Communication and Management Challenges in Large, Cross-sector Research Networks: A Canadian Case Study

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ABSTRACT *In large cross-sector research networks, good communication is critical to the effective management of research partnerships. In this paper we report on a communication audit conducted to identify the communication pathways and flow of information within the Sustainable Forest Management (SFM) Network, a Canadian Network of Centres of Excellence (NCE). The results indicate a range of communication challenges that can be related to an inherent problem in network management—that of orchestrating some kind of "harmony" among the different and sometimes competing voices of the multiple sectors involved. Our findings confirm the need to design and implement formal organizational communication structures to facilitate the process of creating a shared language and unified goals for the different sectors entering into partnerships in large, collaborative network organizations.*

KEYWORDS *Organizational communication; Knowledge management; Networks of Centres of Excellence*

RÉSUMÉ *Dans les grands réseaux de recherche pluridisciplinaires, une communication efficace est critique pour bien gérer les partenariats de recherche. Dans cet article, nous présentons un audit communicationnel mené pour identifier les voies de communication et les flux d'information au sein du Réseau de gestion durable des forêts (GDF), un des Réseaux de centres d'excellence (RCE) du Canada. Les résultats indiquent un éventail de défis communicationnels qu'on peut attribuer à un problème inhérent à la gestion des réseaux : celui d'arranger une sorte « d'harmonie » entre les voix différentes et parfois contradictoires des multiples secteurs impliqués. Nos résultats confirment le besoin de concevoir et de mettre en place des structures formelles de communication organisationnelle afin de faciliter le processus de création d'un langage partagé et de buts unifiés pour les divers secteurs entamant des partenariats au sein de grands réseaux collaboratifs.*

MOTS CLÉS *Communication organisationnelle; Gestion du savoir; Réseaux de centres d'excellence*

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Introduction

Over the last 40 years, there has been mounting interest in transforming traditional "fundamental" science into other forms of knowledge production useful to social and economic development goals (Wixted & Holbrook, 2008). One of the results of this changing research policy climate has been the creation of cross-sector research networks such as the Canadian Networks of Centres of Excellence (NCE), inspired in part by the Australian Cooperative Research Centres (Atkinson-Grosjean, 2006). Here, "cross-sector research networks" refers to collaborative research networks that seek partnerships with different actors from different sectors, including industry, government, and non-governmental organizations, among others. In Canada, the development of NCEs was meant to change the culture of science by enabling inter-sector dialogue about the social and economic considerations that could (or should?) shape scientific research. The NCE's design was influenced by Gibbons and colleagues' "mode 2" model of scientific production (Gibbons, Limoge, Nowotny, Schwartzman, Scott, & Trow, 1994), where science is conducted in the context of application (among other characteristics), and Michel Callon's Actor-Network Theory research (Callon 1994; Callon, Laredo, Rabeharisoa, Gonard, & Leray, 1992), where scientific knowledge production is conceptualized as a network of heterogeneous (human and non-human) actors. It is not hard to imagine that there would be communication challenges facing these cross-sector research networks, charged with promoting research "excellence" and "relevance" as well as meeting the expectations of "applied fundamental" research, inter-sector collaboration, national integration, multistakeholder management, and interdisciplinary research.

Much has been written about the management challenges in large, collaborative network organizations (Agranoff & McGuire, 2001; Provan & Kenis, 2008; Rethemeyer & Hatmaker, 2007), particularly with regard to collaborative research networks[1] (Contractor & Monge, 2002; Hinkin, Holtom, & Klag, 2007), and there is a growing body of work focused on evaluating the effectiveness, impacts, and sustainability of such research networks (Feller, Ailes, & Roessner, 2002; Garrett-Jones, Turpin & Diment, 2006; Harman, 2001; Lee, 2000). However, very little research has been undertaken to address how communication pathways form, and information flows, in the management of cross-sector research networks (Reidlinger, Gallois, Mckay, & Pittam, 2004). Tourish & Hargie's (1998) development of a communication audit tool to evaluate the communication between managers and staff in large networked organizations such as the National Health Services in the U.K. is a very good example of the kind of research that could benefit research managers in cross-sector collaborative research networks, and it is the starting point of our study.

In this paper we report on a communication audit (Hargie & Tourish, 2000) conducted to identify the communication pathways and the flow of information in the Sustainable Forest Management (SFM) Network (a Canadian NCE) and the level of satisfaction of management and staff with the organization's communication effectiveness. We begin by describing our research objectives. We then provide a description of the SFM Network and its governance structure. This is followed by a brief discussion of the meaning of organizational communication and the methodology we

used to assess it. Finally, we present the results of the communication audit and discuss the importance of formal organizational structures and processes for better communication in large cross-sector research networks.

Objectives of the study

The objectives of this study were to 1) assess the effectiveness of communication in the administrative core of the SFM Network, 2) examine the relationship between the network's organizational structure and the flow of information between its structural components, and 3) discuss the implications of the survey results for the management of cross-sector research networks.

The Sustainable Forest Management Network (1995-2009)

The SFM Network was the first NCE in the Canadian forest sector and comprised forest academics, industry representatives, government researchers, Aboriginal representatives, and members of the public. Its mandate was to fund inter-sector scientific research relevant to industrial, social, and ecological sustainable forest development goals. The SFM Network was successful in receiving funding for the two seven-year terms permitted under the NCE program, and compared with other natural resource- and environment-related NCEs, the SFM Network involved the largest number of researchers across Canada (Networks of Centres of Excellence, 2010). By its 14th year, the SFM Network had provided $49.86 million in competitive research-project funding, for a total of 347 projects and 443 researchers (Klenk & Hickey, 2009). Although the academic sector clearly represented the majority of SFM Network members (78.36%), there was involvement from every major sector associated with forests: governments (16.18%), industry (3.91%), Aboriginal (1.09%), and NGO (0.45%). Governments ($65.33 million) were the largest funders of the SFM Network, followed by industry ($10.52 million), the University of Alberta ($1.86 million), Aboriginal groups ($0.8 million), and foundations and NGOs ($0.68 million) (Klenk & Hickey, in press).

Although the SFM Network is deemed a "large" network in comparison with other natural resource- and environment-related NCEs (i.e., ArcticNet, Canadian Water Network, AquaNet, Mechanical Wood-Pulps Network), its organizational structure is comparable with other NCEs. As with all of the Canadian NCEs, the organizational structure[2] of the SFM Network included a board of directors responsible for governing the NCE, a research planning committee that determined the scientific direction of the NCE, and a scientific director who co-ordinated all research activities (Figure 1). The Network also had a manager and staff responsible for the administration of the Network, technology transfer, and communications. The SFM Network Board of Directors (BOD) was the chief executive authority of the SFM Network Corporation and included representatives of industry, Aboriginal peoples, government, academia, and the general public (as well as universities and the host institution). The Research and Planning Committee (RPC) included representatives of Aboriginal peoples, NGOs, and industry partners, as well as Research Area Leaders and a "research review" subcommittee of scientists-at-large who were "experts" at arm's length from the Network. The RPC was responsible for making recommendations to the Board of Directors regarding the SFM Network's annual research program, providing guidance for long-term plans and priorities for the research program, estab-

lishing criteria for the selection of research projects, and acting as a science advisory committee to the Board of Directors. Two subcommittees reported to the RPC: the Aboriginal Advisory Committee and the Knowledge Exchange and Technology Extension (KETE) Committee. The latter was responsible for synthesizing and disseminating research results, promoting the adoption and use of new knowledge, and enhancing the development of sustainable forest policies and practices by forest companies, Aboriginal peoples, and provincial and territorial governments within the SFM Network (SFM Network KETE Sub-committee, 2006).

Figure 1: The Sustainable Forest Management Network's organizational structure as it was originally designed
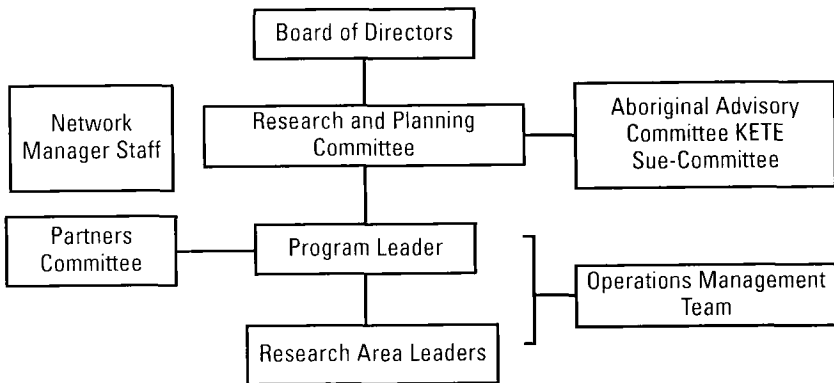

The Operations Management Team (herein referred to as OMT or, simply, "Management") was made up primarily of 1) the Scientific Director (Program Leader), who, along with Research Area Leaders (RALs), was responsible for providing day-to-day direction on the Network's research program; and 2) a manager, who was responsible for the administration of the Network and for the staff. The Partners Committee (PC), which included representatives of industry, government, Aboriginal, and NGO partners, reported to the Program Leader. The PC was responsible for providing advice on research issues of importance to the partners and, in latter years, was instrumental in identifying priorities for research; promoting two-way communication among Network funding partners, investigators, and research staff; and providing advice and input for a range of Network initiatives, especially those related to knowledge transfer and networking.

To help understand the SFM Network's organizational structure, it is instructive to use Mintzberg's (1998) organizational structure diagrams. Figure 2 presents a depiction of the organizational structure of the Network as it was set up, based on the Network's organizational chart and information gleaned from the Network's website. To begin, when we look at the SFM Network's original design, the organization was divided into three main levels vertically: 1) the "strategic apex" composed of the BOD (and to a certain extent the NCE), which had an executive role; 2) the "middle line," composed of managers (PL and manager) supported by a "techno-structure" comprising the RPC, PC, and professionals such as lawyers, accountants, and other required

analysts, as well as support staff responsible for administrative functions; and 3) the "operating core," comprising the RAL and their staff (theme research co-ordinators), the funded researchers, and their collaborative partners, who were responsible for producing research results in light of the objectives and priorities identified by the levels above.

Figure 2: Mintzberg diagram of the way in which the SFM Network was designed
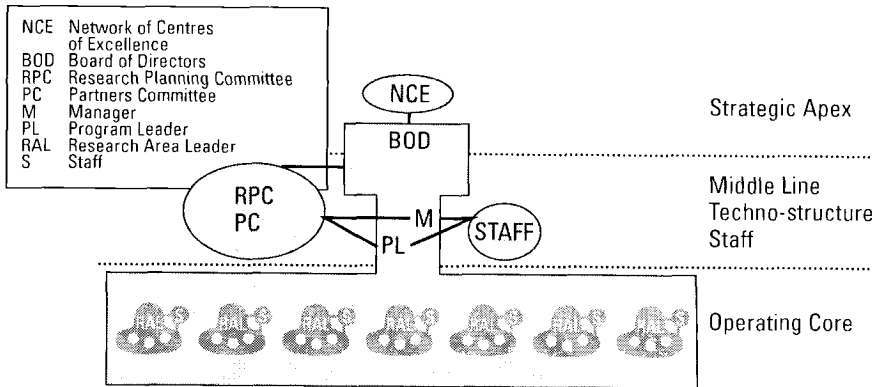
The structure of an organization will have an impact on communication pathways and the flow of information among its structural components. In complex organizations such as cross-sector research networks, the configuration of the organization may include a range of organizational objectives reflective of the diversity of partners involved in the network. To illustrate this, it is useful to employ Mintzberg's (1998) descriptions of different organizational configurations. Applying Mintzberg's typology suggests that the SFM Network was a "Diversified" organization, comprising "Professional," "Innovative," and "Entrepreneurial" structures (Mintzberg, 1998). To begin, the Network had a "Diversified" structure due to its need to bring about collaboration among diverse forest sectors and stakeholders on different research topics. The subsequent diversification reflected the need to build structures that could address very different research interests (from various disciplines) and partnership expectations (industry, Aboriginal, NGO, government). This organizational structure has been typical of forest research networks, such as the Australian Cooperative Research Centre (CRC) for Sustainable Production Forestry (see Ellefson, Kilgore, Skog & Risbrudt, 2007, for an analysis of governance structures of forest products and related research and development organizations).

Within this diversified structure, the Network's administration was designed with the more bureaucratic "Professional" configuration. This Professional configuration was mandated by the NCE (a government program) in order to ensure a governance structure that would have a clear hierarchy of roles for its executive and middle lines, which would facilitate the development of standard procedures for allocating grants to collaborative research teams across the country and ensure accountability. In a Professional structure, there are generally few managers and power is partially distrib-

uted horizontally across staff and the operating core. Professional organizations characteristically develop in complex but stable environments, where complexity requires decentralization to highly qualified staff, yet stability enhances the development of autonomy[3] (Mintzberg, 1998).

At the level of its operating core (Figure 2), the Network followed an "Innovative" structure. According to Mintzberg (1998), an Innovative organization typically has an organic structure, where power is unevenly distributed among teams of highly trained personnel and experts. This kind of organization is meant to be responsive to complex and dynamic environments. Once again, this was an appropriate structure for the SFM Network's operating core, which included the RAL, researchers, and liaison staff who were tasked with responding to dynamic research fields, developing research teams that dealt with questions of an applied nature that were relevant to (changing) industrial, social, and ecological development goals.

Finally, embedded within the "Innovative" structure of the operating core, numerous "Entrepreneurial" structures existed to undertake the research (Figure 2). According to Mintzberg (1998), such an organization will demonstrate little formalization and standardization, resulting in an organic structure with minimal support staff. Within these organs, a simple structure is followed, consisting of a top manager[4] (the Principal Investigator), who dominates, and a group of operators who do the basic work (students, postdoctoral fellows, research associates, et cetera). The "Entrepreneurial" structure for this component of the SFM Network makes sense, since the Principal Investigator is responsible for every aspect of the division of labour and the scope of the research done by their research team and for obtaining the necessary conditions to ensure research success (e.g., grants, laboratory equipment).

To facilitate communication within the organization, the SFM Network used well-accepted mechanisms typical of corporate and government organizations (meetings, memos, work groups, newsletters), as well as electronic media (website, videos, e-lectures, audio clips) and in-person workshops and conferences (Klenk & Hickey, 2009). The SFM Network strove to use diverse means of achieving effective communication both internally and externally (for the benefit of the Canadian public, and to attract new partners and support current partners).

However, given the numerous organizational configurations embedded in the Network, the flow of information and communication satisfaction are bound to be affected by the objectives of "Professional," "Innovative," and "Entrepreneurial" structures, as well as by the organizational cultures of the partners involved. Moreover, previous research in scientific communities has shown that researchers commonly use informal communication pathways to vet hypotheses, share methods and results, test particular interpretations of analyses, acquire a competitive edge, mobilize human and social capital, establish or confirm credibility, et cetera (Crane, 1972; Latour, 1987). Given the important role researchers held within the administrative core of the organization, it is likely that norms of scientific communication had an influence on the flow of information and communication satisfaction within the SFM Network.

Measuring organizational communication

The expression "organizational communication" refers to the transactional, symbolic process that facilitates the co-ordination of actors' activities through mutual adjustment of the behaviour of individual parts to achieve particular collective goals (Goldhaber & Barnett, 1987). In the context of network organizations, the relationship between the quality of communication and a network's effectiveness has been widely recognized (Bush & Frohman, 1991; Hargie, Tourish, & Wilson, 2002). It is important to note that communication is more than information exchange and includes the "co-construction of meaning between organizational actors, who influence each other in the context of asymmetrical power relationships, during which they compete for power, resources, voice and legitimacy" (Hargie & Tourish, 2009, p. 5). However, for the purposes of this study, we are focused on the exchange of information within the SFM Network administrative core and the importance of organizational structure in facilitating this information exchange. Nevertheless, the diversity of partnerships within the SFM Network is discussed in terms of its impact on effective communication and management.

A number of instruments have been developed, generally under the umbrella term of a "communication audit," to assess the quality and identify the strengths and the weaknesses of communication in organizations (Greenbaum, 1974). A communication audit determines which communication channels are being utilized, how well they are used, the amount of confidence that the staff and managers have in various sources of information, and, most importantly, how staff and managers feel communication could be improved (Downs & Adrian, 2004; Hargie & Tourish, 2009). Communication audits may focus on internal or external communication and may involve analyzing current communication practices, tracking the impact of particular measures designed to improve communication, evaluating the impact of communication on the organization's success in achieving its objectives, and prescribing options to inculcate different communication behaviours at all levels of the organization and improve organizational communication (Hargie & Tourish, 2009). For the purpose of this study, a communication audit was used to assess the SFM Network's internal communication patterns to identify the role that formal organization structures and processes play in harmonizing the involvement of different sectors that do not necessarily speak the same "language."

Methodology

There are several questionnaires commonly used in communication audits; however, for the purpose of evaluating the SFM Network's organizational communication, both the International Communication Association Communication Audit Survey (CAS) (Goldhaber & Rogers, 1979) and the Organizational Communication Audit Questionnaire (OCA) (Wiio & Helsila, 1974) were of particular relevance. The CAS is deemed the "… most comprehensive attempt to measure all aspects of an organization's communication system" (Hargie & Tourish, 2000, p.12). One of the CAS's interesting features is that it allows a comparison between the actual and the ideal needs of communication. A number of independent researchers have assessed the validity and reliability of the CAS and have found that it has face validity, predictive validity,

and factorial construct validity (Greenbaum, Clampitt, & Wilihnganz, 1988). On the other hand, the OCA instrument was developed to determine "how well the communication system helps the organization to translate its goals into desired results" (Greenbaum, Clampitt, & Wilihnganz, 1988, p. 259). The literature supports the face and construct validity of the OCA, and independent researchers have found the instrument to be reliable (Greenbaum, Clampitt, & Wilihnganz, 1988). The OCA measures the "communication climate" of the organization and the communication satisfaction of staff, and it can locate possible bottlenecks in organization communication. "Communication climate" refers to measures of supportiveness; participative decision-making; trust, confidence, and credibility; openness and candour; and high performance goals (Hargie &Tourish, 2000).

The survey questionnaire devised for this study was an adaptation of the CAS and the OCA surveys. More specifically, we used the entire OCA questionnaire but changed the questions related to information received to elicit responses about the "actual and desired" amount of information received, as per the CAS questionnaire. The specification of "actual and desired" amount of information received did not affect the validity of the CAS questionnaire, as these questions have been validated in the OCA questionnaire.

The audit questionnaire was divided into eight sections, each addressing a different aspect of communication. In six of the sections, respondents were asked to rate either their level of satisfaction or the quantity of information received on a five-point Likert scale (where "1" was "very dissatisfied" or "very little" and "5" was "very satisfied" or "very much"). The topics of these questions were as follows: 1) overall communication satisfaction, 2) amount of information received from different sources—actual and desired, 3) amount of information received about specific job and organization items—actual and desired, 4) areas of communication that need improvement, 5) satisfaction with the SFM Network website, and 6) use of the website. Levels of satisfaction with communication and the quantity of information received were determined by calculating the difference between the raw scores for the "actual" and the "desired" levels. For example, a score of "0" would indicate that there is no difference between the amounts of received and wanted information, while a positive or negative score would indicate satisfaction or dissatisfaction with the amount of received and/or wanted information. Mean scores were then converted into percentage approval ratings (based on the scale of 1-5, 1=20%, 5=100%). The difference between the actual and the desired level of communication was tested for significance using the Wilcoxon signed-rank test (Keller, 2004). The Kruskal-Wallis test was used to determine the significance of the difference between grouping (independent) variables (organizational position, age, gender, years of involvement, and years in current position) and the items ranked (dependent variable). Follow-up tests were conducted to evaluate pair-wise differences among the grouping variables, controlling for Type I error across tests by using the Holm-Bonferroni approach (Green & Salkind, 2007).

Section 7 of the survey addressed the flow of information across organizational groups. The first question concerned to whom, within the SFM Network, the respon-

dent communicated work-related matters using formal organizational structures (committee or staff meetings, memos, official notice-oral or written-business communication). The second question concerned to whom, within the SFM Network, the respondent communicated work-related matters through informal (grapevine) structures (e.g., chance conversations, spontaneous meetings, personal notes, and phone calls). The significance of the difference between communication pairs (for example: staff ↔ management) was tested using t estimates of the difference between the two means (Keller, 2004).

In the final section of the survey, two questions of a more open-ended nature were asked to ascertain the strengths and weaknesses in communication: 1) the communication challenges the SFM Network incurred, and 2) suggestions for making communication better in the Network.

Results

RESPONDENT PROFILE

The communication audit targeted all members of the governing body of the SFM Network, as well as staff, management, and its various committees (77 individuals). We obtained a 49% response rate and, as Table 1 indicates, the percentage of representation within groups ranged from 22% to 100%. All of the Staff and the Operations Management Team were represented, and we obtained a good proportion of the Research Planning Committee (80%). There were fewer representatives of the Partners Committee (24%) and the Board of Directors (22%). Respondents were asked five questions (grouping, independent variables) about their age, gender, what "body" in the organization best described their affiliation with the Network, the number of years they had been involved in the Network, and the amount of time they had held their current position. Most (45%) respondents had been involved in the Network for 4 to 7 years (minimum: under 1 year; maximum: 14 years) and had held their current position for 4 to 7 years (45%) (minimum: under 1 year; maximum: 14 years).

Table 1: Breakdown of occupational groups in sample

Occupational groups	n	% of occupational group
Research Planning Committee	8	80
Partners Committee	6	24
Operations Management Team	8	100
Staff	11	100
Board of Directors	5	22

OVERALL SATISFACTION

As Table 2 indicates, the overall communication satisfaction across all organizational groups averaged above a 71% approval rating. No significant differences were found within grouping (independent) variables.

Table 2: Evaluation of overall communication satisfaction

	Very dissatisfied	Dissatisfied	Cannot say	Satisfied	Very satisfied	Average	Organizational group (n=5) p level
To what extent are you satisfied with communication in the SFMN?	1 3%	6 16%	7 18%	20 53%	4 11%	3.53 (71)	0.022 a
To what extent are you satisfied with the availability of information you need to perform your work in the SFMN?	1 3%	2 5%	6 16%	21 55%	8 21%	3.87 (77)	0.038 b

The top number is the count of respondents selecting the option. Bottom % is percent of the total respondents selecting the option. The number in parenthesis is the percentage approval rating.

a Mann-Whitney U test: the Research Planning Committee differs from Staff and Staff from the Board of Directors. Holm's sequential Bonferroni test indicate differences are non-significant.

b, c Mann-Whitney U test: the Research Planning Committee differs from Staff. Holm's sequential Bonferroni test indicate difference is non-significant.

INFORMATION RECEIVED THROUGH DIFFERENT CHANNELS

Respondents were asked to rate their level of satisfaction with the amount of information they received through different channels. Results indicated a consistent, albeit slight, perceived need for improvement across all occupational groups except the Board (Table 3). The difference between the actual and desired amount of information received ranged from 4% for the RPC to 14% for Management and Staff. For the PC, Management, and Staff, there was a significant difference (at a level of 0.05) between the actual and desired amount of information they received from different channels.

Table 3: Occupational groups' evaluation of the amount of information received through different channels

Occupational groups	Information currently received	Information needed	Difference in means	*p* level
Research Planning Committee	3.22 (64)	3.43 (69)	0.21 (4)	0.071
Partners Committee	2.94 (59)	3.47 (70)	0.53 (11)	0.005*
Operations Management Team	3.23 (65)	3.92 (71)	0.69 (14)	0.000†
Staff	2.83 (57)	3.55 (71)	0.72 (14)	0.000†
Board of Directors	3.48 (70)	3.36 (67)	0.12 (2)	0.323

* Significant at alpha= 0.05. † Significant at alpha= 0.001.

Average ratings across all occupational groups (Table 4) suggested that the gap between the actual and desired amount of information received from specific information channels ranged from 1% (information from meetings) to 24% (information from the Aboriginal Committee). While there was an apparent desire to obtain more infor-

mation from all channels of information, there was also a significant difference (at a level of 0.05) between the actual and desired amount of information received from Management and Committees as well as from the website (Table 4). There were no significant differences between grouping variables in terms of information received from different channels.

Table 4: Evaluation of the amount of information received through different channels

Sources	Information currently received	Information needed	Difference in means	p level
Board of Directors	2.50 (50)	2.92 (58)	0.42 (8)	0.058
Research Planning Committee	3.32 (66)	3.84 (77)	0.52 (10)	0.021*
Research Area Leaders	2.50 (50)	3.42 (68)	0.92 (18)	0.000†
Management	2.89 (58)	3.42 (68)	0.53 (11)	0.005*
Partners Committee	2.76 (55)	3.89 (78)	1.13 (23)	0.000†
Aboriginal Committee	2.14 (43)	3.34 (67)	1.20 (24)	0.000†
Staff	3.82 (76)	3.61 (72)	0.21 (4)	0.228
Meetings	3.76 (75)	3.81 (76)	0.05 (1)	0.662
Memos	3.45 (69)	3.61 (72)	0.16 (3)	0.374
Newsletter	3.45 (69)	3.29 (66)	0.16 (3)	0.377
Website	3.46 (69)	3.84 (77)	0.38 (8)	0.007*

* Significant at alpha= 0.05. † Significant at alpha= 0.001.

INFORMATION RECEIVED ABOUT SPECIFIC JOB AND ORGANIZATION ITEMS

Respondents were asked to evaluate the amount of information they received about work issues related to the management of the Network and its structure and processes. Taking the average across all work-related information items (Table 5), there was a significant difference between the amount of information desired and received by all occupational groups. The difference in the information received about organizational items ranged from 4% for Management to 22% for Staff (Table 5).

Table 5: Occupational groups' evaluation of the amount of information received about work-related issues

Occupational groups	Information currently received	Information needed	Difference in means	p level
Research Planning Committee	2.81 (56)	3.69 (74)	0.88 (18)	0.000†
Partners Committee	2.63 (43)	3.60 (72)	0.97 (19)	0.000†
Operations Management Team	2.83 (57)	3.66 (73)	0.83 (4)	0.000†
Staff	2.65 (53)	3.74 (75)	1.09 (22)	0.000†
Board of Directors	3.03 (61)	3.65 (73)	0.62 (12)	0.010*

* Significant at alpha= 0.05. † Significant at alpha= 0.001.

Averaging the ratings across all occupational groups (Table 6) shows that the difference between the actual and desired amount of information about specific work-

related items ranged from 7% (training) to 24% (Network research impacts). There was a significant difference (at a level of 0.05) between actual and desired information about finances, role and responsibilities, organizational change processes, partners, impacts, research priorities, and projects (Table 6). There were, however, no significant differences among the independent variables.

Table 6: Evaluation of the amount of information received about work-related issues

Sources	Information currently received	Information needed	Difference in means	*p* level
Finances	2.32 (46)	2.89 (58)	0.57 (11)	0.001†
Role and Responsibilities	2.65 (53)	3.49 (70)	0.84 (17)	0.000†
Organizational change processes	2.76 (55)	3.87 (77)	1.11 (22)	0.000†
Training	2.97 (59)	3.32 (66)	0.35 (7)	0.154
Partners	2.38 (48)	3.63 (73)	1.25 (25)	0.000†
Research impacts	2.32 (46)	4.03 (81)	1.71 (34)	0.000†
Research priorities	3.32 (67)	4.16 (83)	0.84 (17)	0.000†
Research projects	3.39 (68)	4.03 (81)	0.64 (13)	0.003*

* Significant at alpha= 0.05. † Significant at alpha= 0.001.

AREAS OF COMMUNICATION THAT NEED IMPROVEMENT

Respondents were also asked to evaluate the extent to which they would like to see improved communication between occupational groups. The results indicated a perceived need for better communication among all groups, ranging from 62% for communication between Staff and Management to 74% among Committees (Table 7).

Table 7: Tests of difference between groups in the evaluation of communication between organizational groups

Need for improved communication	Rank	Organizational group (n=5)
Organizational groups		*p* level
From SFMN Staff to Operational Management Team	3.08 (62)	0.435
From SFMN Operational Management Team to Staff	3.18 (64)	0.460
From the Board of Directors to the Research and Planning Committee	3.29 (66)	0.037 a
From the Research and Planning Committee to the Board of Directors	3.32 (66)	0.027 b
Among Committees	3.68 (74)	0.242

a Mann-Whitney U test: The Research Planning Committee differs from Management. Holm's sequential Bonferroni test indicates the difference is non-significant.
b Mann-Whitney U test: The Research Planning Committee differs from Management; the Partners committee differs from Management; Management differs from Staff. Holm's sequential Bonferroni test indicates the differences are non-significant.

SATISFACTION WITH THE SFM NETWORK WEBSITE

Respondents' evaluation scores for the Network's website were high, ranging from

68% to 79% in approval ratings (Table 8). The lowest average scores were related to up-to-date news availability (68%), the currency of the information on the website (68%), the historical content of the website (69%), and the availability of up-to-date publication lists (69%).

Table 8: Tests of difference between groups in the evaluation of the website

Website items	Evaluation Rank
Searchability (the URL)	3.68 (74)
Download time of home page	3.95 (79)
Look and feel of the website	3.73 (75)
Ease of navigation	3.53 (71)
Currency (content is up-to-date)	3.47 (69)
Coverage (the focus of the site)	3.66 (73)
Accuracy (Sources of information and factual data)	3.71 (74)
History of the SFMN	3.47 (69)
Mission statement of the SFMN	3.76 (75)
Availability of up-to-date publications' lists	3.47 (69)
Up-to-date news	3.39 (68)
Contact details	3.82 (76)

Respondents' evaluation of the actual versus desired usage of the website indicated that for both the Partners Committee and the Staff, there was a significant difference (alpha = 0.05%) between the extent to which they actually used the website and how much they would have liked to have used it to obtain information (Table 9). However, pair-wise comparisons between organizational groups indicated that there were no significant differences between groups in the extent to which they used the website to obtain information.

Table 9: Occupational groups' use of the website to access information

| Occupational groups	Current use of website	Desired use of website	Difference in means	*p* level
Research Planning Committee	2.63 (53)	3.13 (63)	0.50 (10)	0.102
Partners Committee	2.17 (43)	3.50 (70)	1.33 (27)	0.038*
Operations Management Team	2.75 (55)	3.63 (73)	0.88 (18)	0.059
Staff	3.00 (60)	3.64 (73)	0.64 (13)	0.020*
Board of Directors	3.00 (60)	3.00 (60)	0.00 (0)	1.000

* Significant at alpha= 0.05.

COMMUNICATION PATTERNS

To map the communication flow among organizational groups, respondents were asked two network analytic questions: To whom do they speak through 1) formal and 2) informal (grapevine) organizational structures? The questions did not differentiate between the kinds of information (research programs, outputs, organization issues)

that flowed through formal and informal pathways. Figure 3 illustrates communication patterns through formal channels, indicating that Staff were a central hub (had the most connections), followed by the PC, RPC, and Operations Management Team. The significant differences reported in these figures refer to the differences in the flow of information between two organization components. For example, the Board had less contact with all the other organizational groups, and its mutual relationship with the PC differed significantly (at a level of 0.10) from that with other groups. The results also suggest that the Staff had a strong formal relationship with the Board, the PC, and the RPC.

Figure 3: Formal communication patterns among SFM Network organizational groups. The thickness of the arrows and the numbers represent the frequency of contacts between groups
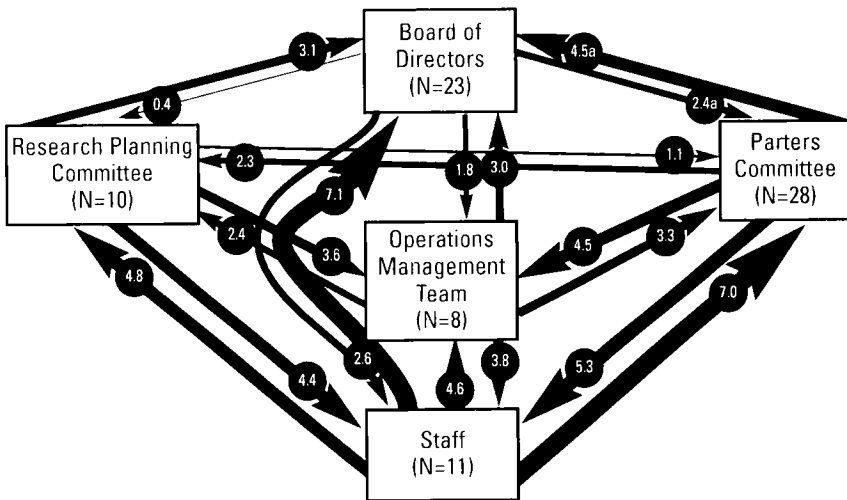
Formal communication patterns among SFM network organizational groups.
The thickness of the arrows and the numbers represent the frequency of contacts between groups.
a= Significantly different at a level of 0.10 p=0.056

Figure 4 illustrates communication patterns through informal channels. These results suggest that the PC and RPC were important hubs in the grapevine communication pattern of the Network, maintaining a greater number of informal contacts with all other organizational groups. In addition, there were significant differences (at a level of 0.10) in informal communication patterns between several pairs of groups. Namely, the RPC reported significantly more informal contacts with the OMT and Staff than the reverse, and similarly, the PC had more informal contacts with the OMT and Staff than the reverse. The Board had a relatively stronger informal relationship with both the Staff and the PC than with the OMT and the RPC. The OMT had fewer informal contacts with all other organizational groups.

Figure 4: Informal communication patterns among SFM Network organizational groups. The thickness of the arrows and the numbers represent the frequency of contacts between groups
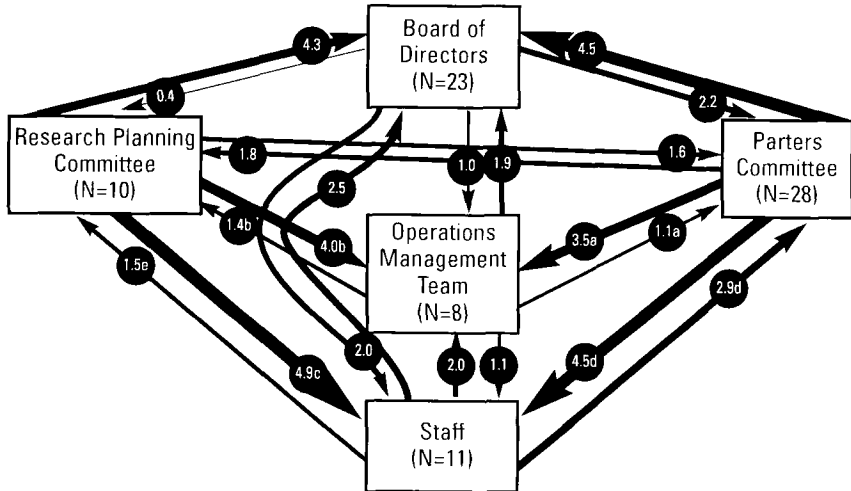
a Significantly different at a level of 0.10. p= 0.017.   b Significantly different at a level of 0.10. p= 0.007.
c Significantly different at a level of 0.10. p= 0.056.   d Significantly different at a level of 0.10. p= 0.037.

OPEN-ENDED QUESTIONS

Respondents were asked to describe what, in their experience, were the major communication challenges the SFM Network had faced. A content analysis of the answers revealed five main themes: 1) information technology, 2) outputs, 3) collaboration, 4) management, and 5) the organizational structure of the Network. To begin, the construction and maintenance of the website appeared to be a challenge, in part because of difficulties involved in delivering useful information to different partners, who had different information requirements. In terms of outputs, there was a perceived lack of communication on the "downstream applications," relevance, and impacts of research results. Language issues (French-speaking staff and website information in French) were also prominent. With respect to collaborative challenges, respondents noted a need to better understand the policy and operational needs of partners, to attract more partners and get them actively involved in the Network, to better manage partners' expectations, and to better execute partners' priorities.

In a different vein, there appeared to be several managerial communication challenges in the Network. Some respondents referred to the need for improvements to the Network's communication strategy and emphasized a desire for better communication structures between Staff and the Management Team (including the Manager, Program Leader, and the Research Area Leaders). With respect to communication challenges at the broader organizational scale, respondents noted that the scope and complexity of the Network and its geographical spread were important challenges for communication.

Respondents were also asked to list any improvements that could have been made to the way information was transmitted in the Network. Responses were divided into two broad themes: 1) knowledge transfer and 2) organizational processes and structures. Within both themes, respondents underscored the need for formal communication structures to address perceived communication weaknesses. For example, some respondents suggested that the Network could have highlighted the practical relevance of research for users by using field courses to interact with stake-holders and regional workshops to facilitate researcher/partner communication. With respect to organizational processes, respondents made a number of suggestions, such as sending e-mail bulletins of research activities to members of the organizational groups, providing regular updates from the Management Team to Staff, and schedul-ing regular work-plan meetings with Staff.

The organizational structure of the Network was also mentioned in the list of potential improvements that could facilitate information flow. In this regard, respon-dents mentioned the importance of clarifying the roles and responsibilities of organi-zational groups.

Discussion

COMMUNICATION SATISFACTION

We begin our discussion by noting that 53% of respondents answered "satisfied" to the first question of the survey: "To what extent are you satisfied with communica-tion in the SFM Network?" (Table 2). This result translated into a 71% average approval rating in overall communication satisfaction, indicating that the Network performed well. It is within this context that the following discussion on the commu-nication challenges in the management of the Network are discussed, with a view to identifying key areas and issues where future efforts to improve communication could be directed. It is important to note that the communication audit survey was designed to examine the flow of information within the Network's governing body, thereby uncovering the potential for improvements in communication structures and processes. As a result, when respondents were asked about specific communication channels and access to information, there were a number of perceived needs for improvement.

ORGANIZATIONAL STRUCTURE AND THE FLOW OF INFORMATION

The network analysis highlighted the impact of organizational structure on commu-nication in the SFM Network. While it has been acknowledged that communication flow within any organization is linked to its formal structure (Allen, 1970), it is never-theless instructive to compare the official SFM Network communication structure with what actualized after 14 years of operation. Assuming that the Network's organi-zational chart (Figure 1) indicates how its formal communication patterns were origi-nally designed, the actual formal and informal communication patterns that were identified through the communication audit evolved to be quite different.

The SFM Network was designed to maintain a vertical centralization headed by the Board of Directors, while selectively decentralizing responsibilities horizontally across Management and Staff (professionalization of the structure). At the same time, the

SFM Network decentralized power within its operating core, where the role of the RAL involved advisory and co-ordination responsibilities, while the control over research projects remained in the hands of Principal Investigators and their research teams.

However, when we use Mintzberg's concepts to understand the actual communication patterns in the SFM Network, a different portrait of structure, based on the flow of information across organizational groups, is revealed. Figure 5 presents a Mintzberg diagram designed to represent the actual communication patterns of the SFM Network (both formal and informal). It illustrates that, in practice, the Network's administration resembled a mixture between an "Entrepreneurial" and a "Political" organization. The apparent lack of appreciation for the formal organizational communication structures that had been put into place is reflective of an Entrepreneurial structure, where typically little of the behaviour in the organization is formalized. Moreover, in Entrepreneurial organizations, leadership is tied to the personality of the leader. Therefore, unlike in a Professional structure, any turnover in key leadership positions (Managers and Program Leaders) would have been likely to have had an important impact on organizational communication. Indeed, as one respondent noted: "The various managers and program leaders have had different styles, which has resulted in varying levels of communication."

Figure 5: Mintzberg diagram of the way in which the flow of information evolved in the SFM Network
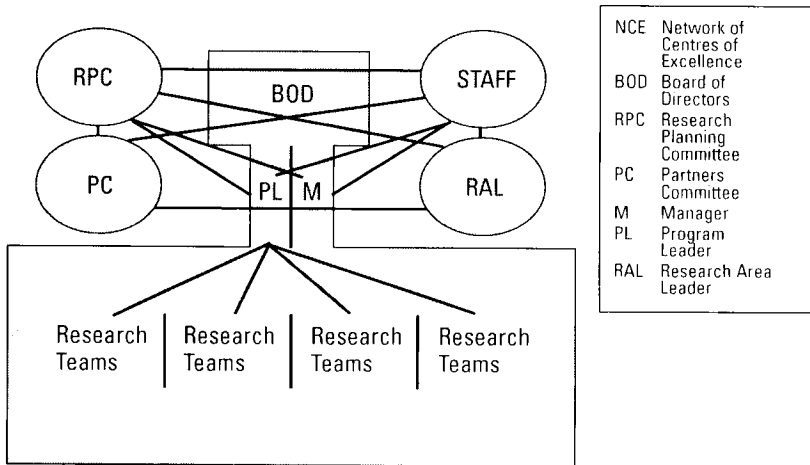
Another actual characteristic of the SFM Network that was identified through our analysis was that although decision-making power resided in the key position of the BOD, the Program Leader, the Manager, the PC, the RPC, and the Aboriginal and KETE Committees held important advisory positions that sometimes pulled the Network in multiple directions (reflecting the interests and expectations of partner organizations). This characteristic is indicative of a "Political" organization, where competing and/or conflicting internal forces tend to pull the organization apart, or at least in different directions. Not surprisingly, cross-sector collaborative organizations

have been shown to be subject to political dynamics that constrain the extent to which knowledge is integrated and shared among sectors (Swan & Scarbrough, 2005). The communication audit suggests that part of the communication challenges perceived by the different organizational groups is due to the very different interests the Network included and served within its organizational structure.

IMPLICATIONS OF THE RESULTS FOR THE MANAGEMENT OF CROSS-SECTOR RESEARCH NETWORKS

A large part of the governance structure and processes implemented in the SFM Network was geared toward facilitating the flow of information between partners of different forest sectors, academics from different disciplines, Management, Staff, and the Board. For instance, the diversity of voices included within the Board, RPC, and PC indicated a wish by the SFM Network originators (and NCE policy to some extent) to be inclusive and foster inter-sector dialogue and trust. In a similar vein, the RALs represented different forest science disciplines from the social and natural sciences, which fostered greater interdisciplinary dialogue among the leading experts in the Network, including the RPC and Program Leader. However, these explicit measures to bring individuals from different sectors together may have fostered informal communication patterns in preference to formal communication channels. It is important to note that there is nothing necessarily "wrong" with informal communication, and it has been recognized that informal communication forms an integral part of how scientists do research (e.g., within "invisible colleges") (Crane, 1972). Indeed, informal communication patterns are often complementary to formal communication structures for research purposes (Allen, James, & Gamlen, 2007; Menzel, 1968) and may have facilitated trust-building between the different sectors in the Network. However, from a management perspective, such organic behaviour within university–government–industry research networked organizations may also make official structures and processes less effective, resulting in management challenges and potential communication dissatisfaction. Respondents' comments about the importance of structure for better communication in the Network and their numerous suggestions for more and improved structured communication processes are indicative of the significance of this issue for the management of research networks.

As with other large research networks, Canada's SFM Network was faced with numerous management challenges from the beginning, the most important being the competing internal political forces and systemic intraorganizational collaborative tensions. Further, the research managers were likely faced with complex and often conflicting responsibilities that may have impacted their ability to enforce formal communication structures and processes (Agranoff & McGuire, 2001). The management literature focused on network management suggests that network managers are responsible for 1) enticing a diverse array of partner organizations to join and inspiring them to remain motivated to participate in the research and management of the network; 2) articulating in a compelling manner the role, responsibilities, and expectations of members; 3) encouraging loyalty and commitment to the network while respecting the different needs and "cultures" of partner organizations; 4) setting and articulating priorities and calls for proposals and managing their subsequent review;

5) fostering inter-sector collaboration, knowledge production, and dissemination; 6) leading the network without much authority and hierarchy; 7) creating a distinct network culture of research excellence and industrial/social relevance; 8) fostering trust among partners; 9) adapting traditional academic research to a "context of application"; and 10) ensuring the effectiveness of network structures and processes, as well as their transparency and accountability to the network's funders—in this case, the NCE and the Canadian public (Agranoff & McGuire, 2001; Provan & Kenis, 2008; Turpin, Garrett-Jones, & Rankin, 1996).

Many of these management challenges are related to an inherent problem in network management—that of orchestrating some kind of "harmony" among the different and sometimes competing voices of the different sectors involved. For unlike managing research in "Ivory Towers," where academic researchers more or less speak in one "tongue," managing university–government–industry research networks involves creating a shared language out of a cacophony of tongues[5]. If communication patterns are unsatisfactory, there is a risk that the network will become mired in a confusion of languages—a risk neatly represented by the metaphor of the "Tower of Babel." Successfully orchestrating these languages requires some kind of "musical score" as a means of bringing together the different sectors' voices into an integrated and purposeful organization (as would be expected from a collaborative endeavour).

However, for diverse sectors to come together and speak as one (integrated and purposeful network entity), managers must facilitate dialogue about partners' interests and expectations and build trust that all partners will follow through on their commitments and do so to the best of their abilities. Achieving these collaborative communication goals necessitates an exceptionally supportive communication climate. A long quotation from one respondent should help depict the communication issue at stake:

> There is an ongoing disconnect between some researchers and partners (as they speak different "languages"). Knowledge exchange is a contact sport and both sides need to take responsibility. Some form of accountability needs to be incorporated into future research programs that link partner expectations around knowledge exchange to research expectations around collection of new knowledge. Regional workshops are the way to go given travel and financial challenges. Liaison staff were a good idea that didn't come to pass very effectively because of staff turnover, but still should be pursued in the next generation. Clear links to partner priorities must continue (and partners must take responsibility in a similar vein to ensure sufficient homework and onus is done by them). Researchers not interested in engaging partners should go elsewhere for funding ... work done here is applied in nature and requires collaboration between partners and researchers.

This passage attests to a perceived divergence between the goals of some researchers and partners, particularly when their objectives did not align. The occurrence of a tension between (industrial, governmental) applied knowledge production and academic "fundamental" science is well documented in the literature on other

university–government–industry research networks (Garrett-Jones, Turpin, Burns, & Diment, 2006). However, the quotation is not solely a statement of the presence of a tension within the network, but of a need to design effective organizational communication structures to facilitate the process of creating a shared language and unified goals for the different sectors entering into collaborative partnerships within research networks.

Limitations and Future Research Needs

Some qualifications apply to the general interpretation of these results. We sought communication patterns focused on information-gathering and the effective use of communication channels, but organizational communication also includes other objectives of communication. Indeed, apart from informative goals (focused on the information required for organizational bodies to execute their jobs), organizational communication also includes regulative goals (communication structures and processes focused on organizational productivity and conformity to plans), innovative goals (focused on activities that enhance the organization's adaptiveness to internal and external factors, i.e., participative problem-solving types of activities), and integrative goals (communication structures and processes focused on enhancing employee morale) (Greenbaum, 1974). However, patterns of information communication are generally involved to some extent in all aspects of an organization's communication goals, hence auditing a communication network can be indicative of the overall communication climate in an organization.

Despite having presented a single case study of a cross-sector research network, our analysis provides several insights from the SFM Network experience that could be of use to other large cross-sector research networks. Communication flow within the Network suggested the emergence of an Entrepreneurial and Political organizational structure, in which the importance of the personalities of leaders and the differences among partners had an important impact on communication satisfaction. Although the Network had been set up to be a "Diversified," "Professional," and "Innovative" organization, comments in response to the open-ended questions of the survey suggested that responsibility for managing research was not sufficiently devolved horizontally, creating communication challenges between partners and management. A greater use of "communication professionals" (including liaison staff, professional facilitators, et cetera) as utilized in Australian CRCs may have facilitated communication between these organizational groups (Reidlinger, Gallois, Mckay, & Pittam, 2004). This is an area that requires further investigation.

Another message from this communication audit, which is also related to organizational structure, is the critical importance of ensuring clarity in the definition of the roles and responsibilities of organizational groups. This result is supported by other studies that have reported that successful cross-sector collaboration and knowledge exchange depends on the effective communication and understanding of the roles of partners (Elmuti, Abebe, & Nicolosi, 2005). Yet, while greater clarity in the role and responsibilities of organizational groups may have strengthened the use of formal communication structures, which some respondents indicated was needed, the SFM Network had a history of grapevine communication. While the use

of informal communication networks is known to be productive in scientific communities (Crane, 1972), the SFM Network's organic communication patterns can be attributed to more than "business as usual" in scientific communities. They are likely the result of the unique difficulties that Management faced in orchestrating cross-sector collaborative research in a highly political and dynamic domain of knowledge and practice.

We believe our communication audit of the SFM Network provides an in-depth analysis of some of the most important communication challenges in the management of this cross-sector research network. The results generally highlight the important role of formal structures in facilitating communication in large cross-sector research networks. First, the results of this study suggest that formal organizational structures are needed to facilitate communication between actors from different sectors that do not share the same "language." Second, the study reveals that communication satisfaction was affected by different partners' organizational cultures and expectations as to how effective communication should be enabled. The employment of communication professionals to facilitate cross-sector dialogue could have been helpful with regard to this issue. And third, the results of this study indicate the need for clarity in the roles and responsibilities of organizational groups. This last insight refers to both organizational structure and principles of good governance, including transparency and accountability.

Although these results offer insights that should be of use to other NCEs, there is a need to compare multiple case studies to provide a more systematic analysis of communication in research networks. There is also a concomitant need to develop a practice-oriented theory of the role of formal and informal communication structures in fostering successful inter-sector collaboration (Barge, 2001; Daly, 2000). Vangen & Huxham's (2003) work on the role of leadership, facilitation, and communication in fostering successful cross-sector collaborations is a good example of an approach that leads to the development of practice-oriented theory. In their experience,

> Most partnership managers express or demonstrate concerns about building infrastructure and relationships to foster what they seem to regard as central tenets for the enactment of genuine collaborative activity. They often refer to, for example, the need to build trust, manage power relations, facilitate communication and handle the different, and often conflicting, interests of members. ... The key sentiment is the focus on activities such as allowing all members to have a voice and seeking consensus with regard to shaping the collaborative agenda. (Vangen & Huxham, 2003, p. 65)

Likewise, in their communication study of Australian CRCs, Reidlinger, Gallois, Mckay, & Pittam suggested that "formal discussions, exhibitions, and feedback workshops with end users can be used to minimize the impact of identities that conflict with the organization and to provide a common language among members of the diverse social groups within it" (2004, p. 75). Both of these passages imply a need for a greater understanding of the relationship among organizational structures, organizational diversity, and the role and place of stakeholders' "voices" in fostering communication satisfaction in university–government–industry networks.

Conclusion

Results from our communication audit of the SFM Network indicate that overall satisfaction was high. When respondents were asked about specific communication channels and access to information, however, there were perceived needs for improvement. Open-ended questions revealed a number of communication issues related to information technology, outputs, collaboration, management, and the organizational structure of the Network. Many of these management challenges can be related to an inherent problem in network management—that of orchestrating some kind of "harmony" among the different and sometimes competing voices of the multiple sectors involved. The network analysis illustrated a complex pattern of formal and informal communications among organizational groups, which did not appear to follow the Network's official organizational structure. This is likely the result of the unique difficulties that management faced in encouraging cross-sector collaborative research in a highly political and dynamic domain of knowledge and practice. Although we believe our communication audit of the SFM Network provides an in-depth analysis of some of the most important communication challenges faced in the management of this cross-sector research network, there is a need to compare multiple case studies to provide a more systematic analysis of communication in cross-sector research networks. There is also the need to develop a coherent theory of organizational communication that addresses the specific challenges associated with managing complex, cross-sector research networks.

Acknowledgments

Notes

1. Also named "cooperative research centres," "university–government–industry networks," and "networks of centers of excellence," among other epithets.

2. The description of the organizational structure of the SFM Network is based on the organizational chart publicly available on the Network's website.

3. The SFM Network evolved within a relatively stable but complex research environment, which required that professionals have responsibility for developing and conducting research projects relevant to the Network's priorities. The network had an unstable environment to the extent that its renewal was not guaranteed. Likewise, researchers who were involved in the Network gained "stability" within the Network if they were successful in securing funding repeatedly over the two terms of the SFM Network. In addition, the evolution of collaborative relationships within the network offered some "stability" to researchers whose Network social capital could be used to access resources within the Network during its 14-year operation and beyond (see Klenk & Hickey, in press).

4. This Entrepreneurial model of an academic research laboratory would be expected to become more complex as individual Principal Investigators worked within larger research teams. Cross-sector research teams would likely involve a Professional structure rather than an Entrepreneurial one.

5. The metaphor of "tongue" includes the values, norms, and cultural beliefs that are embodied in and conveyed through languages. It should be noted that the survey did not ask respondents if the communication strategy of the SFM Network helped in understanding others' views or fields of research.

Nevertheless, we draw upon other scholars' work on the importance of the diversity of partners' "languages" for effective management and communication in cross-sector research networks.

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