specific technologies. Consequently, New World wine industry-oriented science communication is primarily about practitioner choice, less about changing laws, and the potential range of scientific research that might lead to changes in industry practice is broader in the New World than the Old. Focusing on New World wine producers made considering science communication without considering legislative bodies as an additional audience possible.

Across the New World, strategies for research-industry communication and "technology transfer" fall along a spectrum of public versus private investment. With the United States at the extreme public and New Zealand at the extreme private end of that spectrum, the pair make good cases for exploring whether public and private science communication infrastructures enact different research-industry relationships. This study was initially imagined as a starting point for understanding how public versus private extension might facilitate research-industry collaboration and knowledge sharing differently and more or less effectively. As is discussed in more detail in chapter six, private industry-driven science communication appears to engender a researcher-as-client relationship different than the researcher-as-scientist image common in public extension. This observation merits additional research to more specifically evaluate how researcher positioning influences how science communication invites and precludes industry knowledge sharing, and what influence extension funding and governance structures have on how extension communication enacts collaboration. While this study remains wholly tied to the two specific contexts on which it has focused, because it discusses industry-oriented science communication at both ends of the public-private spectrum and focuses on similarities between the two, its results may be easier to employ in other New World winemaking regions.

In the United States, a publicly funded and managed agricultural extension system conducts research, communicates research findings to practitioners, mediates between scientists and practitioners, and serves practitioners' information needs by answering questions and providing resources. Though the agricultural extension system has suffered major cuts in its funding from federal and state budgets, its structure has remained largely intact over its roughly 150-year history. In 1864, the federal Morrill Act gave rise to “land-grant” universities – so called because they were endowed through the sale of federal lands granted to the states – charged with providing education and information services to the residents and agricultural industries of their home states (McDowell, 2001). The Hatch Act of 1887 made these universities the base for public agricultural research stations tasked with improving farm industries through modern science and engineering. Since 1887 and through the present, taxpayer monies have continued to fund freely available scientific research and information services. In the United States, all extension outputs are made available to everyone without regard to citizenship or residency.

New Zealand once housed a similar publicly funded agricultural extension system, but became the first country to wholly privatize its extension services in the 1980 (Stantiall & Paine, 2000; Swanson, Bentz, & Sofranko, 1997; Walker, Bell, & Elliot, 1993). Today, wine industry science communication or "technology transfer" is provided almost entirely via a representative industry organization, New Zealand Winegrowers, which mediates between wine industry members and researchers employed at profit-turning, government-owned but corporatized "Crown Research Institutes" and universities. Internationally, many countries have positioned their agricultural extension services somewhere between these two extremes. I initially questioned how these two structures – the former interpellating scientists as independent investigators providing a public service, the latter as contractors to industry – might produce texts that construct different relationships between science and practice. What I find is that though these two systems do position science differently, particularly in terms of what motivates research, the relationships their texts sketch have much in common. I suspect that this similarity can be traced to the relative recentness of New Zealand privatization compared with the relatively long history of the peer-reviewed scientific research article, as the genres of New Zealand science communication have not shifted far from those well-established roots, but I cannot derive a historical explanation from my analysis.

The United States ranks fourth in the world for national wine volume production, according to statistics reporting 2014 production from the California-based Wine Institute (Wine Institute, 2015). While every one of the fifty states harbors at least one winery, approximately 90% of total national production happens in California (Wine Institute, 2015). Ranking a very distant second, Washington State has about 850 commercial wineries and about 20,234 hectares under vine. New Zealand is comparably sized, with approximately 700 commercial wineries and 35,313 hectares under vine. The Washington State and New Zealand industries are also similar in age, with histories of wine production going back to first European settlement but modern industries which took off only in the 1970s. These similarities made it easier to employ a similar research design in each case.

Differences between the Washington State and New Zealand industries, however, are significant in terms of the range of values, priorities, and research uses that might be formally supported by industry and research communication organizations. Washington State hosts a highly diverse industry served by a single central research and extension program at Washington State University (WSU). No one grape variety or style dominates either the state's wine production or its brand image. This diversity of production makes Washington State unlike New Zealand, sub-regions of California, Oregon, and most other well-known American wine-producing states, each virtually defined by a specific signature wine style on the international market: Napa cabernet sauvignon, Oregon pinot noir, Marlborough sauvignon blanc. Even within the same sub-region, Washington State wineries often work with different grapes and espouse dramatically different images and business models. WSU extension is expected to provide for state needs broadly, but winemakers also have access to extension services from other states and to multiple technical publications from private publishers. The Washington State Wine Commission, a state government agency driven largely by industry funds, has a relatively quiet place in the industry. The commission undertakes some collective marketing efforts, advises on research at WSU, and offers limited direct research funding. It has no connection with the widely read trade publications, however, nor does it have any direct role in WSU extension science communication, and it is only one of multiple players involved in directing research. As a result, various kinds of science, marketing, and other industry communications ask winemakers to engage in relationships with multiple institutions, and the idea of a collective identity around “Washington State wine” is relatively weak.

In contrast, institutions in the New Zealand wine industry pull much more strongly toward a national image and a relationship with a single organization responsible for coordinating a broader range of communications. Wineries within a sub-region are likely to make a similar range of wines, with commercial interests particularly focused on Marlborough sauvignon blanc and, to significantly lesser extents, pinot noir in Central Otago and Martinborough and Bordeaux-style red blends in Hawke's Bay. Winemakers can and do consult overseas sources for scientific information, but New Zealand Winegrowers (NZW) is the primary provider of scientific resources within the country, apart from the many private consultants for hire. NZW not only runs collective marketing but operates the industry's main science communication channels, including the only New Zealand-specific trade magazines: New Zealand Winegrowers Magazine and the Marlborough-specific Winepress. New Zealand Winegrowers also appears to fund, facilitate, and/or advise on the vast majority of the nation's wine-related research. Though data presented in chapter five attest that not all industry members feel closely associated with the organization, New Zealand Winegrowers nevertheless centralizes research and science communication efforts.

Limitations

Structure of the survey and interview populations

In both Washington State and New Zealand, the distance between major wine producing regions meant that in-person interviews were limited to only two (Washington State) or three (New Zealand) of roughly eleven (albeit overlapping, in Washington) regions. Though winemakers and growers across regions were similar in terms of general information resource use preferences, wine producing regions inevitably develop local cultures which flavor winemaker/grower attitudes. Winemakers and growers in Central Otago, for example, often spoke of themselves and their region as isolated from the rest of the New Zealand industry; their geographical separation and the self-identified desolation and extremity of their landscape may incline them toward a more laissez-faire attitude toward goings-on in the rest of New Zealand. In Washington State, winemakers and growers in Walla Walla – relatively cosmopolitan in Eastern Washington terms – have ready access to an excellent community college and a variety of collective marketing events; accessing those resources requires special effort for people working at wineries in the farmlands several hours to the West. Though I chose interview locations with industry diversity in mind, it should still be noted as a limitation of this study that regions in which I was not able to conduct interviews – particularly Martinborough, the greater Auckland area, and Canterbury in New Zealand – have unique identities and including them may have led me to different conclusions. This seems much more likely to be the case with respect to the

New Zealand case study than Washington State because New Zealand industry members described strong sub-regional allegiances while Washington State winemakers were, on the contrary, likely to identify with the state more generally. Still, differences amongst the three regions where I conducted interviews in New Zealand seemed principally attributable to differences in winery size or cultivation method (Central Otago wineries are smaller and more inclined to follow biodynamic practices than those in Marlborough, for example).

With respect both to surveys and interviews, I made no effort to document the scientific information resource-related behaviors or attitudes of industry members who were unwilling to respond to emailed solicitations. Logically, I should expect the characteristics of these non-respondents to be non-random. Practitioners who perceive themselves as not using information resources are less likely to respond to a survey or request for an interview on that topic, an assumption supported by several emails I received stating apologetically that the sender would not be a useful subject because he or she did not use information resources. My responses encouraging that the exact opposite was true produced only a single extra survey response, to the best of my knowledge, and the emails I received surely represented only a fraction of potential respondents with the same views. I deliberately avoided mentioning “science” in emails, asking instead about “information resources,” but my association with the Centre for Science Communication (disclosed in my email signature) and my institutional affiliation with the University of Otago (obvious from my email address and the content of my message) may also have deterred people who are uninterested in or who harbor negative emotions toward science, universities, or academic researchers.

I can also expect to have systematically under-sampled people who do not wish to be involved with students or research projects, who are very busy and unwilling to allocate time to participating in research, and who do not regularly use email. I also undersampled contract growers (grape growers not associated with a winery), whose businesses rarely have a web presence; I interviewed only a single such grower in New Zealand. Again, though I stated no affiliation with research or industry organizations in New Zealand other than the university, extensive previous research organized by New Zealand Winegrowers and other research institutions no doubt primed responses to my own queries and certainly contributed to survey fatigue amongst what wine communications professionals have described to me as an already difficult-to-survey population.

I may also have oversampled individuals with particularly strong positive or negative feelings about information resources, with strong frustrations about the status quo that they felt were going unheard, who are proud of what they perceive as their especially scientific practices, or who invest deeply in their relationship with industry organizations. However, because no comprehensive demographic or research use data have been collected for wine practitioners in either Washington State or New Zealand, I was unable to judge degrees of over- or under-representation against another data set. I can conclude only that the data I have collected indicate winemaker and grower attitudes that are prevalent and that should be taken into account in designing science communication, but not that I have necessarily represented all winemaker and grower attitudes. Capturing all winemaker and grower attitudes with any confidence would have required far more resources than were available here.

Limitations of the corpora for textual analysis

In a decade in which even tradition-minded newspapers routinely produce stories with integrated videos and interactive graphs, and when college composition courses increasingly ask students to compose podcasts and visual narratives alongside traditional essays, limiting my textual analysis to alphanumeric components alone may seem downright quaint. Many elements of a text beyond the strictly alphanumeric are rhetorical: font and page layout, photographs and charts, physical or digital medium, use of color, weight and glossiness of the paper of the magazine or newsletter. Choosing to ignore these various other features was a matter of identifying what elements remain constant for audiences across their various modes of reading. Most texts in my corpora are available in multiple modes: as physical copy or digitally, as an email attachment or a downloadable newsletter, on webpages or the various platforms used by online magazines. A wine practitioner may read the same alphanumeric content from a piece of glossy paper, a black and white photocopy, the screen of a desktop computer, or her phone. Because the purpose of this study was not to track how readers respond to these various media, I eliminated from my analysis those features which change across them.

Focus on research-industry relationships

I attempt to speak to research-practice relationships, but focus on researchers, practitioners, and science communication to the near-exclusion of the other networked relationships surrounding and tugging at those most central to my concerns. Latour's (1999) circulatory model of science describes science as the product of five interconnected classes of "activities." Here, I attend to a limited set of those activities involving "public representations" and "clients" or "alliances" while paying little attention to "nature" or how the world is "mobilized," "scientific colleagues" or the needs and responses of scientists themselves, and the "links and knots" of content (Latour, 1999, p. 99). I have not described a complete system of how applied science emerges from this complex network of relations. I have focused on rhetorical enactments amongst a specific subset of these actors; consequently, the conclusions at which I arrive may fail to account for the practical needs and constraints of other actors. Implementing them in practice will very likely require adjustments to account for those additional factors.

Omission of the scientist perspective

I have spoken of the *mutual* benefit of this epistemically egalitarian co-construction model, to both scientific and industry purposes, while focusing on industry and not answering to how scientific interests are served. Applied scientific research needs to do good work for science, creating tools useful inside the scientific community, and to do good work for industry, creating tools useful in industry practice. Scientific and industry goals are likely to overlap, but not to perfectly coincide. Academic wine scientists need to "deliver value to industry" (see chapter six) to compete for both public and private (industry-sponsored) grants on which their ability to conduct research depends. How researchers and granting bodies measure that value surely differs from how winemakers and wine growers measure it. Moreover, even scientists employed by universities in extension-focused positions generally need to publish original work in peer-reviewed journals to earn tenure and promotion (Warner, 2008). What constitutes good publishable science and what constitutes good applied science in practice may be different. It follows that additional work needs to examine how co-constructive science communication rhetorics can be crafted to serve and preserve scientific interests.

Finally, this study appeals to a material semiotic ontology without tracing how its key objects – science communication texts, researchers and wine industry practitioners, wine and grapevines, scientific knowledge and research agendas – are effects of stabilized relational practices. I appeal to material semiotics as a source of metaphor and theoretical grounding for a rhetorical discourse study without employing STS methods proper. As I touch on above, choosing this path means limiting the realities I can imagine and the objects I can stabilize in my case studies. I have conducted one set of readings of wine research-industry relationships in science communication texts – not the best readings and certainly not the only readings, but one way of practicing realities, and one set of tools for expanding the scope for imagining what science communication is.

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Preface to chapter 3 – How this study of interviews and surveys with Washington State winemakers and growers relates to the thesis as a whole

Washington State winemakers and growers use, and conceptualize the utility, of scientific information in diverse ways related chiefly to their different attitudes toward what constitutes good winemaking. Their diverse perceptions of research use depend on how they relate scientific research to their own practice. Those relationships are not just a matter of topicality, but involve individual definitions of the problem of making “good” wine. *Therefore*, industry-oriented science communication needs to consider that what constitutes “research utilization” varies amongst industry members who conceive of “good winemaking” in different ways, and that audience-aware communication will likely frame science in different ways for these different groups. In addition, while Washington State winemakers and growers almost universally value and pay attention to scientific research, very few view research as providing best practices or instructions; most view the relationship between scientific knowledge and industry as more complex and the authority of science as less absolute. Science communication which encourages any one authoritative relationship of research over industry practice – by focusing on adoption, or by encouraging more scientific attitudes, for example – risks working against this industry diversity, perhaps unintentionally, against broader industry interests, and outside the intended scope of science communication activity.

Additional data from the survey of Washington State winemakers and growers described in this chapter, contributing to the larger arguments of this thesis but not essential to the specific argument made in this chapter, are included in Appendix C. A mock-up of the survey is also included in that appendix.

Chapter 3 - Wine science in the Wild West: Information-seeking behaviors and attitudes among Washington State winemakers and growers[17]

Abstract

This case study provides a foundation for improving the efficacy and efficiency of communicating wine science by investigating winemakers' and growers' behaviors and attitudes around accessing professional information resources. Interviews and surveys of Washington State winemakers and growers yield qualitative data concerning how they interact with the many different information sources available to them, what frustrates or enables their learning, and their attitudes toward employing scientific research findings in their winemaking. Findings show that, beyond a general preference for traditionally authoritative sources, Washington State winemakers and growers are remarkably diverse with resource preferences and attitudes relating to how they think about the role of science in winemaking and the nature of being a good winemaker. Winemakers' and growers' sense of professional identity, in other words, proved the strongest predictor of their resource use preferences, whereas demographic characteristics such as educational background or age failed to correlate with resource use preferences. Attending to this heterogeneity and the reasons behind it may help extension and other science communicators craft messages framed to be more relevant and trustworthy to their industry audiences.

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Introduction

Knowing how winemakers and growers use professional information resources – whether they look for information, where they obtain it, and what they do with it – is vital to the work of agricultural extension and researchers in wine-related fields. Nevertheless, very little work has been done to understand resource use amongst this group of professionals. This study explores those behaviors from a user-centric perspective, querying winemakers' and growers' use of and attitudes toward resources, and developing a typology of resource use behaviors.

Winemaking is an information-intensive job: the challenges of each vintage may require a new conceptual toolbox, and what we know about winemaking shifts and flexes as viticulture and enology researchers (and those from adjoining fields including biochemistry, microbiology, geology, materials science, and others) publish new findings. Granting agencies both public and private now demand that researchers demonstrate how their work will be translated to the industry: how industry members will learn about the research and the financial gains to be had from findings being put into practice (see, for example, requirements for proposals to the American Vineyard Foundation; Deitrick, 2014). Agricultural extension services associated with the American land-grant university system have traditionally supported the information needs of regional agriculture but they are, in consequence and together with researchers themselves, increasingly charged with disseminating new research to the industry (Radhakrishna, Tobin, & Foley, 2014).

This scenario, when explored at all, is usually explored from the perspective of researchers and, by extension – appropriately enough – agricultural extension services as knowledge-holders asking questions about effective ways of disseminating research, of getting winemakers to listen, of getting research into practice (e.g., Gharis et al., 2014; Boshoff, 2014). These aims all begin with foundational assumptions that research is worth disseminating, that winemakers who don't employ research-supported practices aren't listening and need to be convinced, and that the goal of research communication is to bring as much of the industry as possible "on board" with a new innovation (Knott & Wildavsky, 1980). While sensible from the perspective of competitive research funding, these assumptions are unwarranted in light of how winemakers and growers actually practice their craft. They are, moreover, counterproductive when the result is trying to push and pull along winemakers whom experts and communicators have imagined, and therefore constructed, as recalcitrant and ignorant (Wynne, 1992). In short, the researcher-focused approach works within the much-maligned deficit model of science communication which assumes that non-scientists' failure to take up scientifically supported information is the product of ignorance (Sturgis & Allum, 2004; Weigold, 2001). The post-cognitivist tradition of Wynne (1992) and others which has so strongly colored contemporary studies in science communication gives us an alternative: to begin instead with the assumption that winemakers and growers have reasons – complex and comprehensible reasons grounded in their social contexts and personal expertise – for their various attitudes toward scientific information. This study proceeds in that tradition, asking not why winemakers and growers fail to take up scientific practices, but how they interact with available information resources.

Despite the resource-intensivity of communicating new research findings, little research has appeared concerning winemakers' and growers' information resource use or continuing education behaviors; the peer-reviewed literature shows one similar recent study, about winemakers in South Africa (Boshoff, 2014). The present study demonstrates that Washington State winemakers and growers are highly heterogeneous in their information-seeking preferences and behaviors and that education, experience, place of employment, and other demographic characteristics do not explain that heterogeneity. Their attitudes around the role of science in winemaking and being good winemakers, however, do. Because no difference was observed in any case in the responses of winemakers and growers, they are discussed here in aggregate.

Understanding information seeking behaviors and resource use as value-laden is key to extension and researchers communicating with an awareness of how their audience actually perceives and uses scientifically supported information. The concept of market segmentation, borrowed from business marketing research, provides a useful way to think about how scientifically supported messages could be tailored for a heterogeneous audience to be more relevant to audience needs and to better engender trust and participation amongst winemakers. This study thus provides data not only about which resources winemakers and growers are using but also a new framework for thinking about the factors involved in how they approach those resources.

Methods

Washington State was selected as the site of this case study on account of its known diversity. Washington State is second only to California in U.S. wine production with approximately 800 wineries, 350 wine grape growers, and 12.5 million cases produced annually (Washington Wine Commission, 2014). No iconic grape or style dominates either regionally or state-wide and most wineries are small operations (with production generally below, and often far below 20,000 cases/year) producing wines sold for over $20 to a largely regional market.

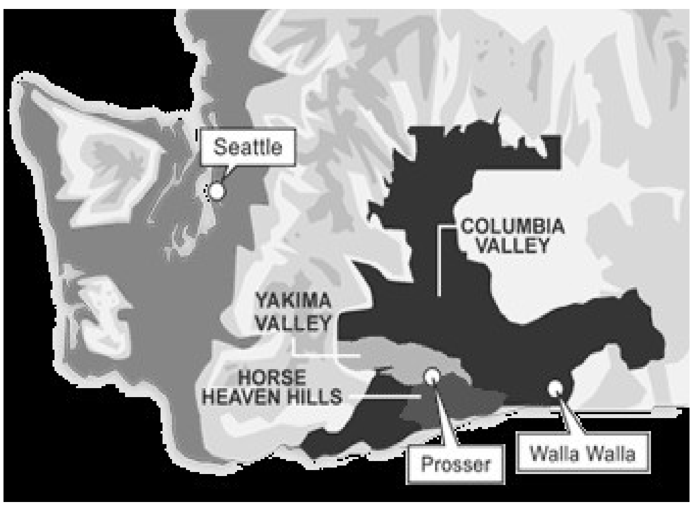

Figure 3.1. Map of Washington State highlighting Walla Walla and Prosser, the communities around which interviews were centered. Reproduced with permission from the Washington Wine Commission.

Interviewees were solicited by personal emails to all winemakers with available email addresses located in Walla Walla or the general Prosser/Yakima/Zillah area (see Figure 3.1). These regions represent a town with an active wine tourism industry and a set of relatively less developed and rural communities, respectively, and were selected to increase the likelihood of obtaining a broad range of diverse responses. Interviews were scheduled with all winemakers willing and able to be interviewed when the research was taking place: sixteen total, one involving two winemakers (neighbors who work together) and one involving a winemaker-grower pair. All took place in the interviewee's tasting room or adjoining office in semi-private settings. While interviewees were chosen by convenience sampling, their heterogeneity mimics that of the industry and suggests that a range of responses has been gathered. They range in age from early thirties to over sixty and in years of industry experience from less than five to well over twenty. One holds an associates degree, twelve bachelor's degrees, three masters degrees (including two MBAs), one PhD, and one a JD. Case production at the smallest of their wineries is less than 1,000 cases per year and, at the largest, approximately 22,000. Two are female. Eight are located in Walla Walla, the remainder in Prosser or the nearby communities of Zillah and Yakima.

Semi-structured interviews – generally sixty to ninety minutes long – were conducted in-person by the author, audio recorded, and manually transcribed (138,004 words in total). A modified grounded theory approach was taken with codes emerging organically from the data and an iterative (or “constant comparative”) approach used to build theories (Evans, 2013; Hallberg, 2006). Initial descriptive coding identified positions and attitudes around information resources, winemaker education, science and technology, and the nature of winemaking. These inductive codes were refined and consolidated into a set of 88 non-exclusive codes (that is, codes could and did overlap on any given segment of text) describing winemaking training, attitudes toward winemaking, attitudes toward research, reasons for and against using scientific information, attitudes toward conflict between scientific knowledge and industry practice, experimenting in the winery, problem-solving strategies, quality of available information, and winemaking identity. The corpus was recoded employing this code book, yielding 1025 coded segments, which were reduced by following repeated themes across interviews. Conclusions developed from those themes were tested against rereadings of the interview transcripts and against survey data. The code book is appended.

An online survey (hosted on FluidSurveys™) was developed expanding on themes from interviews, additional informal interactions with state wine professionals, and a review of available information resources. The survey was distributed through multiple channels: a link in the Washington State Wine Commission's weekly email news blast, an email introducing the study and linking to the survey distributed to the Washington State University (WSU) viticulture and enology extension email list serve, and personalized emails to all wineries listed on the Washington State Wine Commission's website for which email addresses could be found (approximately 500 total). 84 responses were received.

Approximately half of respondents completed the survey after receiving a personalized email, but the remainder responded to a link sent via the WSU viticulture and enology extension email list (none responded to the link in the Wine Commission's news blast). Subscribers to WSU extension publications are, therefore, likely overrepresented in the survey sample. Winemakers who rarely or never employ email or the internet are also likely unrepresented. While the survey was not designed to be representative, the inclusion of respondents from across the state and a range of backgrounds suggest that the scope, though not the prevalence, of winemaker/grower characteristics has been captured (Horst, 2013).

Results

Extensive interviews – forty minutes to over two hours – provided the core data set for understanding winemakers'/growers' attitudes around using information resources with survey data providing supporting evidence from a larger population. In complementary fashion, an online survey yielded a broader picture of what resources winemakers/growers in the state employ with interview data providing explanatory detail. The study as a whole should be considered a qualitative analysis yielding data on the range and scope of winemaker/grower behaviors rather than a quantitative analysis describing population prevalences (Horst, 2013).

Survey respondents were distributed across experience levels with almost equal numbers having less than five, five to 10, 10 to 15, and more than 15 years' experience in their roles. Industry role-specific education levels from no formal education to PhD degrees were all represented, as were general (non trade-specific) education levels from associate’s degree to PhD. Respondents came from all Washington State growing and winemaking regions. Winemakers and growers' response patterns were identical in all cases; they are, therefore, discussed in aggregate. Again, it should be noted that while the survey was not strictly representative, it garnered responses that can be expected to represent the diversity of attitudes Washington State winemakers/growers are likely to hold.

Diversity amongst winemaker/grower responses

> *You know, there's as many ways to do things as there are wineries in this valley, and not everybody does what the textbooks say. You know, I think there's more to it than just what's in the textbooks.*

Perhaps the most striking commonality across interviews and survey responses is the striking lack of commonalities. Washington winemakers/growers do share near-universal trust in traditionally authoritative sources – textbooks and university extension – and a near-universal disdain for seeking information via Twitter. Appreciation for research in general and local, WSU-driven research in particular is also held in common, as is a (wholly predictable) view that all wineries and vineyards are different and each will operate a bit differently. Themes expressed across most or all interviews and supported by survey comments are summarized in Table 3.1. In essentially all other respects, winemakers/growers differ: in their use of specific information resources, their approach to continuing education and understanding of its role in their winemaking/growing, their attitudes toward science, and the frustrations they expressed with looking for information.

No single demographic factor – education in general or education in winemaking/growing, age, career path or years of experience – correlates with information-seeking practices or attitudes (data not shown).

Table 3.1 Major themes common across all or nearly all interviews

Winemaking is highly contextual	Research is most valuable when it's local
Money drives winemaking/growing decisions	More information is a good thing
Good winemakers keep learning	WSU research should be supported
"The proof is in the pudding"	Problems have many acceptable solutions
Washington winemakers don't like to be told what to do	Experimenting in the winery is important

Segmenting winemakers/growers by attitude toward winemaking

While winemakers and growers hold little in common as a whole, they hold much in common with other *subsets* of winemakers. Interviewees expressed patterns of preferences and attitudes that aligned with ideas about the nature of winemaking and what being a good winemaker/grower means, reciprocally creating and reinforcing ideas about winemaking/growing identity. Out of the interviews emerged four patterns or sub- groups, reinforced by survey findings (Table 3.2).

Table 3.2. Winemaker/grower identity profiles

Science-driven Right and wrong do exist in winemaking Follow scientific recommendations first	**Vision-driven** Right and wrong do not exist in winemaking Follow your own winemaking vision first
Utility-driven Winemaking is figuring out what works for you Trust experience first	**Pensive** Right and wrong sometimes exist in winemaking Science's role in winemaking is uncertain

In a study of Danish scientists' attitudes toward communicating with the public, Horst (2013) used 20 interviews as the basis for a similar typology of attitudes which she describes 'not as a typology of scientists but rather as modes' of their behavior (p. 764), each of which "enacts a particular identity for scientists and a corresponding understanding of what science *is*" (p. 771). While Horst emphasizes that her typology is not summative of her interviews, winemakers/growers in this study did align with specific types. The typology is, nevertheless, most useful as a heuristic of "qualitative ideal types" (Horst, 2013, p. 775) for thinking about winemaker/grower attitudes across and beyond Washington State, particularly in crafting messages about scientific research attuned to the different drives of each group.

Science-driven

> *So if someone does something because of conjecture, or because of something that they think is going to make a difference, well, look at what the base information is. Look up where it's coming from. Is this factual? Is it substantiated by the data and the research and that kind of thing, or is it just kind of something that people spread around as common practice? (WA 9)*

Science-driven winemakers state explicitly that right and wrong exist in winemaking and that the right way is to follow scientifically supported recommendations. Good winemakers, in their conception, make wine safely and avoid risks. They tend to imply or state outright that they are better than other winemakers/growers. Though acknowledging that practical constraints may impede following scientifically supported recommendations perfectly, they believe that winemakers/growers should get as close as they can, recognize that they are approximating an ideal, and spare no reasonable expense in doing things the right way.

> *He's a f***ing idiot. I'm sorry, he gets his advice on fertilizer and pesticides from somebody who sells 'em?...The guy down the road, in most cases, he's just a guy*

who's been doing it longer the same way. (WA 16)

Science-driven winemakers actively avoid other winemakers/growers as information sources because they see others often acting in specious, unscientific ways and because others learn from vendors, who they perceive as an obviously biased source. This group overwhelmingly prefers reading the *American Journal of Enology and Viticulture* (*AJEV*) and talking directly with researchers. All reported subscribing to the full complement of trade publications but placed little emphasis on reading them. They eschew both other winemakers/growers and vendors as sources of information – often actively looking down on both as misleading – but still appreciate seminars as opportunities to learn about new research or technology. They identify reading and learning as important parts of their job, say that most winemakers/growers don't do enough of either, and say that while not all research will be relevant or change their practices, staying up to date is important. Their explanations for why other winemakers/growers don't follow correct practices include laziness, ignorance of where to find and how to use resources, and employing scientifically unjustified practices for marketing purposes. When asked about their problem-solving strategies, science-driven winemakers describe rarely encountering problems because they know how to avoid them.

A sub-group of survey respondents (about one-sixth, the same proportion as of interviewees) showed science-driven characteristics: avoidance of peers and vendors as information resources, preference for *AJEV*, and lack of frustration over conflicting information.

Vision-driven

> *I don't have to go with what they say. I just go with what works for me and that's how I make my style. (WA 12)*

Vision-driven winemakers say explicitly that right and wrong do not exist in winemaking. While they believe that scientific research is important and sometimes useful, they emphasize that staying true to one's own ideas of what a wine takes precedence. Because ideas about wine quality are subjective, they observe, following someone else's prescriptions is likely to result in losing one's own personal style. Thus, while they consider themselves well-educated on scientifically-supported practices, they do not always choose to employ them. Vision-driven winemakers think that it is important to take risks and that risk-taking winemakers make more interesting wine than those who follow recommendations and make wine safely.

Vision-driven winemakers discuss wanting to learn and appreciating opportunities to do so but say that time constraints prevent them from reading as much as they might. They make use of varied sources including peers, textbooks, seminars, and trade magazines and are willing to use vendors as information resources. They describe valuing highly their personal relationships with peers with whom they share information.

> *As a winemaker I don't follow a recipe. I always want to get better and to improve it, and maybe by kind of a little research I might take it or take a little part of it*

> *that's going to make me think something, you know, and so I'm not going to take their experiment or their new techniques or whatnot and totally make my wine from them, you know. It's just like, once again, you have to stay true to yourself. (WA 15)*

While all interviewees mentioned in-house trials, vision-driven winemakers in particular were enthusiastic about trying new strategies for the sake of small improvements in wine quality, citing informal conversations with peers as the main source of inspiration for these experiments. They see conflicting information as an inevitable consequence of everyone having different opinions and different preferences and remain fairly untroubled because they will decide what works for them via in-house experiments or their guiding principles.

The vision-driven profile was not easily distinguishable by any pattern of survey responses, perhaps because they are open to learning from all types of sources and because, while they are not frustrated by conflicting information, neither are formalists (but for completely different reasons).

Utility-driven

> *You tend to go through this thought process of, you know, am I going to be able to pull that off with what I've got, and is it worth my time to do it, and then work forward from there. (WA 10)*

Utility-driven winemakers express right and wrong in winemaking/growing as being fundamentally about figuring out what works for your situation. While they see value in scientific research, they emphasize that the test of science's value is in whether it works in a practical setting; experience earns more ready trust than science. They note researchers and winemakers/growers as having different goals – researchers "want to make breakthroughs" (WA2), while winemakers/growers simply want to make better wine – and are consequently likely to dismiss "cutting edge" research as not relevant or practical in real-world production situations. Congruently, they express less concern with trying to "keep up" with new research.

This group is most likely to seek information when they have a specific problem to solve and place the least emphasis on continuing education. Utility-driven winemakers describe being open to finding ideas anywhere so long as the result is making better wine – "We'll take information from anywhere" (WA6A) – but rely particularly on other winemakers, vendor representatives, and seminars. Vendor representatives are seen as helpful, able to offer solutions references to other winemakers/growers who have previously encountered a similar problem, tried the vendor's solution, and can provide a first-hand peer account of how it worked.

> *With my mind I'm not even trying to understand, I'm just doing bench trials and seeing what works instead of trying to understand the science of it. I don't think I'll ever wrap my mind completely around. Just bench trial it. If it works, it works; if it doesn't, move on to the next bench trial. (WA 7)*

Like vision-driven winemakers, pragmatists emphasize that winemaking "is not following a recipe;" while they might collect numerical data, how the wine tastes is always most important. Several noted that scientists can seem out of touch with reality and that scientific recommendations change over time, using these as reasons to trust experience and to be more or less explicitly mistrustful of scientists and scientifically supported recommendations.

> *I guess because wine is so complex that it's very hard for me to believe in numbers. (WA 10)*

> *I was told I wasn't supposed to do it, but I knew a lot of people who did it and it worked just fine and then the research came out and said, well, it works. (WA 3)*

Amongst survey respondents, utility-driven winemakers appear to form an identifiable cluster: very frustrated by conflicting information, more likely to doubt the trustworthiness of textbooks and WSU extension (still a small percentage), more likely to place high trust in their peers as resources, and more likely to use Facebook to gather information. They are also more likely to express other frustrations around using information resources, including information taking too long to find, being hard to use, and not being region-specific.

Pensive

> *I used to be really in-tune with what was going on in science and stuff like that, and now, well I still do. I don't know how to say this. I'm a little bit, kind of jaded, I*

guess, in that I mean I'm grateful for the education I have...I don't know how to say this. What we're trying to do, a lot of it is business, you know, it's marketing, it's selling wine, and so that's partially consumer-driven and partially just taste. Hedonic things, and so sometimes it's like I don't really care what the pathway is for some compound. I just don't. (WA 11)

Two interviewees fell outside all three above profiles resemble each other, appearing to form a fourth profile. Both have strong technical backgrounds and prestigious educational pedigrees, but express doubts about the role of science in good winemaking. They maintain that scientific research is important, are thankful for and say that they actively use their educations. While they see right and wrong sometimes existing in winemaking, they also see many acceptable solutions for any given problem. Though both mention thinking about underlying scientific principles, they explicitly employ many other considerations in their winemaking beyond the scientific.

I don't see its applicability or how applicable it is toward what I'm doing any more. Like, the information I learn is still, the knowledge that I have is still very applicable, but the new tidbits that I'm seeing offered, it's not drastically altering what I'm doing in the vineyard and/or the winery. (WA 14)

I've actually been thinking a lot about the role of science in wine and especially in viticulture, but that's a whole 'nother topic. But anyway, yeah, no, I find experience is typically all I need to look for. (WA 14)

These winemakers find new research interesting, but largely irrelevant to their daily practice and have a growing disinclination toward bothering to keep up with it in general despite a general inclination toward and enjoyment of reading and education. They rely upon *AJEV* as their primary information resource and secondarily upon talking to other winemakers, and are willing to talk to vendors but have reservations about doing so. Both evinced some apprehension or embarrassment about their concerns around the role of science in winemaking.

Use of and preference for specific resources

Survey respondents were asked both about their actual information seeking practices and how they would ideally prefer to learn about new winemaking/growing information, but their stated preferences were in both cases the same. The following list draws from survey and interview data to describe sources in rough order of preference.

1. *Other winemakers/growers*

Together, survey and interview data suggest that peers are the most popular and oft-used information resource for WA winemakers/growers in general: over half consider peers among their primary two or three resources (Figure 3.2). Interview data support the survey findings, but suggest that winemakers with different attitudes consult with other winemakers/growers in different ways. Science-driven winemakers, who trust almost exclusively in scientific winemaking knowledge, report either consulting with a highly selective group of winemakers they consider their “peers” (WA 13) or discounting "hearsay" from other winemakers altogether because neighbors may be acting with "absolutely no scientific basis" (WA 4). With that notable exception, all other interviewees reported that calling a knowledgeable friend is one of if not their first response to encountering a winemaking problem for which they need to learn new information.

> *I'm not so arrogant to think that, someone's probably had the same problem, someone smarter than me's probably figured, at least tried something. It get's passed around. (WA 6a; utility-driven)*

Beyond asking for help with a specific problem, winemakers/growers cite casual, informal, often brief interactions with their peers as among the most frequent sources of inspiration for new ideas to trial in their own winemaking/growing. While some describe conversing with winemakers outside their immediate neighborhood, few say that their network extends beyond Washington State.

2. Trade magazines

70 percent of survey respondents read trade magazines often or consider them a main source. Wine Business Monthly, Wines and Vines, Practical Winery and Vineyard, Vineyard and Winery Management, and Good Fruit Grower are all popular with over two-thirds who occasionally or often read trade magazines at least sometimes reading each.

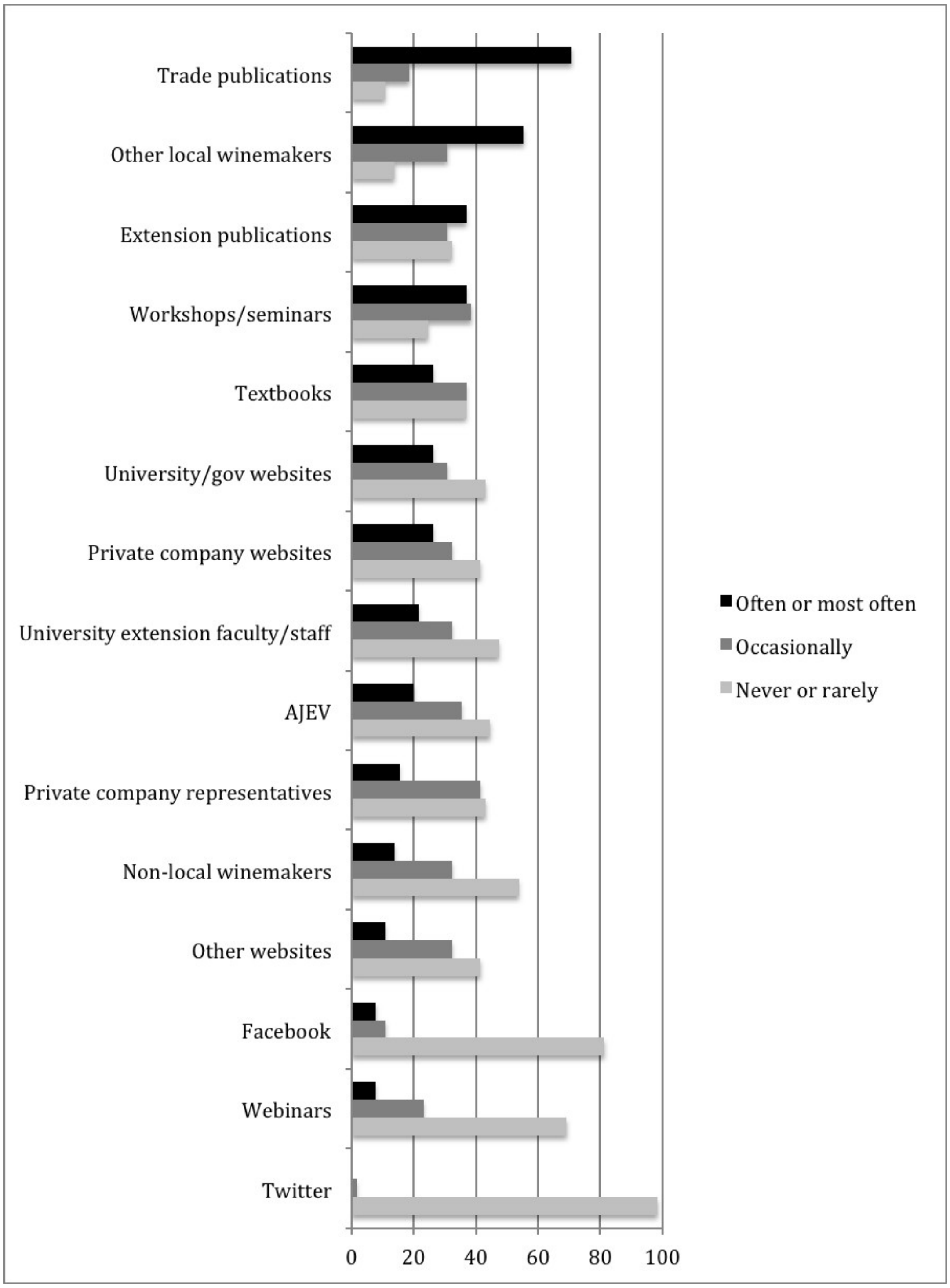

Figure 3.2. Total respondents' information resource usage ("How often do you use the following types of resources to learn about new winemaking/growing information?)

Wine Business Monthly is the most widely read, followed closely by Practical Winery and Vineyard and more distantly by the other three magazines. Approximately 80 percent of readers rely on print copies; 20 to 30 percent read online versions of the magazine (some do both).

Interviews suggest that, while trade magazines are widely read and appreciated, at least some winemakers feel as though they lack sufficient detail to be useful – “they dumb it up, and in that dumbing up you really can’t make any conclusions” (WA 2, utility-driven); “even in those articles that are published that I’m interested in, I just find that I want more” (WA 14, pensive).

3. Seminars and workshops

> *In seminars you can ask questions, so there, you can find out the details you need to find out. (WA 10, utility-driven)*

In interviews, seminars are almost universally highlighted by winemakers/growers of all attitude types and across all demographics as a preferred way to learn; a third of survey respondents attend them often or consider them a main source. Universal consensus was that seminars were understandable, either aimed at about the right level of technical complexity or, in some cases, “too basic” (WA9, science-driven) – a comment made most often by experienced winemakers about seminars sponsored by community colleges for which they felt the intended audience was most likely early-career winemakers. The quality of individual seminars was reported as highly variable and related to the skill and rhetorical expertise (audience awareness, in particular) of the speaker, not to the sponsoring organization. Excepting the occasional skepticism about vendors as information sources (see *8. Vendors as information sources*, below), winemakers/growers discussed seminars presented by WSU extension, community colleges, vendors, the Washington Wine Technical Group without drawing clear distinctions between these sponsors.

4. Textbooks

> *It's kind of tough finding good information. Generally you have to pay for it. So usually it's an archaic textbook that's sitting somewhere. (WA 16, vision-driven)*

Two-thirds of survey respondents report using textbooks occasionally, often, or as a main source; only 10 percent never consult them. Several interviewees commented that textbooks – including older, classic textbooks – often contained key information that could be found nowhere else.

5. Academic journals (AJEV)

The only academic journal that winemakers/growers report reading with any frequency is the *American Journal of Enology and Viticulture*. Unsurprisingly, it is read by those with a self-perceived strong science background, though that may mean a BS, MS, or PhD in enology and viticulture, chemistry, or biology. In total, 20 percent read *AJEV* often or consider it one of their primary sources. Among interviewees both science- driven and pensive winemakers mentioned *AJEV* as among their main sources of information.

6. Extension faculty and newsletters

> *You can go right to the source, and I can call Jim Harbertson at WSU Prosser and*

ask him any winemaking question and get a somewhat more substantial or, well, valid reply. (WA 13, science-driven)

About a quarter of survey respondents reported contacting extension faculty often or as a main resource. Among interviewees who do, WSU extension faculty are perceived as helpful, friendly, and accessible. The ability to develop personal relationships with specific faculty and their willingness to be called about problems were frequently noted.

Extension newsletters and other publications are read often or as a main source by a third of survey respondents, but never read by 20 percent. Interview data corroborated this split, with some interviewees saying that they make frequent use of these resources – "I get the [WSU extension] email blasts, and they give a short summary...and so I took the recommendation on the one and it helped out pretty good" (WA 12, vision-driven) – and others not mentioning them at all with no evident pattern. Without exception, when winemakers/growers are asked about WSU extension in interviews, seminars and direct contact with faculty are mentioned before extension publications.

8. Vendors as information resources

We have a lot of pretty reliable sources. ETS, Scott Labs are both pretty close and pretty accessible for us, and they have a lot of good information. (WA 3, utility-driven)

While approximately 12 percent of survey respondents never contact vendor representatives for information, 15 percent do so often or as a main source and 40 percent do so occasionally. Interviews suggested that, while education level per se was unrelated to using vendors as an information resource, winemakers who perceive themselves as having strong science or viticulture/enology backgrounds are less likely to consult vendors and, on the contrary, more likely to have reservations about or outright decry their usefulness as a resource. On the contrary, those who consult with vendor representatives cite them as extremely useful, developing personal relationships with representatives as they might with extension agents.

9. Internet

Nearly half of survey respondents say that they rarely or never consult university or private company websites and over half rarely or never consult other websites. Approximately half of interviewees recounted rarely going to the internet for general education, but did so universally to find additional resources on a specific topic of interest that they had already identified by talking to a peer, attending a seminar, or reading a book or magazine. Google searches, winebusiness.com and the *Wine Business Monthly* online archives, and the *AJEV* online archives were mentioned most often. The web in general was widely regarded as a “limited” (WA 16) winemaking/growing resource because the overall quality of web-based information is poor, a great deal of filtering is required to identify usable results, and reputable sites are few and far between. As a medium rather than an information source itself, internet-based information-seeking amongst winemakers/growers warrants more detailed attention (Bailey, Hill, & Arnold, 2014).

10. Social media

Facebook and Twitter are not widely used by winemakers and growers as information resources. Less than 10 percent of survey respondents use Facebook often or as a main source of information and two thirds never use it as a resource. Approximately 90 percent never use Twitter to learn about new winegrowing/winemaking information, and none cite Twitter as a frequent or main source. Social networking platforms were never mentioned in interviews. When interviewees mention consulting with peers, extension faculty, or vendor representatives, they reference making phone calls or, less often, sending emails.

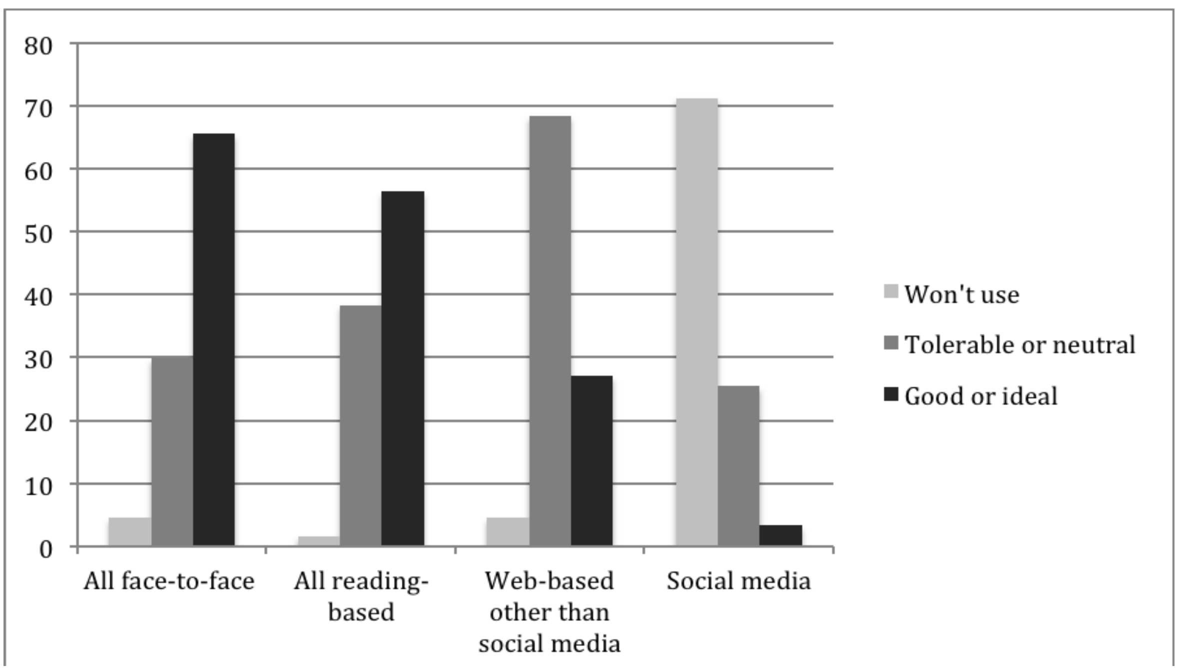

Figure 3.3. Responses to “How attractive do you find the following ways of learning?” aggregated by resource type

Overall, survey respondents showed a strong preference for face-to-face or reading-based modes of learning over web-based sources in general (including websites, webinars, and videos), which most found tolerable, and social media, which a majority said they would not use (Figure 3.3).

Frustrations with information resources

While very few survey respondents said that resource-related problems actively prevented them from learning, frustrations were common and mostly related to time constraints: information taking too long to find or to read (Figure 3.4). Only five percent of respondents thought that having too many resources was a significant frustration, but 20 percent thought that having too few sources was a significant problem and 36 percent felt that being unable to find the information they needed was. Nevertheless, many didn't see these as concerns at all, reinforcing the idea that winemakers/growers are highly heterogeneous in their use of and attitudes toward learning about new trade information. Other significant frustrations concerned the process of finding information taking too long, sources being difficult to read, desired information being buried in information that isn't useful, and information not being specific to their region.

In interviews, winemakers/growers generally expressed positive feelings about information resources and scientific research – "It's always great to have more resources" (WA 7, utility-driven) – true even for those who doubt the relevance of either to their day-to-day work. Some did voice issues related to being unable to find sufficient information or needing to spend too much time doing so as frustrations – two in particular observed that information is sometimes, frustratingly, held privately by large companies – but most described these instead as time constraints.

> *I don't have a lot of free time, so that's why I do that [skim], otherwise I would love to read everything. Sometimes I start reading and I stop, but it's not because of them, it's more because of me. (WA 15, vision-driven)*

While some winemakers/growers say that keeping up with new information isn't a priority for reasons enumerated above, many indicated that they would read more than they currently do if they had the time, with some expressing feelings of guilt or self- judgment around not spending more time on self-education. While interviewees' attitudes were generally positive, then, they might have expressed "takes too long to find what I need" or "what I need is buried in not-useful info" as "frustrations" in a survey context.

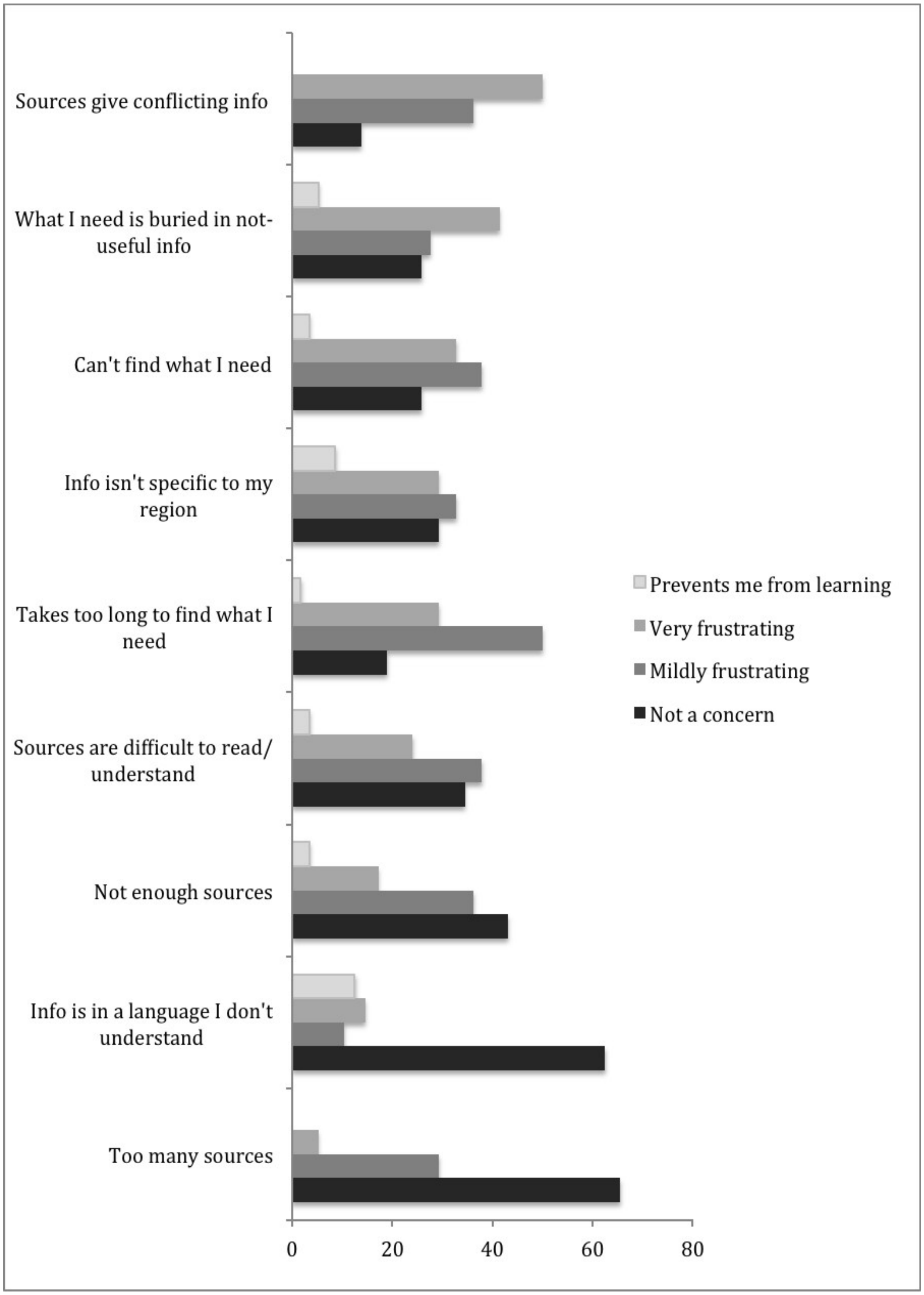

Figure 3.4. Responses to “What are your frustrations in learning about winegrowing/winemaking information?”

In both interviews and surveys, winemakers/growers say that most new information they encounter is not “relevant” or “applicable” to them. Most interviewees acknowledge this as a consequence of winemaking/growing being highly contextual and do not articulate this as a frustration per se. Some, however, think that too much research involves expensive equipment they don't need and can't afford or impractical solutions. Those who complain about the inapplicability of research are, however, in the minority compared with those who are pleased that researchers are investigating their problems “in their own backyard” (WA 12, vision-driven).

Discussion

Boshoff's (2014) study of winemakers' information-seeking behavior found that the “enlightenment model” of research use (per the typology developed by Weiss, 1979) predominated amongst South African winemakers: they value and pay attention to research, but often cannot cite how they have put what they learn into practice. The same held true for the Washington winemakers and growers studied here: interviewees unanimously praised the value of research and yet most struggled to articulate how research impacts their winemaking/growing. Moreover, while all reported routinely engaging in continuing education behaviors, they often did not connect those behaviors with how they practice their craft. Interviewee's subjective impression of how much time they spend on continuing education ranged from “a very small percentage of what we do” (WA 7, utility-driven) to a major part of their job (“There's a lot of stuff out there and reading's what it's all about...You have to spend time doing it;" WA 9, science-driven). Ideas about how much time they *should* spend on self- education and what they expect to get out of it, however, were unrelated.

Assuming that winemakers must have some kind of motivation for continuing to spend time reading, attending seminars, and doing research, that these habits have benefits beyond direct applicability to winemaking/growing seems obvious. Per Carey's (2009) two-model framework of communication, winemakers/growers appear to seek information not just for "transmission" but as a "ritual" directed at supporting and maintaining communities: establishing their sense of self personally and within the community and via the social aspects of networking and participating in events (Burton, 2008). Their efforts may not earn economic capital in terms of higher sales revenues but social and cultural capital instead, as Bourdieu (1990) would suggest.

This study finds evidence for four winemaker/grower types describing four different sets of attitudes and practices around the role of science in winemaking, individually held concepts of what it means to be a *good* winemaker or grower and thus, indirectly, concepts of wine quality. To science-driven winemakers, good winemakers employ evidence-based practices and make wine safely and correctly; good wine is consistent and technically correct. Vision-driven winemakers describe good winemaking as staying true to personal visions of what a wine should be, even if that means doing things a bit differently; risk-taking wine is better than safe wine. They do not doubt the veracity of scientific research, but they do sometimes insist that its goals are not their goals. To utility-driven winemakers, good winemakers trust in real-world experience, not necessarily (though sometimes) disdaining scientific research but ultimately doing whatever they find works for them; wine quality relates solely to the end product. And pensive winemakers actively question what good winemaking means, valuing scientific research and formal training but questioning their role in making good wine or being a good winemaker.

These types are, necessarily, oversimplifications, flattening complex identities and emphasizing the commonalities within subgroups while de-emphasizing individuals' differences (Guest, 2013). These risks may nevertheless be worthwhile when the typology is understood as a tool – limited, but useful in a particular context – relating to what different winemakers/growers find most valuable and therefore to ways in which science communication can be most relevant. Science-driven winemakers will likely find research information most valuable when it focuses on the details and integrity of the science. Vision-driven winemakers may in contrast be best served by research presented as *options* for achieving specific style objectives. Utility-driven winemakers, most likely to be skeptical toward the accuracy or usefulness of scientific research, may see greatest value when connections are highlighted between scientific research and practical experience. And, if scientific research findings might oppose common experience, utility-driven winemakers' skepticism may be assuaged by explicitly addressing that conflict and offering an explanation; in other words, by expressly treating experiential knowledge as real and making the science more real by reenacting it in a familiar space (Woolgar & Lezaun, 2013). The preferences and motivations of pensive winemakers are less clear. In all cases, detailing the parameters of approaches designed for winemakers/growers holding various attitudes will require additional study specifically along those lines.

Market segmentation, borrowed from business theory, may be a useful framework for approaching this additional research. Market segmentation is a means toward tailoring a message to different sub-groups of a heterogeneous target audience based on the values they hold. Per Beane and Ennis (1987), segmentation is conducted for two reasons: "(1) to look for new product opportunities or areas which may be receptive to current product repositioning; (2) to create improved advertising messages by gaining a better understanding of one's customers" (p. 20). In the present context, the first reason becomes seeking to understand what winemakers/growers want from scientific research and extension; the second describes designing research/extension messages to be more attractive to particular types of winemakers. Bruwer and Li (2007) define as "the nexus of market segmentation" "that it allows a business to deal with diverse customer needs in a resource-efficient manner," a statement which seems to perfectly describe the needs of extension and other science communicators trying both to persuade winemakers/growers to employ scientifically supported practices and to support their specific information needs while managing limited resources (King & Boehlje, 2000). Bruwer and Li (2007) review literature showing that demographic information is not an accurate predictor of "diverse customer needs," which are better described by "lifestyle patterns" related to the "needs and values [products] reflect," conclusions congruent with the present study in which scientific information represents both needs and values to winemakers/growers.

Market segmentation techniques have been employed in science and medical communications to design messages concerning climate change awareness for different sub-groups of Americans holding different sets of values (Nisbet, 2010), alcohol abuse prevention (Moss, Kirby, & Donodeo, 2009), and teenage substance abuse prevention (Suragh, Berg, & Nehl, 2013). Similarly, thinking about science communication with winemakers/growers through the lens of market segmentation seems likely to yield new ways of connecting with a diverse audience more effectively. Nevertheless, a marketing approach toward market segmentation may be inappropriate in this setting. Representing attitudes in terms of benefits – that is, assuming that product benefits represent the fundamental rationale for consumer behavior (Honkanen, Olsen, & Myrland, 2004) – could be productively informed by contemporary sociology of science research which observes that individuals' behavior is not always rational, not always internally coherent, and intricately social and political (Law, 2004; Wynne, 1992).

The richest body of literature on information-seeking preferences and resource use patterns exists in medicine around the behaviors of physicians and nurses (challenged only, perhaps, by that surrounding engineers; Leckie, Pettigrew, & Sylvain, 1996). Both groups are expected to engage in evidence-based practice (Kim, Bartlett, & Lehmann, 2005; Kritz et al., 2013; Winters et al., 2007). Evidence-based medicine is, per an article considering surgeons' research use, "a process of lifelong self-directed learning in which caring for patients creates a need for information about diagnosis, prognosis, treatment, and other health care issues" (Bhandari et al., 2003, p. 1183). Making appropriate topical substitutions, we might equally well discuss evidence-based winemaking. A 2003 meta-analysis of physicians' information-seeking behavior (Dawes & Sampson, 2003) and several more recent studies (e.g., Kim, Bartlett, & Lehmann, 2005; Kritz et al., 2013) have demonstrated that textbooks and talking to colleagues are physicians' preferred resources – nurses also make frequent use of practically-focused professional journals (Winters et al., 2007) – but that high variation exists among individuals (none examined physician identity as a potential descriptor of that variation). The winemakers and growers in this study appear, at least in these ways, similar to these other professional groups.

Despite obvious differences in what we expect of health care professionals versus winemakers/growers, the two groups are not wholly dissimilar. Both medicine and winemaking are simultaneously informed by scientific research and everyday practice, involve adjusting scientific recommendations to highly varied circumstances involving financial and other physical constraints, and juxtapose scientists who conduct research but rarely if ever practice the related craft with practitioners who conduct research only informally. And yet, societal expectations of medical professionals are much different than of winemakers. Food producers might be seen as indirect protectors of human health with responsibilities similar in gravity if different in kind to those of physicians, but wine producers are historically not held to the same standards as food producers. As was observed when the United States Food and Drug Administration (FDA) began in 2013 to enforce the Food Safety Modernization Act (FSMA) enacted in 2011, wineries rightly have important differences compared with other food processing facilities. (Wineries and related businesses have been required to register with the FDA since the Bioterrorism Act of 2003, but were only rarely inspected until the FSMA mandated regular inspection of *all* registered food processing facilities; Howe, 2012). Federal inspectors accustomed to touring milk processing plants and the like, now responsible for wineries, were appalled to see winemakers and cellar workers wearing neither gloves nor hairnets, grapes being crushed outside unprotected from birds and insects, and dogs running free through the cellar. (Smith, 2013). Winemakers were equally appalled to be told that these traditional, standard, accepted practices were not only illegal but disgusting. In asking authorities to apply a different set of standards to wineries, wine industry representatives pointed out that no known case of food poisoning has ever been attributed to wine. Because alcohol at wine concentrations acts as a preservative, helped by the low pH wine generally enjoys, wine poses an exceptionally low food safety risk (Howe, 2012). Biogenic amines, heavy metals (Pozo-Bayón, Monagas, Bartolomé, & Moreno-Arribas, 2012), and ochratoxin A (Mateo et al., 2007) can all be real wine-related health risks, but avoiding them is a very small part of a winemakers' job.

Evidence-based practice in winemaking is, then, largely about wine quality rather than wine safety. What “quality wine” means for any given winemaker or grower dovetails with the story they want their wine to tell, the role they see for science in winemaking, and the information-seeking behaviors they practice. Unlike physicians or nurses, winemakers and growers are not constrained by a social mandate to practice their craft in accord with scientifically-supported recommendations. Quite the contrary, social portraits of wine as art and winemaking as romantic and expressive allow for and even encourage deviations from scientifically-supported practices in the interest of telling the story of a particular place, winemaker, or worldview. The concept of evidence-based practice, as it has developed in medicine, exists in winemaking and wine growing; it is strong, for instance, in New Zealand, where corporate definitions of high quality and regionally appropriate style have developed in tandem with industry-oriented research (Brodie, Hollebeek, & Benson-Rea, 2006). Marked by high diversity and perhaps, as some interviewees suggested, a “wild West” or “cowboy” mentality of strong individualism (WA 11, pensive), Washington State is much different. Judging that as a problem necessitates taking a judge's stance on whether Washington State wine quality is acceptable as it is or needs to change, which may, in fact, be what extension or the Washington State Wine Commission wishes to do.

Aside from the potential proscriptive desires of industry organizers, the present research suggests new approaches toward framing winemaker/grower-oriented communication for researchers, extension personnel, and others charged with research dissemination. Rather than targeting winemakers or winegrowers, greater success may be had by targeting communications to science-driven, vision-driven, or utility-driven industry members – that is, to industry members holding specific attitudes towards research and the role of research in winemaking/growing. Acknowledging these attitudes, implicitly or explicitly (if judgmental attitudes can be withheld) does two things. First, doing so frames messages in ways coherent with winemakers’ and growers’ worldviews. In the face of potential contradictions between new and previous knowledge, like the physicians of whom

Law (2004) speaks: "their major preoccupation is in working out *what to do*. In an ideal world all the indications line up and fit together... But since the world is not perfect often those involved need to work out how to act in the fact of conflicting indications" (p. 52).

Communications enact science, and "enactments...don't just present something that has already been made, but also have powerful productive consequences" (Law, 2004, p. 56) for the ways in which winemakers and growers construct their ideas about how wine works. Reducing conflicts between indications by making connections with the realities to which winemakers and growers already subscribe makes it easier for them to incorporate rather than discard a research-based message and asks them to do less work.

Second, doing so recognizes and validates winemakers' and growers' experiential knowledge. Irrespective of whether communicators actually believe in this validity, respecting relevant expertise outside of their own sphere and moving toward the "democratization" of science for which so many have called (see, for example, Carolan, 2008 and Collins & Evans, 2002) improves their message's credibility in the eyes of their audience. As Carrier (2010) observes, scientific experts' "ability to take up social hopes and fears, or aspirations and concerns, is an essential element of good expert advice" (p. 206). Interviewees' comments indicate that peers, seminar presenters and, for many, local extension personnel are strong in this ability while written communications often fall short. This discrepancy will unavoidably have much to do with the value of personal relationships and face-to-face interactions. Nevertheless, those communicating via less personal media can understand the attitudes held by the type of winemaker and grower who comprise the audience for a particular communication tool and employ audience-appropriate, audience-sensitive framing. Doing so not only improves the palatability of the message, but invites co-participation on all sides – from scientists and winemakers and growers – in a knowledge-creating system able to see scientific and experiential knowledge as working not against each other, but in collaboration.

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Appendix – Code book employed with interview transcripts

Abbreviations: W – wine; WM – winemaker; SR – scientific research

Attitudes toward WM	Listen to the plant
	Make W safely and avoid problems
	Much of WM is about business and marketing
	No right and wrong in WM
	Running a winery is hard
	Value of Mexican labor/know-how
	WA industry is young and diverse
	W is a passion
	W quality is personal
	WM need to keep learning
	WM is about finding what works for you
	WM is both science and art
	WM is easy
	WM is fun because it's always changing
	WM is not following a recipe
	WM is serendipitous
	WM is subjective
Dealing with conflict	Complexity of WM is beyond SR
	Hasn't seen conflicting information
	Inaction because of conflicting info
	Many different ways to solve problems
	Rely on a trusted source
	Rely on intuition
	Try to understand and follow underlying principles
Experimenting	Always try new things to keep learning
	Always try new things to make better wine
	Big enough to absorb mistakes
	Distinction between SR and practical WM
	End point is sensory
	Experiment to see whether SR is useful/relevant to you
	Experiments involve small changes
	Financial constraints and considerations
	Lab analysis
	Long term nature of results
	Test of SR is whether it works to make better W
Problem solving	Combination of SR and experience
	Have confidence in ability as a winemaker
	Numbers/data used to guide WM

	Use logic to make decisions
	WM decisions must be made quickly
Quality of information	Frustration that private SR isn't shared
	Applicability is important
	Most SR isn't new
	Not enough detail
	Not enough sources
	Plenty of detail
	Plenty of information
	SR is usually applicable
	SR is more useful when it's local/state based
Reasons against	Cutting edge SR is interesting but not useful
	Don't like doing homework
	More info wouldn't change practices
	Physical WM constraints
	Publications are redundant
	Recommendations change too quickly
	SR isn't applicable to me
	Time
	Value of experiential knowledge
	Washington winemakers don't want to be told what to do
	You don't need high tech to make great W
Reasons for	Importance of practical applicability
	Importance of relationships
	Learn because of curiosity
	More information is a good thing
	SR comes up with new products
	SR confirms experiential knowledge
	Staying current is important
	Viticultural SR more applicable than WM SR
	Winemakers need to know about many things
	WM is always changing
Winemaker identity	I don't do enough
	I'm an analytical winemaker
	Many winemakers aren't self-aware of why they do things
	Most growers/winemakers are poorly educated
	Relationships between grower and winemaker
	Some growers/winemakers are lazy
	Some growers/winemakers are not like me
Winemaker network	Concerns about confidentiality
	Sharing is less free than it used to be
	Supportive community

Winemaker training	Differences based on kind of training
	Learned by reading
	More resources than in the past
	No value in obtaining a formal WM degree
	Trouble with chemistry
	What we're doing is good enough
	WM as apprenticeship
	WM skill not always related to education

Preface to chapter 4 – How this study of interviews and surveys with New Zealand winemakers and growers relates to the thesis as a whole

Winemakers' and winegrowers' “utilization” of scientific information resources includes judging scientific claims for their validity and not only for whether to put them into practice. In other words, winemakers and winegrowers do not limit the scope of their responses to disseminated research to the limited spectrum of decisions concerning adoption. They participate in evaluating the reasonableness of scientific claims, and their participation at this post-dissemination stage is a valuable contribution to the iterative process of developing applied scientific claims valid in both scientific and industry spaces. *Therefore*, a significant part of winemakers’ and growers’ response to research is not well-accounted for in current models of technology transfer or research utilization, which occlude this moment of industry-public participation in science with rhetorics predicated on adoption-oriented technology transfer.

The New Zealand and United States wine industries share many common characteristics in terms of how scientists communicate with industry members via written texts, workshops, seminars, and the occasional video and phone application. However, while the United States has stalwartly retained a publicly funded extension model, agricultural extension in New Zealand has become entirely privatized. All publicly funded wine research in Washington State is freely available to everyone, independent of residency, citizenship, or professional participation in the wine industry. Wine research in New Zealand is officially made available only to New Zealand levy-paying growers of grapes or sellers of wine. Wine research in Washington State is mostly centralized at a single university and communicated via a single extension service, but also in multiple well-patronized private magazines. Wine research in New Zealand is distributed across multiple universities and a variety of other research institutions, but is communicated almost exclusively via the formal channels of New Zealand Winegrowers including the New Zealand Winegrowers magazine.

In designing this study, I anticipated that these differences might provide an interesting contrast in how Washington State and New Zealand winemakers and growers related to science. I found, notwithstanding differences in how each community interacts with specific modes of research dissemination, that they shared a tendency to see scientific information as an information resource on epistemic par with industry knowledge, not an authority over it. In both cases, too, winemakers and growers use research in multiple ways outside traditional research utilization paradigms.

Relevant data from a survey of New Zealand winemakers and growers, contributing to the larger arguments of this thesis but not the specific argument made in this chapter, are included in Appendix D. A mock-up of the survey is also included in that appendix.

Chapter 4 – More than transfer: Research utilization as post-dissemination review[18]

Abstract

Conventional research utilization and technology transfer paradigms limit the scope for "user" participation in the scientific process first, by treating scientific claims as products whose epistemic status is determined before transfer occurs, and second, by limiting the potential scope for responses to dissemination to adoption or non-adoption. Interviews with New Zealand winemakers and growers attest that their responses to technology transfer involve judging the epistemic value of the claim itself and not solely the appropriateness of implementing it in their situation. This post-dissemination review mirrors pre-publication review in judging new claims against an established body of knowledge, but applies wine industry knowledge rather than published scientific knowledge as the relevant standard. By hiding such review under labels of "adoption" or "non-adoption," research utilization and technology transfer paradigms miss visualizing a moment of audience participation in the scientific process, valuable both for its potential to contribute substantively to the development of applied scientific claims and for improving research-industry relationships.

Introduction

In 1998, Fahnestock observed that scientific popularizations entailed a systematic rhetorical shift from the forensic to the epideictic voice: while peer-reviewed research

[18] This manuscript is currently under review.

articles invited readers to deliberate the truth of a knowledge claim, popularizations invited readers to appreciate and value a claim that was unquestionably true. Common paradigms describing science communication to industry audiences implicitly assume that science communication for industry use is more like popular science writing than like peer-reviewed science writing. Technology transfer and research utilization models invite industry audiences to implement scientific knowledge claims whose truth is assumed. By the time research dissemination occurs, a claim's validity is a closed question; left to be decided is only whether or how it may be usefully applied in any given setting. From interviews with New Zealand winemakers and winegrowers, I argue that users' choices are more complex, and that revising research dissemination models to make space for that complexity benefits the process. Industry members evaluate disseminated research not just for its potential use but indeed in terms of its validity, and in doing so contribute their complementary expertise toward strengthening scientific claims. Because technology transfer and research utilization paradigms categorize their responses as adoption or non-adoption, they miss this post-dissemination review and, thus, a valuable stage of industry participation in the iterative process of scientific research.

In what follows, I first briefly describe research utilization and technology transfer models. I then outline how interviewed winemakers' and growers' responses to disseminated research extend outside the scope of technology transfer paradigms and constitute review of the knowledge claims themselves. Making space in research dissemination models for such post-dissemination review should improve the iterative process of applied science as well as the collaborative potential of research-industry relationships.

Technology transfer and research utilization

Research utilization – or, more inclusively, knowledge utilization – is broadly defined as a "complex process" (Estabrooks, 1999, p. 204) by which research outcomes are taken up in a practical way by non-scientists. Two general approaches to modeling that process dominate the literature. The first classifies research utilization by its final form, as in Beyer and Trice's (1982) tripartite typology. Research use can be instrumental: a specific and identifiable research application, most often involving a specific and identifiable technology. It can be conceptual: research affecting ways of thinking without necessarily translating into identifiable ways of doing. Or it can be symbolic: research used to support or justify an action or belief. The major alternative classification instead differentiates on the basis of the degree to which research is used. Potential users climb a "ladder" from research transmission through various stages of thinking about research use toward the goal of demonstrable implementation (Landry, Amara, & Lamari, 2001). For both paradigms, the research being used is fixed before the process of research use begins. Scientists produce research; a second and separate problem is persuading non-scientists to "utilize" it.

Technology transfer, the term used to describe research dissemination in the New Zealand wine industry, denotes a similar concept. Rogers (2002) defines technology transfer as a subset of science communication made more challenging than usual by the need for its results to produce *use*. In the university-as-business model, technology transfer can mean converting research findings into revenue-generating private businesses (Huggett, 2014). In agricultural extension, technology transfer is about communicating research findings to industry stakeholders – wheat farmers, winemakers, or cattle ranchers, for instance – so that they can adopt new innovations (Hill et al., 2015; Rogers, 2002; Warner, 2008). Successful transfer is assessed in terms of how many individuals or what percentage of the industry changes their practices. First, research happens. Then, findings are transferred to industry via a "pipeline" so that industry can "consume and apply this knowledge" (Warner, 2008, p. 755). Though users are likely to be consulted in pre-dissemination phases (see Figure 4.1), when dissemination begins research becomes a closed knowledge product whose value as a claim ceases to be questioned.

A problem shared by research utilization and technology transfer models – henceforth collectively abbreviated as technology transfer – is the assumption that research is a linear, sequestered process culminating in the generation of a knowledge product. Science is made in "placeless places" (Gieryn, 2002, 2006), then transferred outside the (non-)location of scientific production to physical settings of utilization. Utilization is peripheral to the real business of doing science; it constitutes a separate stage of activity after research is complete. Utilization is positive, categorically limited, and ultimately moves toward adoption. What constitutes adoption is defined from the authoritative perspective of the dissemination institution. Consequently, much research utilization scholarship concerns characterizing variables that might be manipulated to achieve the desired adoption outcome (e.g. Bozeman, 2000; Bozeman, Rimes, & Youtie, 2015; Cullen, Forbes, & Grout, 2013; Hill et al., 2015; Landry, Amara, & Lamari, 2001). The user exercises judgment at a yes-no level: yes, to accept the research and its influence at some level, or no, to turn it down. The important question is whether an individual has chosen to follow the scientifically supported practice, and adoption is the correct choice.

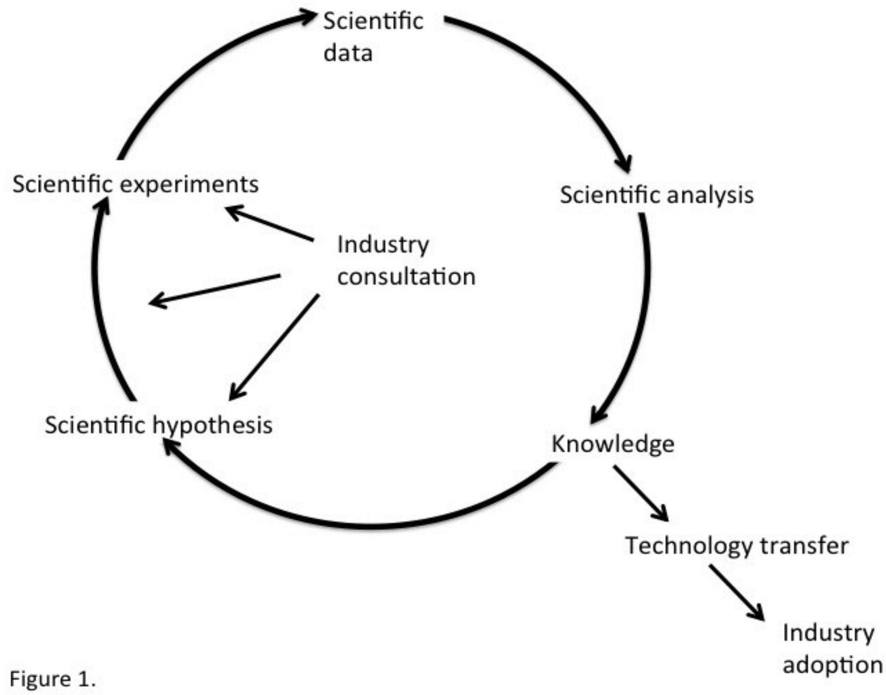

Figure 4.1. The conventional technology transfer process

Technology transfer models, as they are employed in agricultural science communication, have been criticized by scholars of "communication for rural innovation" (Leeuwis, 2004) for promoting top-down strategies ineffective for persuading adults to change attitudes and behaviors. Wider criticism points to the limitations these models impose on the agency of transfer participants. In the California farm advisor system, Henke (2000) noted that the "pipeline" metaphor of technology transfer hides the transfer agent's involvement in preparing a suitable location for transfer to occur and the end user's involvement in the field trials through which transfer is mediated. Active user participation in the transfer process has been highlighted in, for example, the California tree fruit, almond, and wine grape industries (Warner, 2007, 2008) and in Australian rangeland management (Ison & Russell, 2000).

The appropriate extent and role of non-scientist participation in scientific processes remains an endemic question in science studies, and if the concern is more often the participation of lay publics in science policy than of specialized publics in research utilization, the common conclusion still applies that the nature and ends of participation are as varied as the publics involved in them (Quet, 2014). Technology transfer is among the sort of "participatory exercise" of which the "problematic relations put forward with and by those that do not match the epistemic, political, or moral assumptions of the experimental apparatus" have seen less attention (Tironi, 2015). Participatory STS calls for some manner of "exposure to a wider range of public knowledge, values, and meanings (Chilvers, 2008, p. 156) to improve the resilience of scientific claims (Jasanoff, 2003b). Yet envisioning participants and the nature of their participation – constructing the public who participates (Braun & Schultz, 2010), as "configuring the user" (Woolgar, 1991) of technology transfer – limits the forms they can be seen to take; it is not only the technology, but the means of assessing the technology's dissemination that configure possible responses. Through this study of New Zealand winemakers and growers, I suggest that the limited user configurations permitted by technology transfer paradigms flatten user/public responses to research dissemination into unhelpful shapes, missing a moment of "public" participation in the scientific process that could contribute to strengthening applied scientific claims and research-industry relationships.

Method

In 2015, I interviewed winemakers and winegrowers (some members of the industry are both winemakers and winegrowers) across three of New Zealand's most prominent winemaking regions about how they used scientific information resources in their professional practice. I conducted 29 formal semi-structured interviews with 32 winemakers and growers in Marlborough (responsible for almost 80% of national wine production and home to New Zealand's flagship style of sauvignon blanc), Hawkes Bay (a major North Island region known for Bordeaux-style red blends), and Central Otago (geographically isolated in the inner South Island and best known for pinot noir). I also conversed less formally on the same topics with additional winemakers and growers in those regions and on Waiheke Island (a small region near Auckland focused on luxury hospitality). Interviews focused on small and medium-sized wine businesses because an aim of the larger project to which these interviews contribute concerns how written science communication mediates research-industry interactions; large producers are more likely to interact with research directly. Notably, however, the vast bulk of the New Zealand wine industry is comprised of such smaller enterprises in terms of numbers of individual businesses, with only 15 of New Zealand's approximately 800 wineries classed as large (producing at least 4 million liters of wine annually) per the NZW classification as of 2013 (NZ Wine, 2013).

Interviews occurred in person at the vineyard, winery, or nearby office and were audio recorded and transcribed (213910 words). Transcriptions were coded for all mentions of science and scientific research, guided by Myers' (1996) model of critical discourse-based close reading. Initial descriptive coding identified positions and attitudes around information resources, winemaker education, science and technology, and the nature of winemaking. These codes were refined and consolidated into a set of 75 non-exclusive codes (that is, codes could and did overlap on any given segment of text) concerning research relevance, winery trials, specific information resources, winemaker education, problem-solving strategies, winemaker identity, and wine industry infrastructure. The corpus was recoded employing this code book, yielding 1014 coded segments, which were reduced by following themes repeated across interviews. Conclusions developed from those themes were tested against rereadings of the interview transcripts and against survey data. The code book is appended.[19] All anonymous quotes in this chapter refer to interview transcripts.

Technology transfer in the New Zealand wine industry

> *The modern industry is tending to focus in on smaller and smaller areas as we're getting more and more precise in our knowledge...Science is playing a huge role in it. (Grower)*

In New Zealand, technology transfer is institutionalized in the research arm of New Zealand Winegrowers (NZW), a non-profit organization responsible for coordinating a variety of administrative, marketing, research, and communications activities (New Zealand Wine, 2015). Because of the synergy between viticulture (the science of grape growing) and enology (the science of winemaking) and commercial winemaking and grape growing, wine industry organizations invest in research with the expectation that findings will be "transferred" for industry use. NZW-funded researchers are expected to produce brief progress notes specifically designed for industry audiences in addition to full final reports. The latter, though written as formal scientific documents, are also made available to

[19] The code book has been edited to protect the privacy of NZW.

industry members. Some researchers also participate in writing “fact sheets” on specific topics and in presenting at workshops, field days, and other occasional face-to-face events.

Viticulture and enology research helps to solve industry problems, shape new wine styles, and reduce industry costs. Recent NZW-funded research has developed strategies to combat viral disease (grapevine leafroll associated virus 3, or GLRaV-3) and to maximize the pungent aromas of New Zealand's iconic sauvignon blanc. Globally, scientific research is responsible for technologies of scale, speed, consistency, and reliability that have made the contemporary wine industry possible. Though archaeological evidence dates earliest winemaking efforts to approximately 5400 B.C. (Cavalieri et al., 2003), the worldwide, year-round availability of relatively inexpensive, relatively high-quality wine is very much a contemporary phenomenon (Orth, Lockshin, & d’Hauteville, 2007). Wine consumed by the pre-20th century masses was probably closer to what the modern drinker would call vinegar (Phillips, 2001).

Winemakers and growers in New Zealand, like their counterparts in Washington State (Szymanski & Davis, 2015) and in South Africa (Boshoff, 2014), tend to be interested in scientific research and to make an effort to learn about basic scientific principles and new research.

> *[Science] is very much the base. It’s very much the foundation of the whole thing and if you know that, then you can make the choice not to intervene. But if you don’t know that, you’re dancing with death because you don’t actually understand the decision that you’ve made and what the implications of that are. (Winemaker)*

> *My office is that lab down the hall. I'm surrounded by it. We're constantly doing*

trials, we're surrounded by different interactions, what's going on in the vineyard and the winery. Chemistry is a prerogative. (Winemaker)

While denying the benefits of science is rare, some winemakers do protest that scientific innovation is complicit in the “interventionism” responsible for the modern plague of uninspiring, soulless plonk and that traditional methods yield higher-quality, more authentic, or more expressive wines.[20] Wine of exceptional quality continues to be made by people who claim no special scientific understanding using centuries-old techniques, and self-identifying with a scientific mindset is very much optional for being a successful winemaker (Kramer, 2014).

I think you'd find a lot of people would say the same thing if they're honest, have become a lot [less technologically advanced] in the way that their wines' being made, so there's more of a feeling of less intervention.

Because fine wine is not sold as a commodity, boutique winemakers and (to a somewhat lesser extent) the growers who supply them are not compelled to keep up with a set of industry-wide best practices to remain competitive (Scott Morton & Podolny, 2002). In the winemaking “New World,” producers are legally free to choose whatever processing techniques they prefer; laws do not compel industry members to apply scientifically supported recommendations outside of fairly minimal health standards. Winemakers are, furthermore, often encouraged to develop unique styles; “points of difference” (Beverland & Luxton, 2005; Dawson, Fountain, & Cohen, 2011) are marketing advantages when your

[20] Jake Lorenzo’s insightful and humorous column in the American trade magazine *Wine Business Monthly* provides a running commentary on winemaker attitudes that touches regularly on this topic. The column is available online via Wine Business Monthly’s website.

wine is one of many similar bottles presented to a sometimes-bewildered consumer. Consequently, winemakers and growers are free – socially, economically, and legally – to respond to disseminated research in diverse ways.

NZ winemaker/grower responses to research dissemination

The range of winemakers' and growers' responses to disseminated research included, but was not limited to, the categories of use allowed for in technology transfer paradigms. Research is, in the first instance, a product generated by scientists and then handed over; research belongs to *them*, scientists, and *emerges from* universities and other research institutions.

> *They're quite open at the [research institution] so they won't tell you to [go away] if you ask them a question about their research. (Winemaker)*
>
> *There's some good stuff coming out of [university] regarding pinot and there's some good research coming across from Burgundy, so if you want some you can get it. (Winemaker/grower)*
>
> *[participating in research] is just being good for the industry, I think, more than anything, cause there's people that have questions and they need our help and then we get something out of it. It's good. (Winemaker)*

Winemakers and growers described the exchange as some combination of benevolence and economic transaction: winemakers do something for scientists; scientists hand something back via technology transfer instruments. "*The fact sheets come in;*" "*The winegrowers magazine is probably the main source of just keeping up with what's current in terms of* *research*;" "*We all like seminars in the wintertime when it's cold and we don't want to prune*." Having decided that the energy required to engage with these materials is balanced by the potential benefit they expect to receive (Rauen, 2009) and stepping onto the research utilization "ladder" by being complicit in transmission, winemakers and growers may then take additional steps toward positive research use. Most recalled no examples of instrumental use when asked whether they had implemented any research about which they had heard recently, but a few did.

> *There was a whole lot of powdery mildew models, predictive models that have been developed, botrytis models. Powdery mildew has been a problem this year on our place. We've changed what we do, and it's been a win for us. (Winemaker/grower)*

Many seemed to recall instances of conceptual research use, though understanding the significance of winemakers' frequent comment that something they read was "interesting" would require significant additional investigation. Symbolic use also appears common: winemakers and growers routinely expressed satisfaction at learning that something they already do is supported by scientific research or, less often, expressed frustration at seeing scientists spending money "discovering" something practitioners already knew. Judging the extent of symbolic use is, as Beyer and Trice (1982) observe, complicated by users sometimes not realizing – or being unwilling to admit – that research has helped them justify a particular decision. Research utilization thus allows for collecting respondents into four groups: three kinds of adopters, plus non-adopters who might themselves rest on some intermediate rung of the research utilization ladder. This quadriptych conceals a more interesting image, of winemakers and growers contributing their own communal expertise to research evaluation.

Post-dissemination review

> *You read an article and think, hmmm, that could work. I mean some of the research is a bit, you know, removed from what we do here. When it gets down to the practical level you can try it, but some of the stuff's like, emmmm... (Grower)*

Winemakers and growers did not recount moving through a linear decision-making process culminating in use or non-use, nor did they often tell stories about choosing whether or not to use information. Rather, they described applying their own self-acknowledged expert judgment to evaluating the reasonableness and significance of the scientific claim being advanced. They analyze new scientific information against knowledge accumulated through other sources: chiefly personal experience, but also the experiences of their peers shared second- and third-hand, and reading across the broad spectrum of sources afforded by the internet. In other words, they see their aggregate industry knowledge as carrying sufficient epistemic weight to be the standard against which new scientific research is measured.

Their post-dissemination review mirrors the pre-publication review of scientific publishing, but evaluates information against a different relevant body of knowledge: not the previous literature of disciplinary science, but the “literature” of the winemaking community: “the criteria by which members of that society systematically evaluate the validity of public knowledge” (Jasanoff, 2003a, p. 394). Before new research is allowed to enter the canon of disciplinary science, representatives of the disciplinary community evaluate whether the new aspirant is reasonable and significant in light of the disciplinary community's existing body of knowledge. Evaluated on their merits as new scientific knowledge, the applicable knowledge standards are those of the scientific discourse community as largely embodied in the published scientific literature. And, like pre-publication peer reviewers, if less formally, winemakers and growers evaluate whether those new aspirants are reasonable and significant in light of their own community's existing body of knowledge. Their judgments from the collective body of industry knowledge, as communicated via peer networks, are irreducible to answers to the yes/no question of adoption.

Reasonableness

> *I take out of [technology transfer articles] what I want, and some of it I just go aw nah. That's not right, or I'm not doing this or that. But other things I go yeah, cool, that's pretty cool. (Grower)*

Winemakers indicate that newly communicated research must be reasonable in light of what is already known. New scientific publications are expected to demonstrate coherence with established knowledge through references to previous publications. That literature and the established body of knowledge, the "relevant domain of discussion" (Bazerman, 2009), are functionally equivalent, as citation and discourse patterns make evident (Bazerman, 2000; Szymanski, 2016). When research is disseminated to industry members, the relevant domain of discussion expands. To be recognized as acceptable, new knowledge must be reasonably coherent with what is already known through the "literature" of accepted industry knowledge. Failing the reasonability test, new research may be deemed inconsistent and inaccurate *as industry knowledge*, even if the scientific community has already deemed it reasonable scientific knowledge.

> *So yeah, the fact sheets come in. Most of them, most of them aren't up to date, in spite of all the research they're doing. I mean we found the same thing, while I was doing study at [regional technical institute]. By the time the thing got into paper and in a format that was being taught, I'd learnt something new in practical… They'd found where the fault lay in that strategy. So that was a really good idea but you know this happened and that and we've got this block over here so we do it this way now. (Winemaker/grower)*

Winemakers describe evaluating scientific information as "out of date" when scientific claims have failed to account for the literature of the practical. Bourdieu summarizes scientific epistemology by suggesting that all scientific claims are prefaced with an invisible "everything behaves as if" (1990). This winemaker has additional information attesting that everything *does not* behave as if, and so rejects the scientific claim as invalid. Bourdieu's invisible preface, in other words, must here be emended to "everything acknowledged as valid by the formal scientific process of consensus-building culminating in the published peer-reviewed literature behaves as if." The alternative is to match the relevant domain of discussion to the expected context of utilization, acknowledge the existence and relevance of non-scientific knowledge, and validate the winemaker's review.

> *You know the stuff that happens in labs doesn't happen in wineries. I don't think*

they cross over very well in those situations, real-world situations and lab situations…I think you can take a lot of it with a pinch of salt and it really comes down to practical experience with how things work out. (Winemaker)

In comparing scientific claims against the community's "practical experience," winemakers and growers may reject disseminated research as valid industry information. They may also, in effect, be saying that the conditions for application are dissimilar in important ways compared with scientific conditions of production. A scientist might, on that account, very reasonably attest that winemaker testimony has no bearing on the validity of the scientific claim. However, in being disseminated to industry, the scientific claim now appeals for validity in a broader space in which the relevant domain of discussion includes what takes place in wineries as well as in "labs."

I think science is now getting a little bit closer to understanding that you still have to have a sense of, you know there must be a human approach sitting with it, and finding out what we are trying to achieve. And where does it sit really in the bigger picture, I guess. (Grower)

You know there's a lot of research on different treatments for sauvignon to increase methoxypyrazines and all that, and that's sweet, but it changes your chemical penetration and your disease pressures and all that sort of stuff, so I mean you can't just do one isolated little part of the research and expect that it will be sweet for everything. (Grower)

A recurrently mentioned reason for winemakers and growers to question the validity of scientific research concerned the narrowness of scientific investigation: scientific models against which claims were tested were perceived as too narrow or limited to overlap meaningfully with the complexities of industry practice. Communicating a scientific claim, amongst scientists in the same or other disciplines or with any other relevant public, is an act of exploring the boundaries of the domain in which the claim remains true. The scientist's experiments have established that "everything behaves as if" X under her specific experimental conditions. But does everything behave as if X in other laboratories, or vineyards, or wineries? The growers quoted above are suggesting that the "truth space" in which a scientific claim remains valid is too small to include their vineyard. They have additional information about spaces of practice outside the original conditions of scientific production that suggest a boundary to the claim.

Science always involves flattening complex events into much less complex inscriptions that can be picked up, amassed, and aligned to support generalized conclusions made at a remove from the events themselves (Latour, 1986). These growers are arguing that the scientists' models fail to account for details important to their industry settings, but evidently unimportant in the scientific setting. Failing to control for variables relevant to grape growing, the resulting inscriptions do not describe how everything behaves in a vineyard. This lab-vineyard discrepancy may be irrelevant to creating a coherent body of scientific knowledge because the growers' experiences do not meet the conditions for epistemic validity in the scientific community. Nevertheless, in the act of technology transfer, scientific claims are implicitly aiming to become "everything behaves as if" claims about what happens in vineyards.

Significance

Like scientific peer-reviewers, winemakers and growers on the receiving end of technology transfer evaluate new information not for reasonableness alone, but for significance. Criteria issued to journal peer-reviewers instruct that manuscripts should present new research that is “novel” and “of extreme importance to scientists in the specific field,” to borrow wording from the Nature Publishing Group (2016). Winemakers and growers with whom I spoke described making a similar judgment, again, against the standards of a different body of community knowledge, creating the potential for different conclusions regarding novelty, significance of effect size, and value of the effect.

The novelty of a claim is inevitably judged against the existing knowledge of a community: “the same claim may be considered ‘speculative’ or ‘well-defined’, a ‘highly significant’ advance or a ‘well-known’ observation, depending on the body of literature into which it is placed and the audience which is to read it” (Myers, 1985, p. 595).

> *Um, there’s a lot of stuff, like, awww, the effects of leaf plucking on the incidence of botrytis. Well s***, if you don’t know the effects of that by now you shouldn’t be in the industry. But they’re still doing it, and that to me, that’s fluffy stuff that’s pointless. (Grower)*

Even should a winemaker or grower accept the validity of a claim, she may reject it as new, significant knowledge because it is already known by the winemaking community.

Some winemakers and growers also described accepting new research as reasonable and novel, but ultimately rejecting it because the effect size of the finding was too small or was measured in ways that do not meaningfully correspond to wine quality.

> *A lot of research, they’ll say this is better for extraction or this is different, but is it?*

> *From a scientific point of view it could be a better number. But is that number actually better from a sensory point of view and a lot of that stuff is very difficult to do to get a really good accurate sense of link to sensory and what you do that and why, but what does it actually buy? (Winemaker)*
>
> *[More sensitive Brettanomyces detection] was another example where the science was cool, but it wasn't actually making a difference to people, to what the results were…A tuned human palate is far better and more sensitive than a lot of that instrumentation, and the reality was by the time you could actually analyze for those chemical components it was too late…I think there's a lot of that kind of examples in the wine industry that it's cool science, but is it actually helping us become better winemakers? (Winemaker/grower)*

Winemakers and growers highlight problems of significance related to the problem of reasonableness in that the choice of details preserved in the conditions of scientific production do not necessarily correlate well with the details significant to these industry users. They say nothing about *scientific validity*, nor even about reasonableness in the industry context, but comment nevertheless on whether a claim can be accepted into the body of shared industry knowledge. Claims that industry reviewers reject on grounds of insignificance do not become a part of the industry "literature" to be cited, shared, and perpetuated.

Technology transfer paradigms implicitly assume that disseminated research is reasonable and significant knowledge for members of the target audience, who are counted as good, desirable, compliant industry members when they adopt new scientifically supported practices. These paradigms assume, in other words, that the expert opinions relevant to making judgments of validity have already been consulted. This is a mistake. While scientific experts best equipped to judge scientific validity may have been consulted, technology transfer makes it necessary for scientific claims to also be valid industry knowledge and thus calls for judging validity against the shared body of industry knowledge wherein industry members are experts.

Adoption

Industry members' judgments about reasonableness and significance are distinct from judgments about adoption, if not wholly unrelated to them. Winemakers and growers were clear in describing a difference between judging scientific information to be not useful for them versus judging scientific information to be a poor knowledge claim. For some technologies, few individuals may be in a position to make the yes/no decision of adoption, but many more may read and review them.

> *It's nice having pure research information, but if I can't apply that, I don't need to know. But if you come up with a way of new information that's something I can usefully do in the vineyard or winery, I'll be there. (Winemaker/grower)*

> *I've found two articles they sent that it was like, this will be really interesting, and it was all about Marlborough and I was like, aww… (Grower)*

> *If I get some information about growing sauvignon blanc in Marlborough I will read it, because I'm always interested in what's going on down there...If you don't have an interest in it, why are you doing it, know what I mean? (Grower)*

It's just out of pure curiosity. We don't own a vineyard here, so I don't have to worry about [leafroll virus]. (Winemaker)

While some described little patience for research for which they have no practical use, in contrast, other winemakers and growers described investigating research they had no reasonable thought of implementing: out of curiosity, general interest in continuing education, or an interest in peer-to-peer sharing.

Oh, we've got a new enzyme that can do this or hybridizing a grape vine so it can do that, I'm not interested in that because I'm something of a purist and, well, it will just sort of detract from the model that I'm sort of trying to follow. So you know I'm not interested in that sort of stuff, and that sort of thing worries me to a certain extent because it ties in far more easily with that massive industrial complex of creating industrial wines way more than it does, you know, the more interesting stuff that we're supposed to be doing as winemakers. Yeah, but all research is valuable, most of it. (Winemaker/grower)

So what's new is all these ways, you know products and ways of tweaking things to save big companies lots of money. So by adding this, you use less refrigeration which means your cost per liter of wine is you know ten percent less or whatever it is, so a lot of that research really benefits larger companies that are trying to increase their margins, right? Which is not the focus of the boutique premium wineries. (Winemaker)

These winemakers are not disputing the validity of a scientific claim; on the contrary, they and their colleagues spoke often in support of the utility of research for other members of the industry, even seeing such research as beneficial for the industry as a whole, without wanting to adopt it themselves. Research that helps the largest companies, they say, also supports other producers whose bottles have the same place names on the label.

Evaluations of disseminated research as knowledge claims and for adoption are clearly not unrelated; a winemaker is logically unlikely to adopt an innovation founded in a claim she thinks is invalid. Moreover, a winemaker is likely to have more specific expertise and stronger opinions related to a technique she could potentially employ.

> *So if it's something that actually pertains to what you're doing then obviously you're going to pay attention to a little more specifics. Where if it's just something that, this is interesting, wonder what happened, you're probably not going to be implementing it in your own vineyard, then you probably do take it a little bit like, oh, okay, they've done that, that works, whatever. (Grower)*

Review and adoption are nevertheless distinct, with the former a nuanced response possible even when the answer to the adoption question is "no" (summarized in Table 4.1). By focusing on the decision to adopt or not to adopt, technology transfer paradigms miss capturing this additional dimension of audience response and the scientific process is robbed of relevant expertise judging the validity and applicability of a claim.

Table 4.1. Winemaker/grower responses to disseminated scientific information

Good claim, not interesting or useful *Conventional non-adoption*	Poor claim, not useful *Post-dissemination review*
Good claim, interesting or useful *Conventional adoption*	Poor claim, interesting or useful *Post-dissemination review*

The value of post-dissemination review as public participation in the scientific process

Pre-publication peer reviewers participate in the scientific process by helping to shape scientific claims: they contribute their own expertise and channel disciplinary norms and expectations (Mallard, Lamont, & Guetzkow, 2009) in a social negotiation about the value a scientific community will assign to new research (Bazerman, 2000; Myers, 1985, 1990). While pre-publication peer reviewers are sanctioned by the scientific community as legitimate participants and co-constructors of scientific knowledge (Zuckerman & Merton, 1971), technology transfer paradigms do not similarly legitimate post-dissemination review: users' constructive responses go uncollected, configured into yeses and nos along the spectrum or ladder of adoption. In so doing, technology transfer paradigms cap the potential scope for audience participation in science.

While everyone seems to agree that we should be doing participatory science, observers of the participatory movement note that no one seems to have the same idea about what that means (Cook, Kesby, Fazey, and Spray, 2013; Quet, 2013). Critics of the "participatory turn" (Chilvers, 2008; Jasanoff, 2003b) in public communication of science note that "invited participation" can be a strategy to limit "upstream" public engagement in science: inviting public participation at a discrete point in the research process masks or shifts focus away from the exclusion of public voices at earlier, agenda-setting stages (e.g. Bogner, 2012; Braun & Schultz, 2010; Carolan, 2008; Chilvers, 2008; Cook, Kesby, Fazey, & Spray, 2013; Kurath & Gisler, 2009; Kurian & Wright, 2010; Wynne, 2007). Just as limiting participation to carefully defined spheres erases problems upstream, limiting participation to data collection or other invited pre-closure moments erases the possibility of valuable contributions downstream.

Invited participation models can silence public involvement that falls outside the predefined, limited space in which public participation has been made permissible (Bogner, 2012). Technology transfer models likewise silence user involvement that falls outside the predefined, limited question asked post-dissemination: adoption, yes or no. That limitation may, in some senses and circumstances, be warranted. The nature of public participation in science is warranted by the overlaps that can be constructed between the practices of science and the practices of the public. A member of a “general” public likely has little to say about the validity of nanotechnology claims because little in her daily life overlaps with nanotechnology research, though via overlaps with toothpaste and tomatoes she may have much to say about the public policy elements of nanoscience. However, when the “public” in question speaks from a community body of relevant knowledge, the scope for their participation expands. As a group, winemakers and growers may still be ill-equipped to speak to the value of a claim as a disciplinary scientific claim, lacking that expertise and authority, but on the contrary hold “credible expertise” (Jasanoff, 2003a) equipped to comment on the value of an applied scientific claim as it extends across spaces of industry practice.

Participatory approaches are rooted, at least in theory, in the realization that publics' own knowledge systems are reasonable and represent complementary expertise (Heckler, 2007; Herndl & Cutlip, 2013). And yet the salient questions, even in criticisms of mainstream participatory science, revolve more often around participation as a means of structuring power (Cook, Kesby, Fazey, & Spray, 2013), “democratizing” science (Carolan, 2008; Jasanoff, 2003a, 2003b; Lövbrand, Pielke, & Beck, 2011), and benefits to public agency in science policy rather than around benefits to scientific claims themselves (Garfinkel, 2015). Visualizing industry participation in research via post-dissemination review should be beneficial in both respects, improving research-industry relations and the iterative process of developing applied scientific claims.

A recurrent problem with participatory approaches is that “we know rather little about whether the public are as keen on participatory dialogue as those who advocate it as key to democratic governance” (Stilgoe, Lock, and Wilsdon, 2014, p. 7). One substantial advantage of visualizing post-dissemination review as industry participation in science is that winemakers and growers are evidently already engaging – quite willingly, my interviews suggest – in this form of participation. “Utilizing” disseminated research by commenting on its value does not represent an extra demand on their time or an activity conceived by administrators, but something winemakers and growers evidently already find worthwhile. If invited participation is at one end of participatory science, post-dissemination review is in a sense at the other, with non-scientists and their “local” knowledge having active roles (Palmer & Schibeci, 2014, p. 513). If the goal of doing applied science is not just to make good disciplinary science, but to make claims with valid “truth spaces” extending across or overlapping the patterned spaces of both science and industry practice, then review by both scientific and industry knowledge communities seems not only possible, but necessary. And as a set of models, technology transfer does not seem to make space for it. The problem, then, is not to motivate “users” to engage with science – to listen, to care, to provide feedback, to “use” research – but to change the model so that the scientific community can do a better job of listening.

Conclusion: Evading technology transfer

Michael (2012) analogizes lay participants who fail to respond to science dissemination in expected and sanctioned ways as “idiots” and, while he expressly calls on Stenger's figure of the idiot who does not know what she is doing, he also calls up the notion of the fool or the jester who in “misbehaving” (p. 528) outside of usual socially prescribed bounds speaks more valuably than anyone else. Analyses of engagement events tend to deliberately ignore or “clean up” such “overspills” to fit the organizers’ expectations rather than seeing the excesses as productive material for “invention” (Michael, 2012, p. 529). In responding outside the usual bounds of adoption versus non-adoption, industry users/publics with whom I spoke say something valuable, though unheard within the typical bounds of technology transfer.

In theory, a new technology transfer model could be devised that does account for user responses beyond adoption. The idea of technology transfer itself, however, continues to assume the existence of a product handed over and deposited. Technology transfer implies from the outset that the transfer and use process is something spun off from the central scientific process, limiting potential user participation in science along with the scope of potential user responses to transfer. While Rogers (2002) defends technology transfer as “not just a translation but also what happens as the result of a translation,” his argument is that transfer is a two-way endeavor in which users participate in negotiating “a common, shared meaning of the technology” (p. 327). Rogers’ model thus remains resolutely closed: users may help decide what a technology *means* in a practical sense, but not what a technology *is* or its epistemic status.

One way of diagramming an alternate model (Figure 4.2) that allows for the contributions of post-dissemination review is as a recursive cycle whereby scientific knowledge is transferred to industry, industry members test and review claims against their own body of accumulated knowledge, and industry members transfer their results back to the scientific community to inform new experiments and recapitulate the cycle of scientific production. An alternative, avoiding ideas of knowledge products and transfer altogether, might imagine science communication for the sake of use – to industry communities, or to other communities whose practices overlap with scientific practices and who might be expected to implement rather than "celebrate" science (Fahnestock, 1998, p. 333) –

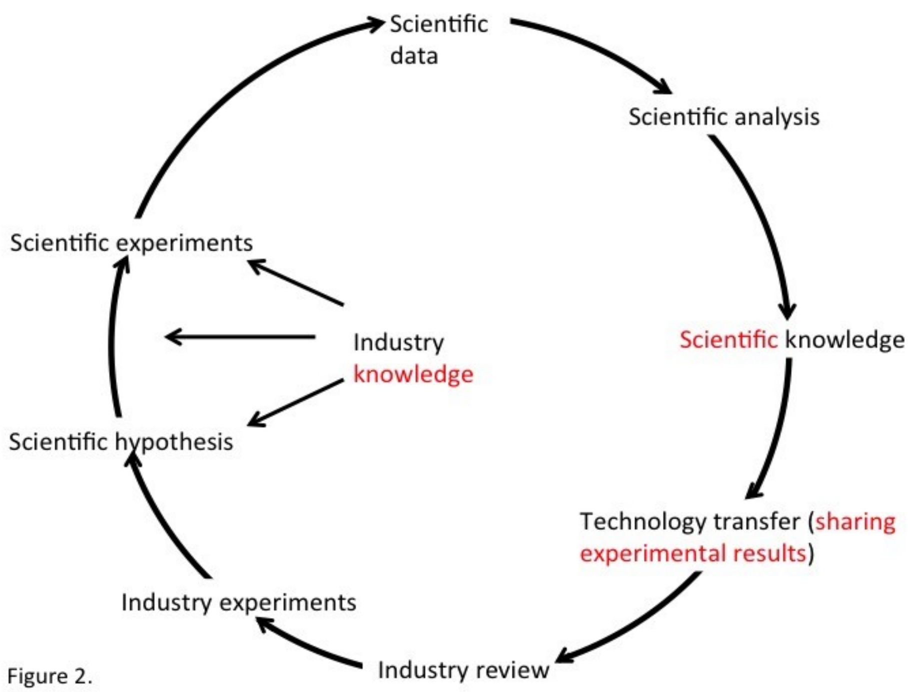

Figure 2.

Figure 4.2. Technology transfer, integrating industry post-dissemination review

as a process of creating points of alignment between research practices and industry practices. A material-semiotic view (Law, 2008) of technology transfer would suggest that each participant in the process constructs their own reality through their practices, and that no innate ordering relations (Law & Lien, 2012, p. 366) compel scientific practices to describe or apply to winemaking and growing. Instead of assuming that science *transfers*, the logic of applied science – which says that research is useful in non-scientific practice – would ask us to "perform" or to perform the work (Law & Singleton, 2000) of ordering relations (Law & Lien, 2012, p. 366) to make one set of practices relevant to the other. Science communication becomes a process of facilitating those alignments. Instead of the dominance of one epistemic community, research dissemination to industry facilitates the "entanglement" of several (Granjou & Arpin, 2015, p. 3).

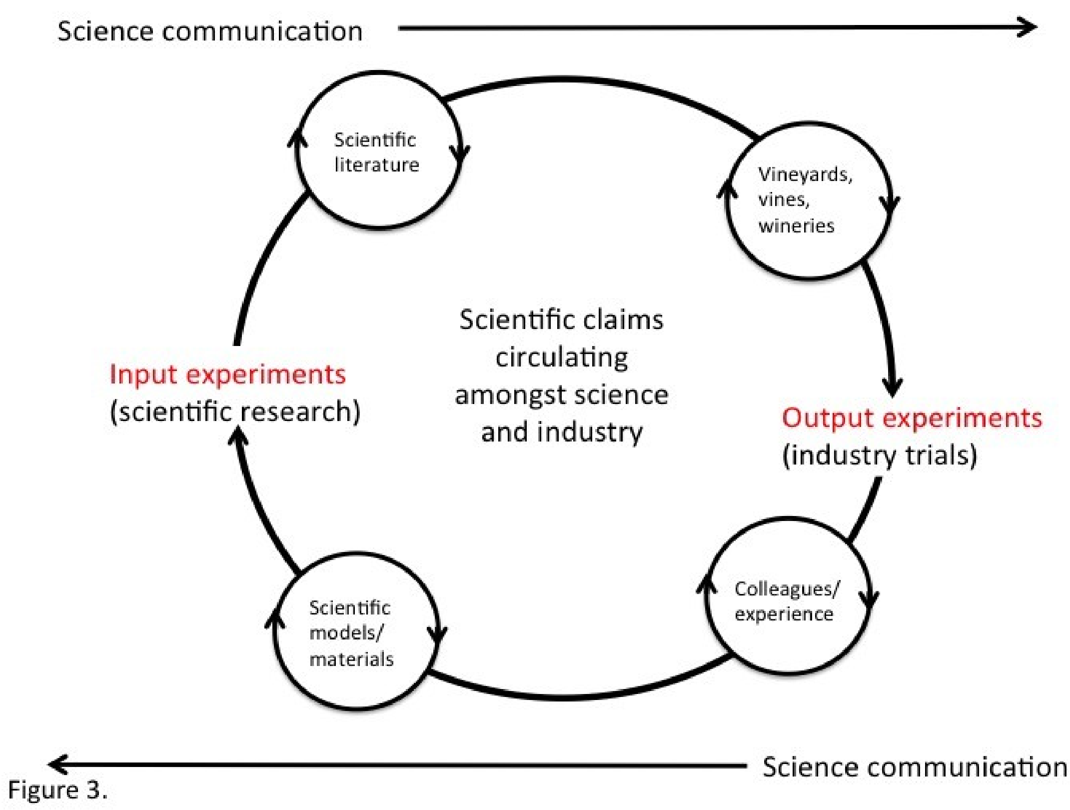

Figure 4.3. A material-semiotic model of technology transfer as science communication

I appreciate that constructing this sort of critique is easier than constructing a new and improved program of action. Moreover, my object in this study has been to understand how science communication structures research-industry relationships, not to create such a program for industry improvement, and I did not undertake the kind of discussion-driven stakeholder evaluation that should inform developing such a program (per, for example, the "fourth-generation" methods advocated by Guba & Lincoln, 1989).

With those caveats, I might suggest that the key point in implementing an alternative to technology transfer is in giving industry members opportunities for open-ended response, and then listening to them. If the multiple choice survey asks whether you read the scientific report, yes or no, and whether you implemented anything you read in the scientific report, yes or no, responding in any genuine or useful way to the scientific claim is impossible. Since constructing surveys that avoid making inappropriate assumptions about the reader is a challenging and highly specialized skill, the survey is perhaps best avoided altogether in favor of in-person presentations that permit open-ended response. If being in the same room does not automatically guarantee open-minded listening, it helps: not only are respondents offered more degrees of freedom, but my interlocuters suggest that speaking face-to-face usually makes understanding each other's logic easier. Along with the value of inviting open-ended response and the value of being in the same room comes the value of making a proposition, offering contingent conclusions rather than asserting certain knowledge. On the one hand, these are simple principles already employed by individual scientist-communicators, mentioned in my fieldwork, whose individual means of relating science and industry knowledge do not necessarily cohere with the assumptions of institutionalized technology transfer. On the other, carried out, these principles entail a fundamental restructuring of scientific epistemology at a policy level. And yet, moving in the right direction really is as simple as being more open-minded in designing communication assessment tools.

A material semiotics of wine science communication would seem to be a lot of extra work. Entangled relations are hard to diagram (see Figure 4.3 for a very unsatisfactory attempt). Research now has to be *made* relevant to industry practice, not simply assumed to be so. Science communication must be involved in actively creating points of contact between research and industry practice rather than transparently conveying scientific content. Assessment must involve communicating rich feedback from industry members to scientists, not simply classifying industry members as adopters or non-adopters, and then speaking louder or more forcefully to the non-adopters to try to convert them. Why bother? One: to employ scientific practices to generate claims that do useful work in both scientific and industry spaces.

Two: to create a replacement paradigm for technology transfer coherent with non-positivist attitudes toward scientific and industry or other “local” knowledges. Independent of whether or not all knowledges are equally valid, or even whether scientific and industry knowledges are equally valid, allowing for post-dissemination review is to say that each “person's position is rational and valid within some context of action and experience” (Wilson & Herndl, 2007, p. 147) and that, for constructing applied scientific claims useful in industry practice, winemakers' and growers' positions, their contexts and experiences are part of the relevant domain of discussion (Bazerman, 2009).

Three: The goals of industry-oriented science communication often remain some form of audience persuasion: to address the “implementation problem or the knowledge gap between research and practice" (Noe et al., 2015), or to "persuade farmers or other target groups to adopt specific technological packages and/or to accept certain ideas or policies" (Leeuwis, 2004, p. 35). A generation of research into science communication for "change" attests that increasing audience participation and listening to audience responses is helpful even when the object of the exercise is to get "the public" to do what "we" want.

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Appendix – Code book

Abbreviations: SR – scientific research; WM – winemaking

Problem-solving strategies	Doesn't have problems
	Doesn't talk much to other WM re problem-solving
	Google first/best resource
	Learns about new ideas first by reading
	Talk to peers to reinforce his own ideas
	Peers: different opinions from everyone
NZW	Doesn't think NZW does much SR
	No idea how NZW SR priorities are selected
	NZW botrytis book is excellent
	NZW dumbs down too much
	NZW fact sheets are good
	NZW good at making things accessible
	NZW is biased
	NZW mostly a marketing organization
	“Pro-NZW”
	Skims NZW materials
	Website has improved
	Website is terrible
Research relevance	Basic SR is valuable
	Board reps are distanced from real WM
	Best research comes from France
	Controls are important
	Good methods are what make SR valuable
	If industry pays for SR, industry should benefit
	Important to know why something works
	Most SR is about specific products
	NZ SR no more useful than overseas SR
	Skeptical of SR from universities
	SR about specific products is biased
	SR builds systems understandings
	SR doesn't seem responsive to industry needs
	SR done wrong from not talking to the right experts
	SR done wrong from not paying attention to the site/taking care in methods
	SR done wrong because done by students
	SR done wrong because researchers don't know WM
	SR from suppliers is useful
	SR generates real knowledge
	SR is an instance of someone trying something
	SR is useful for marketing

	SR most relevant translated through the peer WM community
	SR mostly for big companies
	SR recapitulates what we already know
	SR responds to a specific market need
	SR satisfies curiosity/interest
	SR too small scale to mean anything
	SR useful when it has a specific goal
	University research is always behind
	Unsure what makes research relevant
	Unsure what makes research believable
	Wants to know whether someone has tried it
	Wants SR to provide answers
	Winery driven SR is relevant; scientist-driven is not
Trials	Need to generate own data b/c that's all that's available
	Trials require permission from superiors
Winemaker education	Bookmarks SR for future reference
	Don't need to learn more after years of experience
	Education adequate to read papers
	Expects research to filter through the peer network
	Info literacy most useful lesson from schooling
	Lack of continuity across generation
	Learn from industries outside WM
	Motivated to read SR out of personal interest
	Practical experience more valuable than formal education
	Teaching as a way of learning
	University WM programs more about collecting tuition than providing good education
	We know very little about WM science
Winemaker identity	Cynical
	Don't change too quickly out of respect for consumer
	Good WM about using fewer, not more products
	I'm a reader
	Peer community is open and collaborative
	Scientific mind
	Stock-standard
	WM is a job, not an avocation

Preface to chapter 5 – How this study of science communication texts in the Washington State wine industry contributes to the thesis as a whole

The preceding two chapters together demonstrate that traditional paradigms for describing industry-oriented science communication – paradigms oriented toward interests in persuading industry members to adopt scientific innovations – obscure the multiple, nuanced ways in which wine industry members relate science to their work. Accounting for these industry member responses becomes important when desired research-industry relationships are about collaborative problem-solving rather than about disseminating objectively true, universal, and superior knowledge. Analyses of survey and interview data provide empirical evidence supporting the need for industry-oriented science communication strategies that account for pre-existing industry knowledge at the level of constituting “good” use and at the level of constituting “good” knowledge.

The following two chapters suggest that industry-oriented science communication in the same wine industry settings is not satisfying that need. Analyses described in these chapters point to specific ways in which intratextual features of industry-oriented science communication continue to enact a deficit model: ignoring industry knowledge, creating distance between science and industry practice, and missing opportunities to help industry user-readers connect research with their work. These textual analyses suggest factors which may contribute to the situations described in chapters three and four, of industry members valuing science but finding much of what they read “not relevant.”

I observe in chapter five that industry-oriented science communication potentially impedes industry-readers' perceptions of the relevance of science to practice by failing to make connections between research practices and industry practices. By ignoring industry practices as outside the relevant domain of scientific discussion and outside the scope of knowledge-making practices, science communication texts miss opportunities to locate research with respect to audiences' locations. *Therefore*, industry-oriented science writing should be studied at the microtextual level, and strategically manipulating those textual microprocesses presents an opportunity for making research more relevant to industry user-readers.

Chapter 5 – Constructing relationships between science and practice in the written science communication of the Washington State wine industry[21]

Abstract

Even as deficit model science communication falls out of favor, few studies question how written science communication constructs relationships between science and industry. Here, I investigate how textual microprocesses relate scientific research to industry practice in the Washington State wine industry, helping (or hindering) winemakers and wine grape growers in making research relevant to their work. Critical discourse analysis of a corpus of wine science texts suggests that textual microprocesses continue to enact a deficit paradigm: scientists as knowledge-producers and the industry public as knowledge-deficient. Through its extension of features of scientific discourse, the industry-oriented literature abstracts research practices from context which could aid in drawing relationships with industry practices. In aggregate, these texts suggest an opportunity to increase research relevance to industry practice by writing the research-industry relationship differently, recontextualizing research in practice.

Introduction

This study addresses a question provoked by contemporary constructivist science studies: how does written communication construct the relationship between scientific research and industry practices? Funding and other social infrastructures assume the

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relationship exists, but the relevance of science to industry cannot be taken for granted. Challenges to the positivist narrative have made it untenable to simply assume that scientific knowledge constitutes universal knowledge applicable everywhere. Though post-positivist models differ, the central contrastive point remains the same: scientific knowledge is shaped by human action, subjective and socially situated (Law, 2008; Law & Singleton, 2000). If not automatically united by universal natural laws to which science has privileged access, then work must be done to construct relationships amongst the practices of science and industry (Law & Lien, 2012; Law & Singleton, 2000; Mol, 2003). Relating them must happen via the networks of exchanges in which scientific knowledge is constituted (Latour & Woolgar, 1986). Written communication, as part of these networks, contributes to constructing scientific knowledge and its relationships to other communities. Consequently, writing science differently can make science more or less relevant to industry practices. This article questions how scientific research is made relevant to practice in texts spanning the research-industry interface via an exploration in the Washington State winemaking community.

Studies of the rhetorics of industry-oriented science communication, for all the social import of research-industry connections, have been oddly few. Industry has, it seems, fallen through a gap between studies of peer-reviewed scientific literature (e.g. Bazerman, 2000; Gross, 1996; Myers, 1985; Prelli, 1989) and popularizations (e.g. Dahl, 2015; Fahnestock, 1998; Luzón, 2013, Myers, 2003) for general lay audiences. Latour's (1999) circulatory model argues that all these forms of communication add to the heterogeneous networks through which scientific knowledge moves and in which it is made. Texts for industry audiences, too, contribute to this circulation and are thus not incidental instruments of transfer created after the real business of science takes place, but themselves constructors of scientific knowledge. Industry-oriented science literatures are worthy of study as a unique group, therefore, on three accounts. First, as contributors to scientific circulation. Second, as mediators of how industry members interact with scientific research. And third, as unique from both the peer-reviewed and the popular scientific literatures. Industry audiences sit as a third public somewhere between scientists and lay people, having specialized expertise and expected to make use of research but not chiefly occupied in conducting it. Communicating science with industry thus creates a unique set of rhetorical exigencies.

This case study of science communication in the Washington State wine industry is a contribution to examining industry-oriented science communication as a unique literature with a particular responsibility for making research relevant to industry practices. I follow in the vein of Luzón's (2013) recent discussion of science blogs as a genre in which bloggers write science as relevant to their audiences, drawing connections between research and readers by employing strategies uncommon in the peer-reviewed literature. Here, I examine the intratextual microprocesses (Bazerman, 2004) of wine industry science communication in its capacity to write science as more or less relevant to industry readers' practices. While my conclusions speak most specifically to the wine industry, they point to a systematic disconnection between research and industry practice which may exist in other research-industry systems. They consequently also point to the utility of studying textual microprocesses in industry-oriented science writing in general.

Constructing relevance in science writing

Studies of industry-oriented science communication often rest their assessments on adoption, with the unit measure of success being how many industry members are persuaded to change their behaviors or attitudes in favor of the more scientific option after a communicative intervention is deployed (e.g. Bozeman, Rimes, & Youtie, 2015; Estabrooks, 1999; Hill et al., 2015; Leeuwis, 2004). Adoption is not an ideal endpoint because it assumes that adopting scientific knowledge is accurate, desirable, and useful. By defining in advance what constitutes desirable research use and measuring industry response in terms of those definitions, adoption-based assessments fail to see how industry members productively critique scientific claims (Szymanski, 2016). And even should adoption be the desired goal, that goal informs textual analyses only indirectly. User/reader relevance affords an alternative basis for assessment emphasizing how well texts connect research with their readers.

Relevance as a fluid and context-based concept has resisted definition (Froehlich, 1994). In contrast with earlier emphases on topicality alone (i.e. this article is about chardonnay, and you make chardonnay, so this article is relevant to you), however, recent efforts insist that relevance is relational (Froehlich, 1994). Huang and Soergel (2013) define "relevance-as-is" as "a meaningful relationship R between an information object I and an information need N with the components of *Topic, User, Problem/Task, and Situation/Context* ***(TUPS)***" (p. 20, emphasis original). Research relevance to industry practice thus involves users' ability to draw relationships between research and users' practical work – their problem and context. Sperber and Wilson's (1986) relevance theory is similarly context-dependent but emphasizes relevance as a feature of new information acquisition: new information is relevant to the degree that it offers a high "cognitive effect" in return for the “processing effort” (p. viii) necessary to match new information with meaningful context from pre-existing knowledge. Both theories emphasize that relevance involves users' individual needs and existing knowledge, the relationships between users' contexts and new information.

In this case, I take relevance as a judgment made by the user/reader, extending beyond content topicality alone, involving how and how easily the industry user/reader can draw “meaningful relationships” (Huang & Soergel, 2013, p. 20) that allow the industry user/reader to apply scientific practices as tools in their own practices. As such, relevance avoids assuming that successful science communication means encouraging industry members to be more scientific, instead allowing for diverse forms of research use and creating the expectation that industry members' preexisting knowledge participates in how and whether scientific research relates meaningfully to their work.

Context: The Washington State wine industry

Science communication in the wine industry means science communication as suggestion, which makes it useful for studying how written communication constructs science-industry relevance; in the absence of legislation compelling winemakers and growers to accept scientific advice, the role of written communication in making science relevant is easier to observe. Though the science of wine is a story infrequently told to consumers, winemaking and wine grape growing in all but the most extremely traditional cases involves a lot of science: horticulture in maintaining the vineyard, the microbiology of fermentation, the chemistry of flavor and aroma molecules, and even the physics of oxygen diffusion through oak barrels or the pores of a cork. Scientific research addresses industry problems: grapevine disease, growing grapes with limited water, incomplete or slow-moving fermentations, or ensuring that white wines pour crystal clear (Bisson et al., 2002; Research Task Force, 2013). Winemakers and growers benefit from understanding scientific principles and are largely interested in learning about science, but can almost always choose what to do with scientific information they receive (Boshoff, 2014; Hill et al., 2015; Szymanski & Davis, 2015). Science cannot offer recipes for making good wine: winemaking involves decisions about taste and style, and the science of how to achieve a particular wine style remains inexact.

Winemaking in the United States and other New World wine regions (roughly defined by their contrast with Old World winemaking in Europe) is bound by very few laws about the process itself, excepting only minimum health standards and rare controls against the spread of vineyard disease. The market bears a diverse array of wine styles and prices. Many wine industry members are small business owners able to make fairly autonomous decisions, and many obtain value from wine production in non-monetary terms (Jung, 2014; Scott Morton & Podolny, 2002). Scientists are therefore in the business of offering suggestions with the relevance of science to practice largely not forced by legislation or commodity standards. However, as in many other applied science settings, wine science research is funded with a mandate to communicate research findings to industry members expected to benefit from that research (Research Task Force, 2013).

The United States wine industry is served by the agricultural extension system, where conjoined research and technology transfer functions are institutionalized in the mission of land grant universities to support state agriculture with scientific information resources (McDowell, 2001). In Washington State, the vast majority of public wine research is conducted at Washington State University (WSU), a land grant university with a viticulture and enology research and extension department. Research conducted at WSU is principally oriented toward wine production within the state, its unique wine styles and growing conditions. State winemakers and growers describe feeling connected to and being more familiar with WSU compared with other wine research programs (Szymanski & Davis, 2015). The Washington State wine industry is therefore particularly useful for studying relevance because it is easy to see what is being made relevant to whom: existing infrastructure focuses on making state research relevant to state winemakers and growers (Research Task Force, 2013).

The purpose of this analysis is to identify intratextual microprocesses of science communication texts spanning the research-industry interface that contribute to relating (or, as will become evident, not relating) new scientific research and an industry community expected to benefit from it. Specifically, I ask:

- How do science communication texts represent the relationship between scientific research and practices outside of the laboratory?
- How do science communication texts represent industry knowledge and practices?
- What devices do science communication texts employ to draw connections between research and industry communities?

Method

Corpus construction

To address these questions, I constructed a corpus of texts capturing Washington

State wine-focused science communication from a five-year period, long enough to generate a varied body of texts without provoking questions about time as a variable. I began with peer-reviewed articles published by viticulture and enology researchers at WSU between 2009 and 2014. Publications related to wine (many of these scientists also conduct research in other areas) were identified via Google scholar searches using each staff or faculty researcher's name plus the keywords “Washington” and “wine.” To filter for Washington-focused wine research, only articles published in English and first- or last-authored by a WSU faculty or staff member concerning research conducted in Washington State were included. I then identified additional, non peer-reviewed articles related to the research projects identified in that first search by using their titles, main keywords, and the principle investigator's name for keyword searches via Google and in the online archives of major wine industry trade publications (*Wine Business Monthly*, *Wines & Vines*, *Practical Vineyard and Winery*, and *Good Fruit Grower*). I also manually searched WSU viticulture and enology newsletters (archived online as non-searchable pdfs from 2011, when the newsletter in its current form began) and blog and news items from the WSU College of Agricultural, Human, and Natural Resource Sciences (CAHNRS). I disregarded articles consisting entirely of material duplicated from official WSU press releases which added no new material for analysis.

I grouped the resulting corpus into 11 topical clusters (summarized in Table 5.1), each containing at least one peer-reviewed research article and at least one non-peer reviewed article, comprising 86 items in total (see Appendix). Non peer-reviewed texts were of three kinds: extension articles, written by scientists for the industry audience; trade publication articles addressing the industry at large; and news pieces, mostly in the shape of university newsletter items and press releases. The final corpus thus contains four kinds of communications: scientists addressing other scientists (peer-reviewed research articles), scientists addressing industry (extension articles), industry addressing industry (trade articles), and university public relations staff addressing a non-specialized audience interested in university goings-on (news articles). Notably absent are articles in which industry members address scientists. Though evidence embedded in the corpus and my experience with the wine industry outside it (Szymanski & Davis, 2015) evinces that industry members do indeed communicate to scientists, this search strategy yielded no such articles.

The corpus does not review the full gamut of viticulture and enology research conducted in Washington State during this period, but systematically captures scientific research actively shared outside the professional scientific community. Having peer-reviewed literature at its heart, this corpus in theory risks missing science communication initiated by industry channels. I consider this a minor concern for two reasons. First, my primary interest here is to understand how scientists and those who work in research dissemination make research useful to practice. Second, my search suggests that industry-initiated science communication is largely related to wine companies' private business interests, not visible to the public eye and shared with a smaller community.

Table 5.1. Summary of corpus contents

Cluster moniker	**Peer-reviewed journal articles**	**Trade articles**	**Extension articles**	**News articles**	**Total number of words***
Grape shrivel	4	4	0	3	34102
Nitrogen	3	2	1	2	12293
Brettanomyces	2	2	2	2	11531
Tannins and maceration	5	2	3	4	50226
Tannin additions	1	3	1	2	13399
Water stress	1	2	1	1	7222
Rootstocks	2	5	0	2	20403
Cold hardiness	1	5	1	2	11620
Vineyard site selection	1	1	0	1	6659
Ethanol and aroma	3	2	0	2	18088
White wine finish length	1	0	0	4	9109
Total number of words*	141,437	30,019	7487	15,709	194,652

*Excluding references, which were not part of the analysis.

Critical discourse analysis

I subjected this corpus to critical discourse analysis (CDA). CDA is not a formal method but a “'mode' or 'perspective' of theorizing” (van Dijk, 2005, p. 352), useful here because its mode or perspective emphasizes the relational implications of intratextual features. Following Fairclough and Wodak, CDA is predicated on the assumptions that society is enacted in discourse, that local and more global discourses are related, and that discourse is produced by people functioning both as individuals and as group members (Fairclough & Wodak, 1997; van Dijk, 2005). CDA focuses on power dynamics in texts, often beginning from a known power imbalance. I do not wish to imply that American wine industry members constitute a marginalized group, nor to imply an agonistic power struggle between scientists and the wine industry. However, the positivist scientific epistemology in which scientific discourse is grounded implies its epistemic dominance over industry knowledge (Bourdieu, 1990); by presuming objectivity, science asserts the dominance of its subjective positioning (Haraway, 1988). Finally, CDA expressly acknowledges the meaningfulness of absence and silence, not just what the text says but what it omits (Hucklin, Andrus, & Clary-Lemon, 2012).

I coded (with the aid of the qualitative research program HyperTranscribe™) each text for: explicit or implied mentions of audience, author, and wine industry members or scientists as groups; explicit reference to what science or scientists know or do not know; explicit or implied references to what industry members know or do not know; and discussion or exemplification of the role of science in wine industry practice. Table 5.2 summarizes the coding structure; some codes overlapped. Coded sentences focused close reading, guided by the example set by Myers (1996), for how knowledge-making statements position the claim and the person making the claim in larger context, a body of knowledge or set of practices. These data were reduced by following themes as they repeated across texts.

Table 5.2. Summary of coding scheme

References to scientists	"He"/"she" = winemaker/grower Reference to student researcher Scientist recounts personal observation	Scientist recounts general scientific knowledge "We" = scientists
References to scientific knowledge	Citation of previous peer-reviewed literature Description of general scientific knowledge	Description of original scientific data Research is incomplete/uncertain Research as observation Statistical evidence
References to industry members	"He"/"she" = winemaker/grower Reference to community practice	"We" = winemakers/growers Winemakers/growers conduct experiments
References to industry member knowledge	Reference to general industry knowledge Reference to industry knowledge as belief or anecdote Reference to industry trial or experiment	Winemaker/grower argues from personal experience Winemaker/grower argues from stylistic preference Winemaker/grower called upon as expert
References to the role of science in industry practice	General reference to the utility of research in practice Research answers industry questions Research generates industry recommendations Research confirms existing industry practice Research corrects/contradicts existing industry practice Research explains existing industry practice	Research is grounds to critique industry practice Research is grounds to critique wine quality Research tests "unsupported" industry practices Science explains why wine quality is good Industry requires scientist help Winemakers/growers perceive research as not applicable/relevant
References to the roles of industry related to science	Industry funding for research Industry observations confirm research finding	Industry observations contradict research finding Reference to research-industry partnership

Background: Tannins

In the following analysis, most examples reference a single topical cluster to minimize the need for multiple technical explanations. Quotes represent strategies found throughout the corpus, the quotes themselves chosen for brevity, clarity, and minimal jargon. The topic – tannin management in red wines – is a major research interest internationally and specially important for Washington winemakers, many of whom make tannin-rich red wines.

Tannins are a poorly defined subclass of molecules within the larger chemical class known as phenols. Tannins are responsible for astringency: that rough, furry, or sticky sensation left inside your mouth by many red wines, black tea, and (in an extremely unpleasant case) underripe persimmons. They are most important for red wines because tannins are concentrated in grape skins and seeds rather than the pulp of the fruit; white wines are made by immediately separating out skins and seeds from crushed grapes so that tannins have little chance to leach into the juice, while red wines involve macerating skins and juice together for days or even weeks. Tannins also help stabilize red wine color. For most red wine varieties (pinot noir is the best-known exception, and Washington State makes very, very little of it), critics give higher ratings to high-tannin wines with deep red color and perceptible astringency (Mercurio et al., 2010). On the other hand, excessive or (as the connoisseur's phrase goes) poorly integrated tannins make an unpleasant drink. Many winemaking techniques affect tannins, and winemaking supply companies sell packaged tannin products routinely used by winemakers in Washington State and elsewhere. However, saying that there is no recipe for making wine with a particular astringency and hue is an understatement. Relationships between tannins and grape growing and winemaking techniques are complex, incompletely understood, and active areas of research.

In 2012, associate professor of enology and extension enologist Dr. Harbertson and his colleagues published research in the journal *Food Chemistry* analyzing commercial tannin products. The team concluded that the products were only partially comprised of tannin, were useless in recommended doses, and could be detrimental to wine quality at higher doses as undisclosed non-tannin ingredients could impart unwanted earthy notes. In short, "many tannin additions may be unjustified and have limited or negative impacts on quality" (Harbertson, Parpinello, Heymann, & Downey, 2012, p. 999). In the trade literature, and in interviews I conducted with Washington State winemakers in an earlier segment of this study (Szymanski & Davis, 2015), winemakers who use tannin products recounted doing so because they have found in their own trials that tannin products make a positive sensory impact on their wines.

Findings

I organize the following analysis by type of document, who is speaking and to whom: first scientists addressing other scientists in the peer-reviewed literature, then industry members addressing industry members in the trade literature, scientists addressing industry in the dissemination or extension literature, and journalists addressing the undifferentiated public in news pieces. While only the second and third are intended for industry member audiences, all four together depict how these communities relates, and juxtapositions amongst them are interesting. Key findings are summarized in Table 5.3.

Table 5.3. Summary of key findings

	Author → Audience	Average word length	Key features
Peer-reviewed	Scientists → Scientists	5893	Statements supported w/ citations to existing literature or original data No personal pronouns (excluding rare general "we") Place references mostly in methods, not conclusions Industry references rare, present in introductions and conclusions only as anecdote warranting scientific explanation Science supports anecdotal industry practice
Trade	Industry members, journalists, science writers → Industry members	1035	Abundant personal pronouns and place references Quotes from winemakers/growers and scientists presented similarly as limited personal observations Specific industry examples follow scientific generalities Science presents observations and suggestions
Extension	Scientists → Industry members	832	Statements supported w/ citations to existing literature or original data Industry references present in introductions as anecdotes warranting scientific explanation Science supports anecdotal industry practice
News	Journalists, public relations writers → Lay public	655	Abundant personal pronouns and place references Industry references present as context motivating research or asking questions of researchers Science answers industry questions and solves industry problems

Peer-reviewed literature: How scientific discourse positions science with respect to practice

Peer-reviewed articles in this corpus do not diverge from the peer-reviewed scientific literature generally, rhetorical characteristics of which have been thoroughly characterized elsewhere (e.g. Bazerman, 2000; Gross, 1996; Prelli, 1989; and many others). Several of those characteristics have particular implications for shaping the research-industry relationship and are therefore worth noting here. Peer-reviewed wine science writing says the most about industry practice in what it leaves unsaid. It is conspicuously, predictably, and exclusively self-referential. Statements are supported with references to previous peer-reviewed research articles. Scientists do not reference wine industry practitioners' knowledge or experiences, even when discussing industry practices; for example, a string of citations to the peer-reviewed literature supports the assertion that winemakers add tannin products to increase their wines' tannin levels in the introduction of Harbertson's *Food Chemistry* paper. Contextualizing references to industry practices in introductions and conclusions are not a source of knowledge but rather a reason why knowledge needs to be made. The problems research addresses are framed not as industry problems but as gaps in the scientific literature: "To date enological tannins have received little attention from researchers...As a result there are few publications on the efficacy of enological tannin addition to wine and little published knowledge of the effectiveness of the available products" (Harbertson et al., 2012). Winemaker knowledge – in this case from using tannin products – is, as a means of informing research, manifestly absent (Law, 2004).

Similarly, scientific conventions systematically subtracting references to place and person are noteworthy for what becomes absent: in the movement from methods to results and conclusions, statements “shed” references to the context of their generation, creating general statements from “placeless places” (Gieryn, 2002, 2006). In Harbertson’s 2012 article, what begins as “a [2006] Merlot wine [which] was blended from grapes grown in the Columbia Valley, Yakima Valley, and Wahluke Slope American Viticulture Areas (AVAs) in Washington State (USA)” becomes simply a “Merlot wine” in the conclusions. It remains simply a “Merlot wine” in the corresponding extension article (Harbertson & Downey, 2012). People are deleted via the scientifically conventional passive voice and through displacing grammatical agency onto such non-humans as “the study,” “tannins,” or “some fruit.”

Trade articles: How industry juxtaposes scientific and industry knowledge

The first observation to make about science in the trade literature concerns the contrast it makes with the peer-reviewed literature, the second how scientific knowledge is represented. Winemakers' statements in the trade literature emphasize locality, place, and experience. While scientists depend on aligning with published predecessors, winemakers emphasize difference and, indeed, depend on not aligning. As a consumer, how do you choose one bottle from amongst the hundreds at your local shop or the thousands online? For better wines, at least, you choose a story as much as a beverage, and wineries thrive on narrating a unique story (Beverland & Luxton, 2005; Dawson, Fountain, & Cohen, 2011). Winemakers tell marketing stories to consumers, but they also tell stories of individual experience to each other. They speak to the context of person and place even when speaking about scientific techniques, in contrast with scientists' statements in the peer-reviewed literature which aim for "the widest relevance and therefore assert the greatest generality" (Hyland, 1997, p. 28). Scientists' statements in the trade literature, however, are also presented as stories of individual experience, leveling the epistemic ground between scientists' and industry members' statements.

Winemakers and growers speaking in the trade literature contextualize their knowledge claims, foregrounding the speaker's "problem/task" and "situation/context" (Huang & Soergel, 2013, p. 20). In so doing, they facilitate industry readers' creating meaningful relationships with their own practices which may happen under different growing conditions, use different grape varieties (e.g. cabernet franc instead of merlot), or target a different style (e.g. a light, elegant merlot instead of a bold, fruity one). As the following examples show, winemakers and growers do not limit their claims by hedging – "it seems;" something "might" be true (Hyland, 1996, p. 257) – but by locating their statements in context.

A trade article about controlling the spoilage yeast *Brettanomyces bruxellensis* or "Brett" – if you've ever opened a bottle redolent of wet dog, you've tasted a "Bretty" wine – calls upon the story of Joshua Maloney, "director of winemaking at Milbrandt Vineyards in Mattawa, who has dealt with Brett first-hand at wineries in the past" (Mitham, 2012). Maloney observes "that Brett strains in Eastern Washington show their nasty side at concentrations of more than 5,000 cells per milliliter." Keeping Brett populations below that level works for Maloney, who says that "Brett lives in the bottom. And if you routinely get away from the stuff living in the bottom, if you just rack off and leave it behind, you can actually knock the population down." Maloney invites "you" to learn from his experience, but emphasizes the context-dependency of his claim: your local Brett strains may “show their nasty side” at higher concentrations.

In the following example from a *Wine Business Monthly* article on Washington State rootstock experiments, a highly-regarded winemaker[22] contextualizes his claims in both his location and stylistic goals:

> We have found in the first few years of [grafted vine] establishment, you have to be very diligent about removing roots from the scion. I've literally seen them put out roots five inches above ground to reach soil. I'm still a big believer in the quality advantages we achieve from own-rooted vines, particularly in the early years as own-rooted vines can reach deep into the ground much sooner. We've made the wine separately, and I always prefer the own-rooted to the grafted vines. (Hall, 2009, n.p.)

Rather than advising directly on planting techniques, the winemaker describes what “we have found;” rather than discussing quality as an objective measure, he describes personal preference.

Elsewhere, a winemaker discussing “phenolic analysis and management” does so with respect to his winery's “stylistic goal to produce soft dense reds.” He speaks in the first person: “One wine we’ve really shaped over the past 10 years is Merlot…Now we press it off at four to five days because we know that the CD [color density] builds and maxes out at four days, but the TI [tannin index] will keep going” (Rieger, 2014, p. 51). Rather than asserting a general claim about the relationship between color and tannin index, he

[22] The reason why the winemaker's reputation is significant is because most readers of *Wine Business Monthly* are likely to have heard of this winemaker and even to have tasted his wines. Consequently, when the winemaker makes statements about wine quality, industry readers can draw connections between his statements and their own experiences.

describes what *his* team finds is true for *one* of *their* wines; rather than assert a claim with wide relevance, he connects his claims to his practices such that readers can connect his claims to their own practices. In contrast, scientists quoted in the same article use self-referential pronouns solely in the form of the inclusive “we” (Mulderrig, 2012) indicating the general community – “We tend to want a higher level of phenolics in grapes” – and otherwise displace agency onto their studies or objects of study, as when “moderate vine stress tends to increase phenolic quantity and quality” or “most studies show no or a negative effect on color.”

Scientists are quoted speaking in generalities; however, in the trade literature the epistemic assertiveness of scientists' statements is mitigated through lexical or discourse-based hedging (Hyland, 1996), leveling scientists’ and industry members' statements. Moreover, location is imposed on scientists' statements by interpreting them through the lens of winemaker experience and reframing questions of right or wrong as questions of taste. Trade publications in this sense minimize the processing effort of reconciling new scientific knowledge with existing industry knowledge by foregrounding industry context.

Reporting on another element of Harbertson's tannin research, a trade magazine article presents conflict between scientists and growers explicitly – its title reads “Washington Growers Examine Wine 'Myths' – Speakers Pit Research About Cold Soaks and Irrigation Against Conventional Wisdom” – but takes pains to reconcile that apparent conflict by emphasizing the contexts behind scientists' and industry members' claims (Gordon, 2011). The article summarizes a panel discussion at the annual meeting of the Washington Association of Wine and Grape Growers: scientists presented their research showing that cold soaks, a common winemaking technique for manipulating tannins, are ineffective and possibly harmful; winemakers then spoke of their experience with the technique. Researchers and winemakers are placed on an epistemic par. Like winemakers' observations, research findings are attributed to what a scientist "observed" with the personal pronoun "he" emphasizing the scientist's role as protagonist in a story about an experiment. As observations, they stand unchallenged in the text. But when the scientist and his colleague "explained" a general warning against cold soaks on account of dangerous microbial growth, the statement's force is discursively mitigated. The declarative sentence immediately following offers that winemakers usually add sulfur dioxide to cold soaks. The unstated conclusion is that scientists' concerns are less relevant because winemakers usually add this prophylactic antimicrobial agent (Gordon, 2011; Cutler, 2009). A winemaker on the panel adds that he has never seen microbial growth in years of cold soaking despite checking with "lab tests."

The article resolves the apparent conflict between scientific and industry knowledge by using winemakers' statements to add context back to scientific claims, highlighting key differences of place and taste. The winemaker "stressed that unlike [the scientist's] methods, his soaking wines get no stirring or other active oxidation" that would encourage microbial growth (Gordon, 2011). Another "underlined that researchers disagree among themselves over the effect of cold soaking" and commented that "I think it's like saying black pepper makes food better. Well sometimes it does, but sometimes it doesn't." He uses a modified cold soak on the basis of taste: "he likes how the wine turns out" (Gordon, 2011).

Extension articles: Juxtaposing scientific and industry knowledge, minus the industry

Extension articles closely resemble – indeed seem to extend from – their peer-reviewed counterparts. Consequently, extension articles make science acontextual while continuing to enact the deficit model: scientists know, winemakers do not. In extension articles, abbreviation (see Table 3) exacerbates placelessness and personlessness. A brief extension summary about tannin research, for example, omits methodological detail about specific tannin products tested and winemaking techniques used that are specified in the associated peer-reviewed article (Harbertson & Downey, 2012). The concluding recommendation – that "this research suggests many enological tannin additions may be unjustified and have limited or negative impacts on wine quality" – is unmoored from contextualizing statements accompanying an almost identical statement in the peer-reviewed article. An industry reader thus has no grounds for relating the scientists' practices to her own. Did the scientists use the tannin products the same way they do in their winery? What kind of wines were involved? Were sensory measures important to her winemaking style omitted? If the winemaker has used tannin products to apparent good effect, what contextual differences might explain the apparent conflict?

Constructing meaningful relationships among scientific and industry practices is then doubly hindered when extension articles extend the conventions of their peer-reviewed counterparts in ignoring existing industry knowledge, "problem/task[s]," and "situation/context[s]" (Huang & Soergel, 2013, p. 20). A series of extension articles about tannins begins by observing that tannins are being investigated as a scientific concern:

> The maceration process, the contact of skins and seeds with juice during red winemaking (Fig.1), is an intriguing aspect of modern Enology. Maceration is recognized as a critical step in defining wine style, but some fundamental questions

> still remain: What substances are extracted and what are their impact?; How do these compounds evolve over time and interact with each other?; and How does this evolution influence the wine style? (Casassa & Harbertson, 2011, p. 9)

The motivating interest in maceration comes from “Enology” – the science of winemaking – not winemakers or even the needs of winemaking itself. Though maceration is presumably familiar to the newsletter’s industry-insider readership,[23] the scientist-authors define the term and give ownership and control over it to enology/science. What winemakers know about maceration and their maceration-related questions are absent. The piece employs the passive voice to reference what is known or attributes the act of knowing to science, as in the instance of “recent research” that “is unveiling several new dimensions” about “the chemical fate of tannins during winemaking” (p. 9). The singular reference to non-scientific knowledge is negative, when scientific findings are “contrary to popular belief” (p. 9). The piece's conclusion relates scientific knowledge to an industry task – “Knowledge of the underlying physical and chemical processes that occur during maceration allows the winemaker to adapt this process to the style of wine that is being sought and, ultimately, to what consumers expect to find in the glass” (p. 10) – but does so without adding context.

The “relevant domain of discussion” in any discourse is defined by its citation practices; citation conventions, formal and informal, provide grounds for what constitutes a potential part of that domain (Bazerman, 2009, p. 92; also Gilbert, 1977; Paul & Charney, 1995). The extension literature, like the peer-reviewed scientific literature, defines the

[23] A keyword search for “maceration” in the online archives of the popular trade magazine *Wine Business Monthly* yielded 71 articles published since 2000. For comparison, the same search strategy yielded 97 articles using the word “pruning.”

relevant domain of discussion as peer-reviewed research: immortalization in the scientific literature is what makes knowledge real. Thus, even though enological tannins' "use during fermentation and cellaring is widespread in the wine industry," their "impact on wine are [sic] poorly documented" (Harbertson et al., 2012, p. 999). What counts toward understanding tannins is activity in peer-reviewed journals. In the extension literature, so limiting the relevant domain distances science from industry practice and asks for more "processing effort" (Sperber & Wilson, 1986, p. viii) from readers by giving no explicit aid in reconciling with new knowledge. Restricting knowledge to scientific knowledge implies a condition that is probably not true, that is, that the reader does not already hold significant knowledge about tannins. Because industry knowledge is not included as worthy of being evaluated, considered, and compared, exclusive scientific ownership of legitimate knowledge ultimately impedes relevance by failing to connect the two.

The news: Constructing industry awareness versus industry relevance

All of this is certainly not to say that scientists fail to draw connections between their research and industry practitioners' ultimate interests in making good wine. News articles, however, demonstrate the salient difference between topically addressing industry concerns and facilitating meaningful relationships. News items are where scientists look most like winemakers and growers: photos show scientists in short-sleeved shirts and broad-brimmed hats inspecting vineyards; scientists undertake experiments that wineries, were they big enough, would conduct themselves; partnerships between scientists and wineries are foregrounded; scientists and industry partners sometimes try experimental techniques jointly. Here, moreover, is where the argument that wine scientists work for industry benefit is strongest: university newsletter items and press releases consistently connect research to the joint enterprise of making excellent Washington State wine. In the news, scientists voice their desires, de-emphasized in the peer-reviewed literature, to "answer so many questions important to industry" (Experiments investigate, 2009).

But how news articles connects science and industry practices again reinforces the deficit model: science makes legitimate knowledge, industry listens from a position of ignorance. Scientists are quoted explaining the value of research in giving winemakers information where before they had none: "'We thought this year's enology [best paper of the year] winner was important because a lot of what winemakers do is based on unsubstantiated assumptions'" (Team wins, 2010); "I wanted to conduct this research because it's important for winemakers to have hard data to reinforce their practices" (Experiments investigate, 2009). To similar effect – increasing the processing effort to connect scientific knowledge with what industry members already know – even stories about science helping winemakers make the goal of scientific investigation not improving wine quality per se, but beating back the unknown where science defines the known. News pieces begin with references to "great wine" (What matters, 2013), but research is driven by the very existence of unexplained phenomena demanding explanations. "Co-fermentation raises many questions." "Traditional practices" require research to explain them (Experiments investigate, 2009). News pieces continue to separate science from the non-knowledge-producing things winemakers do, giving little help in overlapping them in mutually relevant context as multiple ways of practicing shared, coherent objects (Mol, 2003).

Conclusion

The cumulative relational effect of science communication across the wine research-industry interface is largely *not* to relate scientific research to industry practices. The extension literature, in particular, extends features of scientific discourse that hamper meaningful research-industry relationships – relationships that enable industry readers to make decisions about whether and how scientific claims can be made to do practical work. While industry members' statements emphasize specificity and location, scientific statements “shed” those references (Gieryn, 2002) and make them difficult to locate in industry context. Additionally, scientific statements enact a power imbalance between scientific and industry knowledge and between researchers as knowledge-producers and industry members as knowledge-needy. Because trade texts validate both scientific and practical knowledge, that imbalance exists on two levels: in the manifest absence of industry knowledge from the peer-reviewed and extension literature, and in the contrast between the peer-reviewed/extension and trade literatures. The resulting power dynamic, beyond working against relevance as the ability to easily draw relationships between new and existing knowledge, is at odds with widespread shifts away from the deficit model. Myriad studies have examined the counterproductivity of deficit model science communication and suggested the advantages of more collaborative approaches (reviewed in, e.g., Leeuwis, 2004; Smallman, 2016; Sturgis & Allum, 2004). Science communicators need not take an epistemic position on whether science is or is not superior to other knowledge systems when failing to acknowledge audience knowledge systems has damaging practical consequences (e.g. Jasanoff 2003; Perrault 2013; Sturgis & Allum 2004;

Wynne 1992).

This analysis therefore points to opportunities to improve research relevance, independent of changing earlier stages of the research process, by communicating research in ways that facilitate meaningful research-industry relationships: re-locating scientific claims in place and taste; writing the context-dependency of scientific claims in the extension literature; acknowledging connections between scientific claims and existing industry knowledge, especially if conflict between the two might be mitigated by making context explicit; placing science among local knowledges rather than outside and above them. This analysis also points to an interesting discrepancy between what happens in text and what happens in face-to-face interactions. In interviews and surveys conducted as part of the larger study of which this analysis is a part, winemakers and growers described valuing extension scientists' knowledge of local context and their ability to make science relatable (Szymanski & Davis, 2015). The same message is repeated elsewhere in the agricultural extension literature (e.g. Bull et al., 2004; Boshoff, 2014; Warner, 2007). Extension faculty and staff and their agricultural practitioner interlocuters often reside in the same community. Some extension researchers have worked in commercial wineries and vineyards. And yet in those same interviews and surveys, industry members reported struggling to relate written scientific information resources to their work: most new information they encounter is not “relevant” (Szymanski & Davis, 2015, p. 280). It is impossible to rule out, from the available data, that differences in topics discussed verbally and in writing might help explain this testimony. Nevertheless, the extension of scientific discourse into the extension literature, with its moves distancing research from practice, may contribute.

Beyond specific implications for the wine industry or for industry-oriented science communication, studying textual microprocesses that enact relationships between science and its publics would seem a valuable enterprise. Drawing on Law, Myers (1996) advocates for using multiple “modes of ordering” (p. 23) to look at the same material in different ways, transforming the agents involved and revealing new ways of seeing and understanding. A content analysis of the science communication texts presented here would have pointed to their topical relevance to practice. Studying the attitudes and behaviors of scientists and wine industry members would doubtless usefully outline points of connection and disconnection between the two. Still, ultimately, much of the interaction between wine research and industry, and between other sciences and other publics, occurs in text. And so, amidst the various other considerations of where texts come from, where they go, and what they say, let science communication studies also make room for asking what texts do (Bazerman & Prior, 2003).

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Impact of ethanol on aroma

Peer-reviewed articles

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Villamor, R. R., Evans, M. A., Mattinson, D. S., & Ross, C. F. (2013). Effects of ethanol, tannin and fructose on the headspace concentration and potential sensory significance of odorants in a model wine. *Food Research International*, 50(1), 38-45.

Baker, A. K., & Ross, C. F. (2014). Wine finish in red wine: The effect of ethanol and tannin concentration. *Food Quality and Preference* 38, 65-74.

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News articles

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White wine finish length

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Preface to chapter 6 – How this study of technology transfer texts in the New Zealand wine industry contributes to the thesis as a whole

The preceding chapter points to a missed opportunity in how industry-oriented science communication bridges research and industry knowledge. Even though winemakers and growers perceive scientific and industry knowledge as complementary, dissemination texts behave as if only scientific knowledge is valid, manifestly ignoring what industry members know and their capacity to make epistemic judgments from that knowledge. The analyses presented in chapter six indicate a different kind of gap: wine technology transfer texts in New Zealand relate research to winemaking and growing practice in general, but leave individual industry members out of the equation. In this space, extant rhetorics of industry-oriented science communication distance scientific practices from industry practices by, in effect, attempting to transfer knowledge from scientific non-locations to scantily defined industry locations. These rhetorics fail to make research and industry practices proximal by constructing scientific knowledge as existing outside context and constructing industry as a generality: not seeing individual industry members, their unique sites of practice, collective knowledge, or capacity to make epistemic judgments on the basis of that collective knowledge. *Therefore*, we need to pay attention to how rhetorics of industry-oriented science communication construct research-industry relationships, and to devise rhetorics that bring these communities together by explicitly *locating* and recognizing the *locations* of each.

Full bibliographical information for the textual corpus analyzed in this chapter is not provided because these texts are not generally accessible; New Zealand Winegrowers technology transfer materials are available only to levy-paying members of New Zealand Winegrowers. I gratefully acknowledge the generosity of New Zealand Winegrowers in granting me access to these texts for the purpose of this study.

Chapter 6 – Enacting multiple audiences: Science communication texts and research-industry relationships in the New Zealand wine industry[24]

Abstract

This study in the New Zealand wine industry suggests that science communication can shorten the distance between research and industry without bringing research closer to individual industry members. Paradoxically, winemakers and winegrowers describe scientific research as relevant to industry work in general, but not relevant to their own work in particular. Analyzing "technology transfer" texts shows connections drawn between research and industry practice but simultaneously held at a distance from individual readers. Because written texts present a crucial face of science to industry, reordering rhetorical relationships may improve perceived research relevance to industry practice.

Introduction

Effective science communication makes science relevant to its audience. For non-scientist audiences who "feel a high degree of spatial and temporal distance from [a scientific] issue," science communication makes that distance shorter (Katz-Kimchi & Atkinson, 2014, p. 757). But what is relevance? Who is the audience? My aim here is to draw attention to two specific problems in how written science communication brings science and readers closer together: first, that science communication may make science

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[24] A revised version of this chapter has been published with *Science Communication*, 2016, DOI: 10.1177/1075547016677042

relevant to an audience in general without creating relevant relationships with individual members of that audience; second, that rhetorical features of science communication texts construct relationships amongst science and readers that can increase or decrease the distance between them. Insofar as relevance is about establishing relationships that go beyond establishing common topics of interest, paying attention to how rhetoric structures relationships becomes essential to making science relevant. I explore those relationships through a case study in the New Zealand wine industry, where winemakers and winegrowers describe valuing the usefulness of science in general but not seeing it as relevant to their own work.

From the perspective of public communication of science studies, the audience I consider – winemakers and winegrowers in New Zealand – is an unusual one. Winemakers and winegrowers have a specialized interest in viticulture and enology, the sciences of grape growing and winemaking. They are likely to apply new research findings to their work; indeed, the administrative networks of "technology transfer" (Rogers, 2002) encourage and even expect them to do so. These wine industry practitioners also have specialized and related expertise. Winemakers and winegrowers are more familiar with the materials and practices of scientific research compared with a typical lay person because winemaking/growing and wine science share some of those same materials and practices. In New Zealand, an industry non-profit organization coordinates both research and a science communication program targeted expressly toward their constituency. Because this research program at least theoretically has something to do with making better (or cheaper) wine, science communication is thus also potentially of economic benefit to its audience.

Nevertheless, this study of wine industry-oriented science communication reflects usefully on science communication to more general audiences in at least three ways. Because wine science communication is targeted to such a well-defined audience, it highlights that connecting scientific research with an audience operates on multiple levels. Second, again as a feature of beginning with a well-defined audience, it points to rhetorical moves as a place where science-audience relationships are made. Third, it adds to scholarship on communicating scientific research for practical implementation from the perspective of building grounds for collaboration rather than “pushing” research as something to be used in specific, predefined ways (Belkhodja, Amara, Landry, & Ouimet, 2007). Exploring a case in which communicated research overlaps so dramatically with an audience's interests and practical work makes it possible to resolve ways in which science writing can still distance research from that audience. In this sense, the New Zealand wine industry in particular is doubly useful because, in New Zealand, research, science communication, and industry practice are united by a common administrative structure that would appear to draw strong connections between research and industry audiences.

When New Zealand’s formerly public agricultural extension system was privatized beginning in the 1980's, “technology transfer” became an activity of independent industry representative non-profit organizations. New Zealand Winegrowers (NZW) represents the wine industry. NZW funds, oversees, and disseminates the results of wine-related research in addition to supporting the industry in diverse other infrastructural ways. Coordinating industry research and education under a single organization with broad industry service roles would suggest close relationships between research and practice. I was therefore surprised when, in interviewing winemakers and growers about scientific information resource use, I repeatedly heard research described as relevant to practice in general but distant from their own practices in particular.

In those same interviews, winemakers and growers cited technology transfer texts – industry-oriented science writing – as the main or one of the main ways they learned about scientific research, along with peer-to-peer conversations and workshops they might attend once or a few times a year. Consequently, I examined technology transfer texts for how they structure research-industry relations, and for clues to the paradoxical relationship with research that I heard industry members describe. That analysis yielded numerous intratextual rhetorical features distancing research findings from industry *practitioners* even while directly connecting research to *practice*. These texts cannot be considered in isolation from the other means by which research-industry relationships are ordered. However, given their central role in making science present to industry members, they also should not go without consideration altogether.

I begin with a brief description of the science communication infrastructure of the New Zealand wine industry, then summarize interview data concerning how winemakers and winegrowers talk about their relationship with research. I then present a textual analysis of relationship-building features of industry-oriented science communication texts and conclude with implications for the case and for science communication to other publics.

Science communication in the New Zealand wine industry

In the late 1800's, agriculture in the United States, Europe, Australia, and New Zealand became drawn into the movement to "professionalize" workers by formalizing their educations and improving their practices through scientific research (Danbom, 1986; Jones & Garforth, 1997; Russell, 2002). Resulting "extension" education systems have been praised for building strong, productive networks joining agricultural practitioners, scientists, and professional extension communicators (e.g. McDowell, 2001; Sparks, 2014; Swanson, Bentz, & Sofranko, 1997). However, traditional agricultural extension has also been soundly criticized for enacting deficit-model communication (e.g. Clarke, 2003; Ison & Russell, 2000; Leeuwis, 2004; Röling, 1990; Vanclay & Lawrence, 1994). While extension communication is not unidirectional – extension agents also facilitate communication from farmers to scientists about current needs and practices (Cash, 2001; Dalton, 2011) – the operating assumption has been that farmers have problems and scientists the power to address them, and that good (progressive, modern, well-informed) farmers follow scientific best practices (Leeuwis, 2004).

After a Cold War era-fed peak in the 1970's, the past thirty years have seen a gradual decline in extension activity as concerns over adequate domestic food supplies and unprecedented government funding for research and education have been replaced by neoliberal privatization and global free trade (Stantiall & Paine, 2000). Globally, many government-supported extension programs have been replaced with various more or less privatized alternatives (Hunt, Birch, Coutts, & Vanclay, 2012; Laurent, Cerf, & Labarthe, 2006; Swanson, Bentz, & Sofranko, 1997). New Zealand privatized its extension system early and thoroughly (Botha, Coutts, & Roth, 2008; Swanson, Bentz, & Sofranko, 1997). Increasing costs, together with a wide-reaching shift in the governmental winds, provoked a major restructuring of the state-owned agricultural research and science outreach program beginning in 1984 (Walker, Bell, & Elliot, 1993). A decade later, the program was fully commercialized and privately sold.

Extension functions have since been taken up by consultants and representative organizations, funded by industry levies and serving the needs of specific industries: dairy, beef and lamb, kiwifruit, wine, and so on (Barry, 2013; Botha, Coutts, & Roth, 2008). New Zealand Winegrowers (NZW) serves the wine industry, with all wine grape growing and winemaking operations *de facto* NZW members by virtue of paying levies on grape and wine sales. Current membership includes about 850 growers and 700 wineries (New Zealand Wine, *About New Zealand Winegrowers*, 2015). NZW uses levy funds for lobbying activities, international marketing of the New Zealand wine brand, industry communications, and research. It supports research in three ways: co-funding government-sponsored programs; receiving, reviewing, and selecting research proposals to fund directly, and commissioning research to address specific industry needs.

In any of these cases, researchers are expected to deliver progress briefs and full final reports, made available to the general membership via the NZW magazine and the members-only section of the NZW website respectively. Some project outcomes are also transformed into short "fact sheets" distributed in physical copy and available to members on the website. Other research dissemination resources made available to members include an annual industry conference at which some research is presented, periodic field days, and online tools and videos. Among these, growers and winemakers highlight field days and printed materials – the magazine research updates and fact sheets, and occasional longer publications – as most oft-used (e.g. "The winegrowers magazine is probably the main source of just keeping up with what's current in terms of research...so between that and that newsletter that comes through and that keeps us abreast of what's happening in various trends and research sort of findings and stuff like that").

One of five primary functions of the NZW research arm is "technology transfer," including “the effective dissemination of information, knowledge and results to the wider New Zealand wine industry” (New Zealand Wine, *What we do*, 2015). By committing to share research and technology developments with all NZW members – which is to say, with all national industry producers – the NZW system ameliorates an issue Laurent, Cerf, and Labarthe (2006) observed in European countries where reduced public extension limited smaller and less prosperous individuals' access to resources enabling them to cope with market challenges. In a review of the Ministry for Primary Industries Sustainable Farming Fund, through which NZW projects have received major co-funding, NZW was praised for having “created strong linkages between research and industry, supported high levels of innovation and uptake, and supported the development of industry best practice” (Oakden, King, & Allen, 2014, p. 42). Insofar as researchers are expected to share these dissemination resources with NZW in advance of any academic publications that may or may not also result from the project, they act as contractors to industry in addition to their roles as scientists. NZW has thus created a shared umbrella under which research and industry objectives, researchers and industry members (in various capacities), coordinate.

Interviews: Winemaker and grower perspectives on the research-industry relationship

I conducted 29 interviews with 32 winemakers and winegrowers in Marlborough – by far the largest wine-producing region in the country – and Hawkes Bay and Central Otago, two smaller but high-profile regions distant from major research centers. Interviews were each about 60 to 90 minutes (two dramatically longer; one shorter), at vineyards or wineries or in adjacent offices, and chiefly concerned how interviewees use and value scientific information resources in their professional work. All were audio recorded and transcribed in full (213910 words), then coded inductively for attitudes related to scientific research and science communication. Initial descriptive coding identified positions and attitudes around information resources, winemaker education, science and technology, and the nature of winemaking. Codes could and did overlap. Quotes included here refer to interview transcripts, anonymized in the interest of participant privacy, and indicate threads sustained through multiple interviews.

As of February 2013, only 15 of New Zealand's approximately 800 wineries qualified as large or "category 3," producing at least 4 million liters of wine annually (3,000,000 bottles, or 250,000 cases) (NZ Wine, 2013). These large companies sometimes collaborate directly and intensively with researchers; smaller companies rarely have the resources to do so and so tend to have less direct interactions with researchers, citing NZW publications as major sources of information. In the interest of understanding how science communication resources make science relevant to practice, therefore, I focused interviews expressly on the majority of winemakers and winegrowers outside of that handful of large players. Winemakers' and winegrowers' responses regarding science communication resources did not segregate by profession, so I treat them here as a single group of wine industry professionals.

Interviewees drew broad connections between research and practice in terms of scientists working on behalf of industry, industry providing research funding, and research aiding industry. This relationship was framed in transparently transactional terms: service provided in exchange for service.

> *"You've got quite a few PhDs here who you know, whose livelihoods it is selling their academic services."*

> *"There is a lot of research and to me, that should be the agreement, in terms of New Zealand research, getting that out to the practitioners."*
>
> *"They're [academics are] pretty keen to interact with people because they're aware it's funding, and otherwise there won't be any funding."*
>
> *"They're there to help us, and I mean the more they help individual companies the more likely they are to be given blocks to do trials in, so it's a reciprocation kind of thing."*

Researchers are obliged to deliver research to industry: industry members have a right to access research, and research is dependent on industry. Industry members also connected research and industry utility in less explicit, broader terms: "All research is valuable, most of it;" "It's all useful;" "I guess it's like any kind of industries in that you do kind of want to keep abreast of what's happening out there in research." "There's always a direct link, tapping into new knowledge."

> *"It's all good for me to sit and talk to somebody about something, but then go out and do it on my own or actually see what someone else has done, you know, that first-hand experience definitely counts a lot."*
>
> *"It's logical, it's visual, it's an easy thing to grasp for most people, and you can see it happening in front of your eyes."*
>
> *"It's labor-intensive for the [winegrowers] putting on the trial, but you know, if they have access to that data in a meaningful way…then it's kind of worth doing."*

The central theme around which winemakers and growers connected research to industry practice was first-hand observation: personally participating in a research project or witnessing a technique demonstrated on someone else's property or at a field trial.

Experienced practitioners build a body of experiential knowledge that permits making situational judgments more nuanced than straightforward application of a general rule (Dreyfus & Dreyfus, 2005; Krzywoszynska, 2015). First-hand observation obviously contributes more complex sensory information to that multidimensional body of expertise than any second-hand retelling; what an experienced practitioner is capable of seeing and what measurements record for the purposes of a written report differ (Perelman, 2004). Still, not all new scientific information can realistically be conveyed first-hand to every interested winemaker and grower. Even if only a second-best measure, written communication is still a vitally important one; interview participants described learning about the bulk of new research this way. And yet, when first-hand experience was not in play, *even while* they continued to make connections between research and industry on general terms, winemakers and growers distanced research from their own practices. Thirteen identified scientific research as being mostly "for" big wine companies, citing that only large wineries benefited from the economies of scale on which much research was perceived to focus, that research develops techniques attractive only to large companies, or that large wineries have the loudest voice in establishing research agendas.

> *"The people from the large regions that make thousands and thousands of tons of it, use technology that we would never dream of. A, we don't need it, B, it would overpower what we do. That's not to say that that doesn't trickle down to some degree, but I think that a lot of that research is really applicable to bigger companies."*
>
> *"I think the research bit of it is more for the industry instead of individual producers…maybe because we might not use it but I think it's important for the*

industry and maybe bigger producers."

"Lots of elements from the [current large research project] are more about what big commercial wineries do than what more high-end wineries do, I guess."

More generally, industry members tended to connect research to segments of the industry other than the ones they themselves occupied. Winemakers described viticulture research as more applicable to grape growing than enology research to winemaking. Grape growers described enology research as more applicable to winemaking than viticulture research to grape growing. Older people said that research was mostly for younger people. Producers who described a non-interventionist winemaking ethos called research interventionist: "I'm something of a purist, and well it will just sort of detract from the model that I'm trying to follow."

Interviewees who had participated in research as a field site (providing a working environment for testing some kind of grape growing technology) or by supplying samples (sending vineyard or winery materials to a laboratory for testing) described their involvement as relevant to their work; the singular exception involved a grower who faulted the design of a project into which the grower had been drawn. Their consensus speaks to the value of place and materiality in how industry members value research, observations on which scholars have elaborated in other deeply emplaced agricultural settings (e.g. Henke, 2000 about field trials on California produce farms; Paxson, 2013 about American artisan cheese makers). Their consensus also speaks to the technology transfer texts which provide the bulk of industry members' contact with research in the many instances *not* involving first-hand contact with a project. It would appear, on the whole, that these texts fail to convince these practitioners that research in which they have not personally participated is connected to their practice.

The research-industry relationship in writing

Consequently, I turned to technology transfer texts to investigate how those texts portray research-industry relations. As discourse – that is, as “social practice” (Fairclough, 1992) – intratextual features structure relationships amongst authors, audiences, and the various other actors they present (Bazerman, 1991; Titscher, Myer, Wodak, & Vetter, 2000). Moreover, writing can only (and must, inescapably) be made to mean something when it is read (Fish, 1980; Nystrand, 1989), and texts are necessarily written and read within communities that predispose and are reciprocally affected by their meanings (Bakhtin, 1975/1981; Fish, 1982; Foucault, 1969). Texts as a series of writing and reading performances are tied up in the same kind of sociomaterial tangle Latour (1999) described for scientific knowledge; knowledge production in both cases is constrained by materials, but also by myriad non-linear social networks extending beyond the scientist or the reader. Texts enact relationships, reflect the conditions of their production, and participate in reproducing and reshaping those conditions (Bednarek and Caple, 2014; Law, 2008; Law and Lien, 2012).

Understanding written science communication as a set of reality-making practices dissolves text-context binaries and, with them, the problem of needing to treat either text or context as primary. If texts are spaces in which the context is practiced, text and context are co-dependent and continually reshaping one another (Bakhtin, 1975/1981; Law, 2008; Phillips, 2011). Therefore, while my textual analysis (of which what follows as a part) was informed by the interviews preceding it, it constitutes another part of the co-constitutive context rather than the explanation for the interview data.

Informed by interviewee's testimony regarding their most important sources of research information, my textual corpus consisted of all research supplements (5, containing 15 research briefs; 7344 words), fact sheets (9; 13,857 words), and full research reports (9; 107,893 words) published during 2014, plus explanations of these materials on the NZW members website. The research supplement, a routine feature of the bi-monthly NZW industry magazine, comprises several brief progress reports written by scientists about their NZW-funded projects. Fact sheets, one to several page updates on specific topics or descriptions of "best practices," may be adapted from one or multiple research projects. Full reports are submitted to NZW at a research projects' conclusion and at intermediate stages in lengthy projects. Though made available to NZW members via the NZW members-only website, full reports were rarely mentioned by interviewees and, unlike research supplements and fact sheets, are written for a scientific rather than an industry audience. They were included here as complementary information to the analysis focused chiefly on industry-oriented materials. Employing the research output of a single year generated a snapshot of current practice; the output of 2014 does not appear to have been quantitatively or qualitatively exceptional compared with 2013 or 2015.

Understanding how intratextual microprocesses enact relationships is about reading texts as discourse, "language use as social practice" (Fairclough, 1992), and as rhetoric, or strategically persuasive action (Bazerman, 2013), reading for what the text does rather than what choices the author made or what content is being conveyed (Walsh, 2010). I conducted a limited discourse analysis concerning the relationship-building functions of words, phrases, and argumentative structures in terms of three questions:

- How is practitioner involvement in research presented?
- How is the rationale for specific research presented?
- How are the practical functions of scientific findings presented?

Addressing these questions involved, first, coding the corpus inductively for all mentions of practitioner knowledge, practitioner involvement in research, and functions of research results, grouping these under common themes via iterative readings. Initial descriptive codes were regrouped into a set of 103 belonging to the following themes: expressions of agency, industry participation, motivations for participation, activities of New Zealand Winegrowers, representations of industry knowledge, and representations of scientific knowledge. I coded 79 segments in fact sheets (again with the potential for multiple codes assigned to any given word or phrase), 355 segments in final reports, 247 segments in research supplements, and 61 segments in contextual materials from the New Zealand Winegrowers website. These data were reduced by attending to main repeating themes as they moved across texts. The code book is appended.

I then categorized the "frame" through which the purpose of the research was justified, concentrating on the beginning and end of each text segment; while framing moves are distributed throughout texts, in these science communication texts introductions and conclusions contain direct statements about how research is expected to function (Dahl, 2015). These categories, too, were the product of iterative reading. Finally, I reexamined explanations of research results for how rhetorical moves strategically position author and audience. The qualitative research tool HyperResearch™ aided in identifying patterns. As is inevitable with such textual analyses, space permits discussing only a subset of the data and analysis.

Text analysis: Industry member involvement in research

As active characters in technology transfer texts, industry members are most often providing resources: directly (in the case of large producers); through the joint investment of NZW; or by providing materials research facilities do not possess such as vineyard space, access to winery equipment, and grape or wine samples. The NZW members-only website reminds producers that, via this investment, NZW members "own" research findings via the shared umbrella of the organization. Describing the function of the NZW research arm, investments are "research that *your levy dollars* have funded," and "oversight is provided by *your peers* on the Research Committee" (emphasis added). Levy-payers are reminded that "most of the resources we create are available only to NZ Winegrower's members" and that they have access not only to research briefs but to the full complement of final reports, all of which exist "for the benefit of the New Zealand wine industry." Many research supplements mention NZW funding in the body of the text, beyond the standard concluding acknowledgment, and emphasize (in ways detailed below) that NZW investment has produced resources which exist for the sake of improving industry practices.

In addition to this *collective* financial involvement, large companies are individually named as directly involved in research. Their support is still primarily financial, but in conjunction with monetary or in-kind investment sometimes includes contributing to experimental design, collecting data, and conducting portions of scientific studies. Reports from such projects conclude with an acknowledgment to the effect of: "The support is appreciated of wine companies, in particular ---, ---, and ---, who *actively participated* in the programme, providing staff, vineyards and machines for the trials." In full final reports, the *negative* impact of industry participation is implicated in several instances when commercial constraints affected study design: the grower's normal fungicide program was applied to a test vineyard plot, for example, or samples couldn't be kept separate during a commercial harvest due to equipment and time constraints. Rarely, positive industry-research co-innovation is highlighted, as when growers modified vineyard equipment for a machine thinning trial. The same six large companies appear repeatedly in these roles, with several others named once each.

These mentions aside, industry members appear in the corpus as "winemakers," "growers," and "they" who have knowledge deficiencies requiring research attention or who serve as the audience for research results. Their participation, in other words, is concentrated in "front-" and "back-end" questions (Carolan, 2008), providing problems and listening to solutions, rather than in middle stages of the research process. Because most companies are not large, and because "active" involvement in the middle stages of research is depicted as the provenance of large companies, texts continue to paint a version of the deficit model in which industry provides questions and science provides answers. Science is the *property of industry members collectively, but the product of scientists and large companies working together.*

Text analysis: Framing the rationale for scientific research

Framing refers to textual strategies leading readers toward a preferred understanding among multiple possible understandings of an event (Entman, 1993; Gee, 2010; Lewis, Broitman, & Sznitman, 2015). A text has many different "frames" respective to its various roles in various contexts. How research *function* is framed signals how texts construct the relevance or utility of research to readers' practice. On a "what we do" webpage, the NZW research arm describes its mission broadly as "to build a knowledge platform that supports innovation and protects your ability to produce exceptional grapes and wine." Research briefs and fact sheets show that general frame interpreted in various more specific ways.

The purpose of individual research projects is framed in three ways: as responding to an industry problem or question, developing industry tools for creating specific wine styles or, very infrequently, as addressing a gap in scientific knowledge. Within those major frames, research also responds to economic threats, generates better understanding of industry-relevant problems, and facilitates technology transfer. Research is only infrequently framed as serving scientific ends, unsurprising given these texts' dual audience of industry members and NZW administrators who, respectively, might be most interested in practical application and expect a practical return on financial investment. Only twice are scientific aims stated as main project objectives rather than subordinated to industry-oriented frames. In one case, scientists fill a gap in scientific knowledge, signaled by phrases common in the peer-reviewed scientific literature: "These yeast metabolisms and fermentation rates *play a role* in volatile thiol production, but how much influence they have is *still unresolved*. The objective of our current project is to *determine the influence*..." (Hyland, 2008). The other case describes a new NZW-funded PhD project designed "to discover the genetic origins" of important aroma molecules. While both have obvious industry implications down the line, neither will likely translate to a change in grower or winemaker practice any time soon. These are singular exceptions to the general rule that frames contribute to research being proximal, for, or on behalf of industry.

The industry problem to which science responds may be a grapevine disease or an expensive or environmentally damaging technique calling for replacement with a more sustainable alternative. “Grapevine trunk and root diseases,” for example, “pose a threat to the longevity of vineyards and the economic production of high quality wines in New Zealand. So it is important that growers can access the latest research results about these diseases.” “Wine in transport or uncontrolled storage runs the risk of forming a protein haze,” and most consumers dislike cloudy wines, so winemakers need preventative solutions. Multiple projects in 2014 concerned reducing crop yields using mechanical thinning as an alternative to expensive and labor-intensive hand thinning, both to establish parameters for its use and expressly in response to “initial [grower] concerns that machine thinning may increase disease.” Scientist-authors also occasionally describe “fielding enquiries from the industry” directly. In these cases and in the more common instances of scientists answering industry questions mediated by NZW, readers see science as a *source of solutions and answers* that they can reliably tap to respond to specific needs.

When not responding to a specific problem or question, research is instead framed as developing industry tools to create particular wine styles. Presumably, these projects either also represent industry needs (i.e. for different style options) or, alternately, were proposals submitted by scientists because they satisfy scientific aims but which were also valued by NZW for the industry tools they were likely to create. Compared with the “responding to a problem” frame, however, language surrounding these aims emphasizes “optimizing” rather than protecting or solving. The words “optimise” or “optimum” appear 17 times in research supplements and fact sheets, a frequency of .06 percent compared with a combined frequency of .0011 percent for optimize, optimise, and optimum in Google

Ngram's corpus of texts written in English in 2000 (Michel et al., 2011). Readers are told, for example, that “optimising wine thiol profiles will allow New Zealand winemakers to further differentiate their product from the competition and to protect New Zealand's unique position as the world's leading producer of premium Sauvignon Blanc wine.” Similarly, a different report instructs that “winemakers will be able to use knowledge developed in this project...to reflect product styles required and brand needs;” in another, that new research “will provide industry with tools to optimise wine flavour profiles.” Readers thus see science *as a strategic tool to meet market needs* and to strengthen their position on the international market, individually and as a national brand.

Text Analysis: Functions of scientific findings

Relationships between scientific findings and industry practices are described in four main ways: science as developing best practices, science as developing industry options, science as providing general industry knowledge, and science as making recommendations to industry. These functions reinforce the research-industry relevance story told in how research rationales are framed. They also reinforce the logic, inherent in the contractual employment of researchers, that science has the epistemic power and authority to make recommendations about practical scenarios. Simultaneously, these texts juxtapose those proximity-generating rhetorical moves with moves that distance research practices from industry practices. In research supplements, which sometimes borrow language directly from corresponding formal final reports, various forms of indirection avoid scientists speaking directly to practitioners. However, in fact sheets, in which researchers explain best practice rather than research per se, scientists-as-contractors make the occasional unhedged imperative – "send samples to laboratory;" "tag and remove symptomatic vines." Scientist-authors, in other words, describe recommendat*ions derived from research* as having direct authority over practice, but *scientific research itself* as distant from practice using conventions of scientific discourse. Indirect agency, hedging, and enthymematic reasoning all contribute to this distancing, particularly in research supplements.

Use of the third person, displaced agency, or passive voice: Consistently in research supplements, and sometimes in fact sheets, recommendations that would otherwise read as direct imperatives are made less personal by referring to the receiver of the recommendation in the third person, even when that person is very likely the audience for the text. Effectively identifying diseased vines means, for example, that "vineyard owners must also seriously consider the timing and frequency of visits to blocks." "Winemakers should be aware" of variables influencing wine stability.

In other cases, agency is displaced from a human actor onto a practice or a natural phenomenon, or the passive voice is employed to avoid naming the subject altogether. When "maintenance of the leaf canopy and leaf removal… has to be carefully managed with other variables," the strong imperative "has to" is applied to the action "maintenance," not to the person doing the maintaining; the imperative is once-removed from the human reader at whom it is ultimately directed. Suggesting that "the optimum period for visual assessment of Leafroll virus symptoms is late in the growing season" says something about the natural environment and nothing about the person who may need to act on that environment. In recommending that "the management strategies developed should be applied consistently and in accordance with our current understanding of best practice," the author attributes ownership of best practice to the ambiguous "our" without identifying either who developed the management strategies or who should be applying them (Mulderrig, 2012). Compared with how these phrases would read if reworded in the second-person or the direct imperative voice – "[you should] be aware;" "[you have to] carefully manage maintaining the leaf canopy" – third-person, once-removed or unnamed subjects allow authors to avoid the liability, and the potential breach of politeness, of telling someone what to do (Hyland, 1997; Myers, 1989). Simultaneously, they enable readers to distance themselves from the recommendation without making the confrontational move of disagreeing with it outright; the text is speaking about other winemakers, perhaps, but not about *me*. Avoiding the second person suggests that scientist-contractors continue to respond to the institutional rationality of the scientific tradition in which scientific claims are understood to be independent of the individuals making or receiving them (Bazerman, 2000; Myers, 1990).

Hedging: Hedges, an extremely common feature of scientific discourse which "convey <u>ideological</u> representations of the scientific community, helping to impart an authority and a detached attitude to an external reality of objective facts" (Hyland, 1997, p. 23, emphasis original). Hedges are, in other words, distancing maneuvers that avoid firmly and personally committing an author to a statement that later research may show to be incorrect. In technology transfer documents, hedges mitigate the force of a recommendation and distance an author from its potential consequences (Skelton, 1988). They are reminders of the ritual disclaimer tacked on to every report and fact sheet – a discourse-based hedge in its own right – asserting good faith but absolving the researchers and NZW from responsibility for any ill effects following from the information contained therein. While saving face and legal liability on the part of *authors*, hedges again give *readers* opportunities to disagree without confronting the authority of science directly. “Categorical assertions leave no room for negotiation” (Hyland, 1997, p. 26), but hedged statements interpolate the reader as a participant in rational logic while simultaneously allow that rational actor to politely arrive at a different conclusion under the premise, in effect, of the exception to the hedged rule (Myers, 1989).

Modal hedges sometimes express the conditionality of a future event – “should [a frost] eventuate, vine defoliation *would* quickly follow” – or express a degree of “accuracy-based” uncertainty – “leaf additions *may* have contributed to” changes in juice antioxidants” – but also distance scientists from making direct statements about industry conditions. Data “*may* provide a clearer understanding of the effect of planting material and vineyard management on disease incidence.” A particular wine clarification technique will “produce less lees [sediment], which *may* be financially beneficial.” The modal auxiliary “should” likewise attenuates the force of what would otherwise be a direct command (Fraser, 2010): “To achieve maximum efficiency, bentonite *should* be properly dispersed before use” is less forceful than an alternative phrase, “disperse bentonite properly before use.” The hedged form allows a reader to reasonably respond in multiple ways: by properly dispersing her bentonite, by admitting that she knows she *should* properly disperse her bentonite but isn't going to, or by countering that the recommendation doesn't apply in her case for any number of reasons. “Should,” indeed, imagines the reasonable possibility of a reader *not* choosing the recommended action. “Should” creates distance between author and reader: rather than being presented with the scientist as a person speaking to them, readers see a distant third party making abstract statements.

Enthymematic arguments: Aristotle's classic enthymeme is a three-part syllogism with one part left unsaid; more loosely, an enthymeme is any argument in which one or more of the premises goes unstated. In these technology transfer documents, enthymematic arguments omitting the conclusion effectively recommend action without actually telling the reader what to do. Enthymematic recommendations tend to take the form:

Major premise: X is important.

Minor premise: X can be accomplished/protected/increased by doing Y.

Unstated conclusion: [Therefore, you should do Y.]

For example:

Major premise: "Flavonoids are important for a range of wine attributes including astringency, colour and antioxidant potential."

Minor premise: "Exposure of grape berries to sunlight and consequently ultraviolet (UV) radiation will lead to a general increase in flavonoid compounds until veraison."

Unstated conclusion: [Therefore, you should increase berry exposure to sunlight.]

Enthymemes as described in classical rhetoric, and as used in the primary scientific literature, presume that the audience is homogeneous; because audience members all share a common culture, they can be depended on to read the enthymeme in the same way, namely, the way intended by the author. Enthymematic arguments in technology transfer documents call upon the same assumptions. The author presumes a preferred reading of the text predicated on a common context shared by the author and audience (Fish, 1982). The reader, then, is invited to share in the author's context, to sit beside the author and look at the same subject, and to participate in the author's logical reasoning. However, the argument is also left open to multiple interpretations, made more likely when the audience is not in fact either homogeneous or homologous with the author. Enthymemes leave readers with the freedom to "fill the missing premises" in multiple ways "and thereby invent ever new understandings of scientific lore" without abandoning faith or interest in scientific practices (Locke, 2002, p. 105).

Presenting the practical functions of science using these strategies, first, depicts scientific research as generating knowledge that works in the practical sphere perhaps even better than informal practical knowledge. Second, scientific research is made distant from most winemakers and growers at small and medium-sized operations. Third, research may apply to "them," the audience, without applying to "you," the individual reader, even while general scientific knowledge has the authority to make practical recommendations.

Conclusion: Texts speak directly to practice, but indirectly to practitioners

Textual production is tangled up in a web of reciprocities. A text is not meaningful in the absence of a reader necessarily embedded in a context; the reader and the context are both altered by the text. Textual meanings stabilize, to some degree, because the spaces in which they are written and read are reproduced (Bazerman & Prior, 2005); patterned similarities make it possible to talk about science writing in the New Zealand wine industry, or winemakers reading. "Institutional rationalities" establish the realm of possible text production (Bickerstaff, Lorenzoni, Jones, & Pidgeon, 2010; also Lemke, 1995), both in terms of authorial choices and in how readers make meaning with or “in front of” the text (Wolff, 2002, n.p.; see also Fish, 1982). Writing and reading are practices through which writers and readers continue to enact their continually enacted realities. The material reality of the text – its detailed design, how it orders relationships and distributes power amongst people and things – is central, along with the reader and the context

Though written texts are crucial to many science communication activities, analyses have focused largely on the reader, the context, and the content functions of the text, often setting aside the many other ways texts structure meanings. Attending to these various other intratextual microprocesses – to rhetorical, relational functions of texts beyond content alone – is important: for understanding the rationalities of various strategies for institutionalizing science communication, for ensuring that institutional macrorhetorics and textual microrhetorics do not work at cross purposes, and for locating opportunities for changing how relationships are enacted. Thinking about texts beyond content, in terms of their relationship-building functions, yields a set of tools for engendering research-audience proximity (or distance, as the case may be) that may be overlooked when written communication is assessed via content analysis alone.

Interview data and technology transfer texts from the New Zealand wine industry point to a paradoxical research-practice relationship: while winemakers and growers see research as relevant to practice, they do not see it as relevant to themselves; while scientists must operate as contractors who satisfy industry clients by delivering value, they must continue to be scientists who respond to the generic expectations of scientific discourse. Industry science communication writes research as relevant to, and having authority over industry practice, but without speaking directly to industry practitioners. Research and industry operate under a shared institutional umbrella, but industry members remain distant from research they do not encounter first-hand. While technology transfer texts speak directly to *practice*, they speak only indirectly to most *practitioners*. Science communication relates research to audiences on multiple levels. Speaking only of connecting "research to practice" or of "engaging the audience" is too simple.

If science communication indeed aims to decrease the distance between scientific research and audience practice, then science communication to professional audiences – and to other audiences comprised primarily of individuals who hold complementary expertise and who are expected to use communicated research – requires its own, and perhaps unique and new rhetorical strategies. The research-industry distancing observed here would not be alleviated solely by supplanting the hedged enthymemes characterizing the former with the direct recommendations occasionally found in the latter. Nor would it be desirable to call upon scientists to serve as industry contractors alone. These data suggest that research-industry partnerships such as NZW may need different metaphors for working together, and a different rhetoric of industry-oriented science communication that mirrors neither the peer-reviewed scientific literature nor technical documentation but that invites readers to use and comment on scientific research without telling them what to do.

Written science communication cannot make research physically present as does attending a demonstration or participating first-hand. But despite their inherent limitations, written science communication texts could still be better designed. First-hand experience readily connects a scientific practice and a site of industry practice. Perhaps science communication texts could do a better job of locating scientific practices in time and space. Perhaps, in addition to drawing relationships between research and industry practice, science communication texts could draw relationships with industry members as situated practitioners. Without aiming to replace first-hand experience, perhaps the rhetorical framing of such texts could make it easier to connect how science relates to its audiences, how research done *elsewhere* relates to the industry practices done *here*.

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Appendix – Code book for textual analysis

Abbreviations: VM/WM – vineyard manager/winemaker; S – scientist

Agency	Push rather than pull
	Researcher poses question
Industry participation	Changes in response to industry suggestions
	Explicit invitation to participate
	Industry body generates question
	Industry expertise is part of data
	Industry experts conduct sensory evaluation
	Industry members generate questions
	Industry listens or attends seminars
	Industry needs are consulted
	Industry practices are a source of data
	Industry practices provide context for scientists to generate questions
	Industry problem provides need for research
	Named VM/WM funds research
	Named winery provides funding
	Named winery provides materials
	Named winery provides trial sites
	Need for commercial trials
	Reader receives direct instruction
	Unnamed VM/WM funds research
	VM/WM use data on own initiative
	VM/WM alter study design
	VM/WM asked to provide samples
	VM/WM collect data per scientist protocol
	VM/WM collect data per own protocol
	VM/WM conduct part of trial
	VM/WM conduct their own trials
	VM/WM encouraged to learn more
	VM/WM formally raise specific questions
	VM/WM generate questions themselves
	VM/WM informally/implied raise questions
	VM/WM provide new data
	VM/WM provide data they already have
	VM/WM referred to experts
	VM/WM review or judge scientific findings
	VM/WM trial-implement scientific findings
	VM/WM wholly initiate and conduct a study
Industry relevance	Directly stated industry relevance
	Hedged industry relevance
	Implied industry relevance

	Implied instructions for VM/WM
	Industry needs consulted
	Need for more research
	Ref to industry conditions
	Research answers industry questions
	Scientist poses industry problems
	Scientist says research makes NZ more competitive
	Scientist says VM/WM can benefit from research
NZW activities	Industry body generates question
	NZW directs research
	NZW economic interests
	NZW funds research
	NZW participates in research design
	NZW reviews research
NZW as proxy	NZW exerts judgment over research
	NZW generates questions on behalf of industry
	NZW provides instruction
	Research attributed to NZW
Other	Ambiguous knowledge attribution
	Female researcher
	Government funding
	Includes organic options
	Intensifier regarding importance
	More research needed
	Natural phenomenon requires a response
	Non-NZW resources mentioned
	Research implies a quality preference
	Scientist makes anecdotal observation
	Tech transfer
Passive/no agency	Materials created – passive
	Research conducted – passive voice
	Unattributed concerns
	Unattributed/ambiguous hypothesis
	Ref to general industry knowledge
Representations of industry knowledge	
	Scientist demonstrates awareness of practical considerations
	Ref to general industry knowledge
	Ref to general industry practice
	Ref to specific VM/WM knowledge
	Ref to specific VM/WM practice
	Ref to VM/WM knowledge/practice as source of valid knowledge
	Ref to VM/WM knowledge/practice as anecdotal
	Ref to VM/WM knowledge/practice as inaccurate
	Ref to VM/WM needing scientific confirmation

Ref to VM/WM as valid
Representations of scientific knowledge
Research answers an industry question
Research develops best practices
Research fills an industry need for options or alternatives
Research is delivered to industry
Research provides industry general understanding
Research will answer an industry question
Scientist judges industry practice – bad
Scientist judges industry practice – good
Scientist makes anecdotal observation
Science protects industry economic interests
S says that data are not relevant to practitioner action
S says that data are relevant to practitioner action
S says that data may be relevant to practitioner action
S strongly recommends what to do
S suggests what do do
S directly tells industry what to do
Shared research/industry setting
VM/WM are told research is very important
Warning issued to industry

Preface to the conclusion

In the first chapter of this thesis, I explained a rationale for thinking about industry-oriented research dissemination as a science communication problem. I suggested that it is useful to see that science communication problem as a matter of making it possible to align or overlap sets of scientific and industry practices, in contrast with technology transfer or research utilization paradigms that would have us export a knowledge product – of fixed objective truthfulness, if not of fixed usefulness in every setting – from decontextualized, unlocatable scientific centers of knowledge production to imperfectly realized industry settings of knowledge needfulness.

By not making explicit what science communication practices and goals imply for scientific epistemology, science communication as knowledge export can end up practicing a contradiction: on the one hand, exhorting public(s) participation and engagement; on the other, limiting knowledge production to the inner scientific circle and looking for acceptance or adoption from audience "participants."

Material semiotic metaphors offer a way to rescue that contradiction. When realities are created in practice, and objects as we know them are a function of stabilized practices assembled through mental work into coherency, scientific knowledge (that is, scientific practice as discourse practice, ratified by the authoritative scientific community) is made useful to industry practices when work – mental, and infrastructural – is done to align them, to create relationships between one and the other. To create those relationships is to locate science in the world, not above or outside it, so that audience readers can draw a map of scientific practices in relation to their own. Research and industry practices must be made locatable with respect to each other. Research and industry practices must be made *relevant* to each other. That information sciences term – relevance – underlines how simple and obvious this suggestion becomes when stripped of its theoretical scaffolding, and yet, as information sciences scholarship makes abundantly clear, how very difficult enacting it in practice remains. This conclusion is about first motions toward a heuristic for enacting it in practice.

Conclusion – Toward a rhetoric of industry-oriented science communication

"You cannot see things until you know roughly what they are." - C. S. Lewis, *Out of the Silent Planet*

The perennial problem of any research investigation is that even the most industrious researcher cannot arrive at a conclusion she cannot imagine. C.S. Lewis's interplanetary traveler cannot make heads or tails of a squeaking jumble until he recognizes a hand or a pair of eyes and, imagining that the jumble might be alive and catching hold of its resemblance to something he's seen before, realizes that something like a large, bony frog in workman's overalls is trying to speak with him. A novice oenophile trying her first gewürztraminer will rarely call up "lychee" as a descriptor until someone suggests it and then – yes, that's it! – the wine tastes of lychees. Unless, of course, she has never eaten a lychee. My goal in this study has been to offer new handles for imagining the purpose and structure of science communication to industry audiences or to other publics whose capacity to use research goes hand-in-hand with their holding related expertise. My case studies do not aim to be representative, either of the wine industry outside of Washington State and New Zealand or of any broader category of science communication. I have not aimed to create generalizations applicable wholesale to any other location of practice. I *have* aimed to suggest tools for seeing new things – or for seeing old things in new ways.

The uniqueness of my case studies aside, the points I make are largely common ones in the existing literatures of rural sociology, science and technology studies, and rhetoric of science. Their application to a science communication problem, and in particular to industry-oriented science communication, however, appears to be uncommon. I hope to have produced a usefully new way of thinking about a problem that is, perhaps, rarely thought of as a science communication problem at all. My explorations of these case studies point toward a common set of structural problems in science communication to specialized audiences and propose potentially useful strategies for thinking through similar problems in other settings.

One: Industry responses to research dissemination are diverse and value-laden

How Washington State winemakers and growers conceptualize the role of scientific research in their work is related to their diverse conceptions of what it means to make good wine and to be a good winemaker; their responses to research dissemination are nuanced, diverse, and entangled with other values. In one sense, this should come as no surprise. Washington State winemakers and growers are a diverse bunch, from many different backgrounds, making many different wine styles. Data presented in chapters three and four and in Appendix B attest that this diversity supersedes any community identity they experience in terms of sharing a common way of relating to research. On the contrary their diverse relationships with science appear to be a tool to support their unique identities as winemakers and growers, important in an industry which depends on crafting “points of difference” (Dawson, Fountain, & Cohen, 2011).

Rural sociology and agricultural extension literatures abound with discussions of how agriculturists’ values are important to research utilization (e.g. Alrøe & Kristensen, 2007; Cleveland & Soleri, 2007; Leeuwis, 2004; Noe et al., 2015; Rogers, 2003; see also Bruwer & Li, 2007, for a comparable approach exemplified in marketing wine to consumers). A prominent thread running through this discussion recommends systematically accounting for users' values so that they can be more effectively persuaded to adopt scientifically supported beliefs and practices. In this view, diverse values are *barriers* (Noe et al., 2015; Rogers, 2003). The goal is to homogenize users' diversity in terms of their responses to the desired practice, responses which should skew as much as possible toward adoption. This approach assumes that science, scientific research, and scientifically supported practices are value-neutral, or at least universal goods; scientific recommendations lay outside of and epistemically supplant users' individual attitudes or values.

In science policy and governance studies, proponents of "post-normal" or "mode 2" science policy and governance recommend instead that non-scientists' values be accounted for to "create science that is more socially intelligent and robust" (Chilvers, 2008, p. 156; see also Jasanoff, 2003; Stilgoe, Lock, & Wilsdon, 2014). Diverse values are a resource for information, not a liability impeding progress. Industry-oriented science communication efforts remain unable to see and appreciate those values as information if science communicators presume the value-neutrality of their message and the universality of scientific recommendations. Instructing a heterogeneous group of practitioners in what research is for is likely to prove counterproductive because a single message about the role of research in practice is unlikely to hold universal audience appeal. But more importantly, encouraging any one correct way of relating research to practice risks applying science communication as a homogenizing force, an additional effect which may be unintentional, undesirable, and unobserved.

Of course, science communication as a homogenizing force may have its benefits.

In Washington State, an endemic debate revolves around whether the state's industry needs the homogenizing brand image of an "iconic" wine. In New Zealand, the bulk of government- and industry-sponsored research caters chiefly to the interests of the several largest producers responsible for the bulk of New Zealand's export volumes and the country's presence on British and American grocery store shelves. Focusing research on the needs of large producers would seem warranted by the direct economic value of wine sold in volume, a warrant accepted as both inevitable and appropriate by most of the winemakers and growers who spoke to the issue during interviews. Yet scanning the international wine media demonstrates that love is poured out for the Pyramid Valleys, the Dog Points, the Satos – iconic, idiosyncratic medium-sized wineries whose global availability is limited and the tiny producers whose wines are impossible to find but whose stories are impossible to resist. No wine economist appears to have compared the relative contributions to a regional wine economy of large versus smaller producers, the former producing large volumes in what tends to be an internationally homogenized style, the latter selling much smaller volumes but attracting much more passionate media attention (Mike Veseth, personal communication, March 12, 2015).

Which adds more economic value: encouraging homogeneity, or encouraging heterogeneity? Encouraging small producers to act like larger ones, or encouraging them in their idiosyncrasies? Is adding economic value the most useful measure in the first place? These are science communication questions because science communication – what communication includes or excludes, how research is framed and related to industry practice – is tied up in communicating and influencing values. A single science communication message promoting research adoption would suggest that research conducted with large producers in mind generates “best practices” which all producers should adopt in the interest of doing things in scientifically supported and therefore correct ways. Recommending adoption of research-supported “best practices” makes scientific research an objectivizing process whereby, independent of whose interests go in, science spits out value-neutral, value-independent scientific statements applicable to everyone.

Many different traditions attest that scientific research is not objective and value-independent. Empirically, sources of research funding affect research outcomes (reviewed in Krimsky, 2013; Sismondo, 2008; also Farrell, 2015). Conceptually, scientific statements are inevitably created by subjective individuals embedded in webs of subjective relations (e.g., Guba & Lincoln, 1989; Latour, 1999; Shapin, 2012). Science is not “subtly infiltrated” (Carolan, 2008, p. 512) by values under less-than-ideal circumstances. Science is always constructed in and with values. Within the homogeneity of disciplinary knowledge, everyone who matters can be reliably counted on to share a common set of values at least with respect to what constitutes legitimate disciplinary knowledge; those values need not be discussed because they can be taken for granted, understood as a given condition of engagement in the particular disciplinary discourse. In communicating across diverse communities, however, homogeneity cannot be taken for granted (Bazerman, 2009, 2013).

Science communication which treats research statements as best practices and encourages one (out of many) way(s) of relating research and industry practice, therefore, acts as a homogenizing force, encouraging the heterogeneous group of all producers to adopt a set of values espoused only by a few. My strictly anecdotal experience as a wine science writer has been that more scientifically driven wineries, where research is seen to provide an idealized instruction manual, tend to turn out less interesting, less enjoyable wine. And independent of the relative quality of any one producer, the diversity of products available is one of the great joys and distinguishing characteristics of the wine industry. Far be it for science communication to strangle this joy by assuming that communicating accurate science and encouraging scientific practice are higher goods.

The broader message for science communicators is that we must be aware that science communication practices, seemingly oriented toward the uncritically assumed good of improving education and increasing the reach of science, are tangled up in other systems of value. In exhorting an audience to know, do, or love more science, science communication practices also tangle with audiences' other ways of thinking and acting. We must ask what those entanglements are, whether we have the right to persuade a public along those value axes, and whether the ways in which we might be doing so are desirable. Asking those questions, we must make a best effort to account for the diverse range of involved stakeholder perspectives. Talking to stakeholders is in itself insufficient. Stakeholder perspectives must be taken seriously, as potentially rational ways of relating to science even (and perhaps especially) when they do not cohere with institutionally sanctioned perspectives. They must be seen as a source of knowledge in their own right rather than merely as data collected for the sake of knowing who still needs to be persuaded to adopt more scientific attitudes and behaviors. Failing to do so, science communication becomes the domineering force domesticating marginalized perspectives into compliance with science's inviolably correct ways of thinking and doing.

Two: Industry publics contribute to scientific knowledge from their related expertise

The second point I make concerns the potential for and worthwhileness of audiences contributing substantial knowledge from their own expertise toward building scientific claims. New Zealand winemakers and growers, in receiving new scientific information, do not accept that information as closed and unquestionable knowledge, the epistemic status of which has been decided once and for all by the scientific community. Rather, they perceive their own community knowledge as having the epistemic weight to evaluate the status of scientific claims. Industry members engage in informal post-dissemination review, questioning the reasonableness and significance of a scientific claim as a knowledge claim, beyond questioning only whether they should implement a scientifically supported practice.

A central tenet of contemporary science communication in the era of the "participatory turn" (Chilvers, 2008; Jasanoff, 2003) is that publics can and should have an active part in the scientific process. Similarly, discussants of science policy call for the "democratization of science and expertise" (Carolan, 2008; Jasanoff, 2003), giving publics a legitimate and important place in deciding how science operates in wider society. The meaning of "participation" in science and in science policy is, however, highly variable across contexts, often poorly defined, and too often left unexamined (Quet, 2014). Critics of science in the participatory mode observe that participatory science most often means "invited participation" (Bogner, 2012; Wynne, 2007): scientists or other decision-makers invite audiences to participate in discrete moments in the scientific process. In doing so, critics argue, they avoid audience involvement "upstream" (Chilvers, 2008; Kurath & Gisler, 2009) in agenda-setting discussions about what science does. Invitations into limited participation may even serve as a "governance tool" (Bogner, 2012), distracting attention away from how the same projects close off other forms of participation and keeping non-scientists out of real decision-making (Cook, Kesby, Fazey, & Spray, 2013; Kurian & Wright, 2010).

To paraphrase Cook, Kesby, Fazey, and Spray (2013), everyone agrees that we should be doing participatory science, but no one seems to have the same ideas about what that means. “Invited participation” projects imply that discrete involvement, usually in scientific production and consumption (Braun & Schultz, 2010; Chilvers, 2008), satisfies that call. Advocates of “citizen science” look for public “engagement” through involvement in the most obvious physical work of science, crafting citizens into distributed data collection tools. Scientific democratizers want to see publics involved in both “front-end” and “back-end” questions (Carolan, 2008) about scientific agendas and science policy. All of these models draw boundaries of some kind around the nature of public participation in ways that would seem to be the result of considering limited ranges of science-public interactions in which scientific practices are esoteric and publics are general. As studies of more knowledgeable publics and more relatable sciences show – Whatmore and Landström’s (2011) investigation of scientist-citizen flood management teams, for example, and my own investigation of viticulture and enology – these limits do not hold up to application in all cases.

The nature of audience participation in the scientific process is warranted by the degree of overlap between audience practices and scientific practices and is therefore a matter of reasoning from context, not of applying ad hoc universal guidelines. Residents of a flood-prone English town know, better than scientists, whether proposed flooding countermeasures will protect important areas and how new anti-flood structures will alter civic living on an average sunny day (Whatmore & Langström, 2011). Those residents (in their role as residents, without excluding the possibility that any one of them also has a degree in fluid dynamics), may be ill-equipped to comment on the reasonableness of the mathematical formulae behind a computer model of flood activity; their expertise, their daily practices and "institutionalized domain of knowledge" (Carr, 2010, p. 19) do not lie in mathematical modeling. On the contrary, they may be ideally equipped to comment on the suitability of that same model to their own town's flooding problem, being far more expert in living in and navigating their town environs than are fluid dynamics scientists from the next county over. The same logic applies to Wynne's (1992) study of Cumbrian sheep farmers and nuclear physicists, and to my study of the wine industry.

In the case of wine industry publics and wine research, overlaps between research practices and industry practices are substantial. Or, more accurately, the infrastructures involved in wine industry technology transfer behave as if overlaps are substantial by making scientific claims which aim to be valid in other spaces. How broadly are we aiming for scientific claims to be applied? How similar are we trying to make scientific and industry practices? They need not be similar at all. Emphasizing elements of scientific practice especially alien to winemaking, and vice-versa, can construct the two sets as very far apart indeed. However, the very act of disseminating research to industry for industry use is to argue otherwise. The logic of research dissemination – the logic of applied science in general – says that scientific practices are sufficiently similar to industry practices for scientific knowledge to do useful industry work. In the act of research dissemination, scientific claims are proposing to be valid industry knowledge. In so doing, those claims become subject to review by experts in industry knowledge, that is, by industry members.

Expertise is always ideological, an "intensively citational institutional action" (Carr, 2010, p. 19) and a structural preferencing and recognizing some forms of knowing over others. Preferencing some forms of knowledge over others is about distributing power, deciding whose way(s) of knowing matters. In questioning who is equipped and able to review a knowledge claim, the question is not who holds expertise in any acontextual sense, but which forms of knowing should be preferenced. The argument for industry members reviewing scientific claims (and participating in scientific processes in other ways) is that their ways of knowing matter to constructing applied scientific claims, and furthermore that it is more useful and more just for science communication to structure epistemically egalitarian power relationships than to make science a privileged and dominating force over industry audiences. To say that industry or other publics' expertise participates in constructing scientific knowledge claims is not to say that each participates equally, but that they contribute to the degree and in the fashion that it is useful for the knowledge-making enterprise at hand to include any given group as insiders, to make their sites of action part of the relevant domain.

Participatory science is predicated, at least in theory, on the understanding that non-scientists' “local” knowledge is reasonable (Heckler, 2007). When participatory project models place ad hoc limits on the scope of public participation, they effectively reduce public participants to tools for serving scientific purposes rather than genuinely contributory collaborators: non-scientists are distributed scientific instruments that allow scientists to collect more data then they would otherwise, or participation exists for the sake of persuading publics to know, do, or like more science. Technology transfer paradigms authorize contributions from industry forms of knowing only in advance of creating a knowledge product and then assume the goal of convincing users to adopt the knowledge product; in so doing, they continue to presume that science is universal and epistemically superior knowledge and that industry knowledge is epistemically inferior. These models preclude meaningful collaboration because science and scientists always remain in a position of power over industry members. Invitations to participate in science that presume scientific superiority are the science communication equivalent of the parent who asks the combative toddler whether she would like to hop, skip, or tiptoe to the car. The toddler may now have an active part in the process, but the process is still about getting the troublesome kid into the car. Arguing in favor of the parent's action in this case is easy. But do we really want to treat non-scientist publics like toddlers?

Three: "Extending" scientific discourse into research dissemination impedes research relevance

Compared with treating non-scientists like toddlers, the opposite problem is treating them like scientists. "Accommodations" (Fahnestock, 2004; Gross, 1991) for non-scientist audiences should not resemble peer-reviewed articles; this is the first lesson of Science Communication 101. My finding that wine industry research dissemination texts nevertheless do resemble the disciplinary scientific literature points to an obvious site for corrective action. But the rationale for writing science differently for industry audiences goes beyond comprehension and accessibility to connection and implementability. Those latter reasons call for different shifts in the language of dissemination communication than would accessibility alone. Rhetorically aware science communication responds to audience needs. In scientific popularizations, author responses to stereotyped audience needs have been codified in genre conventions oriented toward telling understandable stories. Industry-oriented science communication calls instead for conventions aligning science with industry practice.

Assessing the accessibility of dissemination texts was not part of this study. At a glance, however, dissemination texts certainly appear much more accessible – or, rather, accessible to a much larger range of readers – compared with their counterparts in the peer-reviewed literature (in Washington State) or formal scientific reports (in New Zealand). Dissemination texts are universally shorter. They use less scientific jargon, and they define potentially troublesome words. They include fewer of the cumbersome artifacts of the scientific literature – citations, arcane formulae, extensive tables and charts – which might be immediately off-putting to a non-scientist reader.

But despite these many accommodations, dissemination texts still fall short in making scientific research relevant to industry practice. Making science easier to understand does not automatically make science more relatable, and saying that research is relevant to industry practice in general does not necessarily make research more locatable with respect to individual producers' situations and problems. Simpler scientific explanations can (and often do, it seems) continue to treat science as a series of acontextual statements emerging from nowhere. On the contrary, industry-oriented dissemination texts need to be the equivalent of agricultural field trials, physically locating scientific practice in the world (Henke, 2000).

Four: Changing the shape of scientific discourse changes scientific epistemology

Locating scientific statements in the world, as one set of practices that can be made relevant to other practices, means writing science as one of multiple potential knowledge systems. “Technology transfer” is not a useful metaphor for understanding this relocation process. Technology transfer implies that scientific findings are objects that can be picked up out of one location and moved to another, where they will continue to work. While allowing that users have a role in determining what the technology does (Rogers, 2003), technology transfer suggests a demarcation between product development and product utilization out of line with a co-constructive approach that understands “users” as having a role in evaluating the validity of knowledge claims rather than only their potential for application. The means by which technology transfer is most often modeled and assessed exacerbate these issues.

The technology transfer and research utilization paradigms which dominate industry-oriented science communication *begin* after knowledge has been created and packaged. The researcher's interest is in how the boxed knowledge product is shipped to the knowledge-consumer and adopted or not. The relevant questions lie in how to increase adoption of the knowledge product (e.g. Burton, Kuczera, & Schwarz, 2008; Clarke, 2003; Cullen & Grout, 2013; Hill et al., 2015; Hunt, Birch, Coutts, & Vanclay, 2012; Noe et al., 2015; Santiago-Brown, Jerram, Metcalfe, & Collins, 2014). Industry audiences are held at a distance from and on the outside of the scientific process, a position which does nothing to improve the potential for research-industry collaboration or, for that matter, for increasing adoption insofar as audience members then have more difficulty drawing connections between science and their own work. Holding industry audiences at a distance from and outside the locus of knowledge-making, and then expecting them to adopt knowledge-products shipped from that location, expects industry members to value knowledge created at a distance over the first-hand and shared community knowledge of industry experience.

Industry members may respond by evaluating distant scientific claims against their own local expertise – the post-dissemination review I observed amongst New Zealand winemakers and growers (chapter four) – and by trialing claims and essentially converting them into proximal industry knowledge (chapter three), but the dissemination texts (and the scholarly structures for assessing these texts' efficacy) do not invite or allow for these responses.

“Translation” is better. Translation sees science written in an exclusive language and needing to be converted into a different language that extradisciplinary audiences will understand. Better theories of translation see that conversion as a remediation that substantially alters the translated message rather than as a meaning-neutral operation. Another advantage of the translation metaphor is that it depicts research practices and industry practices as languages, which have enduring patterns but which are yet constantly in flux. A problem with translation is that it would appear that all of the work must be done by the translator, who speaks both languages and identifies how to bridge the two, though it would be fair to observe that the reader still has great freedom and involvement in making meaning from the text even when the translator does her job well. A more significant problem may lie in understanding what kind of relationship exists between the two languages.

Material semiotics offers an alternate set of metaphors in aligning, ordering relations (Law & Lien, 2012, p. 366; also Law, 1992), or overlapping (Mol, 2003) research and industry practices. The purpose of science communication is to create relationships between two sets of practices which do not necessarily have any natural relationship in the first place, but which it is useful to make related. In recognizing that both scientific and audience practices are meaning-making from the very outset, it also steps entirely off the slippery slope that so often leads various models of public understanding of science or public engagement with science and technology (Perrault, 2013) to slide back into some version of deficit-model thinking that presumes the inherent superiority of scientific knowledge.

I have also spoken – in chapter five, and in the publication attached as Appendix A – about "relevance" as the goal of industry-oriented science communication: connecting scientific claims to the "situation/context" and "task/problem" of the user/reader (Huang & Soergel, 2013, p. 20). As a concept, relevance emphasizes the necessity of understanding the situational or context-dependent needs of one's audience. Still, relevance is a difficult metaphor for science communication for precisely the same reason that it seems an accessible one. Relevance is an inescapable buzzword in contemporary media. While information science scholars struggle to usefully define relevance in the scholarly literature (Froehlich, 1994), in the popular literature, the term has grown so ubiquitous as to be meaningless. In the absence of a technical definition, too, relevance offers little practical help for writing differently. On the other hand, notwithstanding their obscure theoretical origins, "aligning" or "overlapping" scientific research and industry practice makes for an easily pictured metaphor.

The question for science communication becomes how to construct alignments or overlaps that allow non-scientist audiences to perceive science as relevant and to see how science can be useful in their practices. Among the myriad ways of doing so, I pay particular attention in this thesis to textual microprocesses which, in addition to being absolutely central to the enterprise of wine industry science communication, are under-tended in science communication scholarship.

Five: Science communication should attend to intratextual rhetorics

Texts are meaning-making objects which operate on numerous levels. Yet, though texts – written and non-written, all rhetorical – lie at the heart of science communication interactions, science communication studies often flatten and simplify texts into content carriers alone. The result is both a blind spot in how science communication scholarship understands the institutions of scientific production and a missed opportunity to understand, visualize, and employ a potential set of powerful tools for communicating science more effectively. Employing these tools is not optional. Large-scale goals are invariably enacted through small-scale processes: our actions and interactions are ultimately the product of our individual choices of words and phrases; the structures in which texts participate are intrinsically tied to textual microstructures. Studying or not studying textual rhetorics is not about whether these tools are in play, but about whether we control them, whether we use them strategically or accidentally.

Though contemporary science communication speaks loudly against the deficit model and in favor of alternate models embracing participation, science communication scholarship yields few studies of how these alternate models look and few recommendations for practicing them at the textual level. Many case studies in the pages of *Science Communication* and *Public Understanding of Science* present the experiences of science communicators attempting to practice participatory, democratic, and otherwise non-deficit model theories. Many theoretical studies reflect on principles for these sort of practices, or argue for why we should be employing them in the first place. Yet these studies tend to take a perspective on writing that writing scholars began to dismiss some sixty or seventy years ago (Russell, 2002). In aggregate, by not attending to creating rhetorically sophisticated texts as a specific challenge, they imply that writing is something that can be taken for granted, easy and inevitable, a neutral process of transparently conveying information that just happens once we have decided what we are trying to accomplish. An extensive body of writing scholarship holds, on the contrary, that writing is complex and contextual, that writing and thinking are closely connected, that writing is never a passive process or a neutral space but is inevitably active and ideological. Our specific words and phrases actively make meaning and are therefore meaningful processes to be controlled, not simply conveyor belts for content from author to audience. Studies of textual microprocesses are, therefore, both a means of understanding current science communication structures and a necessary component of enacting change.

Synthesis: Toward a rhetoric of science communication for use

Replacing a rhetoric of persuasion with a rhetoric of taking into account

Science communication for use needs a rhetoric, distinct from the rhetoric of scientific popularizations, distinct from the rhetoric of the peer-reviewed literature. Scientific popularizations tend toward the epideictic genre, exhorting publics to enjoy or appreciate science (Fahnestock, 1998) – a worthy purpose, but not necessarily helpful in facilitating research implementation. Peer-reviewed articles aim to persuade their audiences to accept the accuracy and novelty of new accounts of the natural world. Research dissemination writing needs to invite and facilitate its readers making connections amongst research practices and their own practices such that research can be a useful tool for doing work outside the lab. Rhetorical conventions of the peer-reviewed article became codified via the decorous exchanges of British and French gentlemen of the propertied classes over whether any one of them had won a point in their favored sport of producing descriptions of natural history (Bazerman, 2000). Applying those same conventions to helping scientists share and collaborate across disciplinary boundaries for the sake of jointly solving collective problems seems a bit ridiculous. And yet that appears to be the present situation in the wine industry; the extension communication I examined "extends" from features of the peer-reviewed literature rather than demonstrating a unique set of rhetorical features well adapted to its purpose.

How do we construct an alternative? What features does a collaborative rhetoric of industry-oriented science communication have at a textual level? The answers to these questions are, as are all such heuristics, necessarily context-dependent (Guba & Lincoln, 1989). My data suggest that the following strategies may be appropriate in the Washington State and New Zealand wine industries. They may also be suggestions useful in other settings. Regardless, the foundational principle remains that the features of a rhetoric of science communication depend on what constitutes desirable relationships amongst science and scientific research, audiences and audience knowledges.

Strategies

1. Communicate science in context. Re-place scientific conclusions in the locations of their generation. Specify the practices through which scientific knowledge is created so that scientific claims can be located with respect to other located practices.

Creating research dissemination texts that communicate information about the context of a claim along with the claim itself takes a step back toward the peer-reviewed scientific literature, where the obligatory methods section always details how data were generated. In effect, then, presenting scientific research in context reverses the process of making “scientific statements from nowhere” in which context references are “shed” from knowledge-making statements between the methods and the conclusions section of a peer-reviewed article (Gieryn, 2006). Communicating scientific claims in context thus increases the degree of insider-ness extended to industry audiences, letting industry readers see inside the “black box” of scientific production (Latour, 1987) because this contextual information is relevant both to their evaluation and their use of a claim, just as is the case for scientific audiences. While methodological context may not be relevant to the epideictic intent of scientific popularizations – a general-interest reader needs a different kind of detail, which may or may not include some methodological elements, to enjoy a story about science – would-be industry users must be able to locate scientific claims with respect to where they sit.

Relevant information about conditions of scientific production may in this respect involve physical location: a grape grower can better evaluate the reasonableness and usefulness of pruning information when she knows where the test vineyard was, whether the slope faced north or south and at what angle, and what kind of soil was underfoot. Relevant conditions of production may also include other forms of “location.” Communicating research in relevant context does not mean replicating the methods section of a peer-reviewed article in a dissemination text. The nature of the audience's practices alters what contextual material is relevant – that is, what contextual material helps locate scientific claims with respect to the reader-user's situation and problem (Huang & Soergel, 2013).

2. Draw connections between research practices and industry audience practices, between scientific knowledge and industry audience knowledge. Acknowledge that industry audiences have knowledge. Consider what you know that they know, and perhaps imagine what they may have to add. Assume that your audience's knowledge is important and that your audience will be able to add something to a conversation.

The idea of leaving space for the possibility of forms of knowledge outside the scientific knowledge of the author may seem ambiguous, and I suppose that in the broadest sense it is. Nevertheless, the textual analyses I have conducted here and existing literature in rhetoric of science and in applied linguistics suggests some specific strategies for enacting epistemically open texts. When choosing to use “we,” do not presume that your audience shares your perspective or values in situations in which they might reasonably differ; it may be fair to assume that you and your audience agree that sauvignon blanc is a white wine, but not that sauvignon blanc should be a fruity wine. Expand the relevant domain (Bazerman, 2009) of preexisting knowledge to include information published in the literature of practice as well as in the peer-reviewed scientific literature. The tacit assumption that knowledge only exists if published in the scholarly literature serves well in writing additional peer-reviewed scholarship, where the relevant standards of knowledge generation accept the peer-review process as the obligatory passage point for legitimating scientific knowledge. These assumptions should not be extended into extradisciplinary communication to industry and other non-scientist audiences because they imply that the audience's knowledge does not exist or does not count because it has not been published in the appropriate journal.

Acknowledging industry knowledge and the potential for knowledgeable industry contributions in dissemination writing changes the relevant domain of discussion. Doing so opens up the potential for industry to have a meaningful voice in shared research-industry space, and thus facilitates the possibility of multidirectional knowledge sharing – a more profound kind of collaboration than asking industry members to function as research tools for collecting data or as resources for providing samples.

These strategies are oriented toward writing a "fluid" (de Laet & Mol, 2000) science, in which reader-users are invited to participate in constructing scientific claims which take into account and incorporate elements of their context of use and thus "perform work" (Law & Singleton, 2000, p. 770) in multiple spaces of practice. Instead of research dissemination that makes science work in practice by patterning spaces of use after the lab (Clark & Murdoch, 1997; Gieryn, 2006), making the rest of the world look like science, this is research dissemination that makes it possible for science to do work in practice by incorporating and taking into account the characteristics of spaces of use, creating claims whose truth spaces extend over the lab and over the winery or vineyard. Using Callon's (1986) example of French scallop fishermen and Wynne's (1992) example of British shepherds, Clark and Murdoch (1997) argue that the "'long' networks of science" (p. 50) met resistance in aiming to import themselves into industry contexts because both the fishermen and the shepherds observed that scientific assumptions were not appropriate to their local contexts. Clark and Murdoch say that it was necessary for those scientific networks to make these new contexts sufficiently like the contexts in which scientific claims were generated. While agreeing with their conclusions that agents of scientific extension should treat local knowledge seriously, I would place the emphasis of their argument about ordering spaces differently. Rather than needing to “reshape locales in a fashion which allows these [scientific] artefacts to 'work'” (p. 41), agents of scientific extension need to find – or help their collaborators find – points of alignment or overlap between locations of scientific production and locations into which they would be imported.

The nature of those connections will inevitably vary with the nature of the community's practices and the locations involved. So, likewise, will the nature of a community's participation in constructing scientific knowledge vary. Doing the work of alignment is necessary, however, when the scientific audience in question is not unquestionably like the disciplinary scientific one. Aristotle's rhetorics of persuasion emerged from and applied to a homogeneous society in which author and audience could be safely presumed to share a common worldview, common assumptions about norms for constructing knowledge, and common values. Individuals whose perspectives did not cohere with that norm – women, slaves, infidels – were irrelevant and excluded from conversation. Similar conditions exist inside any given scientific discipline: common perspectives and norms (at least with respect to disciplinary scientific conversations) can be assumed; those who differ lie outside the discipline. In contemporary society in general, and in industry-oriented and other forms of interdisciplinary science communication, the same assumptions do not hold. Different, marginalized perspectives cannot be so summarily, confidently, and appropriately excluded.

Bazerman (2013) suggests that because audiences cannot be assumed to be homogeneous with the author and with each other, straight-forward persuasion can no longer be assumed the goal of texts as it was in the contextually limited scenarios considered by the ancient rhetoricians. “Rhetorical persuasion” (p. 89) is a social act which necessitates accounting both for the audience and the context in which the audience encounters the text. Today, most strategically persuasive writers work less to win a reader over completely to their position than to ask the reader to acknowledge new information. Shifting “attention from the internal beliefs held by audiences and interlocuters to the unfolding of a social process,” the author asks: “How through a speech act can I change the symbolic landscape so as to change the field upon which others will act in order to assert my concerns, interests, contribution, or participation into the process or outcome?” (Bazerman, 2013, p. 88).

Communicating science in relevant context, acknowledging one's audience's preexisting knowledge and capacity for knowing, ultimately implies respecting one’s audience and the reasonableness of their differences. Both strategies are expressly about building relationships with people who already know something rather than giving knowledge to people who don’t yet have any. I strongly suspect that extension scientists, whose jobs routinely have them communicating with industry members face-to-face and over the phone, practice this sort of respect in those personal interactions. My data, while not directly addressing that issue, support that hypothesis. Washington State wine extension scientists' job descriptions include offering personal assistance to industry members. Washington State winemakers and growers who benefit from their services enthusiastically endorsed those extensionists' ability to make science clear and relevant, even when they did not see written science communication as similarly helpful. My informal interactions with these same scientists suggests that they speak of their industry clients as intelligent, knowledgeable people. The conventions of scientific discourse, however, are poorly equipped to convey those attitudes in writing.

Pedagogical implications: "Getting scientists to write better" is not the problem

In this respect, the absence of a "fit-for-purpose" (as New Zealand winemakers might say) rhetoric of research dissemination – and in particular the mirror-image features of existing rhetorics of dissemination texts I examined and the peer-reviewed literature – may be a function of scientists not knowing how to write in any other way. While extensive effort is devoted to helping scientists communicate more effectively to the "general public(s)" in science communication circles, communicating to specialist non-scientist audiences does not receive similar attention. And even if scientists have training in technical writing – a skill set still at the outer edge of most scientists' balliwick – technical writing is writing to convey one singular meaning (Britton, 1965) whereas, as per the heterogeneity of its audience, effective dissemination writing needs to invite multiple interpretations. Dissemination writing, like disciplinary science writing, needs to convey science as a "harmonic" (Baake, 2003) range of potentials for thinking with; unlike disciplinary writing, dissemination writing must speak to an audience whose spaces of practice are patterned differently than the spaces of practice of the author, and whose ways of thinking and knowing may be fundamentally different. Scientists are unlikely to receive training in this kind of locatable science writing. Science communication's extensive, elaborate disciplinary efforts to train scientists in better public communication elide dissemination rhetorics on two accounts: one, ignoring industry members as an important public distinct from general lay publics (or children, or school teachers, etc.); two, ignoring the need to *teach* writing to *change* writing. Writing does not simply happen. Writing must be taught.

"Getting scientists to write better," however, is not the problem. A lasting lesson from my several semesters teaching first-year composition and technical and professional writing is that if I found myself trying to "get" my students to do something, I was doing something wrong. Notwithstanding the usual obstacles of laziness, exhaustion, and fear, my students should see the reason behind my assignments and how they benefited from them, and should experience some kind of intrinsic motivation to follow me. If they could not, I was either not explaining myself well or not serving their goals well, and in either case I was setting up them and myself for failure. Changing the shape of science writing must not be about "getting" scientists to do anything, but about serving mutual goals. Changing science writing must be about helping scientists match their purposes in writing with their strategies for doing so, building collaborations between rhetorical and writing studies expertise and their own expertise in disciplinary knowledge-making toward the end of addressing a common problem. "Teaching scientists to write better" is less about instilling best practices than about helping match their purposes to their strategies, suggesting that expertise in writing practices can collaborate productively with scientific disciplinary expertise.

Helping scientists communicate better with industry publics is, then, not a matter of teaching scientists the best practices of communicating science in context, but of showing scientists the productivity of thinking differently about their audiences. This is a more difficult proposition. How writing mediates science-practice relationships is embedded in and shaped by the other institutionalized structures of science and its extradisciplinary entanglements. Writing is a meaning-making process at the center of what scientific knowledge is. Shifting writing practices shifts scientific epistemology. Looked at from one direction, these connections of writing and thinking make changing writing an impossibly large, complex task: changing writing is not about small shifts in pronouns and sentence structure, but about changing thinking. From a different direction, however, these connections make writing a powerful tool for shaping how science sits in the world, an "institutional change agent" which helps create a science built of practices coherent with our ideals about diversity, participation, and multiple knowledges. Writing shaped the gentlemen's science of persuasion and discovery in the eighteenth and nineteenth centuries (Bazerman, 2000). Writing can likewise shape a science open to multiple perspectives, of collaboration and problem-solving, as a tool located in the world of its utility.

Outside of writing studies communities, writing is still often perceived as transmitting information: an author "just" puts what she knows into words, encoding a message for a reader to decode later. And yet people who actually spend time writing are unlikely to think the process that simple, if only because "just" putting ideas into words can be so difficult. While my experiences talking about writing with scientists have admittedly been mixed, I find that the vast majority are enthusiastic to talk with writing and communications scholars about something so challenging and so crucial to their work. Talking about that commonly experienced challenge of writing may, indeed, be a good way to begin.

Imagining science differently

Haraway exhorts us to envision change in how science works. The change I envision is a rhetoric of science of collaboration instead of conquering, of science in the world instead of science outside and over the world. I imagine a rhetoric of science that says: “Our methods lead us to conclude that this works. How do those statements relate to what your methods lead you to conclude? Do our statements do useful work for you? Can you take them into account? And is there anything you know that we should take into account?” A rhetoric of industry-oriented science of taking into account, that locates science in the world, offers scientific claims as tools for thinking and not as universal truths. A collaborative rhetoric of industry-oriented science communication shares ways of thinking so that, together, science and industry can see more of what things are and imagine solutions for what things might be.

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Appendix A – Extension Resource Use Amongst Washington State Winemakers and Growers: A Case for Focusing on Relevance[25]

Abstract

Surveys and interviews were conducted to understand extension relevance in the context of overall information resource use amongst Washington State winemakers and growers. Relevance, rather than adoption, is suggested as a frame for assessing extension communication to professionals who may employ information resources in varied ways. Results suggest that extension resources are used and valued, but not always perceived as relevant. Moreover, practitioners' resource use preferences were diverse but tended to align with a science-driven, value-driven, or utility-driven profile. Appreciating differences in how these groups perceive extension resources as relevant may helpfully frame more efficient and effective communication.

Introduction

Relevance, as a user-centered way of listening to an audience, is an under-used opportunity for Extension. Audience response to a message is often assessed in terms of outcomes adoption: did the target population change their behaviors or attitudes? Such assessment questions make sense when a message focuses on a specific behavior, but are less useful for assessing how well communications serve a community's information needs more generally. Particularly for professional communities who may use information

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resources in diverse, even unpredictable ways, relevance offers a better model for understanding how extension communications are being received. This sort of user-centric assessment asks not whether the audience has adopted a desired practice but whether the audience has, in light of their own professional expertise, found extension resources useful (e.g. Archer et al., 2007).

Relevance is a fluid construct accounting for not just topicality but environment, information-seeking preferences, and other user-centric criteria (Froehlich, 1994). It differs in this sense from the occasional use of the term to indicate topical appropriateness alone (e.g. Nadeau, Heidorn, Broady, & Whittle, 2010; Smith, 1991). Relevance has been described as a function of information validity and the work required to access a resource, not only in physical terms but in the sense of "cognitive effort" to understand and place new information in the context of what is already known (Huang & Soergel, 2013; Kritz, Gschwandtner, Stefanov, Hanbury, & Samwald, 2013; Ramos 1998). Refocusing on relevance moves away from the much-maligned deficit model which assumes that non-scientists' failure to take up scientifically supported information is the product of ignorance (Sturgis & Allum, 2004; Weigold 2001). Assuming that practitioners who do not employ research-supported practices are not listening and need persuading may well provoke resentment in addition to impeding effective communication (Knott & Wildavsky, 1980). Instead, a more theoretically supportable and likely more effective approach is practitioner-focused, centered on how practitioners see information resources in practical context.

Wanting to know how Washington State winemakers and growers found Extension resources relevant in the context of information resource use generally, I conducted a statewide survey and interviewed wine practitioners around two key wine producing regions. As no patterns of difference in the responses of winemakers and growers emerged, they are referred to here together as "practitioners." Results suggest, first, that Extension resources are used and that practitioners trust and value them, but do not consistently find them relevant. Second, practitioners expressed distinctly different patterns of resource use preferences related to diverse attitudes about what it means for them to be a good practitioner. Understanding such differences may help Extension communicators frame information in ways that improve relevance for these different groups.

Methods

Washington is second only to California in US wine production with approximately 800 wineries, 350 wine grape growers, and 12.5 million cases produced annually (Washington Wine Commission 2014). Most wineries are small with production generally below and often far below 20,000 cases/year and a largely regional (northwest US) consumer base. The wine community is served by a research and Extension program at Washington State University (WSU) with Extension faculty and staff concentrated at the Tri-Cities campus located near key wine producing regions.

Interviews were solicited via personal emails to all practitioners identifiable by web presence located in Walla Walla or the general Prosser/Yakima/Zillah area. Interviews were scheduled with 18 practitioners willing and able to be interviewed when the research was taking place. All took place in tasting rooms or an adjoining office in private or semi-private settings. While interviewees were chosen by convenience sampling, their heterogeneity mimics that of the industry. They range in age from early thirties to over sixty and in years of industry experience from less than five to well over twenty. Their degree qualifications range from associates to professional doctorate level. Case production at the smallest of their wineries is less than 1,000 cases per year and, at the largest, approximately 22,000.

I conducted, recorded, and manually transcribed semi-structured interviews lasting forty minutes to over two hours, then coded data via the iterative or "constant comparative" (Evans, 2013) approach characteristic of grounded theory. Codes around information resources, winemaker education, science and technology, and the nature of winemaking were then developed into themes and tested against both the transcriptions and survey data.

An online survey followed the interviews and was informed by interview responses. The survey (hosted at FluidSurveys™) was distributed to practitioners via multiple channels: a link in the Washington State Wine Commission's weekly email news, an email distributed via the WSU viticulture and enology Extension email list serve, and personalized emails to all wineries with available email addresses (approximately 500 total). 84 responses (a response rate of approximately 17 percent) were received.

Because approximately half of survey responses followed a link distributed via an Extension email list, subscribers to WSU extension publications are likely overrepresented. Practitioners who rarely or never employ email or the internet are likely unrepresented. Unfortunately, because no comprehensive demographic data are available for the survey population, judging the representativeness of the survey is impossible. The survey was designed to indicate the presence, not the prevalence, of winemaker and grower characteristics (Horst, 2013).

Results

Both interviews and surveys included questions about information resources broadly rather than Extension resources alone, aiming to understand what practitioners find useful and relevant rather than the impact of specific communications. In-depth interviews provided core data for understanding practitioners' attitudes with supporting survey data providing evidence from a larger, state-wide population.

Practitioners overwhelmingly expressed appreciation for research in general and local WSU-driven research in particular. Nevertheless, they said that most new information they encounter is not “relevant” or “applicable” to them, either because “it isn't what I want to do” or because implementing it is not practical in their setting. Most acknowledged this as a consequence of winemaking and grape growing being highly contextual rather than articulating this as a frustration per se. Some, however, described thinking that too much research involves expensive equipment they don't need, can't afford, or is otherwise impractical. Those who expressed such complaints remained in the minority compared with those pleased that researchers are investigating their problems “in their own backyard.”

Resource preferences

Selected responses to the survey question “How often do you use the following types of resources to learn about new winegrowing/making information?” are summarized in Table A.1. Both surveys and interviews identified trade publications and peers as practitioners’ preferred and most oft-used resources. Most (approximately 80 percent) access trade publications as print copies. In interviews, practitioners suggested that while trade magazines are useful, some feel they lack sufficient detail to enable coming to any usable conclusions. Additional popular resources included seminars and workshops (hosted by Extension and numerous other agencies), Extension publications, textbooks, and vendor representatives, the last of which are consulted at least occasionally by 55 percent of respondents.

Table A.1. Selected survey responses to the question "How often do you use the following types of resources to learn about new winegrowing/making information?"

Resource	**Often/most often**	**Never**
Trade magazines	71%	2%
Peers	56%	1.5%
Face-to-face seminars and workshops	37%	5%
Extension newsletters/other publications	37%	20%
Textbooks	26%	11%
Extension faculty/staff	**21%**	**19%**
Vendor representatives	15%	12%
Facebook	8%	64%
Twitter	0%	88%

Beyond time and the logistical ease of attending, previous interest in the topic was the most important factor influencing seminar attendance. Excepting occasional skepticism about vendor events, practitioners discussed seminars presented by Extension, community colleges, vendors, the Washington Wine Technical Group, and university guest speakers without drawing clear distinctions among these sponsors' events. Extension is, in other words, one of many information resource providers with which these practitioners regularly interact.

Social media, including Facebook and Twitter, are notably *not* widely used as information resources. Facebook is never a professional information resource for 64 percent of survey respondents, and 88 percent reported never using Twitter for this purpose. Social networking platforms were never mentioned in interviews. When interviewees mentioned consulting with peers, Extension faculty, or vendor representatives, they discussed making phone calls or, less often, sending emails. When asked how they would prefer to access information resources, survey respondents overwhelmingly preferred face-to-face and text resources, either web-based or hard copy, but not social media. Respondents also reported little use of or interest in videos or webinars in this context.

Extension resource use

Extension faculty/staff were a frequently used resource for 21 percent of survey respondents. Interviews made clear, however, that among those who do contact them Extension faculty/staff are perceived as helpful, friendly, available, and valuable. Practitioners' personal relationships with Extension staff and their willingness to be called for help with a specific problem were frequently cited as valuable, but the most vitally helpful characteristic highlighted over and over in interviews and surveys was Extension faculty/staff's ability to understand practical needs of people working in the industry and to make their research “relevant” and understandable. Unsurprisingly, practitioners related that ability to specific Extension staff having spent time working in the practical side of the industry in non-academic roles.

Extension newsletters and other publications such as email “news blasts” and harvest updates are read often or as a main source by 37 percent of survey respondents, but never read by 20 percent. Interview data corroborated this split, with some interviewees describing frequent use of these resources and others not mentioning them at all. The division was unrelated to job description (both winemakers and growers fell into both groups), education, age, or size of winery at which the practitioner is employed. Without exception, when practitioners were asked about Extension in interviews, seminars and direct contact with staff were mentioned before Extension publications. Survey respondents who indicated that they rarely or never consult with Extension staff were also likely to indicate that they rarely or never read Extension publications or use university websites; likewise, those who consult often with extension staff are more likely to read Extension publications and visit university websites often. Interestingly, the level of *trust* practitioners accorded to information from Extension was unrelated to the likelihood of their using extension resources. Extension resources and academic journals were, in fact, the only resources that more than 90 percent of survey respondents believed to be trustworthy or very trustworthy, with only 74 percent according the same level of trustworthiness to trade publications and 35 percent to private company websites.

Diversity and attitudes

Across interviews and surveys, the diversity in practitioners' resource use patterns and preferences is striking. Perhaps surprisingly, the best predictor of what resources winemakers and growers found relevant was not education, experience, age, type of employment, or any similar demographic, but attitudes toward what constituted “good winemaking.” Interview results suggest that three types described nearly all of these patterns: science-driven, vision-driven, and utility-driven.

A minority (about one-sixth) of interviewees and survey respondents aligned with a “science-driven” profile, expressing that clear right and wrong ways of making wine exist, that the right way is always the most scientifically supported way, and that good winemakers follow research-based best practices to the best of their abilities. Peer-reviewed scientific literature and Extension, therefore, were relevant, while peers and vendor resources were not. They were strongly supportive of Extension and saw Extension faculty/staff as one of their main information sources, though implied that Extension publications and events were generally intended for less knowledgeable practitioners and that most were too basic for them.

In contrast, most practitioners aligned with either a "vision-driven" or a "utility-driven" profile with scientific resources serving not as instructions or best practices but as suggestions or tools. Vision-driven practitioners are adamant that right and wrong do not exist in winemaking, that good winemaking is about staying true to a personal vision, and that following recommendations too prescriptively may therefore harm wine quality. They make use of many different information resources to learn about new techniques that they may try out piecemeal to achieve small quality improvements. For them, Extension resources are relevant as one of many reservoirs of new ideas.

Utility-driven practitioners are also information omnivores willing to learn from many sources, but prioritize the practical value of information, tending to ask first "do I have the material resources to try this?" and "will the benefits of this strategy be worth the costs?" rather than "does this serve my personal vision?" Right and wrong, for them, is about what works for their goals in a particular context. While valuing research in the abstract, they care more about whether something works than whether it is scientifically supported. Observing that scientists and practitioners often have different goals, that cutting edge research is often not yet practical, and that scientific recommendations sometimes change over time, they tend to place less emphasis on continuing education or keeping up with new research and seek out information resources more specifically when they have a problem to solve. They were most likely to question the trustworthiness of Extension (though that remained a minority attitude), to be frustrated by conflicting information resources, and to place highest trust in information from their peers. For them, Extension resources are relevant as an occasional source of practical solutions.

Discussion

An obvious point, but one disguised by adoption-focused assessments, is that winemakers and growers are experienced professionals who often resent being told (or perceiving that they are being told) what is "best." All practitioners cannot and should not be expected to be science-driven; indeed, in an industry whose health depends on variety and individual passion, the industry might suffer if they *were* all science-driven. Extension communications assessments should consider that assessing success under the assumption that practitioners should be more scientific may be counterproductive.

The typology outlined here may be most useful as a heuristic for thinking about professional practitioner attitudes in light of framing effective communication tools (Horst, 2013). Envisioning a practitioner community as comprised of multiple sub-communities with different attitudes toward their craft suggests ways of framing information with their various needs and receptivities in mind. Science-driven practitioners are likely to ascribe greatest relevance to resources presenting scientifically supported best practices. Vision-driven practitioners, in contrast, may reject the idea of best practice and find the same information more relevant when presented as suggested techniques for achieving particular goals. Utility-driven practitioners would likely respond best to resources emphasizing the conditions under which information is practical.

Broad surveys were useful for understanding how Extension was valued in the context of information resource use in general, but were not enough to identify these patterns without their being characterized through interviews. Going out to speak with practitioners with an open set of questions about whether and how Extension resources are relevant, however, affords opportunities to listen and discover what someone constructing a survey might not know in advance to ask, and gives practitioners space to discuss how information resources fit into their daily lives. As Extension itself continues to work to be relevant in the second century of its existence, responsiveness and respect continue to form part of the core characteristics of “engaged institutions” (Bull, Cote, Warner, & McKinnie, 2004). Listening to understand practitioner perspectives and user-centric assessments serve those goals.

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Appendix B – Interview questions

Interview questions for Washington State winemakers and growers

1. **When do you look for or to read scientific winemaking information? Is this something you do spontaneously on your own?**
    - **a.** If no: why not?
    - **b.** If yes: examples of situations in which you've gone looking for scientific info?
2. **How do you feel about the amount of information available? Too much? Too little? The wrong kind, just what you need?**
    - **a.** Do any of these frustrations stop you from using any types of information (like email newsletters) or keep you from reading any specific publications?
3. **Do you regularly read any winemaking/growing publications for general education? Magazines, journals, emails, newsletters?**
4. **Do you subscribe to emails and/or newsletters from WSU extension or the Washington Wine Commission?**
    - **a.** If no, why not?
5. **Do you attend educational workshops to learn about new research or to be updated on techniques?**
    - **a.** How do you feel about these workshops versus other ways of learning about new information? Would you rather go to a workshop, read a magazine article, do something else?
6. **Have you tried using any resources in the past that you've now stopped using? Why did you stop using them?**

7. **What sort of problem-solving strategies do you use when you have a specific winemaking/growing problem?**

    a. Do you contact someone to talk about it? Do you try to read about the problem? Do you try to work it out on your own?

    b. When you need to answer a question, do you feel as though you know where to look?

    c. When you look for information (from any of those sources) to try to solve a specific problem, are you frustrated by anything about the way the information is structured or delivered? (i.e. writing is hard to understand, not detailed enough, takes too much time to find or to read, annoying format)

8. **Do you feel as though you have the necessary background to understand the scientific winemaking/growing information available to you or that you want to use?**

    a. Do the people talking/writing to you talk down to you or over your head?

    b. Did you learn those things on your own, or did someone teach you?

    c. Do the people talking/writing to you seem to understand what you need?

9. **Have you ever had different sources gave you different answers to the same problem?**

    a. If so, what did you do? How did you decide whom to trust?

10. **Have you ever found that recommendations given by a resource contradicted your own practical knowledge, what you know works for you in your winery or your vineyard?**

    a. If so, did you keep doing what was already working for you?

b. If so, did you tell anyone (the author, a researcher, your neighbor) that your experience contradicted the resource?

c. If so, did it affect your opinion of the resource?

11. Does your training, either as a winemaker/grower or from a different job, affect how you read about wine science?

a. Do you feel well-prepared to read the wine science you need, or that you think you need?

12. Outside of your job as a winemaker/grower, do you read for fun? Use social media for fun, or for other reasons?

13. Has anyone ever talked to you about how you use scientific V&E information before?

14. **How many cases does your winery produce annually?**

15. How and where did you obtain your winemaking training?

<u>Interview questions for NZ winemakers and growers</u>

1. **When do you look for or to read scientific winemaking information? Is this something you do spontaneously on your own?**
    - **a.** If no: why not?
    - **b.** If yes: examples of situations in which you've gone looking for scientific info?
2. **What sort of problem-solving strategies do you use when you have a specific winemaking/growing problem?**
    - **a.** Do you contact someone to talk about it? Do you try to read about the problem? Do you try to work it out on your own?
    - **b.** When you need to answer a question, do you feel as though you know where to look?
    - **c.** When you look for information (from any of those sources) to try to solve a specific problem, are you frustrated by anything about the way the information is structured or delivered? (i.e. writing is hard to understand, not detailed enough, takes too much time to find or to read, annoying format)
3. **How do you feel about the amount of information available? Too much? Too little? The wrong kind, just what you need?**
    - **a.** Do any of these frustrations stop you from using any types of information (like email newsletters) or keep you from reading any specific publications?
4. **Do you regularly read any winemaking/growing publications for general education? Magazines, journals, emails, newsletters?**
5. **Do you subscribe to emails and/or newsletters from COWA, New Zealand Winegrowers, Plant and Food Research, and/or AgBusiness?**

   a. If no, why not?

6. **Do you attend educational workshops to learn about new research or to be updated on techniques?**
   a. How do you feel about these workshops versus other ways of learning about new information? Would you rather go to a workshop, read a magazine article, do something else?
7. **Have you tried using any resources in the past that you've now stopped using? Why did you stop using them?**
8. **When you come across something interesting or useful, do you share it or talk about it with other winemakers/growers?**
9. **Do you feel as though you have the necessary background – scientific and practical – to understand the scientific winemaking/growing information available to you/that you want to use?**
   a. Do the people talking/writing to you talk down to you or over your head?
   b. Did you learn those things on your own, or did someone teach you?
   c. Do the people talking/writing to you seem to understand what you need?
10. **Have you ever encountered a situation in which different resources gave you different answers to the same problem?**
    a. If so, what did you do? How did you decide whom to trust?
11. **Have you ever encountered a situation in which the recommendations given by a resource contradicted your own practical knowledge, what you know works for you in your winery or your vineyard?**
    a. If so, did you keep doing what was already working for you?

   b. If so, did you tell anyone (the author, a researcher, your neighbor) that your experience contradicted the resource?

   c. If so, did it affect your opinion of the resource?

12. Does your training, either as a winemaker/grower or from a different job, affect how you read about wine science?

   a. Do you feel well-prepared to read the wine science you need, or that you think you need?

13. Outside of your job as a winemaker/grower, do you read for fun? Use social media for fun, or for other reasons?

14. Has anyone ever talked to you about how you use scientific V&E information before?

Appendix C – Survey questions and supplemental survey data for Washington State winemakers and growers

This survey is designed to gather information about how wine growers and winemakers make use of various information resources. My goal is better understanding how wine industry communication is working so that we can devise better ways of communicating new scientific research.

This survey is part of my PhD studies at the Centre for Science Communication at the University of Otago in Dunedin, New Zealand. I will be sharing my results with the Washington State University Viticulture and Enology extension (funding this research) and with the Washington State Wine Commission to shed light on what kinds of communication strategies are or are not working well and how they might be improved.

The University of Otago requires that the data collected be securely stored in such a way that only myself and my supervisors will be able to gain access to it. Data obtained as a result of the research will be retained for at least 5 years in secure storage. Any personal information held on the participants may be destroyed at the completion of the research even though the data derived from the research will, in most cases, be kept for much longer or possibly indefinitely. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand). You will have access to the results of this study via publications through WSU extension and the Washington Wine Commission or by contacting me directly. You will not be asked to disclose any personally identifying information and your responses will be entirely anonymous. You may choose not to participate or to exit the survey without finishing it at any point with no disadvantage to you.

This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 64 03 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome. You are encouraged to print a copy of this page for your own information. If you have any questions about this survey or about my research more broadly, either now or in the future, or if you would like to discuss any of the issues brought up in this survey, please feel free to contact me at szyer363@student.otago.ac.nz.

Erika Amethyst Szymanski
Centre for Science Communication, University of Otago, Dunedin, NZ
64 3 479 7939
szyer363@student.otago.ac.nz

I have read the above information and am willing to take part in this survey.

☐ Yes
☐ No

1. How often do you actively look for new winemaking/growing-related information (for general education, to learn about new research, to solve a specific problem, etc.)?

   ☐ Every day or nearly every day

   ☐ At least once a week

   ☐ At least once a month

   ☐ Several times per year

   ☐ Less often

   ☐ Never

2. When you look for winemaking/growing-related information, how often is your goal:

	Never	Rarely	Occasionally	Often	Most often
General browsing	☐	☐	☐	☐	☐
Learning about established best practices	☐	☐	☐	☐	☐
Solving a specific problem or answering a specific question	☐	☐	☐	☐	☐
Learning about new research	☐	☐	☐	☐	☐
Other (please elaborate):	☐	☐	☐	☐	☐

3. Do you feel that your strategies for finding information work well for you?

   ☐ Yes

   ☐ No

   ☐ Something else

4. How often do you consult with the following types of people to learn about winemaking/growing-related information?

	Never	Rarely	Occasionally	Often	Main source
Other local winemakers	☐	☐	☐	☐	☐
Other non-local winemakers	☐	☐	☐	☐	☐
University professors	☐	☐	☐	☐	☐
Local extension personnel	☐	☐	☐	☐	☐
Non-local extension personnel	☐	☐	☐	☐	☐
Researchers at private companies	☐	☐	☐	☐	☐
Marketing/outreach personnel	☐	☐	☐	☐	☐
Company sales/support staff	☐	☐	☐	☐	☐
Other (please elaborate)	☐	☐	☐	☐	☐

5. How often do you use the following types of resources to learn about winemaking/growing-related information?

	Never	Rarely	Occasionally	Often	Main source
Textbooks	☐	☐	☐	☐	☐
Academic journals	☐	☐	☐	☐	☐
Print trade publications	☐	☐	☐	☐	☐
Online trade publications	☐	☐	☐	☐	☐
University/government websites (including blogs)	☐	☐	☐	☐	☐

Print extension publications	☐	☐	☐	☐	☐
Online extension publications (including blogs)	☐	☐	☐	☐	☐
Extension emails	☐	☐	☐	☐	☐
Private company websites	☐	☐	☐	☐	☐
Other websites	☐	☐	☐	☐	☐
Online videos (hosted by anyone)	☐	☐	☐	☐	☐
Webinars	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐
Local/regional meetings	☐	☐	☐	☐	☐
National conferences	☐	☐	☐	☐	☐

6. In general, how trustworthy do you consider the following sources of information?

	Not trustworthy	Sometimes trustworthy	Trustworthy	Very trustworthy	The most reliable
Other local winemakers	☐	☐	☐	☐	☐
Other non-local winemakers	☐	☐	☐	☐	☐
University researchers	☐	☐	☐	☐	☐
Extension personnel	☐	☐	☐	☐	☐
Researchers at private companies	☐	☐	☐	☐	☐
Textbooks	☐	☐	☐	☐	☐
Academic journals	☐	☐	☐	☐	☐
Trade publications	☐	☐	☐	☐	☐

Print extension publications	☐	☐	☐	☐	☐
Online extension publications	☐	☐	☐	☐	☐
University/government websites	☐	☐	☐	☐	☐
Private company websites	☐	☐	☐	☐	☐
Other websites and blogs	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐

7. How attractive do you find the following ways of learning about new winemaking/growing information?

	Won't use	Tolerable	Neutral	Good	Best
Other winemakers	☐	☐	☐	☐	☐
University researchers	☐	☐	☐	☐	☐
Extension publications	☐	☐	☐	☐	☐
Directly from extension staff	☐	☐	☐	☐	☐
Marketing/communications personnel at private companies	☐	☐	☐	☐	☐
Researchers at private companies	☐	☐	☐	☐	☐
Textbooks	☐	☐	☐	☐	☐
Academic journals (print or web)	☐	☐	☐	☐	☐
Trade publications (print or web)	☐	☐	☐	☐	☐
University/government websites	☐	☐	☐	☐	☐
Private company websites	☐	☐	☐	☐	☐

Other websites and blogs	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐

Other preferred sources? Please elaborate:

8. How would you prefer to receive new winemaking/growing information from your local university extension?

	Won't use	Tolerable	Neutral	Good	Best
Personal email	☐	☐	☐	☐	☐
Personal phone call	☐	☐	☐	☐	☐
Face-to-face meeting	☐	☐	☐	☐	☐
At a conference/event	☐	☐	☐	☐	☐
Website/online newsletter	☐	☐	☐	☐	☐
Print newsletter	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐
Via others in my network	☐	☐	☐	☐	☐
Anything readable on my phone	☐	☐	☐	☐	☐

9. In a few words,, ideally, how would you prefer to learn about new winemaking/growing research?

10. What are your biggest frustrations in accessing winemaking/growing information?

	Not a concern	Mildly frustrating	Moderately frustrating	Very frustrating	Actively impeding
Too many sources	☐	☐	☐	☐	☐
Not enough sources	☐	☐	☐	☐	☐
Can't find what I need	☐	☐	☐	☐	☐
Takes too long to find what I need	☐	☐	☐	☐	☐
Sources provide conflicting information	☐	☐	☐	☐	☐
Difficult to verify reliability	☐	☐	☐	☐	☐
Sources are difficult to read or understand	☐	☐	☐	☐	☐
What I need is buried in not-useful info	☐	☐	☐	☐	☐
Information is in a language I don't speak/read	☐	☐	☐	☐	☐

Other frustrations? Please elaborate:

11. When you find conflicting recommendations across multiple sources, what do you do? (Choose all that apply.)

- ☐ Trust the source I think is most reliable and ignore the other(s)
- ☐ Use my past hands-on experience to identify the most reliable information
- ☐ Use trial and error or experiment to gather my own data

☐ Ignore all of the conflicting information and keep doing what I've been doing

☐ Consult with a peer

☐ Consult with an expert (extension, university/institution researcher, etc.)

☐ I've never had this problem

☐ Something else (please elaborate):

12. What is the single most important factor influencing how trustworthy or reliable you find an article of scientific growing/winemaking information?

☐ Reputation of the author (i.e. article is written by a well-known researcher)

☐ Reputation of the researcher (i.e. I trust research from Dr. Marcus Keller)

☐ Reputation of how I learned about the information (i.e. I trust information from Wines & Vines, information was shared by a knowledgeable colleague)

☐ Personal relationship with the researcher (i.e. I know Dr. Keller personally)

☐ Personal relationship with how I learned about the information (i.e. worked successfully with WSU extension before, information was shared by a friend)

☐ Information/recommendations are coherent with what I already know

☐ All sources seem equally trustworthy to me

☐ Other (please elaborate):

Demographic questions

13. In what AVA is your winery or vineyard?

14. How long have you been in the winemaking/growing industry?

☐ < 5 years

☐ 5-10 years

☐ 10-15 years

☐ > 15 years

15. Which of the following categories includes your age?

☐ < 30

☐ 30-40

☐ 40-50

☐ 50-60

☐ > 60

15. Which of the following best describes your job title? (Choose all that apply.)

☐ Winemaker or assistant winemaker

☐ Viticulturist/grower or assistant grower

☐ Winery technician (enologist, etc.)

☐ Other assistant

☐ Other (please elaborate):

16. What is your level of formal winemaking/growing education?

☐ No formal winemaking/growing education

☐ Certificate, post-graduate diploma, or associate's degree

☐ Bachelor's degree or equivalent

☐ Master's degree or equivalent

☐ PhD or equivalent

17. If you had a career prior to entering winemaking/growing (or if you currently have a second career in addition to winemaking/growing), what was/is it?

18. What languages do you speak or read?

Supplemental survey data for Washington State winemakers and wine growers

An online survey distributed to winemakers and growers across Washington State provided a measure of reassurance that responses elicited in interviews had not systematically missed some segment of the population. Data relevant to the main arguments of this thesis, but not included in the argument presented in chapter three, are summarized below.

Figures

Tables

Introduction

One function of this exploratory survey was to provide data in support of improving the efficiency and efficacy of viticulture and enology extension communications in Washington State. Understanding how winemakers/growers are making use of information resources may help increase the efficiency of resources spent on research dissemination and winemaker/grower education. Knowing which information channels winemakers use and which they avoid may help researchers, extension staff, and other communicators direct their limited time and resources toward channels that winemakers/growers are most likely to access. Being aware of winemaker's/grower's feelings of frustration or satisfaction with resources may help communicators avoid exacerbating them. And seeing how winemakers/growers approach scientific information in the context of their craft may help communicators tailor their message in ways likely to make sense to their audience and, perhaps, be more favorably received by them.

I interviewed, then surveyed Washington state winemakers to investigate how they interact with the many different information sources available to them, what frustrates or enables their learning, and their attitudes toward employing scientific research findings in their winemaking. My conclusions suggest that Washington state winemakers and growers as a whole are remarkably diverse, but that their resource preferences and attitudes relate to how they think about the nature of good winemaking/growing in identifiable ways. Winemakers'/growers' sense of professional identity, in other words, is the strongest predictor of their resource use preferences, whereas demographic characteristics such as educational background or age failed to correlate with resource use preferences at all. In addition, survey data suggest on the whole that Washington state winemakers/growers are conservative in preferring to learn in face-to-face settings or by reading textbooks and magazines over web-based sources or social media.

Method

Descriptions of survey and interview method are located in chapter three.

Selected findings

Demographics of survey respondents and interview participants

The complete unavailability of current demographic data describing Washington state winemakers and wine growers (staff of the Washington State Wine Commission recounted that the Commission has not recently collected these data; personal communication) made it impossible to compare the characteristics of respondents against the larger population. Consequently, survey responses cannot be read as representative or as reflecting the quantitative prevalence of attitudes or behaviors in the population. In the scope of the larger study, the survey was designed to ensure that interviews – which enabled collecting far more detailed data, but which were necessarily limited to fewer respondents in a smaller geographical area because of time and funding constraints – did not systematically miss important sets of attitudes held by some members of the community. Respondents varied in age, education, and years of experience in the industry (see Table C.1 and Table C.2).

Table C.1. Characteristics of survey respondents – Job description and age

Job description	**Percent of respondents***	**Age (years)**	**Percent of respondents**
Winemaker/assistant	65	< 30	2
Grower/assistant	33	30-40	14
Owner	63	40-50	19
Technician	19	50-60	39
Other**	25	>60	26

*Percentages do not add up to 100 because respondents were asked to select all applicable categories and numerous respondents indicated multiple job descriptions.

**"Other" job titles included "educator," "instructor," "consultant/advisor," "hobbyist," and "everything"

Table C.2. Characteristics of survey respondents – Education and experience.

Formal wine-related education	**%**	**Formal education in any field**	**%**	**Years of wine industry experience**	**%**
None	19	Less than high school	0	< 5 years	25
Short courses	35	High school diploma	2	5-10 years	21
2-year degree	16	2-year degree	12	10-15 years	25
4-year degree	25	4-year degree	53	> 15 years	30
Master's degree or PhD	5	Master's or doctoral degree	33		

Universal appeal of the union of scientific and experiential knowledge in narrative

In most respects, winemakers and growers were diverse in their information-seeking behaviors and preferences. In-person seminars were the single resource to hold universal appeal across all winemaker/grower identity subsets (trade publications are also read by nearly everyone, but with less global enthusiasm). Nearly all interviewees spontaneously recounted stories of seeing winemakers present the results of in-house experiments at seminars and being convinced by this testimony, of presenting at such sessions themselves, or both. The positive characteristics of such "show and tell" or "taste and see" seminars were echoed by appreciation for articles in *Wine Business Monthly* which mimic the same format, highlighting the actual practices and experience of a particular winemaker or grower. Though the relationship they envision between the two differs dramatically, all winemakers/growers expressed the belief that making wine well requires both scientific and experiential knowledge. Supporting the one with the other, therefore, is likely to meet everyone's standards for reliable information. Events hosted by the Washington Wine Technical Group, at which winemakers present the results of their in-house experiments, often with resulting wines in tow, often alongside researchers discussing related scientific or technical points, were repeatedly singled out as especially successful – that is, interesting, convincing, and worth attending. Articles in *Wine Business Monthly* following a similar format, with a description of a winemaker's/grower's trials alongside research-driven technical information, were likewise singled out. Specific mentions of both the Washington Wine Technical Group and these *Wine Business Monthly* articles were made by interviewees aligning with visionary, pragmatist, philosopher, and even (though less frequently) formalist identity profiles; they were also singled out in write-in responses in surveys.

Resource use preferences

Table C.3. Free responses to “In a few words, how would you ideally prefer to learn about new winegrowing/making information?” coded by main theme (multiple codes were applied to some responses)

Print sources	6%
Websites	16%
Email	20%
Online newsletter	30%
Small-group seminars	32%
Face-to-face	46%

Table C.4. Free responses to “In a few words, how would you ideally prefer to find help when you have a specific problem or question?” coded by main theme (multiple codes were applied to some responses)

Print media	4%
Vendor representative	9%
Extension faculty	20%
Internet searches	34%
Peer communication	41%

Characteristics of extension material users

Winemakers/growers with higher education levels may be more likely to consult with extension faculty as an information resource, though data are inconclusive (Figure C2). Survey respondents seem to be consistent in their preference for interacting with extension across media types: those who indicated rarely or never consulting with extension faculty/staff were also likely to indicate rarely or never reading extension publications or using university websites; likewise, those who often consult with extension faculty/staff are more likely to read extension publications and visit university websites often. Winemakers/growers who report making frequent use of extension resources were not distinguishable by any demographic feature – age, winemaking education, overall education, years of industry experience, region, etc. How much trust a respondent placed in information from WSU extension was unrelated to how likely they were to use extension resources.

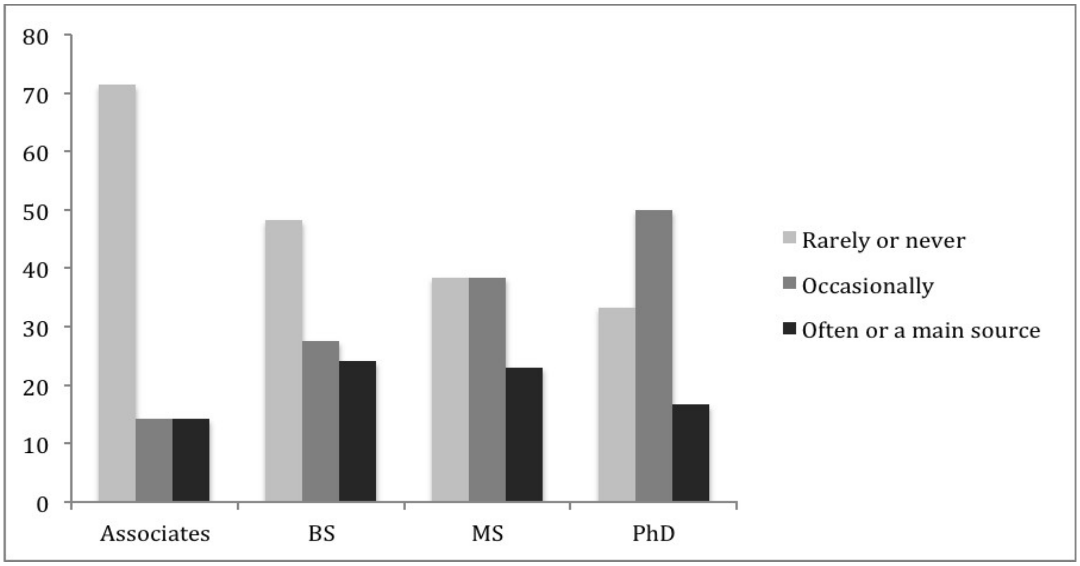


Figure C.1. Survey responses to the question, "How often do you talk to extension faculty/staff for winemaking/growing information?" analyzed by highest education level attained in any field.

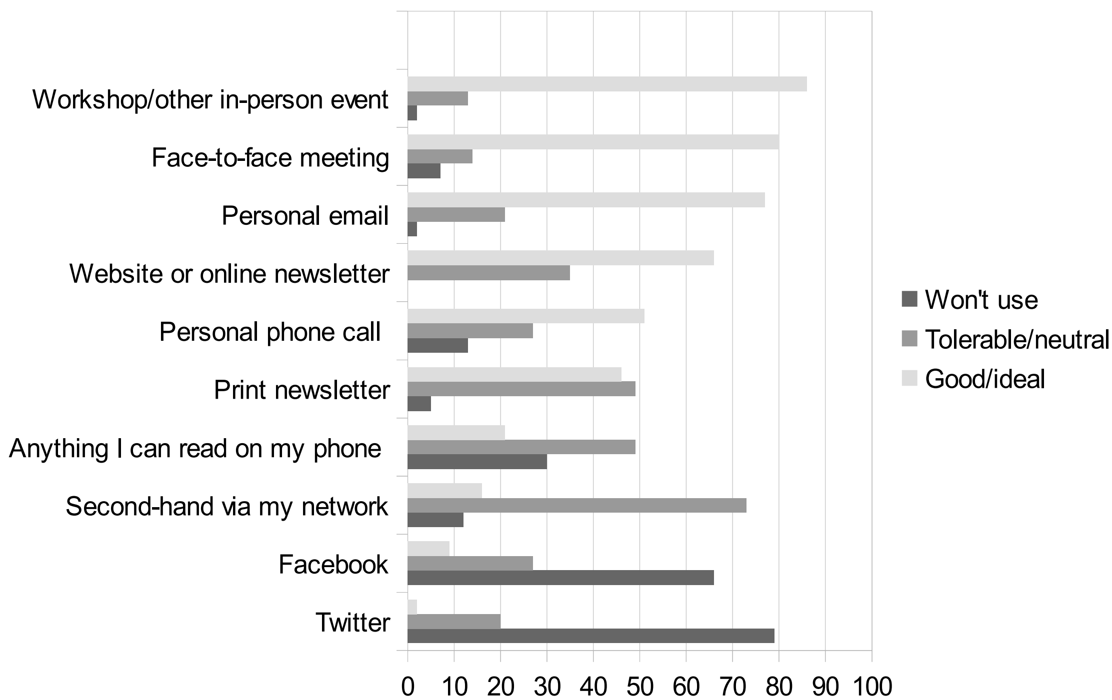


Figure C.2. Survey responses to the question, "How would you prefer to learn about new winemaking/growing information from your local university extension?"

Perceptions of trustworthiness

Winemakers'/growers' consistently allocated stronger senses of trustworthiness to scientists than to vendors or their peers while still placing significant trust in the latter (Figure C.3). Approximately 90 percent of respondents say that WSU extension, textbooks, and academic journals are trustworthy or very trustworthy. Trade publications garner somewhat less trust, with about a quarter of respondents thinking them only sometimes trustworthy. About half of respondents think that their peers are trustworthy or very trustworthy; essentially all of the remainder find them sometimes trustworthy. Only about a quarter identify vendor representatives as always trustworthy though nearly none discount them as altogether untrustworthy. Local and regional meetings and webinars garnered middling levels of trust though, again, nearly none discounted them as altogether untrustworthy.

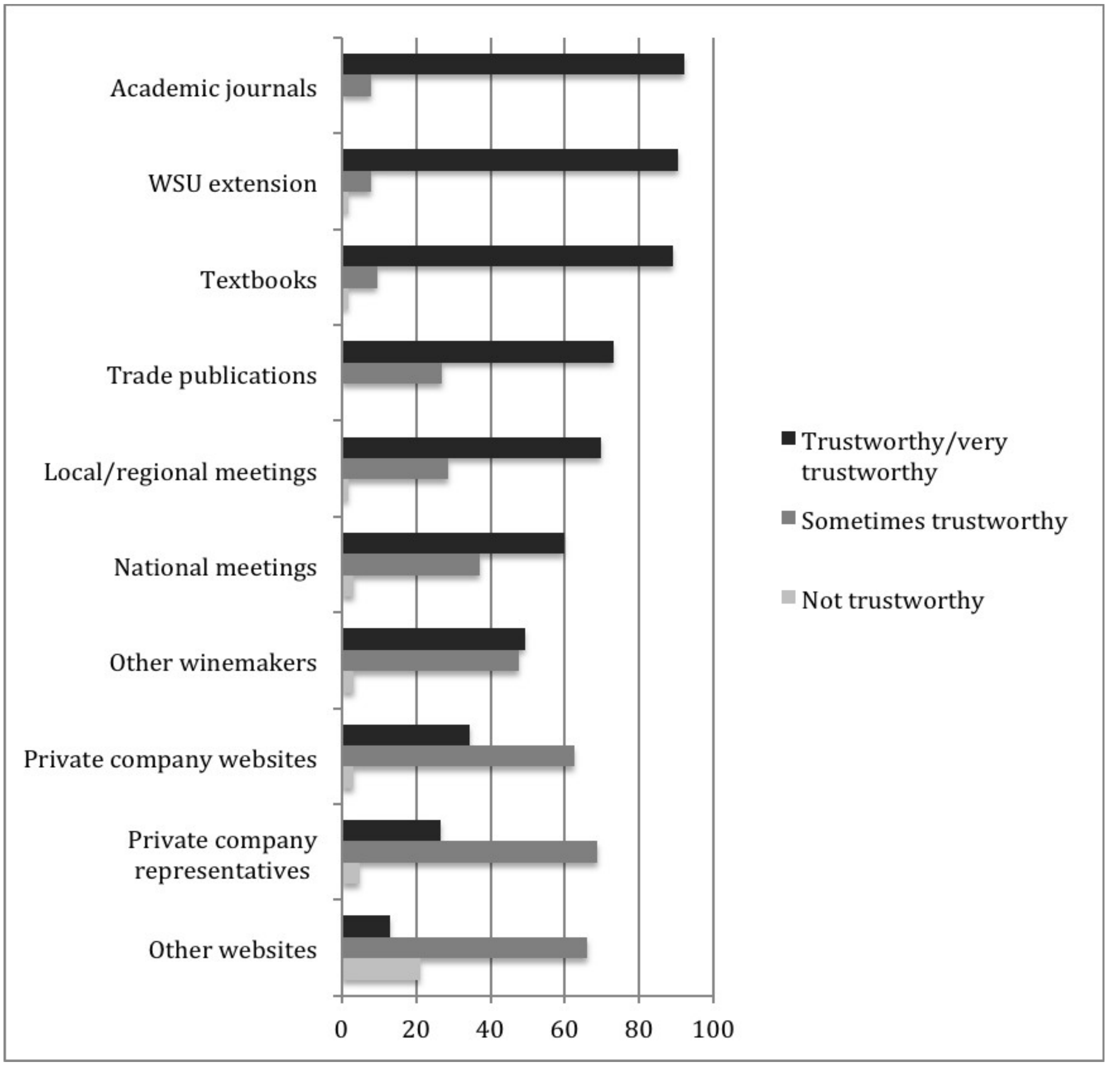


Figure C.3. Survey responses to the question, "How trustworthy do you find the following sources of information?"

Table C.5. Multiple-choice responses to "What is the most important factor influencing how trustworthy you find a source of wine growing/making information?

Reputation of the source	26%
Reputation of the researcher	26%
Info fits with what I know from experience	14%
All sources seem equally trustworthy to me	9%
Personal relationship with source	10%
Personal relationship with researcher	3%
Other*	8%

*"Other" responses included versions of "all of the above," length of experience with local conditions, and versions of "I trust everything"

Frustrations with information resources

Table C.6. All frustrations with information resource use collected from interviews and survey comments

Scientific recommendations change too quickly	Recommendations aren't practical (i.e. replanting vines)
Useful private research isn't shared	Not enough sources on important topics
Insufficient detail in articles	Too much conflicting information
Applicable, unbiased information is hard to find	Too much information is commercial/trying to sell something
New research is hard to find	Having to pay to read research conclusions
Research for the sake of scientific "hubris" rather than practical applicability	Researchers/authors don't understand my local conditions

Dealing with conflicting information

The single most significant frustration noted by survey respondents is having multiple sources offer conflicting information – 50 percent cited it as a major frustration and only 14 percent described it as not at all frustrating. Interview data suggest, however, that calling conflicting information a "frustration" vastly oversimplifies how winemakers/growers feel about this potential issue. Winemakers who self-identify as having strong science backgrounds describe reading extensively or relying on a prior body of knowledge to try to reconcile apparent conflicts by understanding the principles governing the system. Visionaries tend to describe encountering conflicting information as an inevitable consequence of there being many different solutions to any given problem; moreover, they describe these conflicts as "the cool part about winemaking" and ways to "open your mind" (WA 15) to different possibilities.

Table C.7. Multiple-choice responses to "What do you do when you encounter conflicting information?" as percent of respondents indicating each solution

Trust the most reliable source	26%
Rely on hand-on experience	57%
Do my own experimenting/trial and error	29%
Consult with someone I consider an expert	47%
I've never had this problem	5%
Something else*	3%

*"Something else" responses included doing extensive research, weighing individual voices, and looking for hidden agendas

Table C.8. All reasons not to use information resources brought up in interviews and in survey comments

Listening to the plant is more important than doing research	Winemaking is more complex than research can handle
I don't want someone giving me a set of rules to follow	Cutting-edge research isn't practical at my winery
Wine quality is personal, so no one can tell me what to do	Sources recommend things we can't do because of financial and physical constraints
Sources conflict, so I rely on intuition	More information wouldn't change what I do
What we're doing already is good enough	Information resources are redundant
I don't need sophisticated technology to make great wine	Scientific recommendations change too quickly
Research isn't relevant to my local conditions	No right and wrong in winemaking
Lack of time	Experience is more important than education
Much of winemaking success is about business and marketing, not science	Farmers with practical experience are more trustworthy than research
Don't like doing "homework"	Most research isn't new

Future Directions

While I can conclude that the union of scientifically supported and experiential knowledge in the form of first-hand winemaker/grower narratives seems a preferred way of learning among winemakers/growers of all identity types, this conclusion is drawn only from what winemakers/growers *report* and not from data about what types of articles they spend the most time reading, what story structures prompt them to remember the most, or what they find most convincing or trustworthy. Evaluating whether storytelling as such or simply the incorporation of “real world” experiential knowledge is important could involve an experimental study comparing two trade publication articles written on the same topic but in different formats: one traditional article reporting on scientific research, one reporting on scientific research but also including references to winemaker/grower experiences, and one structured as a narrative of how one or more winemakers/growers have employed scientific research findings to change their practices. In addition to collecting metrics on reader behavior, readers might be asked to answer a few brief questions about whether they feel the research about which they've read is relevant and whether or how they imagine they might apply it to their work.

I hypothesize that diversity in winemaker/grower identity is made possible by the diversity in what it means to be a winemaker in the western United States, a perceived rift between the goals of academic researchers and industry practitioners, and cultural representations and expectations of winemaking/growing that encourage winemakers especially to adopt particular attitudes toward their craft. Additional investigations might explore relationships between winemaking identities and conceptualizations of wine quality as expressed by the industry community and as supported – or perceived to be supported – by wine science research and communication.

Appendix D – Survey questions and supplemental survey data for New Zealand winemakers and growers

This survey is designed to gather information about how wine growers and winemakers make use of various information resources. My goal is better understanding how wine industry communication is working so that we can devise better ways of communicating new scientific research.

This survey is part of my PhD studies at the Centre for Science Communication at the University of Otago. I will be sharing my results with the New Zealand Sustainability Dashboard Project (funding this research) to shed light on what kinds of communication strategies are or are not working well and how they might be improved. The University of Otago requires that the data collected be securely stored in such a way that only myself and my supervisors will be able to gain access to it. Data obtained as a result of the research will be retained for at least 5 years in secure storage. Any personal information held on the participants may be destroyed at the completion of the research even though the data derived from the research will, in most cases, be kept for much longer or possibly indefinitely. The results of the project may be published and will be available in the University of Otago Library. You will have access to the results of this study via publications through the Sustainability Dashboard or by contacting me directly.

You will not be asked to disclose any personally identifying information and your responses will be entirely anonymous. You may choose not to participate or to exit the survey without finishing it at any point with no disadvantage to you. This study has been approved by the University of Otago Human Ethics Committee. If you have any concerns about the ethical conduct of the research you may contact the Committee through the Human Ethics Committee Administrator (ph 03 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome. You are encouraged to print a copy of this page for your own information. If you have any questions about this survey or about my research more broadly, either now or in the future, or if you would like to discuss any of the issues brought up in this survey, please feel free to contact me at szyer363@student.otago.ac.nz.

Erika Amethyst Szymanski
Centre for Science Communication, University of Otago, Dunedin, NZ
3 479 7939
szyer363@student.otago.ac.nz

I have read the above information and am willing to take part in this survey.

- ☐ Yes
- ☐ No

16. How often do you actively look for new winemaking/growing-related information (for general education, to learn about new research, to solve a specific problem, etc.)?

    ☐ Every day or nearly every day

    ☐ At least once a week

    ☐ At least once a month

    ☐ Several times per year

    ☐ Less often

17. When you look for winemaking/growing-related information, how often is your goal:

	Never	Rarely	Occasionally	Often	Most often
General browsing	☐	☐	☐	☐	☐
Learning about established best practices	☐	☐	☐	☐	☐
Solving a specific problem or answering a specific question	☐	☐	☐	☐	☐
Learning about new research	☐	☐	☐	☐	☐
Other (please elaborate):	☐	☐	☐	☐	☐

18. Overall, how satisfied are you with your current strategies for finding new winemaking/growing information?

    ☐ Very dissatisfied

    ☐ Mildly dissatisfied

    ☐ Neither satisfied nor dissatisfied

☐ Mildly satisfied

☐ Very satisfied

19. How often do you consult with the following types of people to learn about winemaking/growing-related information?

	Never	Rarely	Occasionally	Often	Main source
Other local winemakers	☐	☐	☐	☐	☐
Other non-local winemakers	☐	☐	☐	☐	☐
University professors	☐	☐	☐	☐	☐
Crown Research Institute staff	☐	☐	☐	☐	☐
Researchers at private companies	☐	☐	☐	☐	☐
Company sales/support staff	☐	☐	☐	☐	☐
Other (please elaborate)	☐	☐	☐	☐	☐

20. How often do you use the following types of resources to learn about winemaking/growing-related information? (Journals and trade publications include print and online versions.)

	Never	Rarely	Occasionally	Often	Main source
Textbooks	☐	☐	☐	☐	☐
Academic journals	☐	☐	☐	☐	☐
All-NZ/Australasian trade pubs	☐	☐	☐	☐	☐
Regional trade publications	☐	☐	☐	☐	☐
University websites	☐	☐	☐	☐	☐

NZ Winegrowers website (including fact sheets)	☐	☐	☐	☐	☐
Private company websites	☐	☐	☐	☐	☐
Other websites	☐	☐	☐	☐	☐
Online videos (hosted by anyone)	☐	☐	☐	☐	☐
Webinars	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐
Local/regional meetings	☐	☐	☐	☐	☐
National conferences	☐	☐	☐	☐	☐

21. How often do you use the following resources provided by New Zealand Winegrowers, Crown Research Institutes, Universities, or partnerships between these organizations?

	Never	Rarely	Occasionally	Often	A main source
Fact sheets on websites	☐	☐	☐	☐	☐
Fact sheets in print	☐	☐	☐	☐	☐
Formal project/research reports	☐	☐	☐	☐	☐
Summaries in trade publications	☐	☐	☐	☐	☐
Presentations at conferences	☐	☐	☐	☐	☐
Workshops	☐	☐	☐	☐	☐
Field days	☐	☐	☐	☐	☐
Other website materials (handouts, summaries, etc.)	☐	☐	☐	☐	☐

22. How trustworthy do you consider the following sources for winemaking/growing-related information? (Journals and trade publications include print and online versions.)

	Not trustworthy	Sometimes trustworthy	Trustworthy	Very trustworthy	Most reliable
Other local winemakers	☐	☐	☐	☐	☐
Other non-local winemakers	☐	☐	☐	☐	☐
University researchers	☐	☐	☐	☐	☐
Crown Research Institute staff	☐	☐	☐	☐	☐
Researchers at private companies	☐	☐	☐	☐	☐
Textbooks	☐	☐	☐	☐	☐
Academic journals	☐	☐	☐	☐	☐
International trade publications	☐	☐	☐	☐	☐
NZ/Australiasian trade publications	☐	☐	☐	☐	☐
Regional trade publications	☐	☐	☐	☐	☐
University websites	☐	☐	☐	☐	☐
NZ Winegrowers website (including fact sheets)	☐	☐	☐	☐	☐
Private company websites	☐	☐	☐	☐	☐
Other (personal) websites/blogs	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐

23. How attractive do you find the following ways of finding out new winemaking/growing information? (Journals and trade publications include print and online versions.)

	Won't use	Tolerable	Neutral	Good	Preferable
Other winemakers	☐	☐	☐	☐	☐
University researchers	☐	☐	☐	☐	☐
Researchers at private companies	☐	☐	☐	☐	☐
Researchers at Plant and Food	☐	☐	☐	☐	☐
Marketing/communications personnel at private companies	☐	☐	☐	☐	☐
Textbooks	☐	☐	☐	☐	☐
Academic journals	☐	☐	☐	☐	☐
International trade publications	☐	☐	☐	☐	☐
NZ/Australiasian trade publications	☐	☐	☐	☐	☐
Regional trade publications	☐	☐	☐	☐	☐
University/government websites	☐	☐	☐	☐	☐
Private company websites	☐	☐	☐	☐	☐
Other (personal) websites/blogs	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐

Other preferred sources? Please elaborate:

24. How would you prefer to receive new winemaking/growing information from Plant and Food Research and the university research programmes with whom they work?

	Won't use	Tolerable	Neutral	Good	Preferable
Personal email	☐	☐	☐	☐	☐
Personal phone call	☐	☐	☐	☐	☐
Face-to-face meeting	☐	☐	☐	☐	☐
At a conference/event	☐	☐	☐	☐	☐
Website/online newsletter	☐	☐	☐	☐	☐
Print newsletter	☐	☐	☐	☐	☐
Facebook	☐	☐	☐	☐	☐
Twitter	☐	☐	☐	☐	☐
Via others in my network	☐	☐	☐	☐	☐
Mobile device application	☐	☐	☐	☐	☐

25. Ideally, how would you prefer to learn about new winemaking/growing research?

26. Ideally, how would you prefer to find winemaking/growing information to solve specific problems or answer specific questions? If same as answer to previous question, please simply write "same as above."

27. What are your biggest frustrations in accessing winemaking/growing information?

	Not a concern	Mildly frustrating	Moderately frustrating	Very frustrating	Actively impeding
Too many sources	☐	☐	☐	☐	☐
Not enough sources	☐	☐	☐	☐	☐
Can't find what I need	☐	☐	☐	☐	☐

Takes too long to find what I need	☐	☐	☐	☐	☐
Sources provide conflicting information	☐	☐	☐	☐	☐
Difficult to verify reliability	☐	☐	☐	☐	☐
Sources are difficult to read or understand	☐	☐	☐	☐	☐
What I need is buried in not-useful info	☐	☐	☐	☐	☐
Information is in a language I don’t speak/read	☐	☐	☐	☐	☐

Other frustrations? Please elaborate:

28. When you find conflicting recommendations across multiple sources, what do you do? (Choose all that apply.)

- ☐ Trust the source I think is most reliable and ignore the other(s)
- ☐ Use my past hands-on experience to identify the most reliable information
- ☐ Use trial and error or experiment to gather my own data
- ☐ Ignore all of the conflicting information and keep doing what I’ve been doing
- ☐ Consult with a peer
- ☐ Consult with an expert (extension, university/institution researcher, etc.)
- ☐ I’ve never had this problem
- ☐ Something else (please elaborate):

29. What is the single most important factor influencing how trustworthy or reliable you find an article of scientific growing/winemaking information?

☐ Reputation of the author (i.e. article is written by Dr. Richard Smart)

☐ Reputation of the researcher (i.e. I trust research from Dr. Marc Greven)

☐ Reputation of how I learned about the information (i.e. I trust information from NZ Winegrower magazine, information was shared by a knowledgeable colleague)

☐ Personal relationship with the researcher (i.e. I know Dr. Greven personally)

☐ Personal relationship with how I learned about the information (i.e. worked successfully with the Marlborough Research Centre before, information was shared by a friend)

☐ Information/recommendations are coherent with what I already know

☐ All sources seem equally trustworthy to me

☐ Other (please elaborate):

Demographic questions

30. In what region is your winery or vineyard?

31. How long have you been in the winemaking/growing industry?

☐ < 5 years

☐ 5-10 years

☐ 10-15 years

☐ > 15 years

32. Which of the following categories includes your age?

☐ < 30

☐ 30-40

☐ 40-50

☐ 50-60

☐ > 60

19. Which of the following best describes your job title? (Choose all that apply.)

☐ Winemaker or assistant winemaker

☐ Viticulturist/grower or assistant grower

☐ Winery technician (oenologist, etc.)

☐ Other assistant

☐ Other (please elaborate):

20. What is your level of formal winemaking/growing education?

☐ No formal winemaking/growing education

☐ Certificate or post-graduate diploma

☐ Bachelor's degree or equivalent

☐ Master's degree or equivalent

☐ PhD or equivalent

21. If you had a career prior to entering winemaking/growing (or if you currently have a

second career in addition to winemaking/growing), what was/is it?

22. What languages do you speak or read?

Supplemental survey data from New Zealand winemakers and winegrowers

An online survey distributed to winemakers and growers across New Zealand provided a measure of reassurance that responses elicited in interviews had not systematically missed some segment of the population. The survey also included several questions of special relevance to the organizations which directly (the New Zealand Sustainability Dashboard) and indirectly (New Zealand Winegrowers) provided funding and access to members-only materials for the study. Only data relevant to the main arguments of this , supplemental to the discussion of New Zealand interview data in chapters four and six, are summarized below.

Figures

Tables

Introduction

This report summarizes findings from an online survey distributed to winemakers and growers across New Zealand, employed to complement data from 29 semi-structured interviews with 32 winemakers and growers in Hawke's Bay (8), Marlborough (11), and Central Otago (10) (see Figure D.1). Five work at companies certified under BioGro, two at companies certified under Demeter. Participants were diverse in gender, age, nationality, years of experience, and educational background. Most interviews were about one to two hours long (one was substantially shorter, two substantially longer). The survey and semi-structured interviews broadly concerned how winemakers and growers make use of information resources, how scientific information is useful and relevant to them, and how communication systems could improve.

Figure D.1. Map of New Zealand depicting major wine producing regions, including Marlborough, Hawkes Bay, and Central Otago where interviews were held. By Mick Stephenson, based on original by Plamen Georgiev, reproduced from https://commons.wikimedia.org/wiki/File:New_zealand _wine_map.gif under a Creative Commons 3.0 license.

Specific questions about SWNZ and sustainability were included in that larger context but were not themselves the focus of the interviews. Because these were included to provide data for other parties and were not immediately relevant to this study, those data are not addressed here.

Method

An online survey, hosted on FluidSurveys™, employed a combination of multiple choice and free response questions. Preliminary testing by several members of the wine industry unconnected with the study region suggested that the survey took approximately ten to fifteen minutes to complete. The survey was distributed via a link in an email newsletter distributed to New Zealand Winegrowers members and via personalized emails to all wineries whose email addresses were available online, following links from the New Zealand Winegrowers website or regional wine association websites. 315 wineries appeared to have successfully received emails, noting that many winery's email addresses were non-functional or unidentifiable. Two personally addressed emails were sent to each address, plus a third final, general reminder sent to all addresses in aggregate. Wineries were not contacted personally when any of the following was true: no email address was listed on the winery's website; the listed email address was faulty; the contact had already participated in an interview for this study; the contact had refused to be interviewed for reasons other than being unavailable (i.e. had indicated unwillingness or hostility about participating in the project); the winery's website indicated that the winery has neither a winemaker nor a vineyard manager (i.e. purchases grapes from other growers and uses a contract winemaking service); the "winery" is a label of another winery/winemaker who received the link via an email address associated with a different winery. These conditions – and in particular the large number of New Zealand wineries who rely on purchased grapes and contract winemaking facilities and therefore have neither winemaker nor grower on staff – account for the discrepancy between the 315 emails sent and the approximately 800 member wineries of New Zealand Winegrowers.

Emails were addressed specifically to the winemaker or winegrower when that person's email and name were available, or more generally to the winery staff when necessary. Emails requested responses from any winemaker or grower in a decision-making position. While junior staff members with fewer years of experience in the industry may have been bypassed as a result (see Table D.1, below), responses were requested from decision-makers in an effort to understand the attitudes of people able to decide how scientific information they encountered would or would not be put into practice.

The survey and interviews were introduced as a component of the author's PhD research at the University of Otago, expressly with no mention of affiliation with the direct (New Zealand Sustainability Dashboard) and indirect (New Zealand Winegrowers) funding organizations or their affiliate programs (Sustainable Winegrowing New Zealand or WiSE, the Sustainable Winegrowing New Zealand industry assessment platform) to avoid gathering more or fewer responses from individuals with strong feelings about either of these organizations, a source of systematic bias which interview responses suggested might be a problem. The project and interview topic were advertised broadly as about "information resource use" and "scientific information."

73 responses were received for a response rate of 23 percent, calculating from the

tally of emails that reached their destination. This is comparable to the 24 percent response rate Boshoff (2014) obtained in his survey of South African winemakers and, while low compared with desired or expected rates cited for surveys of general populations (Rindfuss et al., 2015), winemakers and winegrowers are a challenging population with busy and unpredictable schedules. Moreover, indications from industry organizations, interviewed industry members, and emails received in response to the survey invitation all pointed to endemic survey fatigue within the New Zealand wine industry population, which has been subject to numerous government, industry (and a few academic) information-gathering initiatives over the past several years. The degree to which responses were representative of the larger population in terms of age, gender, education, years in the industry, or other demographics was impossible to judge, as demographic information for New Zealand winemakers and winegrowers is not available (New Zealand Winegrowers, personal communication, November 2014).

Responses were collected and analyzed with the aid of the FluidSurveys™ platform and Microsoft Excel. Short answers to free-response questions were thematically coded via iterative, inductive reading for the purpose of summarizing the common threads across idiosyncratically worded responses. Each free response was assigned one, multiple, or no codes as appropriate with no weighting given to signify main versus subordinate themes: if a response to the question "In a few words, what makes research relevant to you?" mentioned both specificity to small growers and including growers outside of Marlborough, it was assigned the codes "useful for small growers" and "not just Marlborough."

Key findings

The complete unavailability of current demographic data describing New Zealand winemakers and wine growers (New Zealand Winemakers recounted not collecting these data; personal communication, November 2014) made it impossible to compare the characteristics of respondents against the larger population. Consequently, survey responses cannot be read as representative or as reflecting the quantitative prevalence of attitudes or behaviors in the population. In the scope of the larger study, the survey was designed to ensure that interviews – which enabled collecting far more detailed data, but which were necessarily limited to fewer respondents in a smaller geographical area because of time and funding constraints – did not systematically miss important sets of attitudes held by some members of the community. The inclusion of survey respondents from all New Zealand wine producing regions and including a balance of ages and job descriptions suggests that the scope, though not the prevalence, of winemaker/grower characteristics has been captured (Horst, 2013). Together with interview data (included in chapters four and six), this represents a qualitative investigation of the range and scope of winemaker/grower behaviors and attitudes.

Demographics

Responses came from winemakers and growers in all of New Zealand's wine producing regions (Figure D.2). Some industry members work in multiple regions, but respondents were asked to select the single region with which they most identify. Central Otago appears to be notably overrepresented and Marlborough underrepresented, considering that Marlborough produces nearly 80 percent of New Zealand wine by volume.

However, Central Otago is home to a relatively large number of small and "lifestyle" wineries, while Marlborough's volume is produced by a relatively smaller number of larger wineries. 59 emails were sent to facilities in Central Otago and 70 emails to facilities in Marlborough. Central Otago winemakers and growers may also have been more inclined to respond due to feelings of local sympathy with the University of Otago.

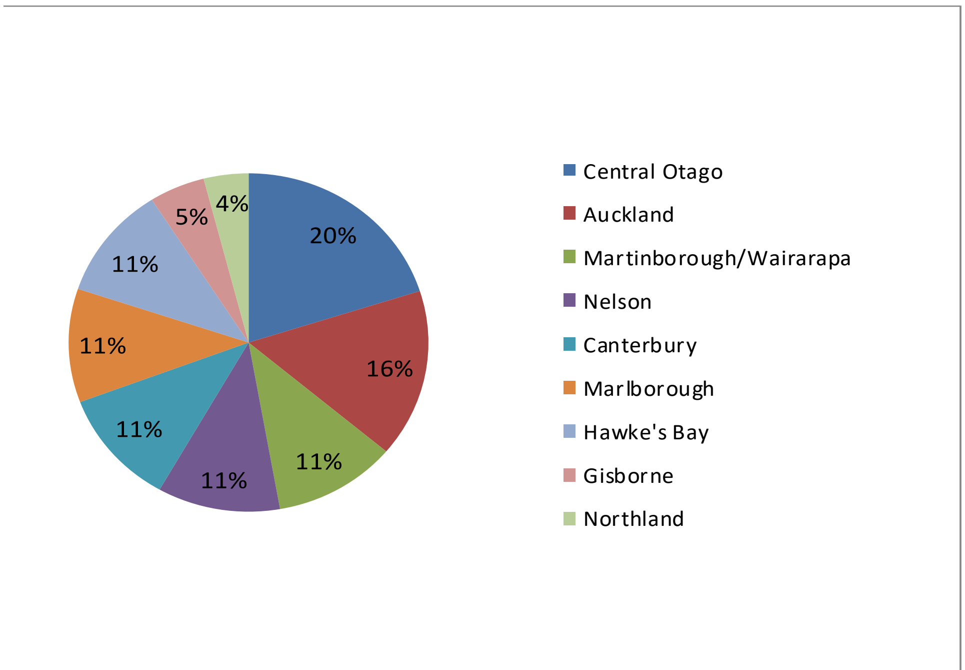


Figure D.2. Survey respondents by primary location in which the respondent works

Responses were received from both winemakers and growers, including some who own their own operations and some who are employed by others (Table D.1). Some respondents also identified as being both winemakers and growers. Again, while no demographic information is available about the age of individuals populating the industry as a whole, survey responses were not obviously skewed toward any one age group.

Table D.1. Characteristics of survey respondents – Job description and age.

Job description	**Percent of respondents**	**Age (years)**	**Percent of respondents**
Winemaker	46	< 30	5
Grower	42	30-40	19
Owner	56	40-50	25
Technician	8	50-60	29
		>60	22

Respondents were likewise distributed in their years of formal wine education, their formal education in any field, and their years of experience in the wine industry (Table D.2). That most respondents (83 percent) had at least ten years experience in the industry and 51 percent were over age 50 may be an effect of the survey being directed toward head winemakers and growers or whomever was responsible for making decisions about winemaking and growing practices at the operation and therefore bypassing junior staff members.

Table D.2. Characteristics of survey respondents – Education and experience.

Formal wine-related education	%	Formal education in any field	%	Years of wine industry experience	%
None	21	Less than high school	2	< 5 years	3
Short courses	13	High school diploma	8	5-10 years	14
2-year degree	36	2-year degree	21	10-15 years	40
4-year degree	30	4-year degree	59	> 15 years	43
		Post-graduate degree	11		

Information-seeking behaviors

Responses to multiple-choice questions suggest that most winemakers and growers look for new job-related information regularly – a majority at least once a month (Table

D.3) – and that they are broadly interested in general browsing, solving problems, learning about established practices, and investigating new research (Table D.4). Interview responses reinforced that the majority of industry members enjoy learning about their work, with several pointing out that the wine industry is about passion and there was no reason to be doing their job – notoriously laborious, dirty, risky, tiring, and poorly paying but personally and socially rewarding – if they were not passionate about the industry and interested in learning about it.

Table D.3. Reported frequency of and satisfaction with information-seeking.

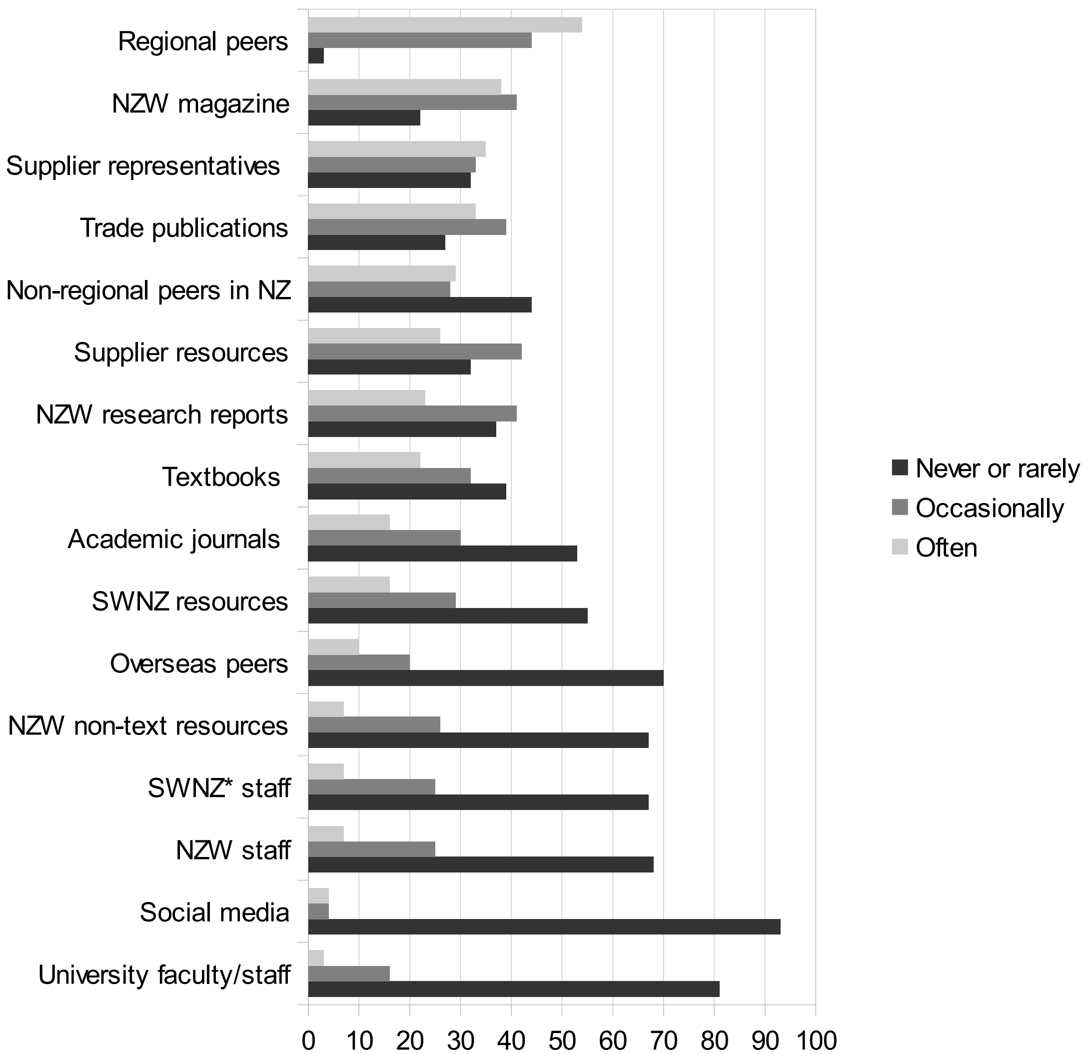
How often do you look for new winemaking/growing information?	**%**	**Do your current strategies work well for you?**	**%**
Daily	17	No	85
Monthly	45	Yes	15
Several times per year	32		
Less often	7		

Table D.4. Reported frequency of information-seeking for specific purposes

In seeking new information, how often is your goal...	Never	Rarely	Occasionally	Often
General browsing	1	11	42	45
Learning established practices	3	25	44	29
Solving a specific problem	0	16	45	39
Learning about new research	6	19	49	26

Preferred information resources

How winemakers and growers go about that continuing education is more varied.



*Sustainable Winegrowing New Zealand, a program of New Zealand Winegrowers responsible for administering the national industry sustainability guidelines.

Figure D.3. Responses to “How often do you use the following types of resources to learn about or find new winegrowing/making information?”

Most rely heavily on their near neighbors or their peers within New Zealand, but a notable minority draws regularly on an international community. That minority is likely to include both employees of international companies, who can count employees of their sister wineries overseas as regular contacts, as well as "flying winemakers" (Giuliani & Bell, 2005; Mueller & Sumner, 2006) who work as consultant winemakers in multiple countries at different times of the year. Respondents indicated an overwhelming preference for obtaining information from traditional print sources rather than social media or New Zealand Winegrowers' non-text resources – online videos and an online interactive disease response decision-making tool (Figure D.3). Notably, the New Zealand Winegrowers magazine and other trade publications were read occasionally or often by approximately 80 percent and 70 percent of winemakers and growers, respectively, suggesting that these are key resources via which industry members learn about research.

Asked what first comes to mind when they think about winemaking/growing information resources, respondents' free associations confirm that New Zealand Winegrowers is a prominent source of information. 48 percent mentioned New Zealand Winegrowers in their free responses, while 12 percent each mentioned their peers and academic or trade publications, ten percent each mentioned specific research institutions or suppliers, and 8 percent mentioned Google.

Frustrations with seeking information

Respondents reported greatest frustration over being unable or needing to take too long to find information; being overwhelmed by the quantity or quality of information was a comparatively minor concern. Across various open-ended text responses, respondents

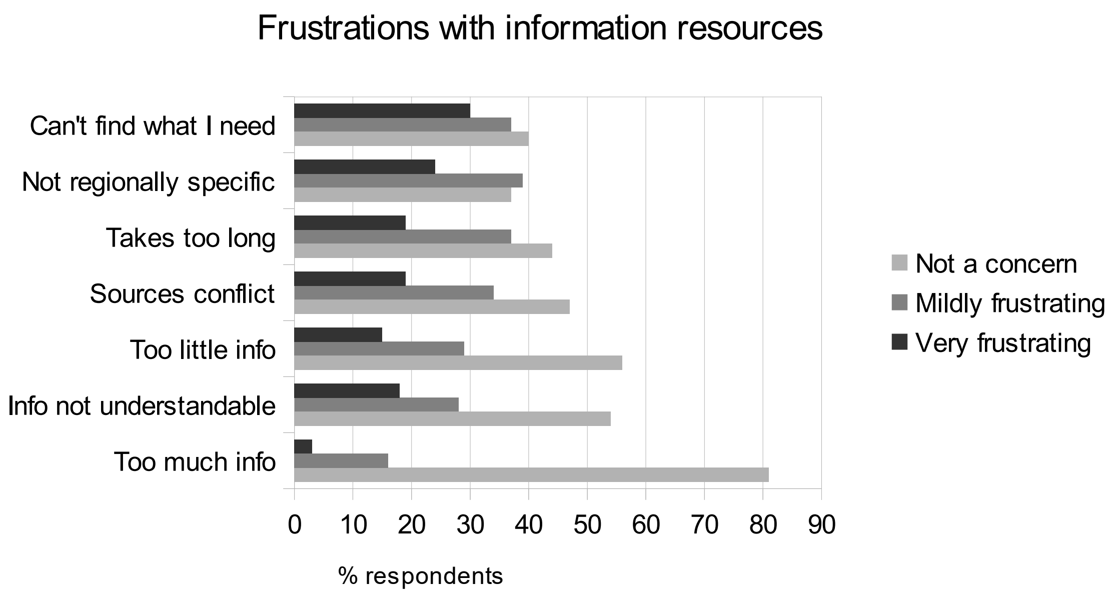


Figure D.4. Percentage of total respondents reporting specific frustrations with information resource use

also indicated frustration with perceived undisclosed biases behind research information, with paywalls blocking access and the high cost of scientific articles, with seemingly repetitive research, and with irrelevant research not inappropriate to the respondent's region, focused on large growers, or not focused on quality.

When asked, “In a few words, how would you ideally prefer to find help when you need it?” respondents' free responses made some reference to online resources 43 percent of the time. 22 percent mentioned their peers, 18 percent mentioned scientists or other recognized authorities outside of their peers, and 4 percent mentioned workshops. 18 percent described some kind of searchable, free, comprehensive, full-text, online resource aggregator that would provide a hub for resources that are currently scattered across many sites and/or located behind paywalls: “have a central NZ wine/viti research database;” “go to a search engine that sorts multiple info sources: trade, industry magazines, websites, books, etc.;” “ideally, there would be a worldwide winepedia type resource which would be continually updated and added to where I would find an amazing selection of articles all pertaining to the exact topic I am searching, with a translator application...haha.” While a few comments had an easily-detected ironic tone, all of these “aspirational” responses spoke to the desirability of some kind of online resource that made web-based information searches faster, more complete, and free. Interviews and surveys both reflected New Zealand winemakers' frustration with being unable to access the full text of peer-reviewed journal articles due to publishers' prohibitively high paywalls, and with the difficulty and labor-intensivity of finding high-quality industry-relevant information online. Several specifically mentioned their appreciation – and, at times, their envy – for the information that they perceive is available to their Australian counterparts via the Australian Wine Research Institute.

When asked to provide free responses to the question, “What makes research relevant to you?” 25 percent mentioned that relevant information is practical and 20 percent that it is specific to their individual needs or values. Smaller numbers of responses – four to seven percent in each case – mentioned that relevant information is focused on quality wine production, that it has some kind of economic benefit, that it improves their understanding, that it is useful for small growers, or that it is not specifically addressed only to the

Marlborough industry.

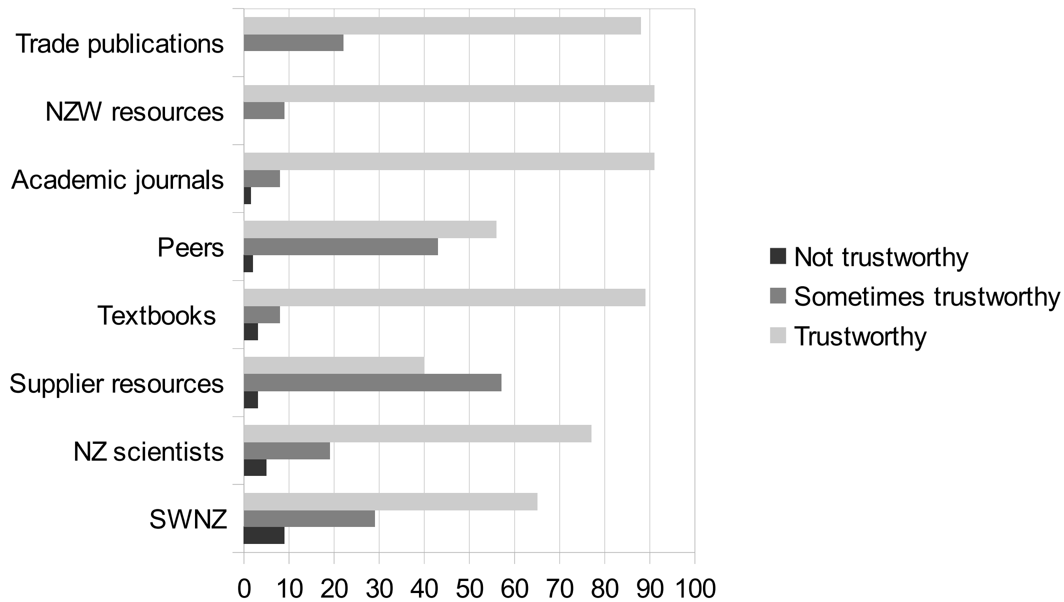


Figure D.5. Survey responses to the question, “How trustworthy do you find the following sources of information?”

Perceived trustworthiness of resources

Respondents were not unequivocally trusting of their peers or of suppliers, but tended to express strong trust in resources which in some way carry the imprimatur of the scientific community. Importantly for the rest of this study, New Zealand Winegrowers resources appear to garner high levels of trust from the winemaking and growing community.

Conflict amongst resources

Most respondents indicated that, when faced with conflicting information from multiple resources, they either rely on hands-on experience (70 percent) or consult with someone they consider an expert (66 percent). Fewer indicated that they would trust the most reliable source and ignore the others (28 percent), use trial and error (37 percent), or that they had never had this problem (7 percent).

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