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Science-Seeking Behaviour of Conservation Authorities in Ontario

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Abstract The communication of science to science users is evolving to an approach that translates knowledge to targeted audiences. Under this evolution, knowledge brokers play an increasingly important role and users help 'pull' the required science to meet a policy or management imperative. To do this effectively, more insight is required into the knowledge seeking behaviour of science users and practitioners. The findings from a series of interviews that identify the science needs of Ontario's Conservation Authorities (CAs) are presented. Results indicate that emerging functions, such as source water protection and integrated water resource planning, require more science input than mature functions. Senior CA officials view personal communication with their knowledgeable staff as the most used, accessible, trustworthy, relevant, shared, and preferable source of science information. While the internet and media were considered highly accessible, they were not viewed as trustworthy. We found no relationship between CA size and science use. Further research is needed to identify where junior and intermediate CA staff obtain their science knowledge from and whether this varies as a function of CA size. Our findings will be of interest to both policy/program communities and science providers.

Keywords Communication · Science-policy linkages · Knowledge translation · Science needs · Knowledge brokering · Conservation authorities

Introduction

A common stereotype in the science-policy discourse is that of the policy maker having an interest only in short-term political gain and asking impractical questions of researchers. Another common stereotype is of scientists chronically lagging behind the timeframes required for decision making and providing overly complex responses to policy makers. Although scientists and policy makers may share the same goal, they do not necessarily have the same long-term and short-term imperatives. (In this article the term policy maker is used in a broader context that also includes those individuals who need and use science knowledge in their work to develop regulations, strategies or guidelines, or manage programs, etc., even though these practitioners are often distinct communities with potentially distinct science needs.) This may result in sporadic interaction between the two groups but when there is dialogue, there can be misunderstanding, miscommunication, and sometimes conflict. An additional factor that perpetuates the divide between scientists and policy makers is that neither the field of research nor the field of policy making is predictable and stable. Within a field of scientific research there are many different areas of expertise, and within these spheres there are different, sometimes conflicting or competing, theoretical paradigms and schools of thought. Nevertheless, it is generally acknowledged that

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scientific knowledge is fundamentally important to inform and guide environmental decision making (Krantzberg 2006).

The difficulties associated with bringing science knowledge into the environmental decision-making process more broadly has received increased attention. Decision-makers can be pensive for further scientific input on a given issue for fear that new questions and differing scientific interpretations can cancel each other out, resulting in political or economic interests to prevail. Further investment in scientific study or prolonged scientific argument can also be used to mask a debate over values, particularly on highly controversial environmental issues (Kinzig and others 2003; Policansky 1998; Sarewitz 2004).

Scientific uncertainty itself may be a barrier to the effective use of science in decision-making (Lubchenco 1998), in part the result of difficulties associated with quantifying uncertainty. To deal with some of these issues, and the increased demand from lay publics seeking a greater role in environmental decision-making, there is a call for the co-production of science and public policy, where technical issues are not divorced from their social setting and a range of participants engage in everything from problem setting to decision-making, eventually yielding more scientifically legitimate and publicly accountable decisions (Corburn 2007).

Additional factors contributing to the science-policy divide have been well documented. The cultures of the science and policy communities are quite different in terms of timescale, language, academic background and incentive structure, to name a few (Doern and Reed 2000; Saner 2007; Schaefer and others 2010; Steel and others 2004). Further, the perception that the science field is purely objective, empirical and non-partisan while viewing the policy process as overly subjective and political is also not helpful at bridging the divide (Institute on Governance 2007).

To help bridge the science-policy divide, more attention has been given to the need to better communicate science specifically to policy makers and develop strengthened avenues for communicating the science needs of policy makers back to the scientific community (Holmes and Clark 2008; Bielak and others 2008; CCMD 2002; Jarvis 1998; S&T Advisory Board 1999; Council of S&T Advisors 1999). Unfortunately much of this literature is relatively silent on how this has been achieved in practice, though this field of inquiry remains quite young. More specifically, there is little documented insight into how and when science is used by policy makers, practitioners and the decision-making process more generally, and improved understanding here is an important prerequisite to strengthening the science-policy linkage. As a consequence, traditional science communication approaches that 'push' or broadcast science findings to undefined audiences, leaving them to sift through and pick from it what might suit them and what might not, are being challenged by new approaches that deliberately translate science knowledge to a given target audience. In these new approaches, knowledge brokers can play an increasingly important role, and the quality, amount and level of science presented are determined by the user's needs ('pull' approach), (Bielak and others 2008, 2009; Shaxson 2009; Holmes and Savgard 2008; Scott and others 2005; Claessens and others 2008).

To provide more insight into the policy pull side of the equation, this article investigates the science needs of Ontario's Conservation Authorities (CAs). Created by the Province in 1946, their mandate has focused on the management of renewable resources, but what has been significant in the design of the CAs is the management of these resources on a watershed basis. Since its inception, the notion of watershed-based management has guided the development of individual Conservation Authorities and their ongoing planning and operational activities. Though flooding may have been the catalyst for some Conservation Authorities, the overall concept of watershed-based management of renewable resources prevails as the pre-eminent organizational activity. They are governed by a board of municipally appointed members, the majority of whom are also elected municipal councillors, and provide science-based advice and services within their watersheds including input and review to municipal Official Plans and planning processes to the majority of Ontario's municipalities. CAs are funded primarily through self generated revenues and municipal levies, with additional sources of funding coming from special municipal projects and select grant programs. They are typified by a close working arrangement with their member municipalities to deal with flooding, erosion hazard management, natural area protection and restoration, and the provision of recreational and educational opportunities. CAs also have important emerging responsibilities such as source water protection (SWP) planning required by the new *Clean Water Act* of 2006. CAs operate in watersheds in which 90% of Ontario's population reside and their increasingly important range of functions necessitates up-to-date science knowledge. CAs were chosen in this project due to their role as on-the-ground science users, the emerging nature of some of their program areas (e.g. SWP), and the variability in the size of their organizations. In this study, decision makers, or science users, are represented by senior managers in Conservation Authorities.

The objective of this article is to help strengthen science-policy linkages through a better understanding of CA practitioners' science needs. Greater insight into their current and preferred sources of science knowledge, the trustworthiness of various sources, and the barriers to accessing science input are important to help ensure scientific knowledge flows to optimally inform the decision-making process. For large generators of research information—universities, provincial and federal agencies, research consortia—this knowledge is important to help transcribe and transfer science products into a form and at a time that optimizes receptivity and use. This study can help identify knowledge-brokering opportunities amongst CAs and how the deployment of science could be more effective in meeting the needs of program and policy implementers.

Dobbins and others (2007) have looked at science capacity issues in different organizations but the link more specifically with organisational size remains unanswered and it would be helpful to understand whether any significant science access issues exist for smaller CAs in Ontario.

To meet the objective of strengthening the science-policy inter-linkages, this article provides information on the use of, and access to, science by CAs. More specifically, this study explores:

(1) The link between science knowledge and the range of activities typically carried out by CAs in Ontario.
(2) How science is used and accessed, what form of communication enables the use of science, when science is used in the decision-making process, and how uncertainty is dealt with in the context of the different types of CA activities.
(3) Whether the above questions are influenced by CA size and capacity.

Methods

From a total of 36 CAs in Ontario, nine CAs were chosen—with the help of Conservation Ontario, a non-governmental organization that represents CAs in Ontario—to participate in this study. To assess whether there was a relationship between CA size and science capacity, these nine CAs were further partitioned into three large-sized, three medium-sized and three small-sized CAs, based on their respective annual budgets, geographic scope and span of activities. The need for some degree of regional representation, mostly in southern Ontario was also factored in.

Interviews were conducted in an informal and semi-structured nature with 3 senior officials from each of the 9 CAs, for a total of 27 interviews. Participants were purposefully selected to include the chief executive/administrative officer, general manager, senior engineer or senior planner. The views of senior officials were solicited because this group is best positioned to articulate the nature of the science-policy dynamic in their respective organizations. Purposive sampling therefore, as opposed to a random sample of all CA employees, was deemed essential to adequately capture the views of senior representatives. The interviews conducted in this study represent a well-balanced cross section of the relevant population but it is possible that given the emphasis on senior officials, some key issues may be overstated or alternatively, given insufficient prominence. Interviews with front line staff (typically more junior or intermediary positions) in CAs in Ontario has been initiated and will be the subject of a separate article.

The questionnaire (available from the authors upon request) consists of 39 questions; a combination of likert scale questions, multiple choices, yes/no and a series of open-ended qualitative questions. Interviewees were encouraged to further elaborate on any of the closed-ended questions. Questions were grouped into several themes: questions exploring the extent that various activities were science informed; questions about when and how science informs decision-making; questions ranking the importance of various sources of science knowledge; questions assessing how capacity issues affect science use; questions on the impact of science on policy making; and questions that better help understand the problem scale and solution aspects. All questions were asked and answered.

Interviews were conducted face-to-face (some by telephone) and on a one-on-one basis at the place of the interviewee's place of work, between October and December 2008. The interviewees were provided information on the research study in advance of their interview to help them prepare, and participated under the condition that their individual views would remain anonymous.

Results

Most Science-Dependent Activities

In this section of the interview, the activities typically carried out by CAs that were most dependent on science input and availability was assessed. Respondents ranked a range of core activities in terms of the degree to which they are informed by science knowledge—also stated here as the amount of science applied to the activity (Table 1). The authors hypothesized that new or emerging functions such as SWP planning and implementation, and integrated water resource planning and implementation would require more science input, compared with more mature activities such as flood protection, reservoir management, permitting, and outreach. Indeed these emerging or innovative CA activities scored higher than the mature or routine activities regarding the use of science. The more established activities of flood protection and monitoring were the exception and remain relatively highly ranked in terms of science-based functions. The need to continuously update

Table 1 Most science-based activities

Activity	Overall % of science invested
Source water protection planning	21
Integrated water resource planning/ management	21
Monitoring/indicators	16
Flood protection	16
Permits and approvals	9
Remediation	7
Other activities (reservoir management, public outreach and stewardship, conservation areas' management, etc.)	10

hydrologic modelling to ensure flood risk delineation is accurate is one possible explanation. SWP planning, integrated water resource planning/management and remediation—which are relatively new CA activities—combined for almost half the total percentage of activities that were highly science-based. This will be further explored below.

The Culture of Science Use: When and How Often Science is Used

A series of likert scale questions queried when and how science is used, and the impact of science on decision making. On the whole, CA officials reported frequent access to, and use of, science knowledge. CAs usually seek out recent science knowledge to inform decisions, support the culture of science-based policy and monitoring, and have staff that are trained to research science findings (Table 2). The results were more variable on the issue of the existence of standard approaches for reviewing/updating policies with new science information. The responses reinforce the finding that CAs update science information more frequently for emerging or new activities than for more routine ones.

When asked about the impact of science on policy making more specifically, there was moderate to strong agreement that science information has helped identify the need for policy action, influenced program planning decisions, assisted program evaluation, and identified staff training needs (Table 3). On the whole, the results from these questions confirm that CAs view themselves as science-based organizations.

While it was hypothesized that access to, and use of, science would vary depending on CA size, this was not the case. When grouped by CA size (large, medium and small), differences were marginal (Fig. 1). Officials from small CAs were equally confident and comfortable about their access to, and use of, science knowledge.

Table 2 When science used, how, and how often

Statement	Avg. answer[a]
1. My CA looks for relevant up-to-date science knowledge to inform program or policy decisions regarding innovative/new activities.	4.33
2. My CA updates its science information regarding routine activities for revision of policies.	3.78
3. My CA's staff is formally trained to research science findings relative to issues/initiatives addressed by my CA.	4.07
4. My CA supports the culture of science-based policy and monitoring.	4.44
5. My CA has a standard system in place for reviewing/ updating policies using up-to-date science information.	3.44
6. Regulations and legislations (provincial/federal) greatly influence the decisions my CA makes about its activities.	4.30

The average shown in Table 2 represents all answers selected by interviewees, multiplied by the scale number and then divided by the total number of interviewees

[a] 5 = always, 4 = usually, 3 = sometimes, 2 = rarely, 1 = never

Table 3 Impact of science on policy making

Statement	Avg. answer[a]
1. Science information has helped identify the need for policy action in my CA.	4.52
2. Science information has influenced program planning decisions at my CA.	4.44
3. Science information has resulted in decision(s) by my CA to conduct program evaluations.	4.07
4. Science information has resulted in decisions to provide staff development training in my CA.	4.27

[a] 5 = strongly agree, 4 = moderately agree, 3 = neutral, 2 = moderately disagree, 1 = strongly disagree

How Capacity Affects Science Use in CAs

Capacity issues (sometimes called organizational barriers) such as time, resources, training and availability of science information, are often documented barriers to improved science use in decision making. This study tested whether these capacity issues were important impediments for CAs. The responses to these questions consistently solicited neutral positions (moderately agree/disagree) (Table 4). Generally, training and resistance to change did not emerge as impediments to the use of science. Lack of time, limited financial resources and lack of available relevant and credible science tended to be somewhat, or moderately, viewed as impediments.

Once again, it was expected that impediments would vary by CA size (i.e., the smaller the CA, the more limited

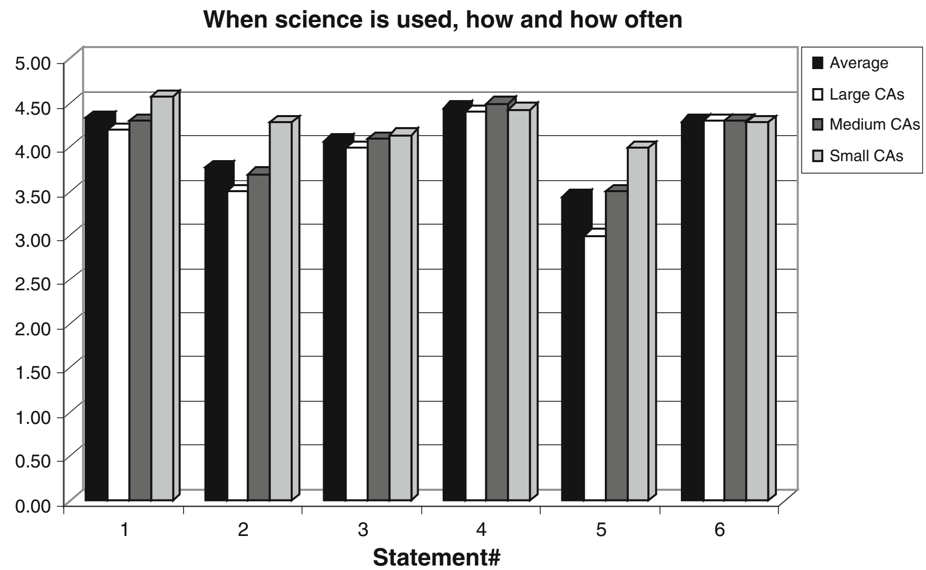

Fig. 1 When science is used, how, and how often

Table 4 How capacity affects science use

Statement	Avg. answer[a]
1. Lack of time is a barrier in the access and use of science information for decision making.	3.78
2. My CA's limited financial resources are a barrier in the access and use of science information for decision making.	3.37
3. The availability of relevant and credible science knowledge is a barrier in the access and use of science information for decision making.	3.52
4. Limited training or experience within my CA in evaluating the quality of science information is a barrier in the access and use of science information for decision making.	2.44
5. Resistance to change in my CA is a barrier in the access and use of science information for decision making.	2.04
6. Working with many initiatives undertaken concurrently by my CA is a barrier in the access and use of science information for policy decisions regarding each initiative (not enough resources to dedicate sufficiently to each initiative).	3.84

[a] 5 = strongly agree, 4 = moderately agree, 3 = neutral, 2 = moderately disagree, 1 = strongly disagree

staff training or expertise would be viewed as a barrier to science use), however this did not hold true. There was no strong trend corresponding to CA's size and capacity in the use of science (Fig. 2).

Sources of Science Knowledge

The sources from which CAs access science knowledge used by CAs were examined more closely to further understand the science-policy culture. Determining the preferred sources of science information for CA officials, such as personal communication or published literature, can help large research providers better tailor their science outputs, thereby improving access and better bridging of the science-policy gap. Sources of science information were grouped into the following four main areas (Fig. 3):

- Personal communication: CA staff, provincial and federal staff, academics and consultants.
- Interactive learning: conferences, workshops and seminars, professional associations, traditional ecological knowledge.
- Published literature: reports (including executive summaries), refereed journals, newsletters, books, briefing notes, special studies (studies conducted for special CA issues).
- Internet and media: internet searches, multimedia (TV, radio, documentaries, etc.), professional websites, newspapers and magazines.

Overall, senior CA officials depend heavily on personal communication for their science information. Personal communication was the most used, accessible, trustworthy, relevant, shared, and preferred way to receive their science information. Reports and workshops/seminars also ranked high as important sources of science knowledge. Refereed journals, consultants and books were ranked slightly lower in terms of use. Internet searches are among the most used and accessible but rank very low in terms of trust. The convenience of the internet, as a source, is understandable especially when time is a constraining factor. Given that CAs view lack of time as a barrier in the access and use of science information (Table 3), the internet will likely remain an important source for CAs. The concern among CA staff with this source lies more with the lack of credibility and relevance.

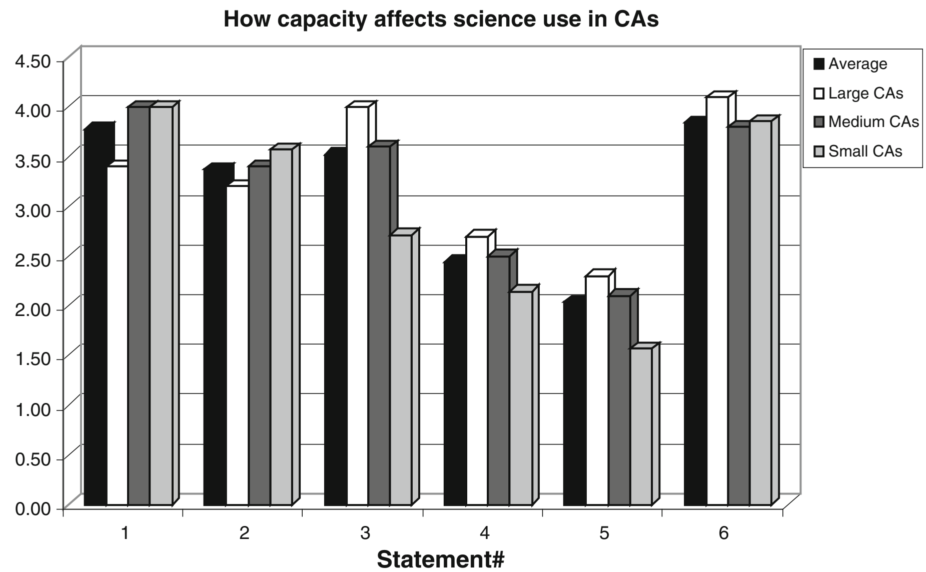

Fig. 2 How science capacity affects science use in CAs

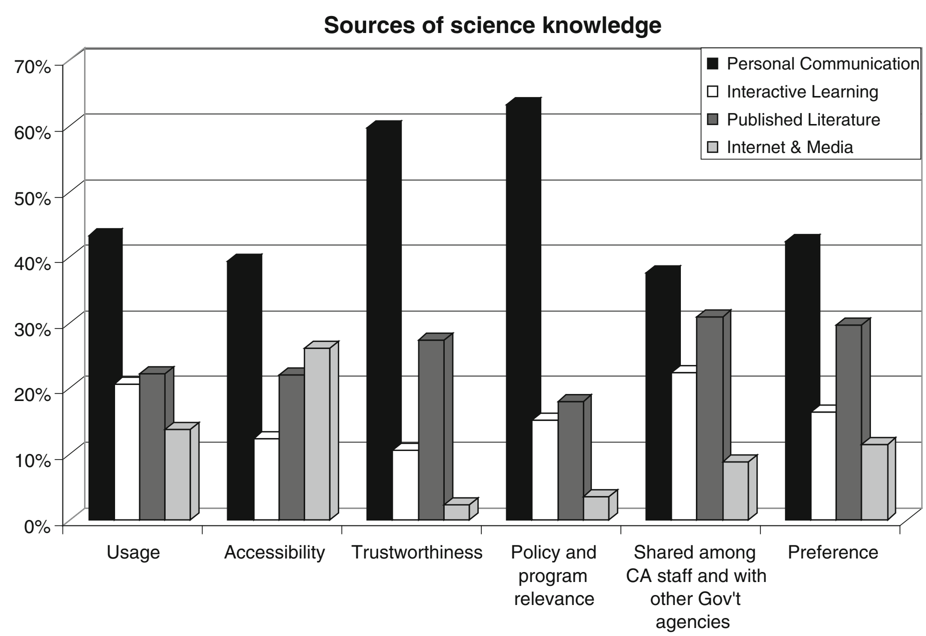

Fig. 3 Sources of science knowledge

Figure 4 further elaborates on the 'personal communication' group, as the dominant group of science sources. Overall, senior CA officials favour their own staff for science information, though provincial staff rank the highest for "most program and policy relevant," reflecting the regulatory relationship between the province and CAs. Academics ranked high in terms of trustworthiness but lower on policy and program relevance. Federal staff ranked higher on relevance but lower on accessibility and overall usage, though a follow-up question found that 100% of the interviewees confirmed that Environment Canada is one of their science knowledge resources.

One final but important question explored the knowledge of CA managers regarding the sources of science for junior staff. Seventy-four percent of the interviewees indicated that their junior staff get their science information from the same sources they get it from. Future analysis of junior and intermediate staff would be required to validate this assertion.

Science-Policy Communication Problems and Knowledge Brokers

In addition to assessing barriers to science use, Table 5 illustrates how CA officials rank what they believe to be

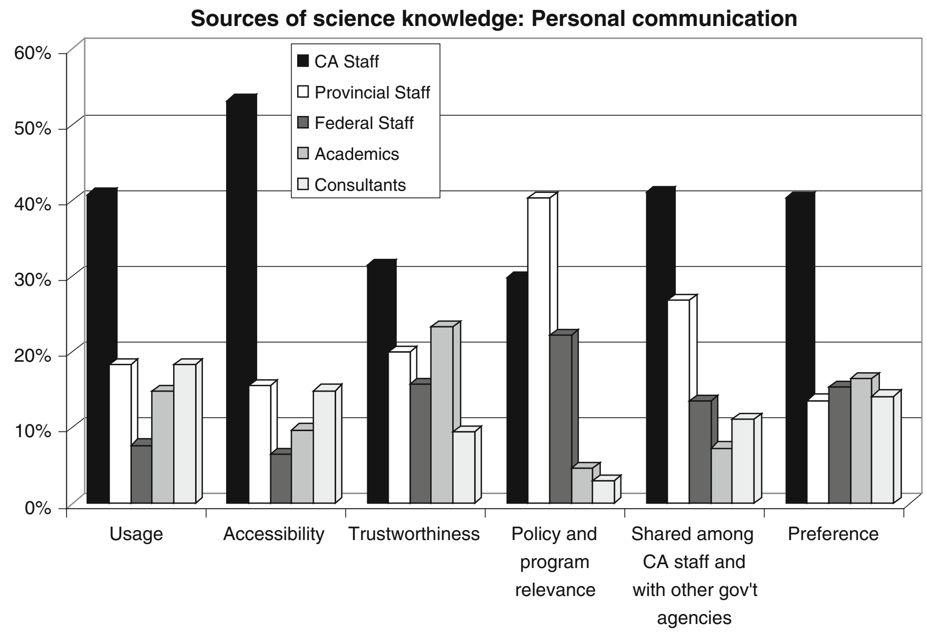

Fig. 4 Sources of science knowledge: personal communication

Table 5 Main causes of communication problems

Cause	Priority (in %)
Timing of communication: time scale of policy makers	26
Researchers do not address concerns of policy makers	15
Different jargon/discourse	12
Financial barriers; resources allocated to knowledge brokering	12
Lack of appropriate communication channels	11
Legal barriers; inflexible regulations of policy communications	10
Lack of tradition in communication	7
Other	7

the causes of broader communication problems between the science and policy/program communities. Our purpose here was to uncover barriers in order to identify solutions. To illustrate, decision makers (or science users) are generally pressed for time, while scientists need time to test, analyze and interpret data, making the issue of competing time scales a potential barrier to improved communication. The results from this study support this as CAs of all sizes consistently ranked the time challenge issue as the number one communication problem. This problem is consistent with what has often been documented in the field of science-policy communication (Holling and others 1997; Schön and Rein 1994). While the lack of an appropriate communication channel did not rank high as a consistent or routine cause of communication problems, a small number of CA officials felt very strongly that new communication channels were indeed needed to better flow information within their organizations.

The use of a knowledge broker or science interpreter—that functions as an intermediary linking the producers of science with science users—is getting more attention as a tool to better bridge science and policy communities (Michaels 2009; Holmes and Clark 2008; Pielke 2007; Defra 2006, Bielak and others 2009). When queried, 26% of the respondents indicated their CA has staff dedicated to knowledge brokering (full-time staff with this, or similar, as a job description). On further questioning, it was found that many CAs are hiring external consultants and creating new positions for this task to respond to the demands of SWP planning and other emerging activities.

Dealing with Scientific Uncertainty

Table 6 shows the perceptions of CAs' senior officials on the approaches used when faced with policy decision in light of high levels of scientific uncertainty. Adaptive management (i.e., to experiment and monitor locally to reduce uncertainty in the future) ranked the highest, followed by the precautionary principle [i.e., taking protective actions even when the scientific evidence of harm remains uncertain (Raffensperger and Tickner 1999)] and then by flexibility in implementing policy. The results clearly indicate that when it comes to dealing with scientific uncertainty in the decision-making process, senior CA officials prefer not to make political decisions.

Table 6 Approaches to policy with scientific uncertainty

Approach	Priority (in %)
Adaptive management (experiment and monitor locally to reduce future uncertainty)	31
Precautionary principle	25
Implement policy flexibly in waiting for more scientific certainty (external sources)	24
Executive political decisions	13
Public appraisal	4
Other	3

Discussion

In this section some of the key findings are discussed in the context of previous study.

CA Activity and Science Knowledge

On the issue of which CA activities are most science informed, there is general agreement that the use of science to review and update CA program or policy decisions was found to be activity dependent. Source Water Protection (SWP) planning scored the highest among the most science-dependent activities of CAs, followed closely by integrated water resource planning/management. Both of these activities are new and innovative CA functions. The SWP planning issue provides a good illustration of the largely policy implementation role of CAs. SWP planning is required of CAs under the government of Ontario's recent Ontario Clean Water Act. According to the Act, CAs are to develop a SWP plan to protect municipal drinking water sources. SWP planning is a new activity for which CAs are assuming a leadership role and it appears this issue has considerable potential for igniting what can be called a science-policy communication revolution in CAs. To illustrate, in some instances two or three regionally close CAs allocate their SWP plan development to a shared committee, thereby building potentially stronger channels of science-policy communication. The need for more interactive science communication between stakeholders across disciplines (policy, science, business, public at large, technical experts, academics, etc.) on SWP planning stems not only from its newness but also because of its continuous and dynamic nature. Source water planning requires ongoing research and monitoring to ensure a current scientific understanding of the different sources and pathways of contaminants. This results in pressure to continually update policy and ensure ongoing community education and involvement.

The important distinction here is that of policy-making versus policy-implementation, and the implications then, for the use of science. Interviewees repeatedly drew attention to the point that CAs often do not make policies; rather they receive them from provincial regulators and are required to implement actions in accordance with policy. CAs take on the responsibility for researching and developing the science needed to implement the policies. As policy implementers they often approach the access and use of science differently than do policy makers in more senior government agencies.

Barriers to Science Use

Senior managers in CAs generally do not believe there are major capacity issues to the access and use of science in their decision-making processes. Barriers of some concern included lack of time, a corresponding feeling of being "spread too thin", and the availability of relevant and credible science information. This mirrors previous research that has found that typical barriers include the inability to search out relevant information due to lack of time, inability to access/find information, and the lack of information at a local scale (Land & Water Australia 2001, 2006; Dobbins and others 2007; Holmes and Clark 2008; Simmonds and others 2004).

Science Sources

Determining which sources of science are used more frequently than others, and which are more preferred, helps not only CAs but also large research providers better customize their science information, improving receptivity. It is clear that senior CA managers depend primarily on their own staff, followed by municipal, provincial and federal staff for science information. This is consistent with previous study which concludes that senior staff primarily depend on their own professional staff and trusted personal contacts, often in a verbal manner to be kept informed and updated on key science issues (Claessens and others 2008; Simmonds and others 2004; Roux and others 2006; Dobbins and others 2007). The implication here is that science providers should therefore be cognizant of the need to provide front line staff with accessible and useable science findings that their senior managers frequently rely on (typically through word of mouth) to inform their programs and activities.

CA Size and Capacity Issues

Contrary to our initial hypothesis, the size of the CA does not influence the use of, or capacity to acquire, science information. It was expected that smaller CAs would be more challenged in terms of their capacity to access science knowledge and in their preferences for certain types of science sources, as examples. In fact, this study found the use of science in small CAs was comparable to large CAs. Stated differently, small CAs did not view themselves as disadvantaged when it comes to the use of, and preferences for, science in the decision-making process. The authors offer two preliminary explanations here. First, given that this study captured only the perceptions of senior officials, it is possible their responses are biased towards presenting a more positive view of the science-policy culture in their organizations. Research underway that interviews intermediate and junior staff will shed more light here. A second explanation is that many small CAs frequently derive expertise from local institutions, universities, and neighbouring (and often larger) CAs. This suggests that they have found the means to acquire science support external of their staff, and thus have moved considerably in the direction of solving their own science capacity issues. On the whole the relationship between organization size and access to science information remains poorly understood and more research here is warranted to conclude whether size is a limiting factor.

Scope of Science

The sentiment that researchers are not adequately responding to program and policy needs is not a new one, and was echoed again in this study. One respondent stated "It is important to get the research community to pay more attention to real contemporary issues. Conservation areas [managed by CAs] are available for researchers to explore and have their research findings directly influence the respective policies. Science often appears to be siloed and too narrow in scope. A more integral approach to science as it relates to ecosystems would be more helpful for the science-policy communication cause." There was recognition however that the onus was equally on science users to better articulate their research needs.

Concluding Remarks

Interviewees pointed out that CAs are diverse and innovative in their capability for acquiring science knowledge. They do argue, however, that there is considerable opportunity to better coordinate among CAs in situations where capacity limitations necessitate the seeking of external science knowledge. The role of Conservation Ontario was said to be central for improving the science-policy communication culture among CAs.

Senior managers in CAs are strong advocates for improved knowledge brokering. They advocate improved channels of communication between researchers and policy and program personnel (workshops/seminars, conferences, etc.). They recommended that CAs should dedicate more human and financial resources to knowledge brokering, thereby strengthening their relationships with academic institutions (universities), large science providers and fostering improved access to the published literature. There was recognition that this improved linkage—including the need to better harvest the science needs of practitioners—was unlikely to happen unless dedicated funding was provided and staff secured with science translation and knowledge brokering skills sets to better bridge the gap. This is consistent with recent literature that advocates that science communication needs to be explicitly considered early in the project planning cycle, and that funding needs to also be dedicated to the movement of knowledge (Holmes and Clark 2008; Scott and others 2005; European Commission 2008; ERFF 2007; Leggett and Elliott 2002; Shaxson 2009; Bielak and others 2009).

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References

Bielak A, Campbell A, Pope S, Schaefer K, Shaxson L (2008) From science communication to knowledge-brokering: the shift from 'science push' to 'policy pull'. In: Claessens M, Gascoigne T, Metcalfe J, Schiele B, Shi S (eds) Communicating science in social contexts: new models, new practices. Springer, New York

Bielak AT, Holmes J, Savgård J, Schaefer K (2009) A comparison of European and North American approaches to the management and communication of environmental research. Swedish Environmental Protection Agency Report 5958. 132 pp. http://www.naturvardsverket.se/sv/Nedre-meny/Webbokhandeln/ISBN/5900/978-91-620-5958-3/. Accessed June 5, 2009

Canadian Centre for Management Development (2002) Creating common purpose: the integration of science and policy in Canada's public service. CCMD, Ottawa, 29 pp

Claessens M, Gascoigne T, Metcalfe J, Schiele B, Shi S (2008) Communicating science in social contexts: new models, new practices. Springer, New York

Corburn J (2007) Community knowledge in environmental health science: co-producing policy expertise. Environmental Science and Policy 10:150–161

Council of Science and Technology Advisors (May 1999) SAGE: Science advice for government effectiveness. www.csta-cest.ca/index.php?ID=90&Lang=En. Accessed October 14, 2008

Defra (2006) Turning the tide – Addressing the impact of fisheries on the marine environment. The UK Government response to the Royal Commission on Environmental Pollution's twenty-fifth report. Cm 6845. The Stationary Office, Norwich

Dobbins M, Rosenbaum P, Plews N, Law M, Fysh A (2007) Information transfer: what do decision makers want and need from researchers? Implementation Science 2(20):12

Doern GB, Reed T (2000) Risky business: Canada's changing science-based policy and regulatory regime. University of Toronto Press, Toronto, 385 pp

Environment Research Funders' Forum (ERFF) (2007) Using research to inform policy: the role of interpretation. ERFF Report 3, 32 pp. http://www.erff.org.uk/documents/2007-03-interpret-study.pdf. Accessed January 17, 2009

European Commission European Research Area (2008) Scientific evidence for policy-making report EUR 22982. http://ec.europa.eu/research/social-sciences/pdf/scientific_evidence_policy-making_en.pdf. Accessed January 17, 2009

Holling CS, Sando R et al (1997) Science and policy partnership for sustainability. Draft CA'se statement

Holmes J, Clark R (2008) Enhancing the use of science in environmental policy-making and regulation. Environmental Science and Policy 11:702–711

Holmes J, Savgard J (2008) Dissemination and implementation of environmental research: a report prepared by the Swedish Environmental Protection Agency to establish the approaches to, and experiences of, research dissemination and implementation by SKEP (Scientific Knowledge for Environmental Protection) member organizations. Report 5681

Institute on Governance (2007) Public science in Canada: strengthening science to protect Canadians. Conference Summary Report, Nov 22, 2007

Jarvis B (1998) The role and responsibilities of the scientist in public policy: a discussion paper on science and government. Public Policy Forum, Ottawa, Ontario, Canada

Kinzig AP, Starrett D, Bolin B, Dasgupta P, Ehrlich P, Folke C, Hanneman M, Jansson AM, Jansson BO, Kautsky N, Levin S, Lubchenco J, Mäler KG, Pacala S, Schneider S, Siniscalco D, Walker B (2003) Coping with uncertainty: a call for a new science-policy forum. Ambio 32(5):330–335

Krantzberg G (Dec 23, 2006) Report on science-policy workshop. McMaster University, Ontario, Canada, May 18, 2006

Land & Water Australia (2001) Knowledge seeking strategies of natural resource professionals: workshop synthesis, 27 pp

Land & Water Australia (2006) Knowledge for regional NRM: connecting researchers and practitioners. Land & Water Australia

Leggett D, Elliott C (May 2002) DEFRA/environment agency flood and coastal defence R&D programme: improving the implementation and adoption of flood and coastal defence R&D results. Technical Report W5G-003/TR, 81 pp

Lubchenco J (1998) Entering the century of the environment: a new social contract for science. Science 279:491–497

Michaels S (2009) Matching knowledge brokering strategies to environmental policy problems and settings. Environmental Science and Policy 12:994–1011

Pielke RA (2007) The honest broker: making sense of science in policy and politics. Cambridge University Press

Policansky D (1998) Science and decision making for water resources. Ecological Applications 8(3):610–618

Raffensperger C, Tickner JA (1999) Protecting public health and the environment: implementing the precautionary principle. Island Press, Washington, DC

Roux DJ, Rogers KH, Biggs HC, Ashton PJ, Sergeant A (2006) Bridging the science–management divide: moving from unidirectional knowledge transfer to knowledge interfacing and sharing. Ecology and Society 11(1):4–23

Saner M (2007) A map of the interface between science and policy. Council of Canadian Academies, Staff Papers, Ottawa, Ontario, Canada, 12 pp

Sarewitz D (2004) How science makes environmental controversies worse. Environmental Science and Policy 7:385–403

Schaefer KA, Bielak AT, Brannen LE (2010) Linking water science to policy: a Canadian experience. In: Quevauviller Ph (ed), Water system science and policy interfacing. RSC Publishing, Cambridge, pp 281–292. ISBN: 978-1-84755-861-9

Schön DA, Rein M (1994) Frame reflection—toward the resolution of intractable policy controversies. Basic Books, New York

Science and Technology Advisory Board (1999) Finding better solutions: a guide to integrating social science and community-based knowledge into planning and policy development, Environment Canada, Ottawa, Report # 4

Scott A, Holmed J, Steyn G, Wickham S, Murlis J (2005) Science meets policy in Europe. A report for the science-meets-policy conference, London, November 2005. Research undertaken by The Knowledge Bridge for the UK Department for Environment, Food and Rural Affairs (DEFRA)

Shaxson LJ (2009) Cost-effective tools for managing the SCP evidence base: taking a knowledge brokering approach to policymaking. Report of DEFRA project EV0410. http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=15656#RelatedDocuments. Accessed May 25, 2009, 56 pp

Simmonds P, Stroyan J, Zaman R (2004) Survey of knowledge transfer between NERC-funded researchers and the users of their outputs, 75 pp. http://www.technopolis-group.com/resources/downloads/reports/441_Final_040708.pdf. Accessed January 4, 2009

Steel B, List P, Lach D, Shindler B (2004) The role of scientists in the environmental policy process: a case study from the American west. Environmental Science Policy 7(1):1–13