Vernacular Knowledge and Water Management – Towards the Integration of Expert Science and Local Knowledge in Ontario, Canada

Abstract

Complex environmental problems cannot be solved using expert science alone. Rather, these kinds of problems benefit from problem-solving processes that draw on 'vernacular' knowledge. Vernacular knowledge integrates expert science and local knowledge with community beliefs and values. Collaborative approaches to water problem-solving can provide forums for bringing together diverse, and often competing, interests to produce vernacular knowledge through deliberation and negotiation of solutions. Organised stakeholder groups are participating increasingly in such forums, often through involvement of networks, but it is unclear what roles these networks play in the creation and sharing of vernacular knowledge. A case-study approach was used to evaluate the involvement of a key stakeholder group, the agricultural community in Ontario, Canada, in creating vernacular knowledge during a prescribed multi-stakeholder problem-solving process for source water protection for municipal supplies. Data sources – including survey questionnaire responses, participant observation, and publicly available documents – illustrate how respondents supported and participated in the creation of vernacular knowledge. The results of the evaluation indicate that the respondents recognised and valued agricultural knowledge as an information source for resolving complex problems. The research also provided insight concerning the complementary roles and effectiveness of the agricultural community in sharing knowledge within a prescribed problem-solving process.

Keywords

Vernacular knowledge, stakeholder networks, collaborative decision-making, agriculture, Ontario

1 Introduction

Many environmental problems involve competing financial, institutional, political, social and technical considerations (Wynne, 2002; Turner, 2004). This is especially true in the domain of water (Fish et al., 2010). These kinds of problems cannot usually be solved using expert science alone. Efforts to use expert science exclusively to manage complex water and environmental problems have led to outcomes that have been ineffective or, in some cases, tragic (O'Connor, 2000a). An alternative that has been proposed is a collaborative problem-solving approach through which diverse stakeholder interests negotiate solutions (Yaffee and Wondolleck, 2000; Innes and Booher, 2010). Collaborative approaches for managing natural resources have been documented around the world, including in Australia, Europe and North America (Leach, 2006; Blackstock and Richards, 2007; Taylor et al., 2012). Despite support in the theoretical literature, the application of collaborative approaches to complex environmental problems has had mixed success. For example, it has been reported that state actors have stymied the efforts of stakeholders to participate in collaborative activities such as the creation and sharing of knowledge (Pahl-Wostl et al., 2011; Taylor et al., 2012). In this paper, the focus is on the efforts of a stakeholder group, and the supporting role of its stakeholder network, to become more substantively involved in a multi-stakeholder problem-solving process.

Collaborative approaches are important in the environmental domain because they can serve as a forum in which stakeholders can share information and concerns, both of which are necessary for challenging and changing entrenched positions, and for reaching compromise in order to resolve complex problems (Falkenmark, 2007; Fish et al., 2010; Lemos et al., 2010). Indeed, the reaching of consensus, or at least acceptance, forms a frequently critical requirement for long-term success. Evidence from numerous settings suggests that the outcomes of such collaborative forms of problem-solving are more likely to be accepted and implemented by stakeholders (NRC, 2000; Yaffee and Wondolleck, 2000). An important function of collaborative forums is integrating expert science with local knowledge, and community beliefs and values (Lee, 1993; O'Riordan and Rayner, 1993; Fischer, 2000). Deliberative processes facilitate the co-production of 'vernacular' science or knowledge through the discussion of problems and the negotiation of solutions (Orr, 1991; Lach et al., 2005; Bartel, 2013). In this context, the term 'vernacular' knowledge refers to knowledge that results from the integration of expert science and local knowledge with community beliefs and values (Fischer, 2000; O'Riordan and Rayner, 1993; Lach et al., 2005).

Solutions to complex problems are increasingly being negotiated by members of stakeholder networks (Crossley, 2010; Fish et al., 2010; Brummel et al., 2012). Such networks are formed by members of a stakeholder group; in this context, we use the term 'stakeholder group' to refer to a group of interdependent persons who typically have a mutual understanding and shared vision concerning some activity or interest (Stoker, 1998; Paquet, 2001). As a consequence, the individual members of a stakeholder group may be part of multiple overlapping networks because of their related, but individual, activities and interests (Crossley, 2010; Wood et al., 2014). For instance, a network may include different individuals who have a common interest in some activity such as farming, although some of the members may not be farmers themselves (e.g., merchants). In many cases, they promote communication and information-sharing internally and externally at different scales and across boundaries (Paquet, 2001; Peters and Pierre, 2004; Reed and Bruyneel, 2010). This is achieved through the interaction of individuals working at different scales (e.g., local, regional, national) in different sectors (e.g., government, industry, public) and who may be located within or outside a particular network. Networks also provide an opportunity for stakeholder groups to share information and to promote increased understanding about particular circumstances and concerns of their members (Chambers, 1983; Tsouvalis et al., 2000; Wood et al., 2014). As a consequence, networks can facilitate the sharing of the knowledge, beliefs and values within collaborative problem-solving processes.

Given the important role that stakeholder networks increasingly play in collaborative forms of water problem-solving, two key questions arise: First, what factors influence the creation and sharing of vernacular knowledge within multi-stakeholder water problem-solving processes? Second, what factors contribute to the success of a stakeholder network in sharing its knowledge within a multi-stakeholder, water problem-solving process? In this paper, these questions are addressed through a case study involving a multi-stakeholder process designed to increase the safety of drinking water in Ontario, Canada. The paper begins with an overview of the theoretical and empirical literature concerning the role of stakeholder networks in collaborative approaches to problem-solving. The background and methods for the case study are then presented. Next, data from the case analysis are brought to bear on the two questions noted above, with findings considered within the context of the literature. The paper concludes with several selected reflections on the relevance of the method and the findings for water researchers and practitioners.

1.1 Stakeholder networks and collaborative forms of problem-solving

Solutions for environmental problems traditionally have emerged from a risk-analysis approach using expert (e.g., objective and quantitative) science that has been generated using a process separated from the everyday concerns of the community (Wynne, 2002; Jasanoff, 2003; Dilling, 2007; Renn, 2007b). There is growing consensus that a traditional risk-analysis approach is poorly suited for dealing with complex problems involving the environment and risk, in the context of competing needs and demands. Complex problems are often described as "quasi-scientific" because expert science alone is not enough for making competent decisions (Turner, 2004). To illustrate, the traditional risk analysis approach is ill-suited to addressing what constitutes a tolerable risk from a societal perspective (Renn, 2008). A commonly cited example is the decision by state scientists to ignore local knowledge in Cumbria, England, following the Chernobyl disaster, a decision that contributed to the subsequent collapse of sheep farming in the region (Wynne, 1996). In the same vein, excluding the community from the water supply management problem-solving process in the Tamil Nadu Region of India resulted in over-extraction of groundwater resources and severe impacts on the long-term availability of drinking water (Nayar, 2006). These examples show why complex problems have proven to be challenging to solve: traditional risk-analysis approaches have difficulty conceptualising and incorporating local knowledge and societal beliefs and values – which are typically qualitative and subjective in nature (Jasanoff, 1998; Slovic, 1998).

Collaborative approaches to problem-solving have been proposed in the literature as an alternative to traditional risk analysis. These approaches pertain to the manner in which "actors influence environmental actions and outcomes" (Lemos and Agrawal, 2006: 298). They provide deliberate forums within which scientists, state and non-state actors can engage in problem-solving that incorporates the concerns and knowledge of stakeholders related to complex environmental problems (Ravetz, 1999; Renn, 2008; Raymond et al., 2010). Nowotny et al. (2003:192) envision this forum as an 'agora' – a mixture of the political arena and market place – in which competing experts, their associated institutions, and various public interests discuss and negotiate knowledge as part of the problem-solving process. Such collaborative efforts are beneficial for challenging and changing entrenched stakeholder interests and positions, and for gaining the acceptance of compromises and trade-offs that are necessary for good problem-solving (Falkenmark, 2007; Fish et al., 2010; Lemos et al., 2010). Collaborative approaches are now commonplace in water management and governance around the world (Margerum and Robinson 2015).

An important part of a collaborative approach is integrating expert science and local knowledge with societal beliefs and values during the problem-solving process (Lee, 1993; O'Riordan and Rayner, 1993; Fischer, 2000; Lach et al., 2005). This can allow stakeholders to co-produce 'vernacular' science or knowledge, as problems are deliberated and solutions are negotiated by stakeholders (Orr, 1991; Lach et al., 2005; Bartel, 2014). The co-production of vernacular knowledge is important for three reasons. First, the process promotes greater involvement by involving the community in the deliberation and negotiation of the knowledge that will be used in developing and implementing solutions for complex problems (Lach et al., 2005; Wagner, 2007). Second, the process helps to mitigate power differentials among actors by encouraging the discussion of value-based issues through reasoned debate and negotiation (Schusler et al., 2003; Reed and McIlveen, 2006; Innes and Booher, 2010). Third, the process encourages the community to participate in a discourse that can generate a mutually acceptable and locally relevant source of knowledge that can form the foundation for the development of solutions to complex problems (Lach et al., 2005; Wagner, 2007). In this way, stakeholders are encouraged to share their multiple knowledges or ways of knowing (historical, contextual, scientific) (Schusler et al., 2003; Carr, 2004) and their associated beliefs and values (Ravetz, 1999; Innes and Booher, 2010). Although the movement to a collaborative approach is ongoing (Pahl-Wostl et al., 2011), there are some examples of how this transition is progressing. For instance, Navar (2006) describes how involving the community in problem-solving processes has led to the development of more economically and environmentally sustainable local groundwater management solutions. Similarly, local and provincial farm organisations have contributed local knowledge that has been important for the development of municipal groundwater protection efforts (Simpson and de Loë, 2014).

In light of these characteristics, collaborative approaches for environmental problems typically require the substantive involvement and contribution of state and non-state actors (Lemos and Agrawal, 2006: Ansell and Gash, 2007). This level of involvement is well beyond consultation where technical experts provide information to stakeholders. Rather, it requires a level of involvement that enables actors to acknowledge their interdependence, recognise shared goals, and perceive themselves as part of the process for finding and implementing solutions (Yaffee and Wondelleck, 2000). Although such involvement is time-consuming, experience with collaborative processes has demonstrated that stakeholders involved throughout the development and implementation of outcomes are more likely to have understood the need to accept and take action proactively because they have viewed problem-solving process and outcomes as fair (NRC, 2000; Yaffee and Wondelleck, 2000; Lemos et al., 2010).

Complex problems are increasingly deliberated and negotiated within stakeholder networks composed of state and non-state actors (Fish et al., 2010). These networks overlap and are composed of inter-dependent members who share multiple knowledges (Wellman, 1979; Crossley, 2010; Brummel et al., 2012). Stakeholder networks can promote communication and encourage cooperation between stakeholders, individually and collectively, concerning issues that span vertical and horizontal scales and cross- administrative, physiographic and political boundaries (Paquet, 2001; Peters and Pierre, 2004; Reed and Bruyneel, 2010). Networks can be formally created in a top-down fashion through regulation, with a prescribed number and affiliation of members, or they can emerge informally from bottom-up efforts (Yaffee and Wondelleck, 2000; Bogason and Zølner, 2007). An example of a formal top-down approach includes the creation of river basin councils in Brazil (Lemos et al., 2010), which contrasts with the locally constituted Landcare groups in Australia that have emerged in an informal manner (Wilson, 2004). Even where a formal network structure has been prescribed, informal networks can still form around, and augment, the formal structure (Robins et al., 2011). Further, establishing prescribed procedures for cooperation and collaboration, even within a very detailed plan, will not prevent the emergence of informal relationships around the formal structures (Robins et al., 2011). The formation and participation of stakeholders in formal and informal networks has been promoted as a means to help to achieve "socially valued outcomes" that meet the needs of both state and non-state stakeholders, by encouraging "the development of a network society" involving decentralised organisations (Lockie, 2006: 23) that can contribute to the development of knowledge and expertise.

Stakeholder networks can influence collaborative problem-solving forums in two ways. The first involves supporting the formal goals and objectives of the problem-solving process (Ivey et al., 2006). This is important from the perspective of the agency that is organising the problem-solving process, particularly where there is a prescribed budget, scope and timeline. The second involves the development and incorporation of stakeholder interests into the problem-solving process (Yaffee and Wondelleck, 2000; Ivey et al., 2006). Although this latter form may at times be in conflict with the former, particularly from a functional perspective, it exists and is a major reason for stakeholders to become involved in collaborative governance (Tsouvalis et al., 2000; Mitchell, 2005; Innes and Booher, 2010). As an example: it is expected that citizens have a right to question scientists and the scientific information they generate, as well as a right to provide alternative sources of information (Susskind et al., 2007). For instance, farmers have contested knowledge that was inconsistent with their own understanding, and have discounted forms of innovation when they believe their concerns and knowledge have not been incorporated (Tsouvalis et al., 2000). However, both roles can be nurtured by building stakeholder capacity and expertise (Carolan, 2006: Ivey et al., 2006), promoting outcomes that are more robust because stakeholders have worked collaboratively to achieve them (Haque et al., 2009; Innes and Booher, 2010).

The main focus of farming throughout history has been to increase agricultural production to provide food and other products to meet the demands of a growing population (Mazoyer and Roudart, 2006; Tauger, 2011). Farmers have achieved this, in part, by becoming members of networks through which they access knowledge and other services (Wood et al., 2014). More recently, farming in

Western economies has begun to transition into a 'post-production phase' where agricultural production must be both economically and environmentally sustainable (Jones and Garforth, 1998; Holmes, 2006). Although the theory and practice of sustainable farming and agricultural extension are still evolving (Cleveland and Solari, 2007; Wood et al., 2014), farmers and farm organisations are increasingly participating in the production of knowledge as part of environmental problem-solving (Tsouvalis et al., 2000). One aspect of this evolution is what Chambers (1983: 201) calls a "reversal in learning" where the "farmer must educate the outsiders". Outsiders include environmental scientists and members of environmental non-governmental organisations, who are largely urban-based, and who, like the growing urban majority of the population, are increasingly separated from where their food comes from and how it is produced (Turner, 2011). This disconnect has been identified as a particular problem when practice-oriented individuals such as farmers have interacted with those who are (Tsouvalis et al. 2000: 914) described as "office type people", individuals who have little or no idea of how a regulation or technological innovation will impact affected communities. As a consequence, the sharing of knowledge by farmers has been accomplished by forming or participating in networks through which they are in contact with other stakeholders involved in collaborative processes (Fish et al., 2010; Wood et al., 2014).

1.2 Source water protection in Ontario and the role of the farm sector

Source water protection (SWP) is a process for ensuring water resources that form the basis for potable human water supplies are not degraded by land-use activities (Patrick et al., 2008). Fundamentally, SWP is an example of a complex environmental problem for which collaborative approaches are well-suited, where alternative courses of action are evaluated, focusing on land and water management practices, often involving competing financial, institutional, political, social and technical considerations (O'Connor, 2002b; Ivey et al., 2006; Patrick et al., 2008). However, SWP efforts have been typically dominated by scientific knowledge and technical expertise (Simpson and de Loë, 2014).

The Walkerton Tragedy in May 2000 is an example of how a complex water-management problem can become a catastrophe. Seven persons died, and several thousand became ill, in the Town of Walkerton, Ontario, when a poorly located municipal water supply was engulfed by run-off from an adjacent farm and contaminated water was distributed throughout the community (O'Connor, 2002a). Justice Dennis O'Connor investigated the causes of the tragedy, and published recommendations concerning the safe operation of water supply systems throughout Ontario. The recommendations were structured around a multi-barrier approach, which included developing watershed-scale source protection plans (SPPs) (O'Connor, 2002a, b).

The Province of Ontario responded by enacting the *Clean Water Act*, 2006 (Province of Ontario, 2006), which provides authority for the Source Protection Planning (SPP) process. This is a form of (SWP) planning implemented through a system of 19 watershed-based entities. These entities are called Source Protection Areas (SPAs) where one watershed is involved, and Source Protection Regions (SPRs) where two or more watersheds are involved. Each SPA or SPR is overseen by a Source Protection Authority formed by the board of local watershed-based conservation authorities. Conservation authorities are municipally funded watershed-based organisations that have been contracted by the Ontario Ministry of the Environment (OMOE) to facilitate the development of SPPs[1] within an SPA or SPR through a collaborative problem-solving process using multi-stakeholder Source Protection Committees (SPC). Each SPC must prepare a Source Protection Plan (SPP) for its watershed(s), in compliance with prescribed requirements concerning the scope, content, timeline, and committee structure (OMOE, 2010). The SPC chairs are appointed by, and are responsible to, the Ontario Minister of the Environment. One-third of the stakeholder members are drawn each from the municipal, business, and public interests, respectively, within the watershed. First Nations' reserves are not subject to the authority of provincial laws such as the CWA. Additionally, from a constitutional perspective First Nations are not "stakeholders" (von der Porten and de Loë 2013). Nonetheless, in recognition of the fact that reserve lands often affect or are affected by neighbouring lands and waters, the SPP process included First Nations' representatives on an SPC where the SPA or SPR contains First Nations' reserve lands. Each SPC also has ex officio members representing the OMOE, and the Source Protection Authority. Administrative and technical support is provided to the SPC by a project manager and administrative and technical staff associated with one or more local conservation authorities from within the SPA or SPR.

Farmers were identified as a key stakeholder group. Although farmers comprise only 2% of the overall population, they own or manage approximately 33% of the land in southern Ontario (OMAFRA, 2012), the part of the province where most of the population and associated municipal water systems are located. As a result, one to three member(s) of each SPC were prescribed to represent the agricultural community in areas where agriculture was classified as a significant local land use. The agriculture sector has supported the concept of SWP from the outset. Provincial farm organisations implemented a process to participate in the SPP process in order to promote consistency between the SPP process and existing programmes that have encouraged economically and environmentally sustainable farming (Armitage, 2001; Bradshaw, 2006; Legislative Assembly of Ontario, 2006). To organise and guide farm-sector efforts, the Ontario Farm Environmental Coalition (OFEC), a stakeholder network that represents 37 farm and commodity organisations concerning agri-environmental matters (Verkley et al., 1998; Morrison and Fitzgibbon, 2014), established a SWP working group. The working group was composed of staff representing four major farm organisations and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). OMAFRA staff members were invited to be part of the working group by the farm organisations, and participated with the agreement of their Deputy Minister. The first author of this publication is one of the OMAFRA programme staff members, and has been a member of the working group since its inception.

The working group recognised the need for agricultural representatives to have capacity to participate effectively in the multi-stakeholder SPC problem-solving setting, and to be seen as legitimate representatives of their local farm community. This is consistent with a growing sentiment in the farming

[1] At the time of the writing of this paper, 22 draft Source Protection Plans (SPPs) had been prepared by 19 Source Protection Committees and submitted to the OMOE for review. Approximately three-quarters of the SPPs have been approved and assigned an effective date by the Ontario Minister of the Environment. It is anticipated that all SPPs will be approved and assigned an effective date by the end of 2015.

community that farmers need to educate the broader public (Tsouvalis et al., 2000) about the science and practice of farming. The OFEC SWP working group prepared a list of qualifications advertised in provincial and local farm publications. A series of meetings was then organised by OFEC and the County Federations of Agriculture throughout Ontario to bring together members of the local farm community to elect agricultural representatives to participate on SPCs. Each Source Protection Authority had been delegated authority under the *Clean Water Act*, 2006 (Province of Ontario, 2006) to select agricultural members for its SPC, and initially opposed appointing locally elected agricultural representatives. However, most (34 of the 37) agricultural representatives elected by the local farm community were eventually accepted by the local Source Protection Authority and were appointed to 15 of the 16 SPCs with agricultural members (VanDusen, 2007).

An important role of the agricultural representative has been to educate other SPC members and staff about farming by sharing a combination of agricultural science and practice, and local farmer knowledge. It was anticipated that this would help SPC members to recognise that municipal drinking water sources could be protected by promoting economically and environmentally sustainable agriculture (Carter, 2005). To support this objective, OFEC secured funding from farm organisations and federal and provincial government agencies, and conducted six workshops to provide support to the agricultural representatives. These workshops included a combination of formal and informal learning activities facilitated by OFEC SWP working group members. The workshops also included presentations by academic, consultant, municipal and provincial government technical experts (OFEC, 2007; OFEC, 2008a, b; OFEC, 2010, 2011, 2012). Each meeting incorporated a facilitated discussion that included the agricultural representatives and OMOE senior management staff members. The workshops were supplemented with frequent teleconference and online discussion sessions concerning topics requested by the agricultural representatives.

The focus in the current study is on how stakeholder networks contribute to collaborative forms of problem-solving, such as the creation and sharing of knowledge. As Bogasan and Zølner (2007) have observed, it is often not clear from the outside what role(s) actor networks play, and how they interact as part of problem-solving processes.

2 Methods

Insights on the creation of vernacular knowledge, and preferences of information sources, during the SPP process were evaluated using a standardised survey questionnaire. Specifically, data were collected concerning SPC members' attitudes regarding the value and uptake of vernacular knowledge within a collaborative multi-stakeholder problem-solving process that began in early 2008. The questionnaire was developed from a review of the literature concerning the role of knowledge in collaborative forms of problem-solving. A draft questionnaire was pre-tested through discussing its content and approach with nine key informants who represented sectors that had a strategic interest and had contributed to the development of the *Clean Water Act*, 2006 (Province of Ontario, 2006) and the SPP process. These people were selected based on their having served directly as a sector representative, or having acted in a supporting role as an agency or NGO staff member, as part of one of the three advisory committees established by the Minister of the Environment during the development of SPP process (OMOE, 2003, 2004a, b). Insights from this process resulted in constructive adjustments to the questionnaire.

Data collected using different research methods as part of the same research question were combined and analysed using the concurrent triangulation approach to mixed methods research (Cresswell, 2003; Johnson and Onwuegbuzie, 2004; Yin, 2009). This approach allowed data to be collected concurrently and with equal priority, and evaluated and analysed in an integrative manner in order to confirm, cross-validate and corroborate research findings (Cresswell, 2003). This helped to ensure comprehensiveness, credibility, reliability and validity of the research process and its findings (Morse, 2003; Teddlie and Tashakkori, 2009). Closed-ended questions used a five-point Likert-type scale to collect ordinal-level data measuring SPC members' perceptions concerning the research themes. Responses to close-ended questions were coded (Strongly Disagree = 1, Disagree = 2, Undecided = 3, Agree =4, Strongly Agree =5), and then analysed to generate descriptive and inferential statistics using SPSS Statistics Version 20.0 (IBM, 2011). The research themes, statistical tests and associated results are discussed in the Results and Discussion section below. Open-ended questions interspersed with closed-ended questions provided respondents with an opportunity to provide specific examples or expand upon ideas related to the closed-ended questions. Responses to open-ended questions were interpreted and categorised in order to understand the perspective of respondents (Babbie, 2001).

An internet link to the online questionnaire was delivered in mid-2011 by email to the 405 members of the 19 watershed-based SPCs, either directly where individual email addresses were known, or indirectly through SPC staff where the email addresses were not known. The internet link to the online questionnaire was also delivered to 30 representatives of organisations that had a strategic interest in, or had been involved with, the SPP process. This included non-governmental actor organisations such as provincial-scale environmental, farm, and watershed management organisations, and three ministries interested and involved in the SPP process in Ontario.

Altogether 211 responses were received, providing an overall response rate of 48.5%. The response rate for individual questions was only marginally lower (on average 39%). This response rate compares favourably with the range of experiences reported for other studies using email questionnaires (Kaplowitz et al., 2004; Gigliotti, 2011).

3 Results and discussion

The study concerns the creation of vernacular knowledge and network participants' perspectives on related information sources in addressing a complex water-management issue. The analysis is organised around two themes: (1) the experience and contribution of SPC members in creating and sharing knowledge, and (2) the perceived value of different information sources.

3.1 Involvement in the creation and sharing of vernacular knowledge

The first theme concerned SPC member involvement with two key components of vernacular knowledge – technical information and local knowledge. Respondents were asked to provide responses to closed- and open-ended questions concerning a series of statements. The closed-ended questions prompted respondents to indicate their level of agreement with each statement on a five-point Likert scale. These statements, the associated response rates (%), and number of responses (N), are presented in Table 1.

Table 1. Questions concerning the co-production of vernacular knowledge.

Sub-theme	Statement	Response (%)					N
		SA	A	N	D	SD	
Sub-theme 1.1 - Providing and discussing local and technical knowledge	SPC members are able to request and receive additional technical information from staff	49.7	45.6	4.1	0.6	0.0	171
	SPC members freely discuss the benefits and limitations of technical information	34.1	51.2	9.4	4.7	0.6	170
	SPC members encouraged to contribute local knowledge	52.4	40.0	6.5	1.2	0.0	170
	The broader community is encouraged to contribute local knowledge	28.8	55.9	13.5	1.8	0.0	170
Sub-theme 1.2 – Integrating, modifying and valuing local and technical knowledge	SPC members are able to collaborate freely to generate locally appropriate solutions	28.1	42.7	19.9	8.8	0.6	170
	SPC members are encouraged to suggest modifications to	20.7	39.6	25.4	13.0	1.2	169

	technical information						
	The problem-solving process incorporates both local and technical knowledge	30.0	50.6	14.7	4.1	0.6	170
	Local knowledge is equally valid and important as technical knowledge	22.5	39.1	24.3	11.8	2.4	169
	Technical knowledge is modified to reflect local knowledge	17.8	39.1	30.8	11.8	0.6	169

The statements and associated responses for Theme 1 are organised into two sub-themes. Sub-theme 1.1 concerns statements related to providing and discussing local and technical knowledge, which are related to the principle of creating and sharing vernacular knowledge. Sub-theme 1.2 concerns statements related to the integration, modification and valuing of local and technical knowledge, which are related to the practice of creating and sharing vernacular knowledge. Both sub-themes are necessary for the creation and sharing of vernacular knowledge. As shown in Table 1, the responses indicate that the majority of respondents supported and participated in the creation and sharing of vernacular knowledge. Indeed, more than 50% of respondents either strongly agreed or agreed with each of the statements presented. However, a closer examination of responses indicates that there is less support for Sub-theme 1.2 compared with Sub-theme 1.1. This observation was tested statistically by comparing the proportions of positive responses (Strongly Agree, Agree) for the two sub-themes using the z test for Comparing Two Proportions (Bererson et al., 1988). A non-parametric test was selected given the ordinal data provided by responses to the Likert-type questions. The test results indicated that two sub-themes were significantly different ($p < 0.001$). This suggests that the respondents' perceived that the activity of providing and discussing local and technical knowledge was significantly greater than the activity associated with integrating, modifying and valuing the creation and sharing of vernacular knowledge. Further, the results suggest that there was significantly greater support for the creation and sharing of vernacular knowledge in principle than in practice.

Open-ended questions asked respondents to share examples of how SPC members have participated in the development or modification of technical information, and to share examples of local knowledge that were provided by SPC members (e.g. personal knowledge about groundwater quality in specific areas). Responses suggested three technical reasons for the reduced perception of activity concerning the co-production of vernacular knowledge from Sub-theme 1.1 and Sub-theme 1.2. The first was that the process for conducting technical work was highly constrained by the OMOE Technical Rules concerning the creation and use of knowledge (OMOE, 2009). As a result, SPC staff and consultants perceived little latitude for modifying the technical information based on the comments and concerns of SPC members. One SPC project manager's response reflected this challenge, noting "at the beginning of the assessment report process SPC members tried to influence the nature of some technical work, but we found that the scope and nature of the technical work was very narrow and that input from the SPC could not be accommodated because of the limitations of the technical rules. The message that I have understood from the province is that the [Source Protection Authority] & SPC have no say in how technical work is done – we must follow the technical rules whether or not they work and whether or not they are relevant to local conditions." A Source Protection Authority representative was more forthright, stating that "due to the scoring of the Technical Rules, SPC members lack the ability to make their input the basis for determining how the decision making process is undertaken."

In some cases, this challenge appeared to have been overcome, as indicated by the survey comments of another SPC project manager, who stated "Our Intake Protection Zone studies were not accepted by the SPC when first presented by the consultant because of strong reservations raised by one SPC member about some of the methodologies used. The study was tabled for nearly a year while SPC members [met] informally with MOE technical staff and the consultants to try and sort out the issues with the methodologies. In the end, staff agreed with the SPC that the current results were indefensible and after 14 months a revised approach/methodology was reached that was acceptable to staff, the consultants and all but the original SPC member who raised concerns." This inflexibility in the prescribed process resulted in some SPC members taking more of a hands-off approach, which was reflected by one municipal representative who stated that "we participated with staff in proving that the sink holes are an issue … [however]… we are not involved in doing the charts, graphs, equations, etc., but we do have input in asking questions on why and how the staff are doing the technical information".

A second explanation was related to the often unspoken assumption in technical circles that expert science is generated using a scientific process, and should not be modified based on local knowledge that is perceived to have been generated using a non-scientific process (Innes and Booher, 2010). For instance, one conservation authority representative noted that "technical information is technical and it would be contrary to the scientific basis of the process for [SPC members] to suggest modifications to the technical information."

However, the generation of technical information often involved making a number of theoretical assumptions that had to be verified to ensure accuracy and reliability (Slovic, 1998; Renn, 2008). For example, the inherent challenge associated with the interpretation of technical knowledge was noted in the comments of a Source Protection Authority representative who reflected that "SPPs are considered science-based by the MOE, however the technical rules go against the recommendations of other scientific studies we have for our groundwater." She expanded on this concern, noting "our recharge area cannot be classified as a significant [groundwater recharge area] due to the [time of travel] outlined in the Technical Rules even though a comprehensive hydrogeological study considers it significant to the quality and quantity of our local drinking water sources."

These sorts of disagreements concerning technical knowledge were overcome by SPC members in at least one instance. For example, one municipal SPC member noted the great deal of effort that was required by SPC members to understand and discuss the "vast array of 'assumptions' that the consultants brought to their respective reports. Staff followed up and a meeting was arranged with all of the consultants. Through extensive discussions, a common set of standards/assumptions were conceived." It is noteworthy that the SPC member who provided this response had considerable expertise in the environmental consulting sector. This status as a technical expert, combined with experience and expertise in negotiating with other experts, may have assisted the SPC member to challenge successfully the assumptions put forward by conservation authority staff and technical consultants.

Third, respondents indicated that technical information was privileged over local information because it is collected by experts rather than by local residents. One public representative raised this point, noting "[the SPC's] decisions that are overruled by the technical people in Toronto. An example of this would be the [Municipal Surface Water Intake Protection Zone] for Ramsay Lake. We did not feel that it was inclusive enough. Our technical staff brought this to Toronto and it was turned down."

Also, one SPC Chair observed that "our committee prefers to act on fact rather than opinion." This was consistent with observations in the literature that local knowledge is often perceived to be less robust than expert science (Montpetit, 2003; Innes and Booher, 2010). Also, there appeared to be some lack of trust in local knowledge particularly on the part of technical experts involved in the process. This was reflected in the response of conservation authority staff associated with two different SPCs who stated that "local knowledge is not always correct and recent and must be confirmed, where possible, before it is used", and, that "scientific technical knowledge should outweigh local knowledge as it is the basis for problem-solving." These comments reinforce claims in the literature that experts often believe other sources of knowledge have less value than expert science (Innes and Booher, 2010).

Three non-technical explanations also emerged from the evaluation that helped to explain the reduction in perception of activity between Sub-theme 1.1 and Sub-theme 1.2. First, not all stakeholders may understand the importance of, or need to question, technical information (Susskind et al., 2007). In this instance, increasing the technical capacity of SPC members to critically assess the validity of technical information was important to ensure it accurately represented what existed in the watershed. One agricultural representative recognised the importance of increasing the technical capacity of SPC members, noting "In most cases the background training offered by [the agricultural sector] has been most beneficial"… because… "[a]fter all one can't possibly know everything on the topics discussed".

The importance of technical capacity for retaining control of decision-making by SPC members was noted by a municipal representative with an extensive technical background who observed that "Our working group held up and required modifications for a report … when not happy with its presentation. We would seldom try to out-technical the experts obviously but when work was not consistent or appeared poorly done we had it changed."

Second, the process had prescribed timelines and other constraints that interfered with the ability of SPC members to adequately and thoroughly review technical information, and to ensure that appropriate changes were made during the problem-solving process. For instance, one public health unit representative observed that the "process appears to be too rushed. When issues are brought forward about wording and the intent comments are made [by SPC staff] that this is wordsmithing and that time has been set aside at the end of the process. This may create a problem that down the road in the final review there may be issues over intent and then [there is] not enough time. The process time should be adequate to discuss issues fully."

An agricultural representative also noted concerns with the prescribed timelines imposed on the problem-solving process, and the creation and sharing of vernacular knowledge, stating "In some cases, because [of] MOE time constraints, local knowledge was not included in the assessment report, not that local knowledge was not sought after and received, just not all used."

Third, in order for stakeholder representatives to be able to understand technical information presented to them by technical experts, they need to be able to internalise and transform that information into knowledge that makes sense within the context of their own beliefs, experiences, and values (Tsouvalis et al., 2000; Michaels et al., 2006). Where stakeholders have knowledge of local conditions, such as farmers who typically have an intimate, and often multi-generational, knowledge of the lands they farm, inconsistencies may be observed between their local knowledge and the technical information that was presented by experts. In this situation, stakeholders will often strive to better understand or modify technical information so that it is consistent with their understanding, to challenge its validity, or ignore it during the problem-solving process (Tsouvalis et al., 2000). Consistent with this perspective, one agricultural representative commented that "Technical working group [SPC members have] had the opportunity to review and question and have changes made to most areas with the exception of livestock density calculations, resulting in bogus numbers being used and submitted."

This suggested that some stakeholder representatives possessed or developed capacity and expertise, which helped them to discuss, and in some cases, resolve inconsistencies in information (Ivey et al., 2006; Carolan, 2006). As a consequence, the OFEC SWP working group members appear to have been correct when they anticipated that the agricultural representatives needed greater capacity and expertise to be able to participate more effectively and question ideas that were inconsistent with their knowledge of farming and the local farm community.

3.2 Relative importance of different information sources

The second theme dealt with the relative importance of information sources during the problem-solving process, and involved responses to one close-ended question and one open-ended question. The close-ended question asked respondents to rate the importance of information sources using the five-point Likert scale. The open-ended question asked respondents to identify specific individuals or organisations that were especially important sources of information. In this instance, non-parametric statistical analysis was used to test for differences between different information sources. The underlying rationale was that different organisations or sectors brought different information to the SPC process, and each would act as a potential information source. The premise was that survey respondents would rate information they found important – and were likely to consider and include it in the problem-solving process – higher than information sources that they judged to be less or not important. The responses to the close-ended questions were analysed using the Kruskal-Wallis test, which compares three or more independent samples of ordinal data (Reaves, 1992; Cramer, 1994). This test is useful for determining whether the difference in the ordinal data from two or more samples is statistically significant (Siegel, 1956; Siebert et al., 2010; Ahmed et al., 2013). In this application, the Kruskal-Wallis test was used to identify information sources (i.e., different organisations or sectors) that were significantly different compared to all other information sources.

The results of the Kruskal Wallis test (Table 2) indicate that the agriculture sector was rated by respondents as the only non-government group that provided information that was identified as significantly different from information provided by other sources. This indicates that the information provided by the agriculture sector was perceived by respondents to be significantly different from all other information sources, as was the information provided by the two provincial ministries (OMOE, OMNR), conservation authorities, and Conservation Ontario, a provincial organisation that represents all 36 conservation authorities.

The organisations or sectors that were determined to be significantly different were then examined for their relative importance to respondents. Table 2 summarises the number, mean value and standard deviation of responses, and the Kruskal-Wallis Test results [Chi-square (x^2) value, and significance level (p) values], for each of the organisations or sectors that was significantly different from other sources. The five organisations or sectors are listed in Table 2 in order of decreasing importance based on the mean value of responses. This ranking indicates the relative importance of the different information sources. Table 2 also indicates the top five receptors of information for each organisation or sector, based on the median score of responses, which are listed in order of decreasing importance. The median score provides a measure of the value that each of the respondents associated with a specific organisation or sector placed on the information from the significantly different sources. Specifically, a score of "1" (Strongly Agree) indicates a greater acceptance of the statement than a score of "5" (Strongly Disagree).

Table 2. Importance of different information sources.

Organisation or Sector	Responses (N)	Mean Score	Standard Deviation	Kruskal Wallis Test		Key Information Receptors	
				X^2	*p*	**Sector**	**Median Score**
OMOE	110	1.52	0.632	34	.000	OMOE	1

				970		OMAFRA	1
						First Nations	1
						Conservation Authority	1
						SPC Chairs	1
Conservation Authority	118	1.48	0.581	34. 683	.001	SPC Chair	1
						Conservation Authority	1
						Public Sector	1
						Municipal Sector	1
						Industry Sector	2
Agriculture	108	1.76	0.735	20. 218	.042	Agriculture Sector	1
						SPC Chair	2
						Public Sector	2
						Industry Sector	2
						Environment Sector	2
OMNR	110	1.98	0.741	8.8 69	.013	OMOE	2
						Environment Sector	2
						Conservation Authority	2
						SPC Chair	2
						Industry Sector	2
Conservation Ontario	96	2.01	0.766	27. 953	.001	First Nations	1
						OMOE	2
						SPC Chairs	2
						Conservation Authority	2
						Environment Sector	2

Overall, the agriculture sector ranked as the third-most influential sector based on the Mean Score for respondent scores summarised in Table 2. The underlying rationale was that the greater the Mean Score of the survey responses, the greater the importance the respondents placed on the information provided by each organisation or sector. The premise was that the higher an information source was ranked, the greater the likelihood the respondent would consider and include that information in the problem-solving process. This is noteworthy because the importance of agriculture was only surpassed by conservation authorities and OMOE, which have both been supported with significant public financial and staff resources for generating and sharing information among SPC members. It is also noteworthy that the information provided by agriculture was rated higher than that provided by Conservation Ontario and OMNR. This result is interesting because these two organisations – Conservation Ontario and OMNR – have also received public funding for communications and technical staff members to support their involvement in the SPP programme.

The data suggested four reasons why the agricultural network was perceived as a key information source. First, responses to open-ended questions suggested that agricultural representatives were recognised by other sector representatives as knowledgeable people who contributed community-specific local knowledge of farming experiences at the local scale. For example, one public representative stated that ”Our agricultural [representatives] in particular frequently provide local knowledge on many topics, including correcting information in draft reports (groundwater quality and threats to groundwater, land use practices, livestock density, nutrient management requirements, etc.)." This perspective was shared by one SPC Chair who noted that "Ag reps have done some groundtruthing and brought observations back to the consultants. Particularly the [agricultural representatives who are] technical working group members who are also committee members." This indicated that agricultural representatives had the capacity and expertise required to share local knowledge about farming practices and related matters. Acknowledgement of this contribution by other sector representatives indicates that the agricultural representatives were able to effectively share local knowledge as part of the problem-solving process.

Second, in the qualitative responses, respondents from different sectors noted that agricultural representatives had challenged some aspects of the prescribed problem-solving process, and had advocated for changes so that local needs were better addressed. One OMOE representative noted one example where local needs were better addressed involving "Re-delineation of [intake protection zones] based on their local knowledge of overland flow and drainage systems that were unknown to technical staff." These observations are consistent with a position in the literature that the community has the right to question scientists and the scientific information they generate, as well as a right to provide alternative sources of information (Susskind et al., 2007). In this instance, the agricultural representatives were able to challenge expert science where it was deemed to be inconsistent with their local knowledge.

Third, local knowledge provided by the agricultural representatives was reinforced actively by farm organisations that were part of the OFEC SWP working group. A public representative observed that "Because they are connected to external organisations, such members often bring or have access to a wealth of knowledge that might not otherwise be known. They also often know who to contact to answer outstanding questions on specific topics." These farm organisations contributed knowledge concerning farming and agricultural science by delivering information through presentations to, and participating in, technical discussions with, SPC members. Another public representative acknowledged the role of the OFEC working group supporting agricultural representatives participating on SPCs, stating "The agricultural representatives seem to be best prepared by outside organisations and seem to serve the interest [of] their members well." One municipal representative supported this conclusion, observing that the contribution of agricultural representatives and external farm organisation representatives has resulted in "the better understanding of nutrient management [regulations] and the agricultural perspective." OFEC SWP working group members also delivered technical information to representatives of networks at the provincial scale (i.e., Conservation Ontario, OMOE), and interacted directly with the SPC Chairs. This was reflected by the identification of the Ontario Federation of Agriculture, the Ontario Cattleman's Association, and the Ontario Farm Animal Council, or their representatives, as key sources of information by respondents.

Fourth, information distributed by OMAFRA complemented the information concerning agricultural science and practices provided by the agricultural community (OMAF, 2012). For instance, responses to close- and open-ended questions indicated that OMAFRA field and programme staff provided expertise at both the SPC scale and provincial scale. OMAFRA programme staff also worked to bridge communication gaps between the OFEC SWP working group, Conservation Ontario and OMOE SPP programme staff, and the SPC Chairs and Project Managers. These efforts were summarised by an OMAFRA field staff member who stated that she "attended three SPC meetings as OMAFRA technical advisor and I was able to provide information on [the Nutrient Management Act]". She added that "by indicating the regulations are looked on the minimum [Best Management Practice (BMP)], the committee decided to use the [Nutrient Management Act] Regulation and recommend BMPs as part of the SPP for those farms not phased in [under the Nutrient Management Act]". These efforts reflected OMAFRA's interest in demonstrating how agricultural regulatory standards and voluntary agri-environmental management practices, which share a common foundation in agricultural science and practice, support the development and implementation of SPP policies across Ontario (OMAF, 2012).

4 Conclusions

Collaborative approaches to environmental problem-solving provide an opportunity for the development of more robust solutions to complex problems, such as the management of water resources (Lach et al., 2005; Lemos et al., 2010). The contribution of stakeholder groups, and the importance of capacity and expertise to enable them to participate effectively in multi-stakeholder problem-solving processes, is an area of emerging interest in the empirical and theoretical literature (Carolan, 2006; Lockie, 2006). The research presented in this paper contributes to this area of inquiry by providing insight concerning the effectiveness of a particular stakeholder group – the agricultural community – to participate and share its knowledge and perspectives on water management as part of a prescribed multi-stakeholder problem-solving process involving 19 watershed-based source protection committees in Ontario, Canada.

The research revealed that the majority of respondents supported, and had participated in, the co-production of vernacular knowledge during the problem-solving process. Interestingly, respondents indicated that they perceived that there was greater activity concerning creation and sharing of vernacular knowledge in principle, compared with its actual practice. This can be attributed to three factors. First, the problem-solving process was constrained by the time available for deliberation, and the type of knowledge that should guide it; these timelines were prescribed by regulation (OMOE, 2009). These constraints reflect the challenges that arise when problem-solving approaches are prescribed for complex environmental problems (Jordan et al., 2005; Lach et al., 2005; Innes and Booher, 2010). Second, there was a prevailing thought on the part of some participants that local knowledge was less valid than technical knowledge, and that modifying expert science to reflect local knowledge was unscientific. This is a concern that others have identified in relation to collaborative processes (e.g., Innes and Booher, 2010), and has been attributed in part to an inertia of some stakeholders to overcome biases towards, and recognising the legitimacy of, local knowledge (Pahl-Wostl et al., 2011). Finally, some of the participants, who had adequate capacity and expertise were able to identify inconsistencies in technical information and were effective in challenging and modifying it so that it was consistent with their local knowledge. This is consistent with experience elsewhere where farmers have contested or challenged information that did not agree with theirs and have provided alternative sources of knowledge (Tsouvalis et al., 2000; Susskind et al., 2007).

The research also indicated that respondents recognised and valued agricultural knowledge as an important information source for the problem-solving process. This was attributed to four factors. First, members of a provincial-scale agricultural network, which included state and non-state representatives, supported the local farm community to elect stakeholder representatives and then helped enhance their capacity and expertise through a series of forums (workshops, email groups, teleconferences). Second, the agricultural representatives challenged expert science where it was perceived to be inconsistent with their local knowledge. Third, the provincial-scale OFEC SWP working group members provided support to the stakeholder representatives by offering technical presentations to groups involved in the problem-solving process at the local and provincial scale. These presentations emphasised the role of agricultural science and practice for meeting the objectives of source water protection. Finally, the state agricultural agency informed SPCs, and organisations and agencies interested or involved in the SPP process, that existing regulatory standards and voluntary programmes met the objectives of source water protection, which complemented information provided by the agricultural representatives and provincial farm organisations

The results of the research also provided broader insight for research and practice. First, although the problem-solving process was prescribed by the provincial government, it still exhibited characteristics associated with a collaborative approach. This is consistent with other collaborative processes that have provided a forum within which state and non-state actors participated in problem-solving that incorporated the concerns of stakeholders (Ravetz, 1999; Wynne, 2002; Nowotny et al., 2003; Renn, 2007a, b). Also, stakeholders were able to co-produce vernacular knowledge, as noted in the literature as part of the discussion and negotiation of solutions (Orr, 1991; Lach et al., 2005; Bartel, 2014) by integrating expert science and local knowledge (Lee, 1993; O'Riordan and Rayner, 1993; Fischer, 2000; Lach et al., 2005).

Second, it was evident that the agricultural organisations worked outside of, but in contact with, the prescribed process through the agricultural network guided by the OFEC SWP working group. This helped to support coordinated action across watersheds at the local and provincial scales. This is an example of an informal network that operated around, and interacted with, the prescribed network (Robins et al., 2011), and shared information between vertical and horizontal scales and across administrative, physiographic and political boundaries (Paquet, 2001; Peters and Pierre, 2004; Reed and Bruyneel, 2010). In this way the informal agricultural network also supported the creation and sharing of knowledge, both internally and externally. This is consistent with efforts elsewhere where the agricultural community has contributed to the development of knowledge (Lockie, 2006) and educated non-farmer members of the process about farming (Tsouvalis et al., 2000).

Finally, the research provided insight concerning the role that stakeholder networks played in the collaborative problem-solving process (Bogasan and Zølner, 2007). In this instance the informal agricultural network supported the co-production of vernacular knowledge. Specifically, the stakeholder network supported the selection, and capacity-building of the agricultural representatives, during a multi-stakeholder problem-solving process. This provides an example of how the capacity and expertise of participants in a problem-solving process can be increased (Carolan, 2006; Ivey et al., 2006). It is also an example of how agricultural science and practice can be shared, accepted and valued by other sector representatives, and integrated during the discussion of problems and negotiations of solutions (Orr, 1991; Lach et al., 2005; Bartel, 2014). The enhanced capacity and expertise helped empower agricultural representatives to question the prescribed SPP process. This is an example of how increased capacity and expertise can enable participants to challenge assumptions underlying a prescribed approach to problem-solving (Tsouvalis et al., 2000).

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