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The influence of capacity and attitudes in the use of water quality citizen science and volunteer benthic monitoring in the freshwater management activities of Ontario's Conservation Authorities

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Graduate Program in Biology

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Abstract

The contribution of non-experts to environmental management has been significant and continues to flourish through their participation in citizen science. Despite its growth as an interdisciplinary field of enquiry, there are many gaps in our understanding of the role that citizen science may play in the future of environmental management. In Ontario, Canada, due to funding cuts and infrastructural changes over the past two decades, the provincial government’s ability to monitor changes in freshwater resources had been severely limited. This has resulted in downloading water monitoring to municipalities through their conservation authorities (CAs) which are watershed-based, quasi-governmental water management agencies. The public has been supplementing monitoring efforts through the thousands of hours they have devoted to water quality citizen science, including volunteer benthic monitoring (VBM). Through their watershed-based structure, their mandate to involve community in their work, their activities managing freshwater and their collaborations with various stakeholders, CAs seem like the ideal organizations to connect the public with the decision makers within the municipalities that manage local freshwater resources. However, their use of citizen science, particularly in benthic monitoring, is rare with most of their data being collected in-house by paid expert staff. By conducting 44 interviews among individuals of CAs and citizen science groups, participating in monitoring and collecting documents published by both these groups as well as administering a survey among all of the 36 CAs, I examined the influence of both CA capacity and attitudes in limiting the use of volunteer benthic monitoring by CAs in their freshwater management decisions. Twenty-nine CAs participated in the survey to some extent, although for 24 of these CAs, only one or two questionnaires were submitted (a total of 67 questionnaires completed). While the CA’s capacity through their organizational dynamics (human resources, flexibility, collaborations) generally supports the use of VBM, they lack the financial and human resources to fully support this form of citizen science. This, along with the attitude that volunteers are not capable of collecting credible monitoring information, makes the widespread adoption of VBM by CAs unlikely. Despite these findings, there is still the potential for CAs to successfully adopt certain types of water quality citizen science that are not as financial and human resource intense as VBM, and that have a broader appeal to variety of types of volunteers.
Keywords

Citizen science, volunteer benthic monitoring, conservation authorities, capacity, public participation, mixed methods, case studies, surveys

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<td>CURA</td>
<td>Community-University Research Alliance</td>
</tr>
<tr>
<td>DFO</td>
<td>Department of Fisheries and Oceans</td>
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<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<tr>
<td>EMAN</td>
<td>Ecological Monitoring and Assessment Network</td>
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<tr>
<td>ENGO</td>
<td>Environmental Non-government Organization</td>
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<tr>
<td>EPA</td>
<td>US Environmental Protection Agency</td>
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<tr>
<td>IWM</td>
<td>Integrated Watershed Management</td>
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<tr>
<td>NCC</td>
<td>National Capital Commission</td>
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<tr>
<td>NGO</td>
<td>Non-government Organization</td>
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<tr>
<td>MDDEP</td>
<td>Ministère du Développement Durable, de l’Environnement et des Parcs</td>
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<tr>
<td>MNR</td>
<td>Ontario Ministry of Natural Resources</td>
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<tr>
<td>MOE</td>
<td>Ontario Ministry of the Environment</td>
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<tr>
<td>OBBN</td>
<td>Ontario Benthos Biomonitoring Network</td>
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<tr>
<td>OMAFRA</td>
<td>Ontario Ministry of Agriculture, Food and Rural Affairs</td>
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<tr>
<td>OSAP</td>
<td>Ontario Stream Assessment Protocol</td>
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<tr>
<td>SMART</td>
<td>Stream Monitoring and Research Team</td>
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<tr>
<td>SSHRC</td>
<td>Social Sciences and Humanities Research Council of Canada</td>
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<tr>
<td>SWP</td>
<td>Source Water Protection</td>
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<tr>
<td>URBAN</td>
<td>Urban and Rural Monitoring and Assessment Network</td>
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<tr>
<td>VBM</td>
<td>Volunteer Benthic Monitoring</td>
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<tr>
<td>WCED</td>
<td>United Nations World Commission on the Environment and Development</td>
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## List of Conservation Authority Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ABCA</td>
<td>Ausable Bayfield Conservation Authority</td>
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<tr>
<td>CRCA</td>
<td>Cataraqui Region Conservation Authority</td>
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<tr>
<td>CCCA</td>
<td>Catfish Creek Conservation Authority</td>
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<tr>
<td>CLOCA</td>
<td>Central Lake Ontario Conservation</td>
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<tr>
<td>HRCA</td>
<td>Conservation Halton</td>
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<td>CVC</td>
<td>Credit Valley Conservation</td>
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<tr>
<td>CVCA</td>
<td>Crowe Valley Conservation</td>
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<tr>
<td>ERCA</td>
<td>Essex Region Conservation Authority</td>
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<td>GCA</td>
<td>Ganaraska Region Conservation Authority</td>
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<tr>
<td>GSCA</td>
<td>Grand River Conservation Authority</td>
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<tr>
<td>GSCA</td>
<td>Grey Sauble Conservation Authority</td>
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<tr>
<td>HCA</td>
<td>Hamilton Conservation Authority</td>
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<tr>
<td>KC</td>
<td>Kawartha Conservation</td>
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<tr>
<td>KCCA</td>
<td>Kettle Creek Conservation Authority</td>
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<td>LSRCA</td>
<td>Lake Simcoe Region Conservation Authority</td>
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<td>LRCA</td>
<td>Lakehead Region Conservation Authority</td>
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<td>LPRCA</td>
<td>Long Point Region Conservation Authority</td>
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<td>LTVCA</td>
<td>Lower Thames Valley Conservation Authority</td>
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<td>LTC</td>
<td>Lower Trent Conservation</td>
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<tr>
<td>MVCA</td>
<td>Maitland Valley Conservation Authority</td>
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<tr>
<td>MRCA</td>
<td>Mattagami Region Conservation Authority</td>
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<td>MVC</td>
<td>Mississippi Valley Conservation Authority</td>
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<tr>
<td>NPCA</td>
<td>Niagara Peninsula Conservation Authority</td>
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<tr>
<td>NDCA</td>
<td>Nickel District Conservation Authority</td>
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<tr>
<td>NBMCA</td>
<td>North Bay-Mattawa Conservation Authority</td>
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<tr>
<td>NVCA</td>
<td>Nottawasaga Valley Conservation Authority</td>
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<tr>
<td>OCA</td>
<td>Otonabee Conservation</td>
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<tr>
<td>QC</td>
<td>Quinte Conservation</td>
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<tr>
<td>RRCA</td>
<td>Raisin Region Conservation Authority</td>
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<tr>
<td>RVCA</td>
<td>Rideau Valley Conservation Authority</td>
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<tr>
<td>SCA</td>
<td>Saugeen Conservation</td>
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<tr>
<td>SSMRCA</td>
<td>Sault Ste Marie Region Conservation Authority</td>
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<td>SNCA</td>
<td>South Nation Conservation</td>
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<tr>
<td>SCRCA</td>
<td>St. Clair Region Conservation Authority</td>
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<tr>
<td>TRCA</td>
<td>Toronto and Region Conservation Authority</td>
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<tr>
<td>UTRCA</td>
<td>Upper Thames River Conservation Authority</td>
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Chapter 1

1 Introduction

There is mounting evidence, from multiple corners (e.g., in the academic literature on sustainability, through the proliferation of non-profit conservation organizations, government attention to environmental issues like climate change) of how humans are degrading their ecological life-support systems. Contributing to this are a myriad of human activities driven by population growth and consumption patterns resulting in climate change, the loss of biological populations, species and ecosystems, the spread of invasive species and the accumulation of pollutants (McAlpine et al. 2015). The hydrologic cycle is being stressed by over consumption and pollution of water sources, and shifts in the cycle are occurring as a result of global climate change. Shifts in the hydrologic cycle arising from these stresses are affecting the quantity and quality of water resources for many ecosystems and societies across the globe; water resources are often “a significant bottleneck for sustainable development and poverty alleviation” (pg. 16, Buytaert et al. 2014). A recent article by McAlpine et al. (2015) discusses the dire circumstances of our situation urging that environmental sustainability and intergenerational equity be at the top of our political agenda and “the core of our personal and societal belief systems” (pg. 2). They discuss the latter in a call for transformational change by society with individuals “being responsible and ethical in our dealings with other people and our environment”, by “better integrating ourselves into our communities” and by “reconnecting with and valuing nature” (pg. 2, McAlpine et al. 2015). One behaviour that can contribute to such societal transformation is citizen science.

1.1 Citizen science and water resources

Citizen science is science that is done by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions. Although citizen science is increasingly common, it is not new and it has significantly contributed to our understanding of the earth’s biological and physical
properties, systems and dynamics. According to Buytaert et al. (2014), citizen science inspires and facilitates interdisciplinary research (Wechsler 2014; Jordan et al. 2015; Crain et al. 2014; Dickinson et al. 2010), improved governance and human rights (Gaventa and Barrett 2012), democratizing of science (Ostrom 1990; Macknick and Enders 2012), and broader understanding of ecology and biogeography (Dickinson et al. 2012; Theobald et al. 2015; Roy et al. 2015; Powney and Isaac 2015). Citizen science can play an important role in improving societal conditions through scientific outreach and education for the promotion of conservation (Macknick and Enders 2012), and by providing innovative thinking and improving relationships among institutional actors by bringing individuals from diverse backgrounds together (Woolley et al. 2010).

Buytaert et al. (2014) argue that water science suffers from a lack of spatial and temporal data, despite its critical societal relevance and the complexity of its governance. They call for reflection on the role that citizen science can play in generating new knowledge about the water cycle and ecosystem services, particularly in decision-making arenas (Buytaert et al. 2014). In Bakker’s (2007) ‘Eau Canada’, Rob de Loë and Reid Kreutzwiser stress the importance of water governance, rather than data, in dealing with the “people issues” related to managing water resources and a long list of both environmental and social problems (as cited in Walker 2009). Pahl-Wostl et al. (2008a) support this concept stating,

The problem that we face when we deal with sustainability lies not so much in our lack of understanding of the functioning of ecological systems, but in our lack of understanding of the governance and cultural systems and how they are structured and managed and interact with ecological systems, and how we produce science and knowledge for policy. (pg. 1)

In water resources management in particular, engineering and controlling environmental problems with technical solutions has been the traditional paradigm, relying on the management of risks and the ability to predict extremes and mitigate their effects with solutions such as dykes, dams and reservoirs (Pahl-Wostl et al. 2008b). Pahl-Wostl et al. (2008b) argue that in “this paradigm, belief systems, human attitudes and collective behaviours are perceived as external boundary conditions and not as integral part of
management” (pg. 484). Increasingly, however, government budget cuts are rendering the ‘command-and-control’ management style ineffective resulting in interdependence among government bodies and other stakeholders; collective decisions based on more than just the technical aspects of the problem are needed to implement effective management strategies (Pahl-Wostl et al. 2007a). There is an increasing recognition that alternatives to top-down governmental control for governing social-ecological systems are needed (Gunderson et al. 1995; Olsson et al. 2006, Pahl-Wostl et al. 2007a). Along with this shift in governance, McAlpine et al. (2015) call for members of society to become more connected both to one another, as well as to nature and their ecosystems. According to Bulkeley and Mol (2003), the “democratic nature” of citizen science can promote more equitable decisions by providing citizens with the information they need to make more meaningful contributions to dialogue and policy-making. As discussed by Buytaert et al. (2011), biodiversity and ecosystem services will continue to erode, and the science that determines the changes society needs to make will become irrelevant in the eyes of the public unless opportunities are provided to individuals to appreciate the natural world and increase their concern for conservation issues (Theobald et al. 2015; DeVictor et al. 2010). Citizen science can provide these opportunities as well as provide individuals with new perspectives on how their behaviours connect them to their ecosystem services. McAlpine et al. (2015) believe that change of motivation is achievable, but will only come through personal belief rather than rational understanding. Hence, providing information is not enough to elicit the behavioural changes that are needed. Changing normative societal values is critical for achieving transformational change where “individuals act ethically as an integral part of an interconnected society and biosphere”, (pg. 1, McAlpine et al. 2015).

There is great demand for sound ecosystem monitoring in Canada because of enhanced awareness of environmental stressors (e.g., climate change, invasive species, development) and the perceived threats these changes can bring on valued components of the ecosystem (e.g., stream flow regimes, biodiversity) (Bliss et al. 2001). Reduced government funding has limited the abilities of their environmental agencies to supply this demand (Whitelaw et al. 2003), and there is an increasing move by concerned
citizens to participate in citizen science as a means of involving stakeholders in planning and management processes (Cuthill 2000). Volunteers spend thousands of hours participating in monitoring programs, but often their contribution is devalued by the view that experts provide the only credible input to environmental monitoring and decision-making (Conrad and Daoust 2008). Exploring this fundamental assumption is the basis of my research. One of the predominant limiters of citizen science in the use of decision-making is the lack of trust in the ability of non-experts to collect high quality, rigorous data (Sharpe and Conrad 2006).

1.2 Water quality citizen science and conservation authorities

Citizen science activities in Canada focused on water quality are increasing to the extent that both Federal and Provincial governments have initiated aquatic biomonitoring networks which are accessible to both volunteers and professional scientists. For example, the Ontario Benthic Biomonitoring Network (OBBN) uses benthic macroinvertebrates as indicators of aquatic ecosystem condition due to their responsiveness to changes in aquatic ecosystems caused by humans. The OBBN includes partnerships with federal, provincial and local governments; Conservation Authorities (CAs); universities; non-government organizations (NGOs); and volunteers. As quasi-governmental water management agencies (Jones et al. 1996), Ontario’s 36 CAs perform a number of duties on a watershed basis, including water quality monitoring, the implementation of source water protection programs, and community outreach and education to foster conservation and stewardship by the citizens in their watersheds. However, CAs have experienced major funding cutbacks in the last two decades, and the lack of long-term and stable financial resources inhibits their capacity to fully take part in all, possibly useful, collaborations (Michaels et al. 2006). Capacity, defined here as “the ability to perform appropriate tasks effectively, efficiently and sustainably” (pg. 45, Grindle and Hilderbrand 1995), is influenced by resources, flexibility, partnerships and collaborations, as well as political support and institutional arrangements (Kean 2008). Capacity is vital for implementing and supporting citizen science in the collection of rigorous data and for volunteer coordination and support, etc.
1.3 Purpose and objectives

The recent call by researchers to recognize citizen science as a distinct field of enquiry (Jordan et al. 2015) comes on the heels of an explosion of research dealing with the process and outcomes of the activity of citizen science. Along with this pursuit comes a vast potential for the development of theoretical ideas that contribute to a growing body of citizen science scholarship, particularly regarding the outcomes of expert-non expert partnerships that involve the collection of data (Jordan et al. 2015). Research on the activity of citizen science itself is growing and it has been proposed by some researchers that more research is needed that “provides sound evidence of citizen scientists influencing positive environmental changes in the local ecosystem they monitor” and more case studies showing the use of citizen science data “by decision makers or the barriers to linkages and how this may be overcome” (pg. 273, Conrad and Hichley 2011).

This research attempts to fill part of these noted gaps by examining the role of capacity and attitudes within CAs for either supporting or implementing water quality citizen science, specifically volunteer benthic monitoring. Given their mandates and structure, CAs appear to be the ideal organizations for using citizen science. As watershed based organizations, CAs interact closely with the most local governments, the municipalities, in delivering services including water quality and quantity monitoring, regulatory and assessment services for development, and education and stewardship to local communities. As well, CAs partner with multiple levels of government and since community involvement and partnerships are considered by them to be fundamental in implementing a successful watershed management strategy (Mitchell et al. 2014), their use of citizens to generate their required monitoring would appear to be win-win strategy for CAs to adopt. However, in pursuing this research, I observed that this is not the case generally, and while CAs do rely quite heavily on community contributions, the collection of scientific monitoring information is relegated to the trained ‘expert’ staff employed by the CAs. Hence, my general research question is “Why is the use of volunteer benthic monitoring (VBM) by CAs not more common?” To answer this question, I examine how two factors (capacity and attitude) may be limiting partnerships between CAs and volunteer benthic monitoring (VBM) groups. My research objectives are:
1) To understand the **capacity** that CAs have to support citizen science, particularly in the context of using volunteers to collect benthic monitoring information.

2) To understand the **attitude** that CAs have about citizen science (i.e. what are their perspectives of the benefits and challenges of citizen science), particularly in the context of using volunteers in their benthic monitoring programs.

3) To understand how the capacity and attitude of the CAs interact and potentially limit the use of VBM by Ontario’s CAs.

### 1.4 Scope and general study design

By conducting open-ended, semi-structured interviews with the staff and board members of five case CAs in Ontario, I explored issues of **capacity** (following a framework modified from Kean 2008) by posing questions about their organization’s resources, collaborations, challenges and strengths. I also explored the **attitude** of each CA by asking about their perceptions about community contribution and its importance to CA mandates, as well as their opinion of the role of citizen science and its potential in contributing to benthic monitoring. To support this approach and determine whether these findings could be generalized to the rest of the CAs in Ontario, I also surveyed all CAs with questionnaires on their organization’s activities (including benthic monitoring), and opinions about and capacity to support various types of community contributions including volunteer benthic monitoring.

To understand the nature of volunteer benthic monitoring conducted in Ontario, I interviewed individuals from three citizen science groups: a group with **no collaboration** with CAs but that conducted VBM, a group that was **collaborating with a CA** and was also conducting VBM, and a group that was **collaborating with a CA** but not conducting VBM. I asked questions about the structure of their groups, their methods for data collection, and about their partnerships and collaborations.
1.5 Organization of thesis

Chapter One of this thesis provides the context and rationale for this study. Chapter Two is a literature review explaining and contextualizing CAs in Ontario, organizational capacity, and citizen science. Chapter Three presents the research methods, including my epistemological approach, background about the CA and citizen science group participants, and the data collection and analysis techniques. Chapter Four presents results from both the case research interviews and the survey. Chapter Five discusses these results and places them within the context of the current literature, while Chapter Six summarizes the project’s findings and provides theoretical ramifications as well as directions for future research. It also provides recommendations directly relevant to CAs and citizen science groups that could promote their collaboration in the pursuit of sustainability in water resources management.
Chapter 2

2 Literature Review

2.1 Conservation authorities in Ontario

According to Conservation Ontario, the umbrella organization representing the network of 36 CAs in Ontario,

Conservation Authorities are community-based watershed management agencies dedicated to conserving, restoring and managing Ontario's natural resources on a watershed basis (Conservation Ontario 2013b) [and] protect and manage water and other natural resources in partnership with government, landowners and other organizations (Conservation Ontario 2013a)

The 31 southern and 5 northern Ontario CAs (CAs) were established by the Conservation Authorities Act enacted in 1946, which addressed the need for jobs for men returning from war and to better manage natural resources in the province of Ontario (Mitchell et al. 2014; Mitchell and Shrubsole 1992). The act, and subsequent revisions and extensions, outline the roles and responsibilities of CAs, as well as their governance and powers; their primary role is to “to establish and undertake, in the area over which it has jurisdiction, a program designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals” (Conservation Authorities Act 1990). Six principles underlie Ontario’s CA program:

1) the watershed as the management unit;
2) local initiative;
3) provincial-municipal partnership;
4) a healthy environment for a healthy economy;
5) a comprehensive approach; and
6) cooperation and coordination

Managing natural resources on the basis of the watershed – focusing on both upstream and downstream water inputs/outputs, uses and economies – has ensured a comprehensive and holistic approach to management as well as effective decision-making through cooperation with other management units (province and municipalities) and stakeholders (Mitchell et al. 2014). Integrated Watershed Management (IWM) is seen as vital in dealing with the complexity of issues facing water resources due to climate change and rapid urban growth (Conservation Ontario 2013c). In response to a survey conducted by the provincial government, CA staff noted the following benefits of watershed management: (1) partnership formation among agencies; (2) role and responsibility clarification; (3) information sharing; (4) greater stakeholder involvement; and, (5) consensus (Ontario 1997).

The task of regulating Ontario’s freshwater resources is shared among the Province (enforcement of environmental regulations), the Municipality (water supply, wastewater, storm water, and rural municipal drains), and the Conservation Authority (monitoring, stewardship and environmental advisory services) (Conservation Ontario 2011a). Currently, CAs regulate development and manage water protection, biodiversity reserves and recreation in watersheds that support 90% of Ontario’s 12 million people (Petland and Wood 2013; Conservation Ontario 2015). Supporting CAs in this role, Conservation Ontario “promotes and champions the issues of importance to the “collective” in the areas of policy and programming, funding, and branding/communications” with its fundamental purpose to “promote and continually strengthen a watershed-based conservation coalition in Ontario” (Conservation Ontario 2011a). CAs are each governed by a board of municipally appointed members, 78% of whom are also elected municipal councilors. As outlined in the Conservation Authorities Act (1990), the number of board members representing each municipality is based on the proportion of each municipality’s population in the watershed (Ministry of Natural Resources 2010). Board members act on behalf of the municipalities they represent and the activities of the CAs are administered by a General Manager and Chief Administrative Officer.
Due to the variation in the size and nature of watersheds, many of the CAs established in the 1940s and 1950s have amalgamated. Although CAs vary in their geography and therefore the focus of their activities, all CAs fulfill their mandate by: protecting people and property against flooding, maintaining land holdings, resource management, watershed stewardship, monitoring watershed health, source water protection, recreation and education (Conservation Ontario 2015). CAs manage $2.7B worth of flood control and prevention infrastructure including 900 dams, dykes, channels and erosion control structures. As well, they own and protect approximately 146,000 hectares, including forests, wetlands, areas of natural and scientific interest, recreational lands, natural heritage and cultural sites as well as land for flood and erosion control. Working with municipalities, CAs monitor and manage low water conditions, creating 22 low water strategies across the province. Stewardship of watershed health is promoted and supported by CAs through projects developed cooperatively with local land owners and include: tree planting, erosion control, clean water diversion, well decommissioning and septic system improvements, agricultural best practices, and the rehabilitation/restoration of shoreline, stream, wetland and fish habitats. CAs track the health of watersheds by monitoring surface and ground water and through the biological monitoring of fish and benthic macroinvertebrates. In partnership with the province, they also provide the technical support for Source Protection Committees in 19 regions across Ontario. Through management of their Conservation Areas, CAs support recreation activities including swimming, hiking and camping and also have outdoor education programs (e.g., water festivals) which are aligned with Ontario’s curriculum programs (Conservation Ontario 2015).

Funding for CAs is derived from municipal levies (average 48%); self-generated revenues (40%); provincial grants and special projects (10%); and federal grants or contracts (2%) (2013 CA Statistical Survey – Conservation Ontario 2013c). Until the 1990s, the principle of “provincial-municipal partnership” meant a 50-50 cost sharing agreement. “With provincial funds matched by fees from municipal levies, financial arrangements reflected a reasonably reliable provincial–municipal partnership.” (Mitchell et al. 2014). In the 1990s, CAs underwent revolutionary change (Priddle 2009) as a result of the province’s changing policy direction in difficult financial conditions.
(Mitchell et al. 2014; Michaels et al. 2006b). In the early 1990s, provincial payments to the CAs were nearly CAD 50 million annually. However, in 1991, provincial funding ceased for all non-core functions of the CAs, including recreation and education (Mitchell et al. 2014). The sharpest decrease in funding from the province occurred over a two year period, with a 70% decrease in operations funding. By 2000, staff resources in CAs were reduced by 50-75% compared to 1995 (Michaels et al. 2006), with provincial funding no longer available for non-structural watershed management, including commenting functions for provincial regulations such as the Planning Act and development controls supported by the Conservation Authorities Act (Shrubsole 1996).

CAs have responded to these financial constraints by selling land and decreasing staff resources, reducing their broad involvement in watershed management activities to focus solely on water management, proactively seeking external sources of funding, raising user fees and creating and strengthening collaborations (Mitchell et al. 2014; Michaels et al. 2006). They worked to enhance their partnerships with municipalities by avoiding levy increases and working collaboratively during the first few years after the funding cuts (which the municipalities were also affected by) (Mitchell et al. 2014). These funding cuts were defined by practitioners as a focusing event for CAs – “a sudden, exceptional experience that, because of how it leads to harm or exposes the prospect for great devastation, is perceived as the impetus for policy change” (Michaels et al. 2006, pg. 983). In an examination of three focusing events that induced policy change and hence, associated learning in CAs, Michaels et al. (2006) found that a number of interviewees emphasized partnerships in response to the provincial funding cutbacks of the 1990s. These partnerships include collaborating with local communities, other CAs, government agencies and private enterprises (Michaels et al. 2006). According to Mitchell et al. (2014, pg. 465), these innovative partnerships were cultivated to “obtain funding and obtain stature with the community, to undertake new ventures (e.g., hydropower generation), and to renew fundraising activities by their associated charitable foundations.”
2.2 Citizen participation in science and environmental management

Citizen participation is the involvement of the public in societal governance including planning, organizing, community development and related fields that enable significant numbers of individuals and representatives of groups to influence the decisions that affect their interests (Baum 2015; Dryzek 2000; Cuthill 2000). In discussing the benefits of citizen participation, Baum (2015, pg. 626) describes how,

…as an exercise in citizenship, it is required by democracy. In this view, people have the right to deliberate on and influence decisions affecting their interests. This right does not depend on whether citizens are experts or especially knowledgeable on issues.

Individuals that participate in such processes will have a sense of investment in the results, gain the experience of being a citizen, acquire knowledge and skills that they can apply to other situations, and develop relations with individuals with whom they may work with in the future. Not only does citizen participation benefit the individual participants, elected officials and professionals achieve legitimacy for their decisions (Baum 2015). As a whole, the community benefits through the “collective competence” gained by the individuals involved and the social capital acquired through the process, and according to Baum (2015, pg. 627) “the society is likely to be more cohesive, and societal institutions are likely to identify and address problems knowledgeably and legitimately in ways that serve many interests.”

There is increasing acceptance of the importance of sustainability by government, industry and individuals. The term ‘sustainable development’ was first introduced in a report for the United Nations World Commission on the Environment and Development (WCED) in 1987 as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987). Based on this premise, there have been various models developed to illustrate the relationships among social, economic, and environmental considerations (e.g., Gibson 2001), and it is generally accepted that achieving sustainability requires greater attention not only to environmental well being, but how this is integrated with social and economic
well-being. To this end, it has been recognized that there is a need for increasing public access to decision making, with several international agreements focusing on sustainability emphasizing the importance of opportunities for citizens to participate in decisions about matters affecting their environment (1992 Rio Declaration on Environment and Development; 1998 Aarhus Convention; 2002 World Summit on Sustainable Development Implementation Plan). Much research has been conducted around the topic of public participation (the process of involving those affected by or interested in a decision) in environmental management (e.g., Fortmann and Ballard 2011; Toogood 2013; Carr et al. 2012; Dodge 2014; Fernandez-Gimenez et al. 2008; Irwin 1995; Fischer 1993; Guehlstorf and Hallstrom 2012; Gottschalk Druschke and Hychka 2015; Hearn and Torpen 2010; Læssøe 2010; Rowe and Frewer 2000, 2004, 2005; Wagle 2000; Meng and Yang 2013; Pahl-Wostl et al. 2007, 2008).

According to Savan et al. (2004), in the early 2000s there was a growth in research examining the changing relationship between government and society (Dale 2001; Ericson and Stehr 2000; Parson 2001). This shift in the study of ‘government’ to a study of ‘governance’, wherein boundaries between the public and private sector become blurred (Stoker 1998), became particularly relevant in the examination of environmental decision making. Pahl-Wostl et al. (2008) describes how the introduction of the term ‘governance’ marks a change in policy thinking from the idea of government as a single decision-making authority to “…multi-scale, polycentric governance approaches that recognize the contribution of a large number of stakeholders…” (pg. 1). Kinchey et al. (2014) discuss the scientization of society – the reliance of lay people on scientific tools (Drori and Myer 2006) – due to the myriad of invisible threats in the environment (Beck 1992), and how there is a move toward “epistemic modernization, in which the public scrutinizes science ‘from below’, and through social movement struggles, is increasingly involved in setting and pursuing research agendas (Hess 2007; Moore et al. 2011)” (pg. 263).

One approach to governance and the inclusion of public participation in environmental decision making is through the contribution of local knowledge or traditional knowledge. Such knowledge may include a mix of scientific and practical knowledge (monitoring
temporal or total protection of species or habitats, multiple species management, resource rotation and succession management), and non-scientific, or more cultural information (the social mechanisms behind management practices such as cross-scale institutions, taboos and regulations, rituals or ceremonies, and social and religious sanctions, etc.) (Ruiz-Mallén and Corbera 2013). According to Tengö et al. (2014, pg. 579), “Indigenous and local knowledge systems, developed through experimentation, adaptation, and co-evolution over long periods of time can provide valid and useful knowledge, as well as methods, theory and practices for sustainable ecosystem management.” A more formal and science-based approach to the public’s contribution of information to environmental decision-making is citizen science.

2.3 Citizen science

Citizen science has received growing attention over the past two decades. Historically, there have been a variety of definitions given for the term ‘citizen science’ (e.g., Irwin 1995; Kruger and Shannon 2000; Cooper et al. 2007). Some of the most recently used definitions in the peer-reviewed literature include “partnerships between those involved with science and the public in which authentic data are collected, shared, and analyzed” (Jordan et al. 2015, pg. 307), and “Citizen science, also referred to as community science or public participation in scientific research, is a growing movement that enlists the public in scientific discovery, monitoring, and experimentation across a wide range of disciplines” (Theobald et al. 2015, pg. 208). It was only just in June of 2014 that ‘citizen science’ was added to the Oxford English Dictionary:

n. scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientist and scientific institutions.

According to Reisch and Potter (2014), citizen science as a defined concept had independent origins in the 1990s in the work of Rick Bonney (Bonney et al. 2009a) and Alan Irwin (1995). While Bonney was concerned with scientist-driven public research projects, with a focus on educating and engaging the public in the process of science, Irwin emphasized science citizenship playing an important role in making science and science policy processes more accessible to the public (Reisch and Potter 2014).
Although citizen science most commonly refers to the collection of data by members of the public, it can also include their contributions including asking questions and reporting and/or interpreting results (definitions from SciStarter 2015 and Citizen Science Central 2015). The dual origins of the term have led to some interesting “hybrid philosophies of participatory science” (Reisch 2015, pg. 632), combining the value of these activities as a democratic exercise as well as an important scientific endeavor. Other terms that also describe one or more of the activities within the realm of citizen science include: community-based monitoring (Whitelaw et al. 2003; Conrad and Hichley 2011), community science (Carr 2004), community-based management (Keough and Blahna 2006), community-based conservation (Western and Wright 1994), community-based ecosystem management (Ack et al. 2011; Gray et al. 2001; Devlin 2011), participatory research (Barreteau et al. 2010), civic science (Backstrand 2003; Ahern et al. 2014), civil science (Fortman and Ballard 2011), crowd sourcing (Jackson et al. 2015; Weschler 2014); and crowd science (Vasileiadou 2015; Franzoni and Sauermann 2014).

Scientific observation by citizens has a long history. Miller-Rushing et al. (2012) describe how the dates of the traditional cherry blossom festival have been recorded by the court diarists of Kyoto, Japan for the past 1,200 yrs (Primack et al. 2009) and in China, citizens and officials have tracked the outbreak of locusts for at least 3,500 yrs (Tian et al. 2011). In fact, before the professionalization of science in the late 19th century, most research was conducted by amateurs who in some cases, were solicited by early ecologists (e.g., John Ray and Carl Linnaeus) to collect specimens and observations from across the known world (Miller-Rushing et al. 2012). Benjamin Franklin (1706-1790) was a printer, diplomat and politician and Charles Darwin (1809-1888) was the voluntary companion of Captain Robert FitzRoy on the Beagle voyage (Silvertown 2009). In other scientific fields, Dickinson et al. (2010) describe the British government’s endeavor to measure the Earth’s distance to the Sun (Transit of Venus project of 1874); data was collected from all over the globe by the most prominent amateur astronomers of the Victorian period (Ratcliff 2008). In the US, the National Weather Service Cooperative Observer Program began in 1890. Some of the earliest and most popular citizen science programs come from ornithology, including the National Audubon Society’s Christmas Bird Count (1900), U.S. Geological Survey’s Breeding
Bird Survey (1966), Cornell Lab of Ornithology’s NestWatch (1965) (Dickinson et al. 2010).

Citizen science projects have proliferated in the last decade as a form of public engagement in science (Crain et al. 2014) and the development of policies and management practices (Jordan et al. 2012a; DeVictor et al. 2010), collecting data at increasing spatial and temporal scales (Dickinson et al. 2010), and public education (Bonney et al. 2009b). Diverse applications of citizen science have included: microbiology (Cooper et al. 2010); paleontology (Bonney et al. 2009a); astronomy (Lintott et al. 2008) and discovering new galaxy types (Cardamone et al. 2009); atmospheric science (Bonney et al. 2009a); monitoring pollutants (Kolok et al. 2011) and litter (Hidalgo-Ruz and Theil 2013; Hoellein et al. 2015; Jambeck and Johnson 2015); crowdsourcing machine learning (Dickinson et al. 2010); protein folding (Hand 2010; Dickinson et al. 2010); genomics and wellness profiling (Dove et al. 2012) and many types of organism monitoring including fungi, plants, gastropods, annelids, arthropods, herpetofauna, birds and mammals (Dickinson et al. 2010).

Citizen science has been commonly used in ecosystem assessment, including status assessment through population monitoring, environmental impact assessment, and monitoring for adaptive management (Stem et al. 2005). To achieve such assessments, different aspects of the ecosystem may be monitored including its composition (i.e., indicator species or species at risk), structure (i.e., biodiversity analysis, keystone species, predator–prey relations, habitat etc.), or processes (i.e., linking species with environment, nutrient cycling, etc.) (Milne et al. 2006). Bonney et al. (2009a) noted that the Cornell Laboratory of Ornithology which has been one of the leading organizations in North America promoting citizen science approaches to environmental assessment. These projects have included the effect of environmental change on breeding success (Rosenberg et al. 1999a; Hames et al. 2002a); the spread of emerging infectious diseases through wild animal populations (Hochachka and Dhondt 2000; Hartup et al. 2001; Altizer et al. 2004; Hochachka et al. 2004; Dhondt et al. 2005); the effects of acid rain on bird populations (Hames et al. 2002b); latitudinal influences on seasonal clutch-size variation (Cooper et al. 2005a, 2005b, 2006); and the mining of databases for the
discovery of patterns and processes in ecosystems (Caruana et al. 2006; Hochachka et al. 2007; Fink and Hochachka 2009; Kelling et al. 2009).

Increase in public participation in research and management of natural resources is documented by Conrad and Hichley (2011), who note increases in monitoring by citizen science groups in Canada (Savan et al. 2003; Whitelaw et al. 2003; Conrad and Daoust 2008), the US (Whitelaw et al. 2003; Keough and Blahna 2006), and many other areas (Sultana and Abeyasekera 2008; Pattengill-Semmens and Semmens 2003; Nagendra et al. 2005). In Canada and the US, this increase has been attributed to the demand for sound ecosystem monitoring because of enhanced awareness of environmental stressors resulting from human impacts (e.g., climate change) and the perceived threats these changes can bring on valued components of the ecosystem (e.g., biodiversity) (Whitelaw et al. 2003; Conrad 2006). With the increasingly complex range and number of environmental issues facing society, there has been increasing concern over the effectiveness of government monitoring due to cutbacks in funding and staffing for ecological monitoring (Stokes et al. 1990; Pollock and Whitelaw 2005; Conrad and Daoust 2008). In Canada, these government cutbacks were sharp and sweeping with an enormous loss in the number of environmental staff positions in 1996 and 1997 within the Ontario’s Ministry of the Environment (Merritt and Gore 2001). This resulted in less ability to respond to environmental emergencies or regular operational requirements (Savan et al. 2004). These cuts were coupled with government’s “alarming disregard for environmental health and public’s access to information” (pg. 31, Sharpe et al. 2000). Moreover, with the complexity of the environmental problems facing society today (e.g., climate change), monitoring data are needed more than ever in order to make effective decisions about natural resources management. With the recognized benefit of more inclusive processes on the government decisions regarding environmental protection and sustainability (Conrad and Daoust 2008), citizen science will likely continue to increase.

As described by Johnson et al. (2014), the rise in interest in citizen science corresponds to growing concerns over environmental issues and enhanced awareness, by both scientists and the public, of human impacts on ecosystems (Bonney et al. 2014; Conrad and Hichley 2011; Kinchy and Perry 2012). Theobald et al. (2015) ask whether citizen
science can be useful in addressing global change impacts on biodiversity or attend to five of the major threats (climate change, overexploitation, invasive species, land use change and pollution) facing the health of our earth’s ecosystems. They argue that in the case of biodiversity, it is a nearly impossible task for professional scientists and resource managers to tackle alone (Theobald et al. 2015). Citizen science is recognized as a promising approach to addressing biodiversity issues (Bell et al., 2008; Couvet et al., 2008; Henry et al., 2008) because it provides the capacity for collecting fine-grain data at regional and continental scales over long periods of time which is essential for really understanding the impacts of biodiversity losses (Theobald et al. 2015).

The importance of long-term monitoring of ecosystems has been recently discussed by Boero et al. (2015), who remind us that we have recognized the importance of long-term observations for understanding our environment since the early 19th century (Roberts 2009). He asserts that the present observable state of ecological systems is shaped by both constraints of natural laws and past circumstances (Boero et al. 2015). As such, accepting the importance of history for understanding the ecology of ecosystems is what makes long-term data so important since they are “the only means of judging possible probability ranges for future predictions on the basis of historical knowledge of the regularity of events” (pg. 13, Boero et al. 2015). They argue that with respect to marine ecosystems, more capacity including “stronger societal involvement” is needed for this type of monitoring since the expertise for recognizing and describing species is rapidly declining in the scientific community (pg. 12, Boero et al. 2015). Not only can citizen science be harnessed to cope with this problem for some variables, even volunteer programs with limited means can contribute toward complementing much needed monitoring efforts (Boero et al. 2015).

The rise in citizen science has developed to the extent that researchers have called for citizen science to be recognized as a distinct field of enquiry (Jordan et al. 2015). The number of citizen science projects, and the reports and peer-reviewed articles resulting from their data has expanded tremendously over the past two decades (Bonney et al. 2014). In fact, recently there have been a number of peer-reviewed journals that have devoted entire issues to research related to citizen science including e.g., *Frontiers in*
Ecology and Evolution (vol 10, issue 6, 2012), Biological Journal of the Linnean Society (vol 115, issue 3, 2015), and Computing in Science and Engineering (vol 17, issue 4, 2015). In a recent review of the resulting outcomes to participants, communities and the environment from volunteer environmental monitoring, Stepenuck and Greene (2015) synthesized 35 peer-reviewed journal articles from a pool of 436 articles about participatory volunteer monitoring written between 2009 and 2013. As well, in March of 2014, the Citizen Science Association (CSA) was launched as a collaborative project by National Geographic and the Woodrow Wilson Centre with the mission to advance understanding, value and participation in citizen science. The first meeting of the CSA was held in San Jose, California in February 2015 and submissions are currently being accepted for the inaugural issue of its open-access peer-reviewed journal Citizen Science: Theory and Practice.

Jordan et al. (2015) list biology, sociology, educational psychology, science teaching and learning, ecology, conservation, and resource management as areas of inquiry that can greatly inform citizen science research and describe how citizen science research examines the socioscientific outcomes of the expert-nonexpert partnerships involved in collecting scientific data. They define socioscientific as “the dimensions of the data being collected, as well as the people and communities who are collecting these data” (pg. 209), and argue that unlike its sister fields (e.g., biology, sociology, ecology etc.), citizen science researchers study the result of combining volunteer training and education with authentic data collection (Jordan et al. 2015). Based on citizen participation, theoretical frameworks unique to citizen science programs and projects have been proposed (Lawrence 2006; Bonney et al. 2009a; Conrad and Hichley 2011; Shirk et al. 2012; Couvet and Prevot 2015) and Jordan et al. (2015) propose a number of areas of conjecture based on one of these frameworks. For example one of the questions that could be answered through coupled research is ‘With greater participation, particularly in systems-based scientific practices, are individuals who are more exposed to broader systems thinking, experiencing an increased understanding the effects of their actions?’ (Jordan et al. 2015). The extent of the variety of disciplines that citizen science is linked to can be exemplified by the recent work by Brosnan et al. (2015) who compares the field of hopeful tourism with that of citizen science. They suggest that both fields argue for
regime changes; citizen science pushes the move to democratizing the process of scientific data collection and sharing, whereas hopeful tourism calls for a “values-led humanist paradigm change in tourism” (pg. 97), and that the similarities could lead to common research agendas. With volunteer tourists increasingly engaging in citizen science, they see citizen science tourism having the potential to promote humanitarian awareness, activism and compassion, challenging the current “dystopian scholarship in tourism” (pg. 98, Brosnan et al. 2015).

According to Dickinson et al. (2010), a number of researchers recognize that citizen science is ideal for research in urban ecology and on coupled human and natural systems (coupled systems research) (Lepczyk et al. 2009; McCaffrey 2005; Machlis et al. 1997). Crain et al. (2014) devotes an entire article to a closer examination of the application of citizen science to coupled systems research and views citizen science as generating “important ecological results as well as results from studies seeking to understand impacts of participation on individuals and communities” (pg. 658). For example, Koss and Kinsley (2010) examined the emotional health and well-being of volunteers involved in monitoring biota in marine protected areas. Vasileiadou et al. (2015) call for a more nuanced study of citizen science, including the changing dynamics of authority and expertise that citizen science entails, how knowledge-power relationships associated with citizen science challenge existing power hierarchies and conclude that “A research agenda on how citizen science is altering (a) research practices, (b) scientific knowledge, and (c) the role of science in society is sorely needed.” (pg. 1516). Summarized by Reisch and Potter (2014), increasing research in citizen science has been conducted through empirical case studies of the public-expert relationship (Cornwell and Campbell, 2012), the experience and motivations of participants (Mankowski et al., 2011; Raddick et al., 2010; Wright et al. 2015), or the learning outcome of public participants either in terms of traditional science knowledge or in terms of knowledge of the scientific method (Crall et al. 2012; Cronje et al. 2011; Jordan et al. 2011; Trumbull et al. 2000).
2.3.1 Benefits of citizen science

There is a growing body of literature that extols the benefits of citizen science (e.g., DeVictor et al. 2010; Johnson et al. 2014; Boero et al. 2015; Conrad and Hichley 2011, Shirk et al. 2012). Conrad and Hichley (2011) point out that citizen science is recognized in many studies as a way to include stakeholders and the general public in the planning and management of local ecosystems (Pollock and Whitelaw 2005). While engaging in the process of participating in scientific discovery, citizen scientists not only learn and acquire knowledge about the system itself (Bonney et al. 2009a), but also how their actions, as part of a society, are affecting and potentially negatively impacting those systems (Branchini et al. 2015). With the rise in urbanization, DeVictor et al. (2015) see less opportunity for humans to experience nature resulting in their feelings of disconnection with it; citizen science provides opportunities for individuals to appreciate the natural world and hence, increase their concern for conservation issues (DeVictor et al. 2010).

If biodiversity science does not engage nonscientists, as biodiversity and ecosystem services continue to erode, it runs the risk of becoming irrelevant in the eyes of a public that may offer local solutions to global problems” (pg. 243, Theobald et al. 2015)

By connecting their actions to impacts on their local ecosystems, public participating in citizen science can engage systems thinking; promoting the understanding of processes linking our economies, societies and environments (Boero et al. 2015). Boero et al. (2015) use climate change to exemplify the need for a more holistic understanding by the public, stating that their knowledge of systems thinking is vital if long-term political measures are to be legitimized in democratic, decision-making processes.

Through participation in the science that drives evidence-based decision-making, citizens not only learn about an ecological system and how they influence the manner in which that system functions, they also learn about the associated social institutions governing the decision-making process with regards to that system (e.g., policies, management practices). Jordan et al. (2012a) argue that collective knowledge and social learning resulting from a group of individuals participating in citizen science may not only be a
measured outcome, but also a driving force for meeting ecological or social project goals. Public participation in natural resources management increases adaptive capacity and promotes the social learning required to develop and maintain resilient and sustainable socioecological systems (Pahl-Wostl et al. 2007b).

Key documents such as the European Water Framework Directive (Commission of the European Communities 2000) and the U.S. Clean Water Act (Federal Water Pollution Control Act 2002) state that public and stakeholder participation in water resource management is required. Public participation in resource management aims to improve management by involving individuals and groups in a democratic way (Carr et al. 2012). As an instigator of social mobilization, citizen science can provide the necessary tools and expertise to initiate complex problem solving (Cooper et al. 2007; Price and Lee 2013). Pahl-Wostl et al. (2007a) agree that collective decisions (i.e. by the public and government) produce the most effective solutions and that “the combination of top-down and bottom-up formation of institutional arrangements may lead to a greater acceptance by all the stakeholders involved” (pg. 2). Similarly, DeVictor et al. (2010) note that a number of scholars recognize that the creation and communication of improved biodiversity policies requires the “value judgments” from the public (Miller 2006; Evans et al. 2007; Fischer and Young 2007; D’elia et al. 2008). The benefits of moving toward a more participatory approach to conservation have been acknowledged (Berkes 2004). Fernandez-Gimenez et al. (2008) found that a community-based forest management approach resulted in social learning – shared ecological knowledge among diverse participants – increased internal trust and external credibility of the projects involved. DeVictor et al. (2010) argues that citizen science approaches are effective in promoting positive reconnection between the public and conservation issues. Shirk et al. (2012) describe how in natural resource monitoring for management, public participation can be a means of engaging diverse stakeholders and accessing new knowledge, making power relationships transparent, adapting activities to evolving conditions, and encouraging both ownership and accountability of the management process among constituents (Kapoor 2001; Armitage et al. 2007; Arora-Jonsson et al. 2008; Wilmsen 2008; Wulfhorst et al. 2008). In a review examining the evaluation of public participation in water management, Carr et al. (2012) found that while only a few studies show resource
management benefits from participation, none of the studies they reviewed proved a negative link between participation and water management.

Along with the benefits of data acquisition and public participation in environmental management, Conrad and Hichley (2011) and Jordan et al. (2012) list advantages of citizen science including: increased scientific literacy, the creation of social capital (Adger 2003), citizen inclusion in local issues, enhanced community capacity (Donoghue and Sturtevant 2007), and improved trust between scientists, managers and the public (Fernandez-Gimenez et al. 2008); benefits to government and to ecosystems being monitored and the democratization of the environment (i.e. making environmental science and expertise more accessible to the public, while also making scientists more aware of local knowledge and expertise; Carolan 2006). Johnson et al. (2014) note some of the research that has focused on the benefit of citizen science contributing to increasing sample sizes and accessing locations and data sites that professional scientists may be unable to access themselves (Brudney, 1999; Cooper et al., 2007; Danielsen et al., 2014), and of engaging the public in “participatory scientific learning and environmental advocacy” (Cornwell and Campbell 2012; Ellis and Waterton 2004; Shirk et al. 2012) (pg. 236). Its benefit as a cost-effective alternative to government employee monitoring has been noted (Conrad and Daoust 2008; Whitelaw et al. 2003; Stokes et al. 1990; Cuthill 2000) and citizen science can easily amount to millions, even billions, in in-kind economic worth (Independent Sector 2011; Bureau of Labor Statistics, United States Department of Labor 2012 as cited in Theobald et al. 2015). Sharpe and Conrad (2006) reported that Environment Canada would have spent 12 times the budget of the 14 citizen science groups coordinated by the Atlantic Coastal Action Program (ACAP) in Nova Scotia for the outputs of the groups between 1997 and 2002 (482 person years of employment and eight million dollars in taxation revenue). Partners in an ongoing community-university research alliance in Nova Scotia have contributed 46,800 hours towards monitoring Canadian waterways at an estimated $1,638,000 worth of in-kind time and knowledge (CURA H2O 2014a).
2.3.2 Challenges of citizen science

Citizen science, however, is not without its challenges. Among the most common of the concerns with citizen science is of the quality of the data being collected. Reisch and Potter (2014) found that this was recognized by the majority of scientists they interviewed who were participating in citizen science programs; these individuals were either personally worried about data quality, or worried about the reaction of the larger scientific community to data being collected by non-experts. Bonney et al. (2014) argue that the practice of citizen science is not universally accepted as a method of scientific investigation and that papers presenting such data sometime have trouble getting reviewed. According to Conrad and Hichley (2011), citizen science data are not taken seriously by decision makers because of questions around the “credibility, non-comparability and completeness of the data” (pg. 281, Gouveia et al. 2004; Bradshaw 2003). Some have challenged the assumption of poor data quality arising from citizen science, claiming that they often yield similar results as those collected by experts (e.g., Newman et al. 2003; Schmeller et al. 2009; Danielsen et al. 2014). DeVictor et al. (2010) notes that once the sampling biases of citizen scientists are clearly established, methods and statistics can be developed to address those biases (Link et al. 2006). Theobald et al. (2015) found that even “messy” citizen science datasets are valuable, provided sample sizes are large, since variation among participants can be dealt with statistically (Schmeller et al. 2009; Dickinson et al. 2010; Bird et al. 2014).

Whether collected by citizen scientists or experts, there are a variety of ways to ensure the quality of the data being collected. In establishing monitoring programs, it is necessary to ensure the right data is being collected for the information being sought from the ecosystem. Considerations around this include breadth; ensuring there is enough data collected from enough sampling sites, and depth; the data is detailed enough. Protocols need to include the appropriate tools and equipment for collecting the data, procedures to monitor the quality of the information being collected (quality assurance and control; QA/QC), as well as to ensure accuracy in the recording/transcribing of the data. In the field with these protocols, individuals collecting the data need to be sufficiently trained and their abilities to collect data according to the protocols, assessed. While these best
practices apply to both volunteers and experts, more effort is likely required where citizen scientists are concerned since unlike experts who have background knowledge, education and experience, volunteers have varied backgrounds and may often lack these characteristics entirely when first participating in citizen science.

Other challenges include ethical considerations including issues of data ownership and remuneration for services presumably given for free, and possibility of citizen science limiting the opportunities for scientists (Reisch 2015). With regards to participation, Pandya (2012) notes how individuals of certain racial groups have been historically underrepresented in science participating less than the majority groups and affluent participants outnumber less-affluent participants (Trumbull et al. 2000; Evans et al. 2005), hence being less likely to reap the benefits of participating in citizen science programs. Since often a goal of citizen science is to promote interest in science careers by participants, Pandya (2012) argues that the low numbers of minority participants in citizen science may reduce diversity in the current and future scientific workforce. Finally, citizen science programs themselves face numerous challenges including volunteer fatigue, lack of volunteer interest or networking opportunities, lack of funding, and lack of access to expertise or information (Conrad and Hichley 2011).

2.3.3 Coordination of citizen science in Canada

With the rise in citizen science across Canada, in 2002 a nationally coordinated partnership was developed between Environment Canada’s Ecological Monitoring and Assessment Network (EMAN) Coordinating Office and the Canadian Nature Federation (CNF) and funded by the Government of Canada’s Voluntary Sector Initiatives (Pollock et al. 2003). The Canadian Community Monitoring Network (CCMN) pilot project set out to discover the best approaches for engaging monitoring activities, with the goal of increasing the use of citizen science information by policy makers and the use of citizen science data to facilitate sustainable decision-making. The outcome was the creation of a model framework for nationally coordinated community based monitoring initiatives which was tested on 31 citizen science initiatives across Canada (Pollock et al. 2003). Established in 1994, EMAN was to monitor ecological changes on a national level and facilitate central coordination of monitoring initiatives from all government agencies.
(Environment Canada 2012), and during the early 2000s, EMAN compiled a directory of volunteer monitoring groups and to assist these groups in communicating with one another (Savan et al. 2003). As well, in conjunction with the NGO Nature Canada and other organizations, it supported NatureWatch, a nation-wide citizen science program aimed at getting the Canadian public to help researchers track changes in the natural environment. The first website for Nature Watch was launched in 2000 and hosted PlantWatch, FrogWatch and IceWatch, programs developed in the mid-1990s (WormWatch was included a few years later). Around 2008, EMAN was “reorganized” by the federal government resulting in a loss of coordination and support for national scale environmental monitoring (Weston 2011). Responsibility for the current Nature Watch program and website was transferred from Environment Canada to the Geography Department at the University of Ottawa in 2011 (NatureWatch 2015). Also as a result of this “reorganization”, the CCMN web presence was gone by around 2010 and its associated Citizen Science online directory of Canadian monitoring and management groups was gone sometime after 2011 (pers. observation). In a 2011 study examining the potential for using citizen science in Environmental Assessment follow-up and for the support of adaptive management of projects during both their implementation and their decommissioning stages, Devlin (2011) identified 273 community monitoring groups across Canada that had self-identified on the CCMN online Citizen Science directory.

2.4 Freshwater ecosystem monitoring and assessment using citizen science

The use of citizen science for water quality monitoring has a rich history in North America. Currently in the US, there are thousands of mainly volunteer-based, local non-profit organizations involved in the monitoring, protection and management of freshwater systems (Latimore and Steen 2014). According to Firehock and West (1995), monitoring of water quality by volunteers in the US has its roots in environmental watchdog programs, with the first national-scale volunteer monitoring initiative starting in 1969. Kinchy et al. (2014) though, state that water quality citizen science has historically developed from at least three objectives: public education about conservation issues, the production of scientific knowledge, and also policing environmental violations. With the
passage of the 1972 Clean Water Act requiring the assessment of surface water quality, many grassroots volunteer monitoring programs were born (Lee 1994). By 1995, monitoring projects were present in 45 of the States, and over half of the survey respondents sent their data to government agencies (Kerr et al. 1994 as cited in Firehock and West 1995). By 2002, the United States Environmental Protection Agency listed over 700 programs in the national directory (Savan et al. 2003), by 2009 there were 920 citizen monitoring groups collecting information on water resources (Heim 2010), and by 2014, this number climbed to more than 1800 programs in the United States (Volunteer Water Quality Monitoring 2014 as cited in Buytaert et al. 2014). Recently Laird et al. (2013) note that water quality volunteer monitoring has gained particular interest because it is place-based (i.e., engagement in the local) citizen science and allows for an emotional connection to water by participants (Gooch 2005; Measham and Barnett 2008). In a study examining the volunteer monitoring organizations collecting water quality data, Laird et al. (2013) found that the majority of citizen science groups were associated with professional scientists, many of them indicated their data were collected primarily for educational purposes and only 75% of the groups that were surveyed indicated their data were being used for watershed management. More recently, citizen scientists have begun water quality monitoring in response to the controversial technique of hydraulic fracturing to extract gas from geological formations (Kinchey et al. 2014).

Canada has a long history of water quality citizen science as well. In Ontario, Stokes et al. (1990) discussed the ‘Self Help Program’ initiated in 1971 by the Ontario Ministry of the Environment. This program provided the materials and information to cottage associations to establish their own long term water quality monitoring collecting Secchi-disc depths and chlorophyll samples that were analyzed by the Ministry’s laboratory. Approximately 90 to 100 lakes were sampled annually through this program with 27 lakes sampled continuously for 10 or more years up until 1990 (Stokes et al. 1990). Sharpe et al. (2000) described the activities of Citizens Environment Watch (CEW), a province-wide, non-profit environmental monitoring organization at the University of Toronto, Ontario, which during the period between 1996 and 2008 assisted in the assessment of the health of local waters through monitoring of chemical and physical parameters including pH, temperature, turbidity, ammonia and phosphate. During the
period between 1997 and 2001, an average of 20 groups per year participated in monitoring of water chemistry and these groups consisted primarily of middle and high school students (age 12-19) (Savan et al. 2003). As described by Savan et al. (2004), the formation of CEW, along with other citizen science groups, was initiated in response to “steady withdrawal, absence, and shift in government's approach to monitoring and regulation” (pg. 606, Krajnc 2000; Miller, 2002; OPSEU, 1997; Donnelly et al. 2001; Molot et al. 2001).

In Nova Scotia, the Community Based Environmental Monitoring Network (CBEM) was established in 2004. With a particular focus on water quality, this network assists individuals, community groups and other organizations in environmental monitoring by offering information about protocols, lending equipment, and offering long-term support from advice on initiation of a monitoring program to the documentation of a perceived environmental problem or threat. They also conduct suspended sediment analysis, water quality testing, stream health assessments, forest research, etc. (Climate Action Network 2015). Building on the work of the CBEMN, and with funding from the Social Sciences and Humanities Research Council of Canada (SSHRC) in 2011, CURA H₂O ‘Community-University Research Alliance’ was established to standardize data collection at the community level through a water monitoring training and certification course and an accompanying Wet-Pro (TM) toolkit that will provide all equipment necessary to conduct methods taught in the course (CURAH₂O 2014a). Along with their goal of standardized water monitoring training, during the five year funding period, research is being conducted on links between government and community based monitoring (CBM) groups, the state of CBM in Nova Scotia and across Canada, the quality of CBM data and perceptions of experts and governments to CBM data, the actual ecosystem benefits that may be resulting from community based monitoring by their network (CURAH₂O 2014b).

The Living Lakes Canada Network was established to protect, restore and rehabilitate the water bodies and watersheds in Canada with one of their six main mandates being community-based watershed monitoring. Initiated by the partnership among Wildsight, Global Nature Fund and Lake Winnipeg Foundation in 2010, the network unites lake associations and water stewardship groups throughout the country (Living Lakes Canada 2015a). The eastern CBEMN and western Living Lakes Canada are just two examples of
networks in Canada that are focused on the health of freshwater ecosystems. According to a report by Devlin (2011), water quality citizen science was among the most common citizen science programs in Canada.

2.4.1 Benthic macroinvertebrate monitoring

In his report on the Walkerton water contamination crisis in 2000, Justice Dennis O’Conner recommended that “The first barrier to the contamination of drinking water involves protecting the sources of drinking water” (O’Conner 2002). The drinking water supply for the town of approximately 5000 people became contaminated with the bacterium *E. coli* causing seven deaths and illness for a majority of the town's population.

In implementing this recommendation, the Ontario government is in the process of implementing regional Source Water Protection (SWP) programs under the *Clean Water Act* which are currently being delivered by Ontario’s CAs. One aspect of these programs includes monitoring the chemical components of drinking water sources, providing a snapshot of conditions at the time of sampling.

For non-drinking water (most surface water including streams, rivers and most lakes), there has been a move toward the use of biological criteria to assess the condition (bioassessment) of such freshwater ecosystems. Bioassessment is the evaluation of a condition of a water body using biological surveys and other direct measurements of the resident biota (Matthews et al. 1982; Rosenberg and Resh 1993; Gibson et al. 1996 as cited in Engel and Voshell 2002). Using benthic (bottom dwelling) macroinvertebrates (insects) as indicators of aquatic ecosystem health, biomonitoring integrates the condition over a longer period of time because these organisms are relatively sedentary and their life cycles range in length from months to years (Jones et al. 2006a). Sensitive life stages will be affected by stress but because of longer lifespans, the measurement of impairment in the assemblage can be detected, especially since these invertebrates have a wide range of sensitivity to all types of pollution and stress (Engel and Voshell 2002), and they are also responsive to changes in both water and sediment quality (Jones et al. 2006a). Hence, this method has the advantage of measuring the history of contamination to the benthic community over its lifetime (Au et al. 2000) by examining the diversity, abundance, trophic relationships and overall composition of the benthic
The use of benthic macroinvertebrates to assess the health of aquatic ecosystems has been quite extensive across North America, particularly in the US. Penrose and Call (1995) observed that in the US, 75% of the volunteer monitoring groups that were active in monitoring streams used benthic invertebrates as an indicator (76% by 1998; USEPA 1998 as cited in Nerbonne and Vondracek 2003). Nerbonne and Nelson (2004) conducted a survey to examine the types of state support for, and internal motivations of, among over 130 volunteer macroinvertebrate monitoring groups that were in existence in half of the US states at the time; they identified 366 groups in 18 of the 24 states. In Canada, the CEW switched from monitoring chemical and physical properties of streams to benthic monitoring in 2002 because organizers saw the use of biological indicators as a means of providing “…citizens with a relatively simple yet reliable tool for assessing river and lake health, or ecological integrity (Karr 1998; Karr and Chu 2000)” (pg. 565, Savan et al. 2003). In doing so, Savan et al. (2003) believed that despite giving up a more direct indicator of upstream point source pollution, adopting benthic monitoring provided a “broader and deeper understanding of ecosystem health” in addition to gaining access to a larger network of similar groups doing the same type of monitoring (pg. 565). As well, the use of benthic monitoring was considered to be the most effective at combining
…education, citizen empowerment and the production of useful data, while insisting on government’s continuing responsibility for investigation and enforcement when environmental quality problems are detected.” (pg. 565, Savan et al. 2003)

In the early 2000s the Ontario Ministry of Natural Resources established standardized protocols for collecting information about rivers and stream in Ontario. The Ontario Stream Assessment Protocol (OSAP) contains a series of modules outlining methods for identifying sites, evaluating benthic macroinvertebrates and fish communities and describing the physical habitat, geomorphology, hydrology, and water temperature in wadeable streams and headwater drainage features (Stanfield 2013). Since then, both the Ontario Provincial and Canadian Federal Governments established networks that promote the use of their services and protocols for community based monitoring of freshwater ecosystems. Environment Canada established the Canadian Aquatic Biomonitoring Program (CABIN) in 2002 (Sharpe and Conrad 2006) to assess the health of freshwater ecosystems in Canada (CABIN 2015). The Ontario Benthic Biomonitoring Network (OBBN) was developed by the Ontario Ministry of the Environment (MOE) and Environment Canada’s EMAN in 2004 (Toronto and Region Conservation Authority 2008). It was established in response to the problems arising from the “historical patchwork approach” to monitoring water quality in Ontario, and to fill the need for using biological criteria for evaluating aquatic ecosystem condition (lakes, streams and wetlands) using standard methods with the benefits of providing training, free data sharing and automated analysis (Jones et al. 2006b, pg. 458).

Initially developed as a pilot project for a Canada-wide aquatic biomonitoring program that is accessible to both volunteer “citizen scientists” and professional researchers, OBBN promotes partnerships, free data sharing and standardization with the goals of increasing the capacity for both adaptive community based management, and informed local decision-making (Jones et al. 2006b). The specific objectives of the program are to use benthic macroinvertebrates as indicators of environmental quality in streams lakes and wetlands, to provide a performance measure with respect to the management of aquatic ecosystems, to provide a biological complement to the provincial water chemistry monitoring program (Provincial Water Quality Monitoring Program established in 1964),
and to facilitate a reference condition approach where minimally impacted sites are used to derive the expected biological community in a test site (Jones et al. 2006b). Their partners include federal, provincial and local governments; CAs; universities; non-governmental groups; and volunteers. Currently, all three protocols (OSAP, CABIN and OBBN) are in use in Ontario. While OBBN was designed to be compatible with the CABIN protocol, there appears to be a move towards streamlining the variation in the number of certifiable protocols. For example, the latest edition of the OSAP protocol manual (Stanfield 2013) was updated to include the coarse-level identification features from the 2007 OBBN manual (Jones et al. 2007) making it consistent with the ‘Traveling-Kick-and-Sweep-Transect’ method of OBBN.

A major partner in the OBBN is Ontario’s CAs, with the majority having their own, staff-run benthic monitoring programs. Only nine of the 36 CAs have no established benthic monitoring sites of their own and from those CAs that collect and use benthic monitoring data, only three use methods other than the OBBN protocols while two CAs use the OSAP protocols (Conservation Ontario 2011b, unpublished data). OBBN also partners with citizen science groups in Ontario. For example, the Urban and Rural Biomonitoring Network (URBAN) which was established in 2010 and is coordinated from McMaster University in Hamilton, has the goal “to increase public awareness about threatened aquatic habitats in the local Hamilton region through community outreach and involvement in monitoring wildlife and ecosystems” (Cartwright et al. 2013).

While not as extensive as in the US, volunteer benthic monitoring programs have existed across Canada for a number of years. In Nova Scotia, Sharpe and Conrad (2006) reported on the identification of 43 stewardship groups involved in environmental stewardship activities. Of these, at least 10 groups were conducting volunteer benthic monitoring using CABIN protocols. Among these groups, the Clean Annapolis River Project (CARP) has been collecting benthic monitoring data since 2002 (Toor and Freeman 2015). In western Canada, a number of projects (Lake Windermere, Upper Athabasca, Columbia Headwaters, Flathead River and Elk Valley), in the Living Lakes Canada network have conducted volunteer benthic monitoring using CABIN protocols (Living Lakes Canada 2015b). SurVol Benthos is a volunteer benthic monitoring
program in Quebec used to increase the spatial coverage of monitoring the health of small streams in different regions of Quebec. Developed by G3E and Ministère du Développement durable, de l’Environnement et des Parcs du Québec (MDDEP), data collected by volunteers are used by the ministère du Développement durable, de l'Environnement et des Parcs du Québec to help in the search for locations representative of biogeographic regions called reference stations. The protocols used by this network were developed by the MDDEP and in 2006 a comparison to the OBBN protocols indicated that for distinguishing impacted and control stations the MDDEP was a good compromise between OBBN and family identification levels (Beauport River Enhancement Committee 2006). In Ontario, Citizen Scientists is an entirely volunteer driven, not-for-profit group which was established in 2001. Its members are dedicated to monitoring stream health in the Rouge River watershed in Toronto and the Greater Toronto area. Among other types of monitoring, they conduct volunteer benthic monitoring using but unlike URBAN, Citizen Scientists use the OSAP protocols (Citizen Scientists 2015a).

While there is currently no directory or comprehensive list of CS groups collecting in water quality and specifically benthic monitoring data, recently, a study by Kebo and Bunch (2013) identified only 21 environmental non-government organizations (ENGOs) across Canada that collect their own water quality monitoring data and from those, only eight utilized volunteers for their data collection. In their survey, only two ENGOs collecting water quality data were identified in Ontario (Citizen Scientists and Lake Ontario Water Keepers; Kebo and Bunch 2013). While temperature and pH were the most frequently collected indicators by ENGOs across Canada, 75% of the ENGOs collected fecal coliform data and only six of the 21 collected benthic invertebrate data. When asked about the suitability of using different water quality indicators for public education, only 3 of the 21 groups considered volunteer benthic monitoring suitable (Kebo and Bunch 2013).
### 2.5 The importance of capacity in implementing successful citizen science programs

A major challenge facing the implementation of citizen science programs is capacity: sufficient resources are needed to sustain citizen science activities over a period of time, for collecting sound and rigorous data, for use in environmental management and/or policy development or perhaps for education and outreach of the public about human impacts on natural resources. Hence, not only are resources and skills (both social and technical) needed for the collection of data (to train volunteers, for data collection materials and equipment), but also for the coordination, data storage and analysis, and reporting of that information. Regardless of the mandate (i.e. outreach, education, contribution to environmental management or policy change), Pollock et al. (2003) describe the factors for success they determined from their case study of 31 community based monitoring programs across Canada. These factors include 1) approaches to engaging community that are context specific, 2) establishing effective information delivery systems, 3) providing meaningful experiences for participants, 4) effective program coordination, 5) partnership development, 6) working collaboratively, and 7) obtaining national support for a coordinated network of citizen science practitioners (Pollock et al. 2003). More recently, Lefler’s (2010) review of the literature summarized five factors for the success of community based environmental monitoring programs: 1) obtain adequate funding, 2) use a monitoring protocol, 3) use a monitoring framework, 4) adopt an appropriate monitoring approach, and 5) link monitoring with decision makers. Savan et al. (2003) describe what in their experience necessitates a successful citizen science program stating that

> It is clear that staff resources, stable funding and a wide range of partnerships are critical for the delivery of long-term monitoring programs. A network of eager volunteers depends on human, financial and technical support and the inspiration and encouragement provided by meeting other citizen monitors and learning about local successes in following up on results that cause concern. (pg. 567)

Finding long-term, reliable funding to support this process of executing a successful citizen science program is often cited as a significant challenge (Au et al. 2000; Bliss et

Many of the factors contributing to successful citizen science programs require that adequate resources are available to provide a salary for paid coordination. This vital coordination involves both time and skill for executing a number of the other factors (e.g., those providing meaningful experiences for participants). Paid or unpaid, coordinating skills include both technical skills (i.e. for site selection and sampling time frame, training volunteers, quality assurance/quality control, data management and analysis etc.) and social skills (for coordination including communication to manage and support volunteers, deliver results and progress to volunteers and other intended parties, coordinate partnerships and apply for funding etc.).

Funding is but one of the components to take into account when considering the capacity of an organization to execute its mandated tasks. Grindle and Hilderbrand (1995, pg. 445) define capacity as “the ability to perform appropriate tasks effectively, efficiently and sustainably.” The capacity of CAs has been examined for tasks including protecting groundwater and source water (de Loë et al. 2002; Ivey et al. 2006a), adapting to revolutionary changes (Priddle et al. 2009) and associated learning from focusing events (Michaels et al. 2006), and for adapting to climate change (Kean 2008). In the study of capacity there appear to be two components to consider in deciding what indicators will comprise the framework for study: the type of organization or group (etc.) within which capacity is being studied, the activity for which capacity is in question (e.g., adapting to climate change). Currently there are no studies examining the capacity for supporting citizen science; however, studies that examine watershed based management organizations like CAs include those by de Loë et al. (2002), de Loë and Kreutzwiser (2005) and Ivey et al. (2002, 2004 and 2006a). As explained by de Loë et al. (2002, pg. 219), “capacity is a function of several interrelated dimensions, and that the relative importance of these dimensions varies from organization-to-organization, and from community-to-community.” Drawing on these studies of capacity within CAs, Kean’s (2008) framework for examining a CA’s adaptive capacity for climate change was deemed ideal for use in examining the capacity of CAs to integrate citizen science into
their programs and decision-making. Hence, with minor adaptations to fit the biomonitoring context, this framework for capacity is used as a methodological tool in this research to examine the capacity for integrating volunteer benthic monitoring by CAs.

Within the organization, capacity to participate in citizen science can be limited by resources including human, information and financial resources, and by the internal dynamics of the organization: its flexibility, learning and adaptive management as well as its networks, partnerships and collaborations (Kean 2008). Outside of the organization, capacity can be limited by a lack of community support and involvement as well as a lack of political support and guidance.

**Human resources** play a vital role in the capacity of an organization to perform tasks effectively. Capacity can be influenced by the quality of staff, the quantity of staff and the organizations support of their staff. As described by Kean (2008), high quality CA staff are skilled and knowledgeable and willing to continuously learn requiring support by the organization they work for; the organization needs to have not only the resources and mandates to enhance staff capabilities (Schuh and Leviton 2006), but also the processes and resources to be able to use increased staff and/or external expertise (e.g., consultants; de Loë et al 2002). The quantity of staff is also very important to capacity of the organization because no matter how capable the existing staff are, if there are not enough of them to do the work, this can result in staff with numerous responsibilities that can limit their ability to focus on one set of tasks (Kean 2008). For organizations that are limited in staff numbers, the additional responsibilities required by overseeing citizen science projects may be too challenging.

A lack of **information resources** can limit the capacity of an organization in a combination of ways. Without the appropriate information and technology, staff may not be able to effectively undertake specific tasks and responsibilities required for citizen science. This may not only influence their capability to participate, oversee, collaborate or coordinate citizen science, but also limit the CA’s ability to integrate citizen science in their benthic monitoring or other water quality monitoring programs. If they cannot
access the literature discussing the benefits and challenges of citizen science, they will have no way of exploring the potential costs and gains that citizen science might bring to their organization.

**Financial resources** are central to the capacity of an organization to effectively execute their mandates. As outlined by Kean (2008) indicators of financial capacity can refer to the ability of an organization to maintain balanced budgets and to secure external funding, as well as whether financial resources are made available for particular management tasks (Timmer *et al.* 2007). Both the amount and the type of resources play a role in influencing capacity (de Loë *et al.* 2002). Adequate funding can be used to enhance human resources (increase staff, acquire quality staff, and provide training) and information resources (Ivey *et al.* 2004), while limited finances can put projects and tasks at risk of being unsuccessful (Schuh and Leviton 2006). There is more capacity in the dollars acquired through long-term stable funding. Short-term funds in the form of external grants for example are often time consuming to acquire and deliver on, and also often difficult to maintain over multiple funding periods due to changing objectives of the funding agencies. As well, the availability of these funds from year to year can fluctuate resulting in situations where organizations or communities that rely heavily on external sources of funding are no longer able to continue conducting their activities due to a reduction in the level of funding by these sources (de Loë *et al.* 2002, in Kean 2008). Often, however, these external and short-term sources of funding can play a very important role in the capacity of a CA and therefore the organization’s ability to successfully acquire such funding (e.g., by adapting their activities to match the mandates of the funding guidelines) is an important indicator of its overall capacity.

Organization dynamics play an important role in capacity. Kean (2008) discusses the importance of **organizational flexibility** to capacity; flexibility is the ability of an organization to modify management approaches, policies and tasks when new and changing information becomes available (Naess *et al.* 2006). A distinction can be made between adaptive and spontaneous flexibility - adaptive flexibility is defined as “the ability to adopt new strategies to solve a problem when old methods have led to an impasse, or to redefine the problem in order to find an original solution”, and spontaneous flexibility as
“the ability to find diverse solutions to a problem when there is no external pressure to be flexible” (pg. 167, Georgsdottir and Getz 2004).

Enhanced capacity also depends on sufficient flexibility of individual staff to consider different perspectives to existing problems and develop creative and innovative solutions. For this to occur, a management style is required that allows staff to feel that they can take the risks to be innovative because they are supported by their managers for better or worse. Learning and adaptive management plays an important role in the capacity of an organization. More specifically, adaptive management requires the organization establishes a “…process for continually improving management policies and practices from by learning from the outcomes of implemented management strategies” (pg. 51, Pahl-Wostl 2007). In this process, information is gathered, processed and then change is made based on the results of the information processing. Kean (2008) notes that adaptive management is promoted more through an inherent management approach of constant learning and development in day to day activities (i.e. in how staff are dealt with, how policies are made, how partnerships are maintained etc.), rather than periodic training exercises guided by external consultants. Accordingly she notes that organizations must not only provide opportunities for suitable training and educational opportunities to develop their skills and abilities (Franks 1999), they must also develop an environment that allows staff to effectively make use of their new knowledge and expertise (Crisp et al. 2004) (Kean 2008).

Another set of organizational activities that Kean (2008) included in her framework for indices of capacity are the establishment of networks, partnerships and collaborations both within and outside the organization. Within the organization, collaborations among staff from different departments and with varying specializations, provides the opportunity to investigate problems from a variety of perspectives (hence, increasing organizational flexibility) (Georgsdottir and Getz 2004). As well, these collaborations allow individuals with specific skills to concentrate on a particular management task (Schuh and Leviton 2006). Collaboration with external agencies is considered of critical importance to capacity through which organizations acquire additional technical and financial resources, data, expertise and managerial abilities (de Loë et al. 2002; Smit and
Wandel 2006). Smit and Wandel (2006) suggest that greater access to financial resources, as a result of developing partnerships with other organizations, can enable an organization to provide training opportunities and provide greater access to technical resources. de Loë et al. (2002) suggest that municipalities lacking in financial and technical resources can enhance their capacity by strengthening vertical and horizontal linkages with other organizations. An organization that communicates and forms networks with other groups can benefit from unique insights and approaches to problem solving outside its own range of experience, thereby enhancing its ability to respond and cope with change; it is improbable for an organization to effectively respond to changes outside its “range of experience” (pg. 567, Tompkins and Adger 2005).

Kean (2008) describes how capacity can come from outside the organization through the support and contribution of community members and from the political guidance and support that comes with effective institutional arrangements and collaborations. Community can contribute skills, knowledge and financial resources and their participation in management decisions can result in better support for projects in their community (de Loë et al. 2002). It can also increase the likelihood that management tasks will be undertaken successfully. Organizations can promote community contribution and support through education programs, and through pursuing collaborations that promote public participation and consultation (Kean 2008).

Considered together for the purposes of this research, Kean (2008) considers political support (leadership, financial and technical support, legislation and partnerships) separately from political guidance (clear policies and responsibilities through the presence of effective institutional arrangements). Local political support for the management tasks of organizations can come in the form of guidance and direction as well as financial or technical support for specific projects through the development of institutional arrangements. Kean (2008) describes how institutional arrangements are defined as “legislation and regulations, policies and guidelines, administrative structures, economic and financial arrangements, and political structures and processes” (pg. 196, Ivey et al. 2006b). The quality of such institutional arrangements must be considered to determine their contribution to enhanced capacity.
According to Kean (2008), capacity is decreased when responsibilities that are spread across various levels of government (both vertically, i.e. from one level of government to another, and horizontally, i.e. between different government departments), several different organizations can invest unnecessarily in decisions about a single activity.

**Institutional arrangements** consisting of strong, clear policies identifying the roles and responsibilities of the agencies and individuals are necessary for an organization to effectively undertake related tasks (Franks 1999; Ivey et al. 2004). Kean (2008) also notes that institutional arrangements can lead to inflexibility and act as “a filter through which new perspectives must pass” (Naess *et al.* 2005, pg. 136). Ideally, according to Grindle and Hilderbrand (1995, pg. 454) for institutional arrangements to be capacity building “…rules must be straightforward and consistent to ensure transparency and fairness, but they must also provide organizations with clear performance standards, room to maneuver in solving problems, and control over decisions that are central to producing the results they are responsible for.”

### 2.6 The importance of attitude in implementing a successful citizen science programs

The lack of regard for and use of citizen science by decision makers has been recognized (e.g., Conrad and Daoust 2008; Nerbonne and Nelson 2004; Sharpe and Conrad 2006). The primary concern is the mistrust in the general ability of the citizen participants to rigorously collect data which most accurately represents the information being sought. If managers do not recognize the value of the data collected by citizen scientists, their incentive to invest in collaborations with such groups will be significantly reduced. Quality of volunteer monitoring data has often been cited as a challenge for its use by resource managers and policy makers (e.g., Engel and Voshell 2002; Nerbonne and Nelson 2004 and 2008; Fore *et al.* 2001; Penrose and Call 1995; Sharpe and Conrad 2006; Conrad and Hichley 2011; Conrad and Daoust 2008, Milne *et al.* 2006; Riesch and Potter 2014). Riesch and Potter (2014) found that scientists are often as concerned about how their use of volunteer data will be viewed by their peers, as they are about the actual quality of the data. Nerbonne and Nelson (2004) found that the leaders from three states were not able to use volunteer data because of their questionable quality. They also
found that volunteer benthic monitoring groups whose goal was to contribute to decision-making were no more likely to collect quality data (e.g., take a random subsample of the invertebrate sample, use a microscope and identify invertebrates to family level) than groups primarily interested in educating the public and raising awareness (Nerbonne and Nelson 2008). Surprisingly, number of training hours, amount of in-kind support, the education and profession of the CS group are all poor predictors of the quality of data collected by a volunteer benthic monitoring group: (Nerbonne and Nelson 2008). According to Conrad and Hichley (2011), many researchers lack confidence in training that volunteers get, particularly when it comes to identifying organisms.

Especially over the past 10 years, the number of peer-reviewed articles that deal with the topic of data quality from non-expert/lay/volunteer groups has blossomed. Comparisons of citizen science to expert data collection have been done for rocky reef kelp forests (Gillet et al. 2012), vegetation benchmarks for rehabilitation projects (Gollan et al. 2012), Vancouver Island White-tailed Ptarmigan (Jackson et al. 2015), Eastern screech owls (Nagy et al. 2012), American pika (Moyer-Horner et al. 2012), mountain goats (Belt and Krausman 2012), Taiwanese moths (Lin et al. 2015), nutrients in surface water (Loperfido et al. 2010), chemical and physical indicators of groundwater quality (Peckanham and Peckanham 2014) and surface water quality (Shelton 2013), geographical human impact and land cover type (See et al. 2013). As well, the assessment of the quality of volunteer macroinvertebrate monitoring has been well examined (Penrose and Call 1995; Fore et al. 2001; Navis and Gillies 2001; Engel and Voshell 2002; Nerbonne and Vondracek 2003; Gowan et al. 2007; Nerbonne et al. 2008; Medeiros et al. 2011). This research has examined factors including the types of protocols used, the level of training received by volunteers, the indices calculated from the collected data, etc.

Other types of inquiry have been conducted around the topic of volunteer data. For example, Yu et al. (2012) evaluated automated approaches to improving the data quality of a broad-scale citizen science project that collects bird observations, whereas, Hunter et al. (2013) evaluated software services which enhance the reliability of online volunteer data on coral reef health. Isaac and Pocock (2015) provide suggestions for recording
methods that minimize certain types of bias in the presence/absence monitoring of biological records in the United Kingdom, and similarly, Sunde and Jessen (2013) examined observer-specific (e.g., age, experience) detection of nocturnal animals. Gonsamo and Dodorico (2014) established post collection, computational methods for dealing with observer bias in plant phenology data.

In a recent review of peer-reviewed literature on the quality of data collected by volunteers, Lewandowski and Specht (2015) found that in only 4 of 7 cases were professional data more accurate when compared to volunteer data when compared using the same accuracy standard. As well, of the studies they examined (n=71), few showed that professional data were less variable than volunteer data and they found no strong evidence to support the belief that volunteer data are consistently less precise than professional data. They recommended that monitoring project managers who wish to compare the quality of their volunteers’ data with that of professionals’ data, first take steps to verify the quality of the professionally collected data (Lewandowski and Specht 2015). A number of researchers have claimed that volunteer data are comparable to expert monitoring data (e.g., Sharpe and Conrad 2006; Conrad and Hichley 2011; Whitelaw et al. 2003), and most commonly volunteer training, standard protocols, data quality control and validation are cited as methods for ensuring the quality of data collected by citizen science groups (e.g., Sharpe and Conrad 2006; Riesch and Potter 2014).

The objectivity of citizens collecting scientific data is often challenged. The perception of science’s role in society is dominated by the positivist or ‘enlightenment’ worldviews. Positivism encompasses the view that objective (value-free) truth exists, that complex situations can be understood by breaking them into parts and that useful information can be derived through deduction and controlled measurement (de Neufville 1985). Related to this, ‘enlightenment’ thought suggests that progress depends on science and any divisiveness between science and the public is due to either irrationality or a lack of understanding on the part of the public (Irwin 1995). Hence, the common assumption is that this citizen science can be improved by enhanced public education by experts. However, due to the predominantly technical nature by which environmental issues are
presented, citizens are passive witnesses rather than active participants (Irwin 1995). This is not conducive to citizen participation in the process of resolving environmental issues. However, increasingly these perspectives are being challenged. Constructivists consider that every step of the scientific process is steered in some way by personal, social, financial or political preferences. This notion disputes the neutrality of science, because scientists live their lives embedded in a particular social and political setting (Lewontin 1991). As well, with the increased complexity of environmental issues, scientific knowledge is often provisional, uncertain and incomplete. Thus the competing of expert knowledge in the politics of science has led to the erosion of the authority and legitimacy of science as objective knowledge (Bäckstrand 2003). Relying on information gathered by citizens to inform policy and management decisions profoundly challenges the top-down flow of information that characterizes expert-led decision-making structures; citizen science puts citizens in the role of transmitters as well as receivers of knowledge (de Neufville 1985). Hence, with the collection of scientific information as well as the incorporation of other ways of knowing (e.g., traditional ecological and local knowledge), the delineation between scientist and non-scientist is blurred (Ellis and Waterton 2004; Brosnan et al. 2015; Buyaert et al. 2014). These factors contribute to the reluctance to accept citizen science as a valid source of information for use in the management of resources or in the development of policy.
Chapter 3

3 Methods

3.1 Methodological approach

When first approaching this topic, my initial question was “What factors contribute to collaboration with citizen science groups and use of volunteer benthic monitoring data in the management of freshwater resources by Conservation Authorities (CAs)?” As I began my preliminary research and reconnaissance for developing my study design, I soon learned that collaboration between volunteer benthic monitoring groups and CAs was much less common than I had expected. Hence, my focus became gaining an understanding why this was so and therefore my study question evolved. This study took an inductive, mixed-method approach to answering the following question: “Why is the use of citizen science for benthic monitoring not more common by Ontario Conservation Authorities?” In taking an inductive approach to this research, the objective was not to test a theory, but rather to collect data that could help develop theory. Although inductive, the inquiry did have some direction with questions focusing on the possible roles that both attitudes and capacity may play in limiting the use of volunteer benthic monitoring by CAs in Ontario. A mixed-method approach was used to provide depth (qualitative case research - understanding the personal perspectives of individual staff/board members regarding the value of, and capacity to integrate citizen science in freshwater management activities by their organization), as well as breadth (quantitative survey - to determine whether opinions/situations/practices of CAs observed in qualitative case research extend to the rest of the CAs in the province), with respect to the issue under examination. Using both quantitative and qualitative methods enhances the rigor of the information discovered through the triangulation of ideas and theories between methods. The qualitative data collected consists of a multiple-site, case study evaluation that includes semi-structured, open-ended, one-on-one interviews supported by document review and direct participation/observation. The quantitative data collected includes a survey consisting of two questionnaires administered to all of the 36 Ontario
CAs. Ethical clearance from the Office of Research Ethics at The University of Western Ontario was acquired prior to conducting the interviews and surveys (Appendix A).

Epistemology is the theory of knowledge; asking questions about knowledge itself such as: “What can be known?”, “Who can be a knower?”, and “How is knowledge created?” What researchers know about a phenomenon, and what they want to learn through their research, are the basis of an epistemology (Nagy Hess-Biber and Levy 2004). The epistemology held by the researcher therefore influences all further aspects of their research including who the subjects are, how the questions are framed, what the goals of the research are (e.g., to contribute to social change), the methods that are used to conduct the research and the theoretical frameworks that are used to understand the findings (Guba and Lincoln 2004). As discussed by Gehrels (2013), there is consistency provided from realizing the paradigm or epistemology that drives decisions regarding strategy, methods and analysis.

Being the primary researcher in this study, there are a number of factors that play a role in my epistemological position and hence, have influenced how this study was conducted and the conclusions that I have drawn. The strong influence of positivism in my academic training, the discipline in which I have predominantly been trained (ecology), and my values, have all played a role in how this study has proceeded. Having been trained in the natural sciences (biology/ecology) for my entire academic career has likely played a significant role in how I have approached this research. I was trained to believe that good science could only happen in the absence of bias and that most ecological problems possessed a single knowable solution based on the science. During the course of this research, my epistemological views have shifted to believing that bias is inherent when humans do research because their beliefs, experiences and understanding of knowledge influences how the research process unfolds. After spending a considerable amount of my employment experiences prior to this research pursuing work that allows me to make (what I feel) to be a positive contribution to the state of the environment, I realize that this research is not value-free. I hope that what is discovered will be used by managers of our freshwater to help create a reality where equal attention is given to the
engagement of stewardship and inquiry by the public as is given to the management of our natural resources.

With the predominantly inductive approach that I took with this research, a grounded theory method made the most sense as to how I would collect and analyze data. Grounded theory methods are a set of inductive strategies for collecting and analyzing data with the aim of developing theory (Charmaz 2004). There are a number of premises underlying grounded theory and this research generally followed these methods with a few exceptions. A fundamental premise of grounded theory is that the researcher begins with an area of study then builds their own theoretical analysis based on discoveries about what is relevant in the actual “worlds” that are studied (Charmaz 2004). Moving into the data collection phase, I had some knowledge about citizen science and its connection to various social phenomena (e.g., citizen participation, sustainability science, democratization of science). Grounded theory provided an excellent framework for trying to understand the actions and interactions in a particular context from the point of view of the people involved (McCallin 2003). This allowed me to put aside or critically examine my preconceived ideas of the dynamics between CAs and citizen science. As well, when I began this research I knew that there were citizen science groups collecting benthic monitoring data in Ontario. I also had some understanding about the general structure and function of CAs through my previous employment as a receptionist with one of the CAs. However, I was unaware of the role that benthic biomonitoring plays in CA activities or the extent to which CAs depend on community contributions (e.g., field volunteers, committee members) for the work they do. So by using grounded theory method, the data that I collected evolved during the process depending on the information that I was collecting and the experiences that I was having. This process allowed me to focus more and more closely as the research progressed, on answering the questions posed at the start of this study. One way this can occur is when participants are not predicted from the beginning of the research (Denscombe 1998); I started with a rough of idea of the types of individuals that I wanted to hear from, but then followed the opportunities and suggestions of the participants as the research unfolded to determine who the most relevant individuals were that would help me find the answers to the questions I was asking.
While there was a general ‘follow the data’ approach taken, it was not as systematic as described by some of the practitioners of grounded theory. Likely because of my past experiences, data collection was scheduled in a way that did not allow me to organize and examine each interview before the next was conducted (I had a limited amount of time to collect the information which would then be examined and analyzed as a whole). As described by McCallin (2003), by analyzing each interview prior to the next, the researcher can look for patterns in the data and determine which directions to follow the data in order to clarify emerging theories. I did this to the extent that I based changes to the questions that I asked using my flexible topic checklist on previous interview experiences (all interviews were conducted by myself, the primary researcher of the study).

3.2 Case Studies

3.2.1 Case descriptions and data collected

3.2.1.1 Conservation authorities

Five of Ontario’s 36 Conservation Authorities participated in this part of the study: Ausable Bayfield CA, Upper Thames River CA, Toronto and Region CA, Grand River CA and Rideau Valley CA (Figure 3.1). These CAs varied in (among a number of other things), the size of their watershed and population, predominant land use, size of their organization, structure of their monitoring programs and association with volunteer benthic monitoring.
Figure 3.1 The relative locations of the five Conservation Authority cases (dark grey) that participated in this study (ABCA = Ausable Bayfield Conservation Authority, UTRCA = Upper Thames River Conservation Authority, GRCA = Grand River Conservation Authority, TRCA = Toronto and Region Conservation Authority, RVCA = Rideau Valley Conservation Authority.)
The **Ausable Bayfield Conservation Authority** is located in Southwestern Ontario bordering the southwestern shore of Lake Huron (Figure 3.2) and covers approximately 2,500 km² (Conservation Ontario 2011b, unpublished data) of primarily agricultural land (85%) (ABCA 2012). Figure 3.1 shows the relative location of all the research cases within the 32 CAs located in Southwestern Ontario. The watershed area encompasses drainage basins of the Ausable River, Bayfield River, Parkhill Creek and the gullies between Bayfield and Grand Bend draining directly to Lake Huron. Within the 16 municipalities, the population of the watershed is 47,925 (Conservation Ontario 2011b, unpublished data) and some of the major populations centres include Exeter, Bayfield, Lucan, Clinton, and Parkhill. The Ausable Bayfield Conservation Authority was the first conservation authority established in Ontario in 1946. From the 16 participating municipalities, 9 board members oversee the activities of ABCA. With the equivalent of 20 full-time and 1 part-time employee, ABCA performs its activities on a budget of $3,718,569 (2011 revenue only; Conservation Ontario 2011b, unpublished data).

The **Rideau Valley Conservation Authority** is located in the central part of Eastern Ontario with its northern boundary along the Ontario/Quebec border (Figure 3.3) covering a 4,243 km² area (Conservation Ontario 2011b, unpublished data) and is comprised of the drainage basins of Jock River, Kemptville Creek, Lower Rideau, Middle Rideau, Tay River and Rideau Lakes. The area is a mix of rural and urban land including the urban Ottawa Region which includes the city of Ottawa and its surrounding communities (Glouchester, Napean and Kanata) at the north end of the watershed and the more rural community of Westport, and the towns of Perth and Smiths Falls to the south. Within the 18 municipalities, the population of the watershed is just under 1 million people (Conservation Ontario 2011b, unpublished data).
Figure 3.2 Map showing the watershed boundary, communities, roads and waterways of the Ausable Bayfield Conservation Authority (http://www.abca.on.ca/page.php?page=watershed-report-card-2013).
The Rideau Valley Conservation Authority was established in 1966 and is overseen by 22 board members from 18 participating municipalities (Rideau Valley Conservation Authority 2015). With a budget of over $9,000,000, RVCA performs its activities with the equivalent of 60 full-time and six part-time employees (Conservation Ontario 2011b, unpublished data).

Figure 3.3 Map showing the watershed boundary, communities, roads and waterways of the Rideau Valley Conservation Authority (http://www.rvca.ca/watershed/subwatershed_reporting/index.html).
The **Upper Thames River Conservation Authority** is located in the center of Southwestern Ontario (Figure 3.4). Composed of 28 drainage basins, the area is highly developed, covering a 3,432 km² area comprised of mostly rural land (predominantly agriculture) with the exception of large urban centers of London, Stratford and Woodstock.

Within the 22 municipalities in the watershed is a population of just over 500 thousand people. In 1947, the Upper Thames River Conservation Authority was the sixth authority established in Ontario. From its 17 participating municipalities, 15 board members oversee this CA. Working with $12,763,589 in revenues are the equivalent of 109 full-time and 3 part-time staff (Conservation Ontario 2011b, unpublished data).

![Map showing the watershed boundary, communities, roads and waterways of the Upper Thames River Conservation Authority](http://thamesriver.on.ca/water-management/thames-river-levels/).

**Figure 3.4** Map showing the watershed boundary, communities, roads and waterways of the Upper Thames River Conservation Authority.
The **Grand River Conservation Authority** is located in the center of Southwestern Ontario bordering the northern part of the Upper Thames River watershed (Figure 3.5). It is the largest watershed in the southern half of the province covering 6,800 km\(^2\) and drains the Grand, Conestoga, Eramosa, Speed, and Nith rivers and Whitemans, Fairchild, Big, McKenzie and Boston Creeks into Lake Erie at its southern tip. This watershed is characterized by several large urban, commercial, industrial and residential centres (Guelph, Kitchener/Cambridge/Waterloo, Brant and Brantford) surrounded by rural land used for intensive agriculture (Grand River Conservation Authority 2012). The population of the watershed is 951,863 (Conservation Ontario 2011b, unpublished data). The Grand River Conservation Authority was established in 1966 from a merger between the Grand River Conservation Commission established 1932 and the Grand Valley Conservation Authority established in 1948. The operation of GRCA is overseen by a 26 member board arising from 38 municipalities in the watershed (Conservation Ontario 2011b, unpublished data). Working from $29,932,682 in revenues are the equivalent of 162 full-time and 16 part-time employees (Conservation Ontario 2011b, unpublished data).
The Toronto and Region Conservation Authority is comprised of nine watersheds (Carruthers Creek, Don River, Duffins Creek, Etobicoke Creek, Mimico Creek, Highland Creek, Humber River, Rouge River, and Petticoat Creek; Figure 3.6) covering 3,467 km² area comprised of mostly urban areas supporting a total population of 4,314,876 in 20 municipalities (Conservation Ontario 2011b, unpublished data). Toronto and Region Conservation Authority was established in 1947 and is overseen by 28 board members from six participating member municipalities (Conservation Ontario 2011b, unpublished data).

Figure 3.5 Map showing the watershed boundary, communities, roads and waterways of the Grand River Conservation Authority (https://library.mcmaster.ca/maps/images/GRCAMap.gif).
data). With a budget of $84,319,059 in revenues are a staff of 583 full-time equivalent employees and 85 part-time employees (Conservation Ontario 2011b, unpublished data).

**Figure 3.6** Map showing the subwatershed boundaries, communities, and roads of the Toronto and Region Conservation Authority (http://waterbucket.ca/rm/files/2014/08/TRCA_watershed-map.jpg).

Conservation Authorities were chosen for the case study component of the research based on their willingness to participate (in some cases cultivated from historical collaborations between the CA and the research group from which this research was conducted), their accessibility, and their association with a citizen science group collecting freshwater monitoring information. ABCA was chosen as a pilot case - all the same data was collected for ABCA as for the other CAs but with the process of data collection involving the assistance of the participants in my learning and adjustment of how I procured
information. Since ABCA had previously collaborated closely with the group at Western conducting this research, I felt that its participants would reliably comment on their experiences, feel comfortable critiquing the process of data collection as well as provide me with advice about how to work effectively and respectfully as a researcher given the cultural norms of CAs. UTRCA was chosen based on its accessibility and willingness to participate in this research. My lab and this CA had previous research relationship which facilitated their willingness to participate and since this CA resides in the same city (London, Ontario) as Western University, this made it very accessible for data collection. GRCA was also chosen based on accessibility and willingness to participate in this research. TRCA was chosen predominantly because of its partnership with a citizen science group (Citizen Scientists) that does volunteer benthic monitoring (VBM). RVCA was also chosen predominantly based on the citizen science group (City Stream Watch) that it coordinates.

While the above criteria were used to individually select CAs, there were also a number of reasons that the group that resulted from these selections was maintained. Not only are there some similarities among the CAs, there are some interesting contrasts. Except ABCA and TRCA, the CAs are similar in size in terms of land area and the population served by the CAs. A contrast is the range of predominant land uses in the watersheds that these CA serve (e.g., TRCA – predominantly urban; ABCA – predominantly rural; GRCA, UTRCA and RVCA – a mix of urban and rural). Another contrast I found interesting when selecting the CAs was the fact that GRCA is unique in the large number of dam structures that it manages compared to the other CAs. GRCA also is unique from the other CAs in that it does not have its own benthic monitoring program. Both of these (land use and dam management) likely influences the CAs’ activities (e.g., how and what they monitor, how and to what extent they generally work with community etc.). Finally, there are distinct differences in the CAs where there is collaboration between the CA and citizen science groups. While the TRCA collaboration with Citizen Scientists is relatively loose and both of these organizations are autonomous, the RVCA collaboration with City Stream Watch is completely different; City Stream Watch is a program created and coordinated by RVCA.
Interviews were conducted with up to five employees and two board members of each CA (Table 3.1). My general approach to finding participants was similar to snowball sampling but with the use of a gate keeper in each of the CAs. The process of acquiring participants began by soliciting assistance from CA staff contacts that I had made (through workshops, conferences and third parties). By email, I provided these individuals with a brief description of my research that included some context, objectives of the study, specific details of the time and effort I was seeking from participants (Appendix B), as well as the Letter of Information for Research Participants (Appendix C). These staff contacts either approached their General Manager (GM)/Chief Administrative Officer (CAO) about the CA’s participation in this study or directed me to do so. In all CAs but TRCA, the GM/CAO acknowledged their CA’s willingness to participate in this research and directed one of their staff to be my point of contact for logistics and participant selection.

Prior to the start of the study, participants were sought out based on their broad knowledge of how the organization operates and their level of interaction with community and/or involvement with the water quality and monitoring activities of their CA. At the start of the study and with my limited understanding of the variation in organizational structure among CAs, there were types of individuals that I wanted to interview based on their job title/description listed on the CA’s staff list webpage. These individuals included the General Manager/Chief Administrative Officer, a ‘freshwater manager’ – a staff member who had some responsibility in determining and overseeing monitoring of freshwater resources, a ‘community liaison’ – a staff member who works closely with community in stewardship and/or education activities, as well as two other participants. I was hoping these two other participants would include a staff member at a lower organizational level who works more in the front-lines of either water monitoring or community stewardship/education and where possible, a staff member in the communications department of the CA. The communications staff member was sought for participation because it seemed that this individual would not only work closely with individuals throughout the CA (hence have a broad view of how the CA operates), but would also have a link to community in what they are conveying through their
communications. Along with these five staff members, up to two members from the Board of Directors were sought for participation in interviews.

When recruiting participants, in some cases the individuals that I had chosen based on job title and organizational structure were not available to be interviewed or they were deemed in some capacity by someone in the CA to not be as appropriate for interviewing as other staff. In these cases, participants were provided by the CA. To approximate the suitability of these ‘assigned’ participants, I asked participants during interviews to suggest other staff members who might provide relevant information to this research. In all cases, their suggestions aligned well with those participants that were provided by the CA.

The choice of members of the CA’s Board of Directors to participate in interviews was made by the CA – the only role the researcher played in recruiting these individuals was to send the contact staff member an information package (study description and Letter of Information for Research Participants) that could be provided to the board members. In all CAs but TRCA, both relevant staff and the two board members participated in interviews. In two of these CAs, only four staff members were interviewed. In the other two CAs where all five staff members were interviewed, I found that by the fifth interview, there was very little new information forthcoming regarding my research topic – it seemed like information saturation had been met (Morse 2004). For TRCA, however, the CAO (was too busy) and three staff members (deemed themselves inappropriate choices) declined my request for an interview, and my request for interviews with board members was also declined (no reason provided). Despite this, four upper-level staff members from TRCA agreed to be interviewed for this study.

3.2.1.2 Citizen science groups

The Urban and Rural Monitoring and Assessment Network (URBAN) serves the City of Hamilton and surrounding areas and was developed in 2010 at McMaster University in collaboration with the Bay Area Restoration Council and the Royal Botanical Gardens. The program is funded by the RBC Foundation, McMaster University and the Baille Fund. There are three partners involved in the group’s work; the Bay Area Restoration
Council, the Marsh Monitoring Program and the Royal Botanical Gardens. URBAN is run through McMaster University under the direction of a biology professor and through the coordination of two paid biologists (PhD and MSc). There are three areas of monitoring that the group conducts through the work of approximately 70 volunteers; marsh monitoring of amphibians and birds through the Marsh Monitoring Program, benthic monitoring of streams, and volunteer aquatic plant surveys. URBAN was developed to provide education and outreach to the community on environmental issues relating to water and water resources, to involve the community citizen scientists in monitoring those resources in sensitive areas, and to provide long-term data based on these citizens scientists, to community groups or stakeholders.

URBAN’s benthic monitoring program uses the protocols of the OBBN and the group collects data on 10 streams in the local area (Spencer Creek, Sulphur Springs, Sherman Falls, Shoreacres Creek, Tuck Creek, Valens Conservation Area, Tiffany Creek, Eramosa Karst, Felker Creek, Veevers Dr.) approximately annually. Small groups of volunteers participate in each stream monitoring event and are supervised and guided through the data collection process by an OBBN certified staff member. The site visit includes collection of physical stream data (total phosphorus, total nitrogen, chlorophyll a, turbidity, conductivity, pH, dissolved oxygen and temperature), vegetation data, and a sample of stream benthic invertebrates. After the invertebrate sample is collected the staff member and volunteers on site pick out the appropriate number of bugs from the sample. The completeness of each subsample picked by a volunteer is checked by the trained staff member in the field. The invertebrate sample is preserved and brought back to the university where at some later point in time, one of the two paid coordinators sort and identify the invertebrates according to the OBBN protocol.

Citizen Scientists is a registered not-for-profit organization that was founded in 2001, and is directed by an Aquatic Systems Analyst at Toronto and Region Conservation Authority. Decisions are made about the programs’ activities and monitoring by the director and two unpaid coordinators. Other positions of leadership include a complement of 10 volunteer crew leaders that assist in coordinating and supervising the monitoring activities during the field visits. Program funders/partners include the RBC
Blue Water Project, Rouge Valley Foundation and Rouge Valley Conservation Centre and the Toronto and Region Conservation Authority. There are from 40 to 60 individuals that come through the program every year with approximately 16 or 18 that are responsible for the majority of the monitoring during a given season. Following the Ontario Stream Assessment Protocol (OSAP), the group monitors a number of components of the aquatic environment including physical features (channel morphology: size, shape and substrate composition; temperature; flow regime etc.) and biological features (riparian amount and condition, stream invertebrates, fish, and aquatic invasive species) in seven sites in the Rouge watershed. As well, the group has completed a mussel survey and surveyed dragonflies (including the collection of exuvia (the shed skin of the dragonfly pupae), at more than 20 sites and also has two established salamander monitoring sites at which they also collect detailed forest information. Through this monitoring, Citizen Scientists work with partners and other agencies to provide volunteers with environmental education experiences: Ontario Stream Assessment Protocol (OSAP), Fish and Benthic Invertebrate Identification, Ecological Analysis, Redside Dace Research (in collaboration with TRCA and University of Toronto), Project Crayfish (in collaboration with Toronto Zoo), Vernal Pools (in collaboration with the Ontario Vernal Pool Association). The main goals of this group are to educate volunteers on how and why stream monitoring is important and how it connects to environmental protection, to foster local stewardship through building awareness and understanding of local aquatic ecosystems and their related issues, and to monitor local watersheds to collect reliable long-term data to share with government agencies, environmental organizations, researchers and the general public.

The program offers two types of volunteer benthic monitoring activities; 100 Bug Count and Full Bug Collection. These are full day events consisting of both an in-field and in-class session. For the 100 Bug Count, volunteers complete the initial part of the OSAP protocol at one of the monitoring sites and then return to the Rouge Valley Conservation Centre to identify and count the bugs and fill out the benthic macroinvertebrate form. All data collection and bug identification is done under the supervision of one or more crew leaders. All crew leaders are trained and certified by MNR in the collection of OSAP information. For the Full Bug Collection, volunteers complete the initial part of the
OSAP protocol at four of the monitoring sites and then return to the Rouge Valley Conservation Centre to sieve and preserve the sample. The invertebrate samples are identified by a taxonomist.

**City Stream Watch** is a stream monitoring program, directed and coordinated since 2002, by staff of Rideau Valley Conservation Authority in partnership with the their collaborative members including: City of Ottawa, Heron Park Community Association, Ottawa Flyfishers Society, Rideau Roundtable, National Defense HQ – Fish and Game Club, Ottawa Stewardship Council and the National Capital Commission. Working with up to 200 volunteers from the Ottawa area, the group conducts stream assessment, fish community sampling and remediation/restoration activities (including cleanup, planting, invasive species removal etc.). Decisions about the program are made by an Aquatic and Fish Habitat Biologist and the coordinator (paid staff of RVCA) of the program. From funding acquired through a number of agencies, seasonal staff are hired to supervise volunteers on all field excursions. “The goal of the program is to obtain, record, and manage valuable information on the physical and biological characteristics of creeks and streams in the City of Ottawa, while ensuring that they are respected and valued natural features of the communities through which they flow.” (RVCA 2014).

Their main activity, stream assessment, is conducted using protocols originally developed by Ontario Ministry of Natural Resources. Officials at RVCA have modified the procedures to facilitate its use by community volunteers. For this assessment, an entire length of a stream is monitored in 100 m sections for land use surrounding the stream, surficial geology, riparian buffer characteristics, level of erosion present, in-stream features (temperature, width, depth, substrate), water quality (dissolved oxygen, conductivity and pH), and fish and wildlife observed. Twenty-five stream catchments are included in their program and are monitored on an approximately five year rotating basis with between three and seven streams assessed annually. This monitoring program does not include the collection of benthic information and is separate from RVCA’s staff-run benthic monitoring program.
The three citizen science cases were chosen based on their accessibility, willingness to participate, on the type of data their group collected, and on their collaborations with CA cases in this study. URBAN was chosen because this group does VBM and because of their willingness to participate. Citizen Scientists was chosen because they do VBM, collaborate with TRCA and were willing to participate. While the data collected by City Stream Watch is not benthic monitoring data, it provides a case where a CA is coordinating a freshwater monitoring program using volunteer data collection. RVCA has its own benthic monitoring program (i.e. data collected and analyzed by paid staff) and so I thought it would be interesting to examine what factors, decisions, considerations were made to preclude the use of VBM for their benthic data collection.

Up to five individuals from each citizen science group were interviewed including two people who held a leadership role within the citizen science program (e.g., coordinator, director, supervisor or steering committee member) and at least one person who was active in data collection (i.e. volunteer) (Table 3.2). As well, up to three more individuals were interviewed in order to understand the various perspectives of the resources, objectives and dynamics of the organization. The number of interview participants ranged from between four and five individuals.

3.2.2 Interviews

As principal researcher, I conducted all of the 44 interviews. Each interview was conducted in person during the period between March and September of 2011. Interviews were conducted at a location comfortable and convenient for the participant. All participants consented to having their interviews digitally recorded. Two small recording devices were used for most interviews but for a few, both a small recorder and a laptop computer set out of the way were used. A flexible topic checklist was used during the interview and in many of the interviews not all of the questions were asked due to time constraints. In most interviews, the order of questions posed depended on answers provided by the participant in order to maintain a topic flow and assist in the development of ideas that the participants were sharing. However, the main topics were covered in all cases. I attempted in all interviews to be sensitive and flexible, particularly with respect to the comfort of the participant, realizing that the narratives of the
participants would be influenced by the interview situation. Some of the factors that contribute to a given interview situation include the way an interviewee was invited to participate in the research, the setting of the interview, the presence of a recording device and the position of the interviewer. For each of the interviews, I attempted to articulate the position that I believed I was coming from at the time of the interview. I provided a brief background of my academic and employment experiences that were related to the topic at hand (or how I arrived at studying this topic), an overview of my methodology (i.e. case research with interviews of individuals at both CAs and citizen science groups), and review of my objectives for this research. For all interviews, participants were given the opportunity to add information that might not have been covered with the checklist and also offered the opportunity to comment on their experience of being interviewed.

The topic checklist was different for the CA participants than the citizen science participants except where the individual was associated with both. In those situations, selected questions from both topic checklists were asked based on the conversation flow and the path of ideas the answers created for me the interviewer (i.e. I would base the questions on ideas I was developing during the course of the interview). Interviews took an average of one hour to complete and the shortest interview was just over 30 min while the longest was just over two hours.

To fulfill my objectives of exploring the influence of capacity and attitudes of CAs, the topic checklist was designed to get information from CA participants about the general capacity of their organization as well as explore the attitudes held by CA participants with regards to the use of citizen science and volunteer benthic monitoring (VBM) by their organization. The topic checklists were a modification of the questions asked in the evaluative framework for capacity developed by Kean (2008). This checklist focuses heavily on indicators of capacity with some specific questions about citizen participation, citizen science and volunteer benthic monitoring as well as some more open questions about future issues, CA challenges, CA accomplishments and wishes for their CA (Appendix D & E). The topic checklist for the citizen science groups I developed was based on exploring their structure, collaborations, challenges, benefits, motivations and volunteer base (Appendix F). I asked participants about the structure of their citizen science groups, in particular about funding and collaborations (particularly with CAs),
their motivations for participating in citizen science, about their desired outcomes for the program, challenges and positive experiences. I also asked questions about the data their group collected; to the coordinators I asked about protocols and to the volunteers I asked about data quality. The coordinators described the protocols that their group was using while the volunteers gave their opinions on the rigor and quality of the data they were collecting. As well, participants were asked about the outcome of the data, i.e. who it was shared with and how their findings were reported.

3.2.3 Collection of documents

CA documents were used as a literature source providing information on the extent to which case CAs collaborate with community groups, are involved in citizen science and use data collected through citizen science in their management of freshwater resources. Documents including agendas and meeting minutes, formal studies (watershed and subwatershed management reports), internal documents, and press releases, etc. were used to corroborate the information of interview participants and provide additional information that did not arise during the interviews (Yin 2003). In most instances, documents were collected from the CA’s website and were limited to only those documents available. However, some documents were procured opportunistically during the interview process where participants would offer relevant documents that were not available on the website.

A similar approach was used for procuring citizen science documents, which in some instances, provided additional information that did not arise during the interviews (Yin 2003). Documents including protocol and training manuals, data collection forms, presentation materials, website documents and volunteer group email correspondence were used to provide context for the formation of the group, information about objectives partners, funding, protocols etc. Most of these documents were procured from the website, but some were requested from the coordinator of the citizen science program.
3.2.4 Direct participation/observation

According to Yin (2003), “Observation evidence is often useful in providing additional information about the topic being studied” (pg. 93). For each of the CAs, I observed up to two board meetings to get a feel for the institutional culture of the CA. Not only was attending the board meetings a way of accessing potential research participants, it allowed me the opportunity to observe how the activities of the CA staff get translated into decision-making by the Board of Directors. These experiences also provided me with some context to the discussions that arose during interviews with board members and occasionally with CA staff.

For two of the CAs, I assisted in the collection of their benthic monitoring data. I assisted the technician at ABCA on two occasions and the aquatic biologist at UTRCA on one occasion. I did not have the opportunity to assist either the TRCA staff or the RVCA staff in their benthic monitoring. Assisting the TRCA would have provided me with an interesting contrast because unlike the other CAs, TRCA uses the Ontario Stream Assessment Protocols (OSAP) rather than the Ontario Benthos Biomonitoring Network (OBBN) protocols that the other CAs use for their benthic monitoring programs. GRCA does not have a benthic monitoring program.

I compared my experiences in the field with the CA staff to those I had collecting benthic field data with the citizen science volunteers. I participated as a volunteer with URBAN on two occasions, with Citizen Scientists on one occasion, and with City Stream Watch on one occasion. I observed the complete monitoring of two sites by URBAN; on each of the two field excursions, all the data for a site was collected: I observed physical measurements being taken, the benthic sample collected and then I assisted the group of volunteers (under the supervision of the URBAN staff member) in sorting 100 bugs from the sample. On my one trip out with the Citizen Scientists, only the benthic sampling was conducted for one site. After observing their sampling in the field, I assisted the group of volunteers (working under the supervision of the Citizen Scientist Crew Leaders) to sort at least 100 bugs from each sample. My one field excursion with City Stream Watch consisted of a fish survey for one site. I observed the seining of the site by a number of volunteers and (under the supervision of the City Stream Watch staff member) the
sorting, identifying and counting of fishes. As well as participating in the citizen science field collection, I observed the training sessions for both URBAN and Citizen Scientists. As well, I had the opportunity to observe a series of informational talks about City Stream Watch given to individuals at the National Capital Commission meant to promote the formation of a partnership. Finally, I had the opportunity to observe the end of the field season reception given for volunteers of URBAN and the public. The reception consisted of presentations summarizing the collected data, a plenary talk given by the former mayor of Toronto David Miller and a social mixer that included food and beverages.
Table 3.1 Table summarizing the case study data collected from the conservation authorities.

<table>
<thead>
<tr>
<th>Data Collected</th>
<th>ABCA</th>
<th>UTRCA</th>
<th>GRCA</th>
<th>TRCA</th>
<th>RVCA</th>
</tr>
</thead>
<tbody>
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<td>Director</td>
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<td>Yes</td>
<td>Declined</td>
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<tr>
<td>Observation/Participation</td>
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<td>Benthic monitoring</td>
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Table 3.2 Table summarizing the data collected from the citizen science groups.

<table>
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<th>City Stream Watch</th>
<th>Citizen Scientists</th>
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<td>Observation/Participation</td>
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<td>Initial training/orientation</td>
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<td>outreach events</td>
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<td>Field Sampling</td>
<td>Benthic monitoring (2)</td>
<td>Fish sampling</td>
<td>Benthic monitoring: 100 bug count</td>
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</table>
3.2.5 Data analysis

I chose to analyze my case study data using NVivo (QSR International; version 10). This software helped me to manage and synthesize my ideas through the process of linking, shaping and modeling the textual data. By providing the tools for pursuing new understandings and theories about the data, it allowed me to construct and test answers to my research questions (Richards 1999). Interpretive qualitative data analysis is an iterative process with multiple steps that requires the investigator to break apart, and then reorganize the data in a meaningful way. After conducting and recording the interviews, the interviews were transcribed. Nineteen of the 44 recorded interviews were professionally transcribed by the company ‘Way with Words’, 13 were transcribed by trained volunteers and the remaining 12 were transcribed by myself, the principal investigator and the interviewer. The advantage of professional transcription was the time it saved me, the principal researcher, and it also likely resulted in increased consistency as I had no experience prior to this research in transcribing recorded interviews.

The transcriptions were imported into NVivo and each was open coded. Open coding is the process of reading through the transcriptions and creating codes (categories or themes) which segments of transcript text are then associated with. For this open coding process, almost all of the text of each transcript was coded. NVivo provided a way to cut up transcripts and reorganize them into themes and sub-themes, creating a virtual tree of categories (Buck 2008). This process of creating codes was a continuous process during the first review of all of the transcripts. The 14 transcripts of interviews conducted with the participants in the citizen science groups had a separate set of codes than the 30 interviews from the CAs. Throughout the initial review of the transcripts, codes and sub-categories within codes were created, sets of codes were consolidated, and hierarchies of codes were established.

After the all transcripts had been open coded, the text contained in the codes was reviewed to refine the tree of categories; some codes were consolidated and renamed (e.g., to remove redundant codes), new codes were established if there were instances of text that did not fit very well in a particular code (Appendix G). This stage of focusing,
linking and connecting allowed me to “play with the data in ways that helped lead to insights that reading transcripts alone might fail to highlight” (Kitchin and Tate 2000, p.245). For me, the next stage of the process involved summarizing the content of codes into a number of categories. An important part of this process was incorporating the participants quotes that supported my summaries – these quotes were used as data to provide confirmation of the claims that I made in my summaries. The summary of the code contents that I created was imported again into NVivo and this document was coded again based on some broader themes and subthemes than what were considered in creating the first summary. From this new coding stage, connecting ideas were consolidated or unique information teased apart, creating a more succinct interpretation of the important themes that emerged from the data. This process of focusing on the relevant information (i.e. that data that would allow me to answer my questions and contribute to meeting my research objectives), involved cross-checking the data to avoid errors and to assess the evidence for its support of explanations that I had formulated during the analysis process.

All of the documents that were obtained from the websites of both the citizen science groups and the CAs were imported into NVivo. These were used in the process of cross-checking to support ideas and proposed answers to the research questions that had been generated during the analysis of the interviews. A variety of tools in NVivo (particularly queries) allowed me to sample the documents to determine whether those sources corroborated the ideas presented through the interviews.

### 3.3 Survey of Ontario conservation authorities

#### 3.3.1 Development and design

A survey consisting of two separate questionnaires was administered to Ontario’s 36 CAs. The questionnaires were drafted with the help of Conservation Ontario (CO), a non-governmental organization that represents CAs in Ontario. CO provided some of the data that was requested in the questionnaires and this enabled considerable streamlining
of the survey. CO also provided advice for administering the survey (e.g., how to make contact, format to put the questionnaires in etc.).

Two questionnaires were developed to discriminate between facts about the CAs and their monitoring programs (Appendix H), and the opinions of the staff and board members of the CAs on topics related to monitoring and community contribution (Appendix I). The questionnaire seeking information about the CAs asked questions about the activities of the CA (after Sheikhelden et al. 2010), including water quality monitoring programs of the CA while the questionnaire of opinions within the CA asked questions about the relative importance of various types of community contributions to the activities of the CA. Only one completed information questionnaire was required for each CA, however, a number of completed opinion questionnaires were sought from each CA to get a range of perspectives. While it was the intent that the answers provided in the information questionnaire be based completely in fact (e.g., Do you acquire benthic monitoring information from sources outside your CA?), some of the responses may have differed slightly among staff in the same CA depending on who answered the questions (e.g., rank the three most important activities of your CA or rank the importance of benthic monitoring information to various types of CA reporting). Questionnaires were located on GradNet, Western University’s graduate student portal maintained by the School of Graduate and Postdoctoral Studies Web Developer.

3.3.2 Administration

For CAs in which I had already established a contact (either through my case research or attendance at various meetings), I sent an email that requested participation in the survey, provided instructions for completion of the two questionnaires, provided contextual information, a letter of information for research participants and links to the online questionnaires. These emails were sent during the second week of November, 2012. At the same time, for CAs for which I had no prior contact, I chose an individual from the online staff directories to call on the phone. The chosen individual was, in most cases, the General Manager for CAs with a smaller employee complement. In larger CAs, I contacted the person in management responsible for water resources or monitoring etc. For cases where this information was not available on the CA’s website, I relied on the
CA receptionist to refer me to the appropriate individual. After the initial phone call introducing the survey/study and requesting assistance/participation, an email was sent with the same information contained in the email sent to the CAs for which I had a contact person. Initial contact was made to all CAs by November 16, 2012. On December 10, 2012 a follow up email and/or phone call was sent/made to all of the CA contacts who had not yet initiated participation in the survey (i.e. by completing at least one of the questionnaires). The closing date for the survey was set for December 31, 2012.

By the closing date of the survey, 29 of the 36 CAs had participated to some extent; however, there were issues regarding the level of participation. The major concern was that for 17 of the CAs, only one opinion questionnaire had been completed. While a number of CAs indicated that they would not be inviting their board members to complete the opinion questionnaire, a number of CAs indicated that the questionnaire link would/had been sent to more than one staff member. I therefore assumed that year end obligations within the CAs may have precluded participation by the invited individuals. As well, some of the participating CAs had only completed the information questionnaire while others only completed the opinion questionnaire. I therefore decided to try and address these issues by extending the closing date of the survey to January 31, 2013.

3.3.3 Data analysis

The CO data consisting of information such as the size, population, monitoring programs, staffing etc. of each CA were summarized in MS Excel, and then combined with the questionnaire data for the multivariate analysis. Twenty-seven of the 36 CAs returned the questionnaire providing information about their monitoring programs. There were three CAs for which multiple questionnaires had been submitted. In one case, it was evident that the respondent did not complete the questionnaire on the first attempt and so the data from the second submission was included. In the other two cases, it was likely that more than one individual had completed the questionnaire. For each question set, the responses that were included in the data to be analyzed were either chosen haphazardly, or selected if the question set was more completely answered (i.e. more of the questions
in the set had responses instead of blanks). This approach allowed for at least some of both participants’ responses to be included in the analyses. This resulted in only one set of responses for each CA.

Sixty-seven of the opinion questionnaires were returned by respondents from 29 CAs (Figure 3.7). Only two of the questionnaires were completed by board members. Both questionnaires of the survey consisted of ordinal based questions with ‘0-5’ Likert items. Dummy variables were used to code nominal scale categorical variables. For some of the questions, responses were qualitative and these were summarized in the results section. The responses to each survey question were graphically summarized using MicroSoft Excel to show the distribution of responses.
All data from submitted opinion questionnaires were included in the graphical summaries; however, in order to be able to compare responses among CAs for the multivariate analyses, the median response of the multiple opinion questionnaires for each CA was calculated. This resulted in only one set of responses for each CA. Using the statistical package ‘R’ (R Core Team 2013), the multivariate analysis consisted of generating non-metric multidimensional scaling ordinations (Vegan package by Oksanen et al. 2016; function ‘monoMDS’) on subsets of related information. These subsets were created based on themes of information; the list of data subsets and their descriptions is given in Table 3.3 (Conservation Ontario 2011b, unpublished data) and Table 3.4 (information questionnaire data), and Table 3.5 (opinion questionnaire data). Graphical summaries show only patterns in the frequency of each characteristic but provide no information regarding which CAs are contributing to those trends. Non-metric multidimensional scaling (NMDS) was used to represent the pairwise dissimilarity (or distances) among CAs (as closely as possible) in a two dimensional space (i.e. a plot).

**Figure 3.7** Frequency in the number of opinion questionnaires completed by each of the CAs. Most of the CAs submitted one or two questionnaires whereas SCRCA and HRCA submitted eight and 18, respectively.
Distances are based on differences between the CAs with regards to groups of related characteristics (e.g., watershed size, land area, staff numbers; Conservation Ontario 2011b, unpublished data) or responses to related questions (e.g., opinions about a type of community contribution; survey), and so these ordination plots provide some information regarding which CAs contributed to the trends observed in the graphical summaries. For example, there were seven questions each asking the respondents what their level of agreement was regarding a particular characteristic of volunteer labour (VLABOUR; seven characteristics = useful, trustworthy, program and policy relevant, used by other staff, use by other CAs or government, overall preferable to other types of community contributions). For the first step, the Euclidean distances were calculated for each pair of CAs based on their responses to this group of questions.

\[ \text{Distance}(jk) = \sqrt{\sum (x[i_j] - x[i_k])^2} \]

Where in this example, x denotes the particular question (in this case it is about volunteer labour), and \(i = \) the response for each characteristic \((i=1, \ldots, q; q = \text{number of characteristics of question x, which is seven in this case})\), for CA\(j\) and CA\(k\) \((j = 1, \ldots, n; k = 1, \ldots, n; n = \text{number of CAs in the analysis})\) (Oksanen et al. 2016). Only those CAs that provided answers to all seven of these questions were included in the analysis (i.e. CAs with any missing data were omitted, hence 27 CAs were included in this analysis). These differences among the CAs were visualized in two-dimensional space via NMDS (arbitrarily using ‘MSD1’ and ‘MSD2’ to denote the dimensions). The process is iterative and happens over several steps starting with the rank order of differences (instead of absolute differences, hence, ‘non-metric’) from the distance matrix. The starting configuration of the CAs was random (default for function ‘monoMDS’) in the two dimensions (Oksanen et al. 2016). NMDS used an iterative algorithm where these positions of CAs are adjusted to minimize the stress among CAs (Buttigieg and Ramette 2014). The process involves monotone regression (Oksanen et al. 2016) of the distance among points in the configuration against the observed ranks of distances (Lefcheck 2012). Stress is the disagreement between the two dimensional configuration and the predicted values from the regression such that,
\[ Stress (S) = \sqrt{\frac{\sum (d_{jk} - d_{hat_{jk}})^2}{\sum d_{jk}^2}} \]

where \( d \) are distances among points in ordination configuration, \( d_{hat} \) are the fitted ordination distances for each \( jk \) (pair of CAs) (Oksanen et al. 2016). The CAs are repositioned on the plot in the direction of decreasing stress, and repeated until stress falls below some threshold with a maximum of 200 iterations. A final value of stress that is less than 0.2 is deemed acceptable (Lefcheck 2012; Buttigieg and Ramette 2014). Stress, along with two correlation-like statistics (“nonmetric fit” and “linear fit”), describe the goodness of fit of the NMDS. The “non-metric fit” is based on stress \( S \) and defined as \( \sqrt{1-S^2} \) and the “linear fit” is the correlation between fitted values and ordination distances. Hence, ordinations (i.e. plots) of the non-metric multi-dimensional scaling for these subsets show, in two-dimensional space, how similar CAs are in their respondents’ level of agreement with the applicability of the seven characteristics in describing volunteer labour. CAs closer together in ordination space have similar values for that set of questions and those farther apart have less similar values of agreement for those questions. Scaling, orientation and direction of the axes and their labeling are arbitrary (Oksanen et al. 2016).
Table 3.3 Names and descriptions of the data subsets created from the Conservation Ontario data that were used for the non-metric multidimensional scaling ordinations.

<table>
<thead>
<tr>
<th>Subset</th>
<th>Description of Subset</th>
<th>Variables Included</th>
<th>CAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMMON</td>
<td>The number of monitoring sites allocated to three types</td>
<td>NumSW: # of surface water sites, NumGW: # of ground water sites, NumBen: # of benthic sites</td>
<td>36</td>
</tr>
<tr>
<td>STAFF</td>
<td>The staff complement</td>
<td>FTPStaff: # full-time permanent, PTPStaff: # part-time permanent, CStaff: # contract, CFTE: # full-time equivalent from contract staff, SStaff: # seasonal, SFTE: # full-time equivalent from seasonal staff, FTETotal: sum(FTPStaff, CFTE, SFTE), PTETotal: sum(PTPStaff, CStaff, SStaff)</td>
<td>36</td>
</tr>
<tr>
<td>BOARD</td>
<td>The board complement</td>
<td>BmemTot: # total, BmemE: # elected, BmemNE: # non-elected, PerBmemE: % total elected</td>
<td>36</td>
</tr>
<tr>
<td>LAND</td>
<td>land holdings, watershed size and conservation areas</td>
<td>Areakm: area of watershed (km²), LowerMun: # lower-tier municipalities, UpperMun: # upper-tier municipalities, TotLandHec: total land holdings (ha), NumConAreas: # conservation areas, ConAreasHec: area of conservation area land (ha)</td>
<td>36</td>
</tr>
</tbody>
</table>
Table 3.4 Names and descriptions of the data subsets created from the information questionnaire data that were used for the non-metric multidimensional scaling ordinations.

<table>
<thead>
<tr>
<th>Subset</th>
<th>Description of Subset</th>
<th>Variables Included</th>
<th>CAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERMON</td>
<td>The percent of monitoring time allocated to three types</td>
<td>PerSW: % of total devoted to surface water, PerGW: % of total monitoring devoted to ground water, PerBen: % of total monitoring devoted to benthic</td>
<td>Select one of: 0-20%, 21-40%, 41-60%, 61-80%, 81-100% (median values calculated)</td>
</tr>
<tr>
<td>IACTIVITY</td>
<td>The importance of activities to the functioning of the CA</td>
<td>AIFlood: flood control, AIRes: reservoir management, AIPermits: permits and approvals, AISWP: source water protection, AIRemed: remediation and restoration, AIWRM: integrated water resource management and planning, AIMon: monitoring and indicators, AIOutr: outreach and stewardship, AIConArea: conservation areas management</td>
<td>Likert 6: 1-not at all important to 5-very important (0=not carried out by CA)</td>
</tr>
<tr>
<td>RACTIVITY</td>
<td>Three highest ranking activities of their CA</td>
<td>ARank1: most important, ARank2: 2nd most important, ARank3: 3rd most important</td>
<td>For each select one from 9 activities listed for IACTIVITY</td>
</tr>
</tbody>
</table>
Table 3.4 Continued…

<table>
<thead>
<tr>
<th>Subset</th>
<th>Description of Subset</th>
<th>Variables Included</th>
<th>CAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMBENEFIT</td>
<td>The importance of benthic monitoring to CA activities</td>
<td>BenUFlood, BenURes, BenUPermits, BenUSWP, BenUREmed, BenUIWRM, BenUMon, BenUOutr, BUConArea (same activities as for IACTIVITY)</td>
<td>21</td>
</tr>
<tr>
<td>BMDetail</td>
<td>Details of the CA’s benthic monitoring programs including changes in the past 5 years and use of external benthic data</td>
<td>BenStart: year benthic program started, Numsitechng: change in # of sites, Locsitechng: change in location of sites, Freqchng: change in sampling frequency, Protchng: change to protocol, Taxlevel: taxonomic level benthos are identified to, CSBen: use of citizen science data, NGOBen: used of non-government organization data, ProvBen: use of provincial data, FedBen: use of federal data, MunBen: use of municipal data, ConBen: CA staff coordinated volunteer data</td>
<td>19</td>
</tr>
</tbody>
</table>
Table 3.5 Names and descriptions of the data subsets created from the opinion questionnaire data that were used for the non-metric multidimensional scaling ordinations.

<table>
<thead>
<tr>
<th>Subset</th>
<th>Description of Subset</th>
<th>Variables Included</th>
<th>Respondents (CAs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MONTIME</td>
<td>Attitudes of the sufficiency of time allocated to water quality monitoring</td>
<td>SWMtime: surface water, GWMtime: ground water, BMtime: benthic</td>
<td>66 (29)</td>
</tr>
<tr>
<td>VINPUT</td>
<td>Opinions about the characteristics of volunteer input (ideas, knowledge, etc.)</td>
<td>VIUseful = Useful, VIAvail = Available, VITrust = Trustworthy, VIReliable = Program and policy relevant, VICAuse = Used by other staff in your CA, VIOtheruse = Used by other CAs or government agencies, VIPrefer = Overall, preferable to other types of community input</td>
<td>63 (27)</td>
</tr>
<tr>
<td>VLABOUR</td>
<td>Opinions about the characteristics of volunteer labour (e.g., tree planting)</td>
<td>VLUseful, VLAvail, VLTtrust, VLReliable, VLCAuse, VLOtheruse, VLPrefer (same characteristics as VINPUT)</td>
<td>64 (27)</td>
</tr>
</tbody>
</table>
Table 3.5 Continued…

<table>
<thead>
<tr>
<th>Subset</th>
<th>Description of Subset</th>
<th>Variables Included</th>
<th>Respondents (CAs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMON</td>
<td>Opinions about the characteristics of volunteer monitoring of any kind (e.g., stream temperature)</td>
<td>VMUseful, VMAvail, VMTrust, VMReliable, VMCAuse, VMOtheruse, VMPrefer (same characteristic as VINPUT)</td>
<td>Likert 6: 1-strongly agree to 5-strongly disagree (0=don’t know) 61 (27)</td>
</tr>
<tr>
<td>VBENMON</td>
<td>Opinions about the characteristics specifically of volunteer benthic monitoring</td>
<td>VBMUseful, VBMAvail, VBMTrust, VBMReliable, VBMCAuse, VBMOtheruse, VBMPrefer (same characteristic as VINPUT)</td>
<td>Likert 6: 1-strongly agree to 5-strongly disagree (0=don’t know) 60 (26)</td>
</tr>
<tr>
<td>COMINPUT</td>
<td>Opinions on the importance of any kind of community input to CA activities</td>
<td>VIFloodP: flood prevention, VResMan: reservoir management, VIPandA: permits and approvals, VISWP: source water protection, VIRandR: remediation and restoration, VIIRP: integrated water resources planning and management, VIMandI: monitoring and indicators, VIOandS: outreach and stewardship, VICArea: conservation areas management</td>
<td>Likert 6: 1-strongly agree to 5-strongly disagree (0=no community contribution) 59 (28)</td>
</tr>
<tr>
<td>Subset</td>
<td>Description of Subset</td>
<td>Variables Included</td>
<td>Respondents (CAs)</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>VBMBENEFIT</td>
<td>Opinions on the level of benefits provided by volunteer benthic monitoring to proposed situations</td>
<td>VBMPR: enhancing public relations, VBMPed: improving public education, VBMSocialCap: increasing social capital, VBMCont: promote community contribution to other CA activities, VBMLabour: cost-effective labour, VBMSampling: increase the number and frequency of benthic sampling, VBMProblems: finding better solutions to problems</td>
<td>56 (25)</td>
</tr>
<tr>
<td>VBMOSCOLLAB</td>
<td>Opinions of potential obstacles to collaboration between volunteer benthic monitoring groups and CAs</td>
<td>StaffTrain: lack of staff training to deal with volunteers, NoNeed: lack of need for VBM data, NoCADesire: lack of desire by staff or board to use VBM data, NoCapacity: lack of CA capacity to provide support to VBM group, Protocols: lack of confidence in protocols used by VBM group, VolAbility: lack of confidence in volunteer ability, SiteSelection: lack of cooperation in site selection, Interest: lack of interest by citizens to participate in VBM</td>
<td>59 (27)</td>
</tr>
</tbody>
</table>
### Table 3.5 Continued…

<table>
<thead>
<tr>
<th>Subset</th>
<th>Description of Subset</th>
<th>Variables Included</th>
<th>Respondents (CAs)</th>
<th>Likert 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VBMOBSDATA</strong></td>
<td>Opinions of potential obstacles to use of volunteer benthic monitoring data by CAs</td>
<td>DatNoRes: lack of CA resources to coordinate VBM,</td>
<td>61 (28)</td>
<td>1-5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DatNoNeed: lack of need for VBM data,</td>
<td></td>
<td>not at all</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DatNoCapacity: lack of CA capacity to provide support to VBM group,</td>
<td></td>
<td>beneficial</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DatNoDesire: lack of desire by staff or board to use VBM data,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DatQual: lack of CA training to evaluate quality of VBM,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DatProtocols: discrepancy between protocols used by CA and VBM,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DatSites: discrepancy between sites monitored by CA and VBM</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VBMSCENARIOS</strong></td>
<td>Selection of scenarios under which CA would replace their own benthic monitoring</td>
<td>FundingCut: funding to in-house benthic monitoring lost,</td>
<td>67 (29)</td>
<td>Select all</td>
</tr>
<tr>
<td></td>
<td>program with VBM</td>
<td>FundingAvail: funding was available for CA to coordinate a VBM group,</td>
<td></td>
<td>that apply;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FundingCollab: funding was available to collaborate with an existing VBM group,</td>
<td></td>
<td>NoScenario=</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FundingBID: funding was available to CA staff to sort and identify benthos</td>
<td></td>
<td>Y/N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>collected by VBM group, NoScenario: none of the above scenarios selected</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 4

4  Results

4.1  Case Study

4.1.1  Conservation authorities

4.1.1.1  Capacity: Human, informational and financial resources; management and flexibility

Human resources

All of the CA staff that I interviewed demonstrated in some manner of comments, statements or suggestions that they enjoy their job, take pride in the work that they do, respect their coworkers and have a really positive opinion of the organization that they work for. For some this was demonstrated through the comparisons they made to other CAs. Also, there were a large proportion of participants who had worked for many years at their job, and almost all participants that I spoke with had really positive attitudes toward their coworkers. One of the strengths most participants noted when asked was their CA’s exceptional people. Not only did many participants describe the positive qualities of both their board and their staff, some described the type of management they felt their CAs demonstrate to be able to acquire and retain such exceptional people. Several comments were made particularly relating to the dedication and passion of the people working in the CA using words like “exceptional”, “committed”, “impassioned”, “dedicated” and “empowered”. CA staff were described as people who believe in what their organization is doing and enjoy their work, who connect well with other agencies and community, and who really have the best interest of the watershed in mind. One manager described his staff as “second to none”, stating “I think the dedicated staff that we have…they really are great people. They’re professionally competent and they really are trying to lead and that’s something you can’t put a price tag to or a value on I think.”

Comments were made by a number of participants about staff motivation for working at a CA. Most agree that it is not the money that motivates them and as one participant put it, “most of the people are here because they believe in what we’re doing and they enjoy
what they’re doing.” Someone else stated “People stay here despite the fact that their pay is lower and they could go someplace else and do much more with more money, but they just like to be here…they really go the extra mile …”, and from one upper level manager: “…there’s nobody I can think of that’s not genuinely dedicated to the work that they do. They’re very passionate…and you know, certainly put forth more effort than what you get compensated for.” Along with their dedication and passion, staff were recognized for their interpersonal skills which create a cohesive dynamic that allows staff to collaborate effectively. One manager noted “…we excel as staff as a team that works together well.”

Despite their struggles with finding the capacity with which to fulfill all of their mandates, CAs participants see their organizations and people as flexible and responsive; one individual described how impressed she was about how much the staff in her organization accomplishes with so few resources and how creative they have become in acquiring the funding (e.g., private funds) they need to get the work done. Another stated “I think the organization is very good at finding creative solutions, in finding compromises without compromising the integrity of the watershed…ways of making the rules work without denying people the things they’re trying to do.” According to some participants, these qualities were a result of the funding and structural transitions in the ‘90s. According to one manager, his CA used “…to see itself as the big regulatory agency and our first response is to say ‘no’. Well I think right now our first response is to say, ‘How can we make this work?’”. Along with this change in outlook, the activities of CAs also have shifted. One CA manager mentioned that this shift in priorities to engage watershed management has come with an incredible increase in productivity by his staff, stating “we’re ordinary people doing extraordinary things. So it’s amazing when you consider the amount of good work that we do with the small number of people…we just do a huge amount of work and it’s incredible.” Echoing this were statements from a number of participants about how their organization is creative in finding sources of funding, and works really well with the funding they do have. For many CAs, this has meant diversifying their activities in a way that still fulfills their mandates – working on a variety of projects while still working toward the goal of keeping watersheds healthy.
Many of the CA participants interviewed commented on how there was just too much to do and not enough resources to do it with. “In fact, our biggest problem is that we take on too much and spread ourselves a little thin.” One participant described how the jobs people are assigned just eventually get too much for them to deal with and eventually something gets neglected. According to one CA participant, dealing with limited capacity is all about picking priorities; you’ll never have enough capacity to face all the challenges, so moving forward is all about selecting priorities and acting on them. An opinion shared by all CA participants interviewed is the fact that staff really want to do all the work; they take pride in their jobs. One participant described this general understanding that staff are sufficiently motivated and if things are not being able to get done, either more resources are needed or a timeline needs to change. Many of the participants commented on how their CAs are always short of money to make changes they want to make or work on the projects that they think are important. The lack of funding for staff was something that a number of participants stated was a critical factor in ability to accomplish all that they hope to.

Management

There were a number of comments regarding the importance of management in creating this dedicated and flexible staff complement. One way was by selecting the “right type of people” to staff the CA and according to one participant in communications, these include “…people with the best education, yes having people with the smarts, but also having the ability to work with people and [having] some of those interpersonal skills and team skills.”. He also noted that “There’s not a negative person in the whole building and I think that is reflective of the management that has put priority on some of the intangibles…” As summed up by one general manager, “…retaining good staff…to me, the cultural fit is far more important…”

Staffing was one potential future issue that was discussed by participants. One manager discussed the importance of having a staff complement that includes diversity in age, gender, ethnicity and technical expertise. He sees this a vital to facing the multitude of changes that their CA will experience in the future and stated “So if I have the right staff
who know that we have a long vision and positive direction, and they know that I’ve supported us getting there, and not just having the status quo, then they’re going to help us with those changes that we need to make.”. One CA participant mentioned that there would be a gap in their staffing due to concurrent retirements and this could lead to a loss of vital expertise (e.g., dam management), and that it was necessary to draft an appropriate plan to avoid this loss and provide some knowledge transfer during the transition involving careful mentoring. As well, since there will be many retirements in the government sectors because of the baby boomers, there will be a heavier reliance on CAs doing the work that was once done by government staff who have retired and not been replaced.

Along with selecting the right people, a number of participants believed that creating a cohesive positive dynamic was also a result of how people are managed. Some of these management strategies included being flexible and supporting independent decisions and trusting the decisions and expertise of the staff. One manager stated “I see my role as really a facilitation role…They're the experts, I'm the generalist.” Another strategy managers seem to have in managing staff is to promote transparency. One general manager described how he accomplished this stating

Our staff work really hard to have an open culture...we’re very quick to share information around here and we’ve really embodied a culture where we accept and forgive that people aren’t perfect (including me) and we make mistakes and we declare them early, and we seek help to resolve them. So people aren’t afraid to ask for help when they need it around here. So that’s a really cultural thing I’ve really worked hard on over the years.

Related to this is the type of interaction among staff that managers promote, “…in fact we encourage debates, disagreements whatever you want to call it. But we want to be able to have that debate in any professional congenial way. So I want the staff to be able to disagree and at the end of it all carry on, and not hold grudges and not play silly games.”
All of the participants conveyed their satisfaction with the support they receive to fulfill the tasks of their position. This comes in the form of providing professional development opportunities, providing support for independent decision-making and through working collaboratively on task management; everyone agrees that there is often not enough time/resources to accomplish everything, so staff and managers work together either on particular tasks or on task delegation in order to flexibly find the most effective and efficient solutions to their time/resource deficits. Most participants determined that they had easy access to all of the pertinent information they needed to perform their tasks although a couple of individuals mentioned issues with respect to 1) not having the time to explore the new developments in the fields in which they work, and 2) not having the technology to access the needed information quickly and easily.

One participant, who is responsible for his CA’s aquatic monitoring program, describes how important it is to re-examine what you’re doing and why you’re doing it. He goes on to say that “we get so busy doing our day to day business it’s hard to kind of stand back and say ‘Why are we doing this?’ ‘Can we do it more efficiently?’” The importance of these questions for strategic planning was described by one manager as particularly important for creating a more aligned package relating to community outreach and stewardship. He believes that this is where strategic planning should focus because “…it’s so important, because that’s the work that is necessary. You can do all the planning you want to do around the regulations to stop future issues from occurring, and conservation areas are nice, but if you’re not actively doing stewardship work, then you’re not improving watershed conditions” Hence, the planning should involve making sure the CA is “…always on top of what are the essential tasks that we need to do and then having the resources to back them up…responsive to changes in our communities, and that we bring the people along with us and that because we bring them along with us, they’re willing to give us what we need to do those things.”

Having effective board members was something mentioned by three participants. Their definitions of effective included having an engaged board, one with a balance between elected officials and “really committed environmental types”, and one that works to maintain the interests of the entire watershed. One participant described his CA as having
a strong and engaged board and another felt his board consisted of members that are “easy to work for because they want what’s right for the watershed and what’s right for the people, not just their own little corner and their own selfish motivation, you know.”. From another CA, a participant described her Board of Directors as positive, and consisting of individuals that are very “environmental-conservation minded” who are very supportive of the work and people running the CA. One manager suggested that the structure of the CA, particularly with the existence of a board of directors, keeps the CA productive and working well because of the accountability they represent; their presence at the CA twice a month for board meetings reminds staff of what they are working towards.

Financial Resources

CAs acquire funding from a number of sources. The municipalities pay CAs levies for their work in regulating and permitting development in floodplains and for other services related to the conservation and management of water resources. As well municipalities pay fees for services such as erosion control and park maintenance, reviewing subdivision documents and municipalities also provide CAs with capital funding. Money comes to CAs from the public in the form of fees for services (e.g., conservation area use and associated services (e.g., boat ramp, campgrounds, sewage inspections, permits etc.). Many CAs also have their own foundations which are charitable organizations that work “semi-autonomously but in very close cooperation” with CAs. According to one participant, “their entire function is to secure funds from the private sector to support activities that we could not normally fund otherwise...[things] which are beyond our normal mandate, but we feel are critical to achieving the overall long-term objective.”. These funds are used for things like development of trails and boat launch activity, children’s education, funding nature centers, and buying sensitive lands that need to be preserved for many reasons, i.e. climate change, protection of the animals, and preventing flooding.
In discussions about funding (and to a lesser degree, collaborations), most CA participants referred to the Conservative (Mike Harris) government cutbacks in the mid 1990s as a pivotal period in the history of how their CA operates. The primary change brought by this government was to cut the funding from the Ministry of Natural Resources by up to 80%. This was a very significant event, since for many CAs, up to half of their budget came from this provincial department. Described by one participant, “…there was evisceration in ‘99 in the Harris years and we cut staff…well we cut our staff in half because there was no money for a lot of things…” Another participant described it this way “And in ‘96 with about two months notice we were told that our funding would go from 1 ½ million to 100,000. So we went from 30 staff to eight staff.”

As a result of this loss of provincial funding, a vital source of funding for many CAs appears to come from external sources. These sources include grants that are awarded upon successful application and are often competitive (CAs have to compete for these funds with other organizations that have projects that fit the grant funding mandates). Sources of these grants include the federal and provincial governments, NGOs, service clubs, consortiums, corporations, and private foundations. There was a long list of external funding sources mentioned by participants. Some examples include the Habitat Stewardship Program (Environment Canada), Ontario Trillium Foundation, Species at Risk Funding (Ministry of Natural Resources), Field Naturalists (NGO), Optimists and Rotary (service clubs), Canadian Water Network (consortium), TD Friends of the Environment, the Herb Family Foundation, and Garfield Weston Foundation (this list is not exhaustive). As demonstrated, competitions for government funds play a significant role for some of the programs executed by CAs. For example, DFO funding competitions for special projects and equipment has been an important source of funding for RVCA’s City Stream Watch program. Environment Canada provides Habitat Stewardship funding as well money through their Community Action Framework and EcoAction Community Fund, and from the provincial government, Species at Risk funding (MNR) and the Provincial Water and Erosion Control Infrastructure Grant (WECI). These are some of the sources mentioned by participants, not an exhaustive list of funders.
A number of managers admitted that a substantial proportion of their time was required to compete for these types of funds as well as to provide the deliverables to their funders. One manager said that about 30% of her time was spent on external sources of funding; “I spend quite a bit of time making sure that records are in order and that projects are being tracked as well as proposal writing and writing my own internal requests for funding, so probably up close to a third [of my time].” According to another participant, “...it’s always been a struggle to get our jobs done to the level we’d like to just because of chasing money.” In the opinion of one CA participant, “We could have people sitting here all day, and that would be their fulltime job is essentially to look for where the money is and make, fill out applications for funding.” One person suggested that 8 to 10 years ago in their CA, people were going after contracts to basically keep themselves funded even if the contracts had very little to do with their mandates. “It was the hunt for the almighty buck instead of doing what we needed to do…that's always a challenge to keep focused while struggling to get funding.” This change coincides with events following the cuts by the provincial government in the mid ’90s where services were almost completely downloaded to the municipalities (i.e. government withdrew the funding and support from the CA’s association with the Ministry of Natural Resources). Some individuals worried that a similar situation will happen with the Ministry of the Environment and Source Water Protection; that MOE will withdraw their support and the CAs and municipalities will be responsible for the cost of implementing the source water protection plans.

Managers also discussed how unstable most external funds tend to be, not only because mandates of the funding source may be dynamic across years, but also because the majority of these sources tend to provide funding over a short time period (one, maybe two seasons). Another significant drawback mentioned by some participants was that often it is difficult to stay focused on their mandates while struggling to get funding. This problem was described well by one participant who said that “20% of our money comes in as special projects or contracts...some of them will be provincial, but some of them will be not for profits or foundations. We’re very good over the past 25 years at scrounging available pots and often taking our applications and trying to twist and around to meet the objective of the funder, to continue to do the work that we think needs to be
done.” Since CAs rely quite heavily on these funds, and often success requires matching funds, many participants commented how important their partnerships with community groups, and other NGO groups are to their organization.

One participant discussed the difficulty in getting municipal infrastructure funding for their dams. Since the CA itself can not apply for the funding, one of their member municipalities needs to give up their opportunity to get municipal infrastructure grants by putting their support behind the CA; “So our eligibility for infrastructure funding to maintain the extensive water infrastructure we have in this river system…that’s a major, major challenge.” Levies pose another major challenge. I observed a board meeting where the proposed increase in municipal levies was discussed – a significant proportion of the meeting time was devoted to discussion with proposals that ranged from 3 – 15% increases by the various members of the board. One participant described how common it is to only get a fraction of the levy increase their organization needs to cover the increased cost of maintaining programs. The result is that either programs are lost, or more time is spent finding soft money to support them. One participant mused how compared to the amount of tax that people pay, such a small percent goes to the work that CAs do.

When asked to make a wish list that would include anything that they feel would be beneficial for the ability of their CA to fulfill its mandates, overwhelmingly participants included items directly related to funding. While many just listed “more funding” as the ultimate item on their wish list for their CA, some were specific about what they would use this funding for. Items that participants would acquire given extra funding included equipment (i.e. a water auto-sampler); land including wetlands, floodplains, sink hole areas and land on which “to do some restoration projects that benefit watersheds…” and funding “…to manage all the land we have already”; infrastructural upkeep (e.g., education centers require upgrades to windows and HVAC systems); a provincially funded tree program (in the past the province sold tree seedlings for pennies to promote planting by landowners and stewardship groups); up-to-date information technology – funding that would “enable [the CA] to take advantage of the growth in technology and other business practices to make [the CA] as effective and efficient as possible”;
restoration projects – more of them and that are not compromised based on budget; incentive programs for stewardship activities in the watershed; public education programs that run over longer time periods; and one CA participant specifically asked for a volunteer manager who would “…work with the community groups that we're already working with now and establish new relationships with other community groups and almost mentor them or foster new groups…” Other items listed were the funds to retain high quality staff and the tools they need to do their jobs, to provide incentives to private land owners to make changes to their land or practices, to support and nurture community collaborations and stewardship, to deal with the upcoming issues that are just currently hitting the scientist’s radar (e.g., pharmaceuticals in water), to deal with the cost associated with the issues (e.g., flooding) caused by climate change, the cost to meeting mandates with an ever increasing time sink created as a result of continually looking for new sources of funding and lobbying, and to deal with the costs incurred through the downloading of services by higher levels of government to the municipalities (e.g., costs of implementing source water protection plans).

4.1.1.2 Capacity: Partnerships and collaborations; institutional arrangements; community and political support

Partnerships and collaborations

There is a strong consensus that partnerships and collaborations play a very important role in the work that CAs do. There is an abundance of partnerships that CAs engage in including those with other CAs and CO, academia, government, NGO’s and community. These partnerships have been described as building capacity of the CA through the work done by volunteers, knowledge transferred among professionals, contributions of local and community knowledge, and through sharing resources including access to funding CAs may not otherwise be eligible for. One participant summed up the importance of their organization’s partnerships stating “The many associations and partnerships we have are what keep the energy in the organization…the diversity of folks that we get to work with, those are actually drivers for us.”
Participants indicated that their connections with individuals at other CAs are an important resource. Through Conservation Ontario committees, conventions and conferences, and monitoring networks (e.g., Provincial Water Quality Monitoring Network/Ground Water Quality Monitoring Network and OBBN), connections are created that allow CAs and their staff to collaborate with other CAs and their municipalities. Staff draw on the knowledge and experience of individuals from other CAs, share resources (e.g., digital aerial photography flights), and work toward common goals (e.g., the Conservation Authorities Aquatics Group). CAs also partner with universities in a variety of ways; to gain access to infrastructure (e.g., the use of a research lab for sorting and identifying benthos), student expertise (e.g., students assisting in the business planning of the CA parks), data sharing, direction in CA projects and planning, and to gain access to provincial permitting. One participant mused how, historically, CA partnerships with academia have been one-sided, with academics using CAs to get certain things without giving back. She felt that this was reflected in the level of participation of one CA with URBAN; she felt that there was a low level of participation with the program because the CA is so “stretched” for resources.

**Institutional arrangements**

Another aspect of collaborative work that was mentioned by participants was the importance of maintaining good working relationships with government departments. According to one CA staff, some of these good working relationships including those with government organizations; CAs work with federal groups like Parks Canada, Department of Fisheries and Oceans (DFO), and National Capital Commission (NCC), as well as provincial groups including Ministry of Natural Resources (MNR), Ministry of the Environment (MOE), and Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). The most evident relationship that CAs have with the federal government is through DFO. In the late 1990s the CAs worked with DFO establishing a drain classification system. Currently, most CAs have some level of formal agreement with DFO in order to help streamline the permit and regulations process for landowners. On behalf of DFO, some CAs screen development activities that have the potential to result in harmful alteration to fish habitat under the Fisheries Act. When certain criteria are
met, the case is handed over to DFO. Many CA participants described a relatively effective relationship with provincial government offices. Currently CAs work with a number of departments and ministries within the provincial government to execute their mandates including Ministry of Education, MNR, MOE, OMAFRA, and Ontario Ministry of Energy (through the Ontario Power Authority). An example of the type of support provided to CAs is the support MNR provides interpreting legislation; if CAs want to sell any of their land, they have to get approval from the MNR and individuals in the ministry assist the CAs through that process. As well, much of the funding and direction for source water protection is provided to CAs through the MOE.

This effective relationship with provincial departments exists despite some significant changes over the past 15 years. CAs were born out of provincial legislation and acted more like an extension of the MNR because they were primarily funded by the MNR (see ‘Funding and Capacity’). During the cuts by the Harris government in the mid 1990s, most of the funding and board representation by the provincial government was lost. Although CAs still receive a small portion of their funding from the provincial government, their collaborations with particularly the MNR, has changed substantially since the 90s. Described by one CA general manager as a “fairly significant milestone in the relationship process”, the working relationship between the CAs and MNR continued because

…[the government] still had to get things done. They didn't have that, essentially, on the ground, connection anymore because it had all been downloaded to us. Any mandates with regards to hydrology, water quality/quantity, those sorts of things were still a responsibility of say for example, the Ministry of the Environment. But they really didn't have… they needed the authorities to be part of that process, at what I like to call sort of the first level geography.

Despite the job losses created by the cutbacks by the province in the 90s, it seemed that most participants do not currently see the evolution of their organization resulting from these events in a negative way. Summed up by one general manager,
The silver lining in that cloud was that we really understood who we work for and it’s the municipalities and local people. It’s not the province and so in a way, it was a blessing in disguise even though we lost staff and it was really difficult for a couple of years. We certainly know who we’re accountable to now and gear our programs accordingly. And, in fact, now we’re so much stronger than we ever were.

One participant described a significant shift in the type of relationship that CAs generally have with municipalities “…the GRCA and the other Conservation Authorities acted more like an extension of the Ministry of Natural Resources because they were primarily funded by the Ministry of Natural Resources. As the funding from the province was cut dramatically in the early to mid nineties, the authority developed a whole different consultative approach…”

CAs provide a variety of services on behalf of the municipalities within their watersheds. When it comes to development, CAs ensure it meets provincial policy around hazards, floodplains and slopes, and for this and other services, the municipalities within a given watershed provide their CA with a levy. As well, municipalities work collaboratively with their CA on planning (e.g., water management plans). The municipalities also provide representatives from their councils to sit on a board of directors which oversees the activities (e.g., regulatory and budget) of the CA. For the most part, CA participants felt that members of their municipalities understood and accepted their CA’s work. According to one participant, the daily interaction at the staff level with the municipalities of their watershed was a major strength of their organization. Another mentioned that especially through their source water protection work, his CA gained a lot of acceptance from the municipalities as well as from the province.

However, a number of participants noted that they had encountered municipal members who felt that CAs have too much power to regulate the activities that can happen on private land and a number of participants noted how most of the push back during levy increases was from the smaller municipalities within their watershed. According to one general manager, he sees CAs as “special purpose bodies, separate from the municipalities that have their own legislation and governance structure”. As such, the appointed representatives “are legally bound to serve the best interests of the
Conservation Authority. They are not there as a watchdog for the municipalities or to relay councils desires. There are sitting as a representative of the Authority first and foremost.” According to another participant, they see the role of the CA as not “so much to take direction on what we should be doing with water management issues from the local municipalities, but providing them with information and sort of trying to direct them in the right direction.” One manager mentioned how his CA could improve on the work their organization does by having more time to engage municipalities “…to just go and say ‘Hi guys, here’s what we’ve been doing for the last year and a half or six months”

Community and political support

Some CA staff believe that over time, there has been a greater interest by community in dealing with environmental issues, with individuals becoming more involved and taking more responsibility. This has led to greater contributions from community to the processes by which CAs manage resources and deal with issues. All of the CAs in this case research work to some extent with ‘Friends of…’ groups who support CAs in fundraising and stewardship activities. Other groups that CAs work with include Lake associations that assist in lake planning initiatives. For example, a number of these groups in the Ottawa region have put together stewardship or lake management plans for which RVCA provided the technical review, expertise and guidance through the planning process.

Working collaboratively with community was seen to play an integral role in how CAs successfully fulfill their mandates and one of the discussions I had with participants during some of the interviews was about the continuum of community contribution to their CAs activities. At one end of this continuum is the public’s participation in stewardship activities (specifically in their execution e.g., tree planting). Stewardship programs take on a variety of forms, but the activity plays an integral role in most CAs’ broad mandates. Depending on the size and organizational structure of the CA, there may be a department dedicated to this or a few staff from different departments within the CA whose responsibilities include working on various aspects of stewardship initiatives. Stewardship work taken on by CAs include, but are not limited to: bringing
together stakeholders to discuss the issues, providing technical and scientific expertise to help community determine the best course of action, providing information about funding available for various projects and assistance in accessing/applying for that funding, coordinating the labour and logistics necessary for executing remediation/restoration/clean-up projects, coordinating and assisting community stewardship groups (e.g., ‘Friends of…’ groups), providing communications updating stewardship achievements and ongoing projects and providing education about the natural environment through their Conservation Areas programming, school programming etc.

The workforce of any stewardship endeavour consists of volunteers. Some of the participants discussed the subject of volunteers; they see a big demand by the public for volunteer opportunities with the CAs (especially those that get people outdoors), and see this as a gap that their organization needs to fill. However, some participants discussed the difficulties finding in enough volunteers for the programs and also about volunteer burn out. Some of the reasons for lack of participation proposed by interviewees included the observation that there are so many other activities drawing their time or that there are a lack of people willing to organize the people and activities of the programs.

Some participants felt their CA showed strength with respect to their stewardship activities, particularly in their ability to work one-on-one with landowners to draw up a plan and get the finances (and paperwork) in place. They felt this really accomplished a lot of positive change in their watershed. At another CA, someone described how there are people on a waiting list to access their financial incentives tied to their clean water stewardship program. Other CAs noted the consistently high level of volunteer participation in stewardship events like tree planting or clean ups of garbage or invasive plants.

Toward the other end of the continuum of community contribution is public consultation. One board member commented how it seemed that almost every activity GRCA undertakes requires a public consultation process, to “…hold public open meetings to update on progress and get input from the general public or interest groups on almost
everything.” Also, environmental groups with an interest in a particular area of watershed health may make presentations to the board at one of the monthly meetings as a part of their advocacy. These presentations are often triggered by development proposals or rezoning by municipalities and GRCA investigates and provides feedback and input on the situation. As part of their Heritage River Study, GRCA included open houses, workshops and focus groups as well as soliciting public input on the draft report. At TRCA, public consultation was incorporated into their task force to bring back the Don River to the city of Toronto. Citizens were invited on the task force through an application process and the whole plan was built through consultation and science. Similarly, their initial watershed report card was developed through public consultation primarily through a citizen advisory committee. One TRCA participant described the characteristics of effective public consultation. She explained that stronger communities that are more linked are more effective in contributing to decisions, especially when they are more organized in their feedback. Such a level of public concern or information gets “flagged in the process and gets weighed against whether or not we really are going to go through with that option. There are often larger considerations at play than necessarily can be accommodated by the public input alone.”

Public consultation can result in knowledge flowing both ways; to the public and from the public through their local knowledge of the ecosystems within which they live, work and recreate. One of the TRCA staff noted how local naturalists, particularly anglers, can provide the CA with very useful information because those individuals have been angling certain streams for years and years and know their fish. That makes them qualified to provide good information – qualitative information though, not quantitative. An example of this sort of local knowledge was a person who recorded the dry stream days outside her back garden. Although it did not feed into a quantitative analysis, it validated the data collected by the CA showing how water levels had been changing. She went on to describe how the stories and concerns of the communities they work in give context for TRCA’s decision-making. These concerns include, for example, contamination and subsequent loss of their well water or loss of their ability to access green space that they currently do right now because it's undeveloped.
At the far end of the continuum of community contribution is community input in the form of planning and decision-making of CA activities, i.e. community members sitting on planning committees of the CA, using their position to inform, suggest and possibly direct the current and future activities of the CA in their watershed. At ABCA a manager commented on how they work, not only with community groups, but with the greater community as a whole to try and rectify issues of land and water degradation. Instead of, for example, assisting a community group’s stream side project of creating a riparian buffer strip or shoring up an eroding bank (i.e. stewardship activities), they will work with the entire community by setting up a stakeholder group (i.e. community input). ABCA will then facilitate discussion among the community members in order to determine the origins of the problems and provide a forum to talk about land use and options for change and improvement.

Participants provided some examples of this type of community input; ABCA has organized a pivotal planning committee called the Conservation Strategy Team. This group is composed of 30 individuals from the community tasked with creating a strategic planning document for the ABCA to work with over the next 10 to 20 years. The group meets once a month for a period of a year to complete the document. UTRCA seeks this type of community contribution on a subwatershed scale on a more ongoing basis. They utilize this community based decision-making by bringing to the community all the information that they have for an area and according to one manager, ask “What do you think the issues are and what actions do think are needed to move forward?” instead of “Here’s what we want do, what’s your opinion?” These community based watershed management strategies involve getting the community to air all their issues and environmental concerns. They then they work through a series of exercises where they prioritize the concerns and then UTRCA tries to develop their strategy with those prioritized concerns in mind. Another UTRCA participant described how

It feels like, we do the strategy and we have all the science background, all the science built into it - but we try and really marry that with the priorities of the community so that when we put those two things together, we get the community buy in, and we get the solid science behind it and then we can really focus on stuff that is going to get our biggest scientific bang for the buck.
According to one UTRCA manager, this process enables community to make decisions about which directions to take, and because “they have the vested interest”, it leads to their involvement in the directives the community created. He notes that it’s “…the only way to get the work done because we could never hire enough people to do the work.”.

An example from the TRCA is the Etobicoke-Mimico Coalition which is made up of representatives throughout the whole watershed including municipalities, residents, community groups etc. This group provides direction on the watershed management plan. This group examines the issues and concerns and looks at the watershed from a larger perspective than just what the scientific data provide. This coalition is made up of sub-committees that change depending on where the focus is. Some are more site specific (e.g., headwaters) whereas other sub committees are continuous; the communications group is used to provide feedback and vet some of the communication products that the CA is producing. Some of these planning committees have a long history with the CAs.

One GRCA participant discussed how the formation of a Steering Committee usually happened for the development of any sort of environmental plan (e.g., reclamation plan, master plan, fisheries plan etc.). For the fisheries master plan, the committee was made up of some general public but usually primarily other interest groups like fish and angling groups as well as River Watchers and general public, “…anybody that might conceivably be interested, not just in fisheries as throwing a line into the water, but the health of the watershed fish population.” Also, environmental groups with an interest in a particular area of watershed health may make presentations to the board at one of the monthly meetings as a part of their advocacy. Another participant described how for one of their fisheries management plans, they have community members that have been attending regular meetings for up to 15 years and that these individuals seem “like they are part of GRCA, even though they are not”.

According to most participants that were interviewed, one of the most important collaborations that CAs nurture is with their community members. A number of participants cited their close relationship with their community as a strength of their CA.
One participant summed it up, stating “We continuously go back to the community. Our whole process is kind of community driven with having the Board of Directors listen to our stakeholders, our partners, the community. We work with them when we can. We work with them at different scales of activity.” This was echoed by someone from UTRCA who stated “But through our community groups and our community based decision-making, I think, I honestly think we approach it in the right way - that we’re just there to enable people to do the right thing - whether it’s helping them find money, giving them money, just providing the expertise. And I think everybody here is professional but courteous in their dealings with the community and respectful.” Another participant at this CA added emphasis to this idea stating “But I think people who live in our watershed, I think for the most part feel like we listen to them. And I think that’s something that’s important and can’t be taken for granted.” According to one participant from GRCA, it is the responsibility of everyone at the CA from the community conservation services people to the CAO; all the individuals associated with GRCA are ambassadors and have role to play in connecting with community. According to some participants, their CA’s work in partnership building is key for staying adaptive and responsive. In fact, more community partnerships was the top item on the wish list of one participant who felt that working with the community was the only way for stewardship to be accomplished. This participant also noted that staff, to develop and nurture these community partnerships, would also be needed to support community organizations’ abilities to sustain themselves over the long term. Strategic planning around community needs was something participants also related to improving the public’s perception of the CA’s work; one noted “We don’t really have to manage watersheds where there are no people…but in areas where we’re intensively using the landscape, there’s a balance between the economy of what it is we’re yielding out of the landscape, out of the watershed, and what are some of the requirements for ecosystem health.”

During discussions about working with community, some of the conversation focused on the challenges that CAs experience in their attempts to maintain strong collaborations. Overwhelmingly, participants noted time as the primary challenge to maintaining effective collaborations with their communities. They describe how time and effort are
needed by staff to communicate with partners and hence to cultivate the relationship; time needed for travel to meetings, time for providing good feedback and analysis of data for reports, time to produce the quality of information partners should be getting. Other challenges mentioned along with time included working with diverse personalities and establishing realistic expectations.

Frequently mentioned by participants was the challenge they face maintaining a positive impression with the public in spite of their regulatory function. In these discussions many of them spoke about how they do, and even more so in the past, get a bad rap for their work in the area of permitting and regulations. They cite this as often the reason for community viewing the CA negatively. As stated by one CA staff “…you do meet landowners that are totally against the Conservation Authority. They don’t want you anywhere near their property…And it’s just that they’ve had a bad experience with either our regulations, because we are a regulatory agency, so regulations, or with drains.”

CAs seem to be working to combat this negative perception by the public. One approach some CAs have taken is to reducing the negative public perception by the public was by “putting a friendlier face on the CA so it’s not just seen as a regulator or a planning authority that is really strict in how it applies the rules.”. This was done by combining stewardship activities with the regulatory roles of the CA so that not only were they assuring people to abide by the rules, but as one manager described, “we’re here to help you understand those rules and we’re also here to help you accomplish something really good for the environment on your property, so we’ll not only help you with advice, but maybe we’ll help you with a bit of an incentive to do the right thing.” As well, a number of CAs mentioned that they have worked hard to streamline the process that landowners need to go through in order to get the proper permits for land development. For some CAs this has meant taking on some of the regulatory responsibilities of the DFO and assessing the proposal for species and fish habitat issues. As one participant explained, “We want people to have one point of contact… [we want to] treat them right and with respect and things like that and don’t put them through some bureaucratic hoop.” One participant felt that their CA could do a better job of making the information about
regulations more accessible, i.e. something easily understandable by the public, educating them about what each regulation entails and why it is needed.

Similarly, a number of participants noted that their staff is working toward improving landowner relations in how their permitting staff deals with the public. Mentioned by a couple of participants was the idea of spending more time working with the public on helping to find solutions to regulating issues. They spoke of finding ‘win/win’ situations in terms of providing incentives (the ‘carrot’) to conforming to the regulations, rather than just simply providing a verdict (using the ‘stick’). Most participants who talked about this suggested that their organization has improved how they deal with the public by being more collaborative in this role by finding solutions that are acceptable as possible to a wide range of interests, i.e. being flexible, being responsive and quick to help people solve their problems. Describing his colleagues in this regulatory role, one participant stated “they've done a very good job of maintaining where the rules are but getting the job done without creating too much animosity.” In fact, one participant mentioned how a positive interaction usually follows when a landowner sees the truck with the logo of his CA parked on his road.

Another challenge that one board member discussed was how difficult it is to please some NGOs; “we don’t always give them everything they want. They often want us to be more aggressive than we think is prudent, but they also provide us with input and eyes and ears and a different point of view and will tug us in a given direction which is helpful.” Another participant explained how the expectations of the public are higher than in the past and they demand their concerns be addressed. The challenges arising from this, she felt, is that the public believes it the responsibility of the CA to take care of all the publics’ concerns. A few participants mentioned how in the future, an ongoing struggle will be to more fully align the public’s perception of CAs with the actual activities carried out by the CA. Echoing these comments, one participant described how the perceptions of CAs by some are too grandiose and of people having “expectations about the things that we can do that don't line up with what we can actually do. They think we're a bigger more comprehensive environmental organization than we actually are.” Countering these perceptions involves prioritizing and not duplicating the work of
other organizations. One participant summed up the challenge as “…terribly important that people see us and our public persona is a positive, helpful, useful, well-valued, you know, kind of asset, kind of thing, as opposed to yet another government agency that’s costing money.”

Overwhelmingly though, participants thought that their CAs could do a better job of communicating with the public, particularly in promoting the work their organizations do and their successes in that work. As one participant put it “…there’s a lot of people who don’t know a lot of the things we do. And when they do know, are thrilled - like just astonished by the kinds of things we do and the breadth of things we do…we don’t think our message is getting out. And that’s sometimes our fault because we don’t think maybe people outside of our world, care much as they maybe do.” Another participant indicated that “if we're seeing a group there that doesn't know about what we do, we're missing the boat somewhere. We've got to figure out how to communicate more effectively, in different venues, to different people.” A significant proportion of the participants interviewed stated that their greatest wish for their CA was for watershed-wide endorsement of their CA’s activities. Some described how this would look: “stronger recognition within the community…there are large segments of people that have no idea of what a conservation authority does”, “I would wish for an even higher and more public profile for Conservation Authorities”, “I wish that a lot of municipalities would better understand the value of a good conservation plan and a conservation authority”, “if people really understood what’s going on at the Conservation Authority…I think you’d maybe get a better appreciation as to what, you know, these organizations provide for them.”. One participant summed up this sentiment well stating she wished for more awareness I guess and support for what we’re trying to do because I think we do our job so well that we’re almost invisible…so I think an understanding of what the Conservation Authority brings to quality of life and water management as a whole and how we are basically helping the municipality meet their requirements for municipal drinking water and waste water…we provide an essential service that people don’t know about, and I think if they did know about it, then we’d have a lot more support than we have.
One manager discussed this problem, stating “we’re more interested in the work that we’re doing and a lot of us aren’t really skilled at promotion and marketing and branding and all that sort of stuff. You know, we’re engineers, we’re planners, we’re scientists.” He believes his CA needs to “seize on opportunities to market ourselves better and so people understand who we are and what we do and be proud doing it.”

As well as the public having a better understanding of what the CAs do, CAs need to understand the motivations and perspectives of the public that they need to work with to accomplish their mandates. One participant discussed this issue from a more holistic standpoint, maintaining that

...the emergence of ecosystem services, ecosystem valuation, and connections over to human health...they're starting. Other CAs have been thinking about this as well, and making moves in that direction. The disconnect between environmental health and human health is unbelievable here. So that is the area that I would strike - what motivates people and how community can be much more enthused in that attempt to bridge those two worlds.

Getting community more enthused will necessitate understanding the publics’ perceptions and motivations, beyond just focusing on the science of the environment; “...there still are wide gaps in the public’s attitude toward the environment and the watershed, and so on, but also very little mechanism to actually know what they think.” And so according to this manager, one of the biggest future challenge faced by CAs is how they communicate with the public based on people’s true attitudes towards nature. She explained that currently society does not really “buy into the value of a functional ecosystem”, although the “messaging” of CAs assumes that people value nature for nature’s sake; “We operate, we try to go forward on very long-term planning basis with a message that doesn't reach people and doesn't address people's behaviour of only reacting to very immediate threats that cause behavioural change.” (e.g., acid rain peeling the paint off your car). She believes the messaging should be that “‘ecological services provide human health benefits’”, and that CAs need to start marketing and advertising these links, sending the messages that enable the public to associate the “CA name with ecological services that ‘help keep your family healthy’, not the requirement of keeping places that you don't know about healthy.” In light of this, she believes
…that's the kind of thing that we need to be doing a lot more of; to understand what people - what motivates people - what causes their decisions to go this way or that way and what their perceptions are of value. We're going to have to do that on a much broader scale...we all need to be social scientists more so than technocrats…

4.1.1.3 **Monitoring:** CAs consider monitoring fundamental to watershed management

Monitoring was considered by all participants interviewed, to be a critical activity of their CA. For most CAs, biological monitoring was a particularly important activity for assessing the quality and the health of the freshwater ecosystems within their watershed. Such information was relied on for many types of decisions made by their organization and beyond. GRCA, however, appears to invest the majority of its monitoring effort in water quantity and has an elaborate system that gauges flow across the numerous dams within its watershed. Most CAs appear to make good use of the data that they collect. UTRCA has an extensive biological monitoring program which is funded through their levy money. One manager stated that

…monitoring is the basis, it is the foundation of this organization because we need the data to convert to information to inform all of our staff about local decisions. It informs the managers and the board about what programs we need and what parts of the watershed need work. Relatively speaking whether there’s whole areas of effort required, it directs us to where funding is required, is the basis of everything we do.

and described monitoring as “sacred”. A manager at RVCA described how important it was working with planners to provide monitoring data that provides a good picture about the data that they require for their studies. He sees this synergy as helping to feed into the stewardship programs which will help mitigate planning impacts, avoid them or remediate where there are past problems. One CA participant explained how unfortunate it was that the data that was collected through studies conducted during the Environmental Impact Assessment (EIA) process were not somehow fed into the CA’s databases. Currently, there is a lot of paper information and often “a person will spend $10,000 doing a study, and the next person comes along and doesn't know it was just done upstream or downstream, or next woodlot over, or that woodlot, you know, two years before.” According to one participant, the EIA process requires all existing natural
heritage data for the area under study. While their CA gets requests for fish, water temperature and other physical data, benthic data is rarely requested.

One staff member at RVCA explained that the data they collect is important to keeping municipalities accountable and states that the “…numbers don’t lie…increasingly trying to take that science based information and turn it into an understanding, a defense—a defense mechanism sounds dire, but like, it’s the credibility right? We know this. We have this information…and therefore, we need to start using that at our level for decision making, right? But also in turn…the municipalities need to embrace that as well for their official plans…”

The City Stream Watch macro data collected through RVCA has been found to have many uses in their organization. Among those uses, a manager described how the information can identify areas along the stream that may be causing a decrease in quality [as measured through the water quality and benthic monitoring programs]. She went on to describe how they are getting about 70% of the information from their monitoring data and she does not believe they could take that information any further since they are “doing a fairly comprehensive job on the reports”. She does see some untapped opportunity to use the information to engage landowners to improve their lands, particularly the larger landowners like the federal government, National Capital Commission and the Airport Authority. The vision of another RVCA manager was to see the GIS department of his CA take on the monitoring data and create a “living data management program”, where for example, CA staff looking at a planning application can click on a property lot on a map and find out all the monitoring information and report findings organized in an integrated way. This sort of interactive database was also described by a manager from TRCA when the interview discussion focused on data storage and similarly, the board member at GRCA indicated that his CA is continually working to improve monitoring and that now improving the computer modeling and the application of that monitoring is becoming critical.
The monitoring of aquatic and terrestrial natural heritage conditions across the nine watersheds of the TRCA are used to support many corporate products and initiatives, including policy and planning development review, the development of fisheries management plans, the preparation of watershed strategies and management plans, and watershed report cards. It is also used by other groups including property managers and conservation parks to convey information to the public and the users as to what the natural conditions are. A lot of the data is shared among regional and municipal partners, and they use techniques and protocols that are consistent with the way other conservation authorities and other partners and agencies collect data, such that it can be “rolled up or down to various scales, to allow a broader utility and reporting of that information”.

According to one TRCA manager, long term monitoring data is a key and needed piece to watershed planning and management. Their own program came about as a result of a gap analysis that examined the different players within their jurisdiction and what the different data collection elements were. The gap analysis was initiated as a response to the cutbacks in the provincial ministries resulting in the reduction and elimination of monitoring sites. Now their challenge is maintaining this long term monitoring by communicating the findings that will demonstrate the need of this network to those that decide on funding priorities within the CA.

A staff member who conducts water quality monitoring at ABCA, sees monitoring as step towards implementing stewardship programs because monitoring can be used as a way of generating interest and bringing people on board while providing education and outreach. One of the Collaborative members of City Stream Watch envisions what he calls Urban Stream Watch where the same protocols as those for City Stream Watch are used but the program just focuses on the areas where you have the maximum number of volunteers and the maximum impact from various urban activities. As well, he looks forward to seeing a consistency of approaches to monitoring across the CAs in the Ottawa area.
A common discussion was about how broadly the monitoring information collected by CAs gets shared with others. One UTRCA staff discussed how it was important to find ways of communicating the information they collect because, as he states “We have a lot of data, we have a lot of information that’s stored between my ears, knowledge of the watershed. It’s just to get that recorded and figure out ways to communicate it.” His opinion is that the watershed report cards are a great start as they are a way to get the information from the monitoring out there to community, municipalities, and developers. He went on to state how it was a waste for monitoring data to only be used internally and that he thought it should be shared because when “You share the information, people understand what’s going on and are immediately motivated to do something.” He also noted that the number of people who are demanding this information seems to be growing.

One manager discussed how it can be tricky to keep funding for long term monitoring data because when the data is needed but not there, funding it is a priority, whereas when there is lots of data there but it is not acutely in demand, it is tough to keep resources tied to that program. Hence communicating findings as broadly as possible is one strategy for keeping long term data a priority. Networks play an important role in sharing data and a TRCA manager described how the OSAP network played an important role in determining the threshold for rainfall draining into the soil; 11% impervious surface caused a marked reduction in absorption resulting in a marked reduction in fish communities. As well, the evolution of the Stream Monitoring and Research Team (SMART) networks now serve the function of bringing likeminded agencies together to facilitate the discussion around standardized methods and approaches to monitoring and work towards a broader framework called the Flowing Waters Information System.

4.1.1.4 Benthic macroinvertebrate monitoring: Most CAs have benthic macroinvertebrate monitoring programs conducted by expert staff

Benthic monitoring was considered an important aspect to the monitoring repertoire of each of the case CAs except GRCA. Although benthic monitoring programs vary among CAs, they are consistent in their use of protocols (OBBN or OSAP). ABCA has approximately 35 benthic macroinvertebrate monitoring sites and for most of the 16
watersheds, there is a site in the main channel and another in the headwaters. Not all of the 35 sites are sampled annually with some watersheds only having either their main channel or headwater site sampled. At each site a three minute kick and sweep is conducted to collect the benthos. This sample is preserved and usually sent to an expert taxonomist who identifies the bugs to the lowest possible level. The data is then used in the watershed report card and to produce the benthic summary report. These reports are produced every four to five years. At the time of the interviews, ABCA were not participating in the OBBN or any other network. Similarly, GRCA did not have a benthic monitoring program. One manager explained that they were in the process of determining what information such a program can bring, what other CAs are finding out and where the information gaps are in these programs.

At TRCA, managers have described their current aquatic monitoring network as monitoring ambient condition whereas they would like the ability to track large-scale land development and really understand the “more cause and effect relationships”. They are in the process of designing a more refined monitoring network of higher management priorities to accomplish this. A TRCA manager described the types of monitoring that their CA funds listing temperature, benthics, fish, water quality and the monitoring of their stream gauges. She went on to describe how municipalities also have their own stream gauges and how TRCA networks and shares this data. She also offered the opinion that many other CAs do not have the capacity to monitor to the extent that TRCA does. The benthic monitoring at TRCA can show stratification between urban and rural landscape; however, there are not enough sites sampled each year to determine cause and effect. For some areas, more detailed benthic monitoring will be conducted to assess a particular stream reach to try and understand what exactly is going on. TRCA follows OSAP protocols and is part of the SMART network.

RVCA has a benthic monitoring program where a series of sites are sampled twice a year (spring and fall). Their program is part of the OBBN and follows the associated protocols. They also participate in the Eastern Ontario Biocriteria Project at the Ministry of the Environment. They send their all their benthic samples out to be identified and currently, while they have the in house expertise, the cost to send the samples out is much
less than paying for the time (even at the same efficiency) it would take their staff to identify the bugs in the samples. At RVCA, funding for monitoring has increase substantially over the past 10 yrs and the program has grown to the extent that the manager supervises three technicians and two students for the various programs in their aquatic monitoring division.

According to one manager, RVCA’s benthic data is a good baseline to understand what is going on and she has found that it has provided strength to arguments for riparian buffers. Generally she sees it as useful information when it comes to planning decisions and regulatory review. For this type of data, however, she feels the indices for measuring the state of the streams could be examined more closely than they are. To get a really significant jump in their level of understanding of their watershed, she feels a doubling of sites to include more reference sites would be needed. Currently their benthic sites are located at the bottom of the sub-catchment to see how that sub-catchment is influenced by the larger catchment. By including a minimally impacted, or reference site higher up in the sub-catchment, she feels that they could get a much better understanding of the upstream influences on the health of their watershed.

UTRCA follows a modified OBBN protocol for their benthic monitoring program. Samples from approximately 100 sites are collected annually twice a year and taken at the same locations as the Provincial Water Quality Monitoring Network sites, from reference reaches, and at representative sites along watercourses to provide adequate information for assessment purposes. Benthic sampling also targets areas where monitoring activities can track changes occurring on the landscape such as urban development and in-stream habitat improvements. The sampling methodology includes a combination of a modified version of the US Environmental Protection Agency (EPA) rapid bioassessment protocol and OBBN protocols (Creek 2008) (Friends of Medway Creek 2008). The benthic samples they collect are processed in house, and CA staff identify the bugs to the Family level.
4.1.1.5 **Perceived benefits of citizen science:** CA participants recognize a number of benefits of citizen science

CA participants were asked about *citizen science* within a variety of contexts during interviews; however, most of the ideas presented below were thoughts about citizen science discussed during conversations about community collaboration and monitoring. Some of the thoughts expressed refer to citizen science generally while other opinions are specific to volunteer benthic monitoring. It was clear from most of the conversations that participants were considering citizen science in the context of collecting water monitoring information.

CA participants discussed a number of **benefits** that they believed citizen science could have for CA activities including collecting monitoring data that might not otherwise be collected, collecting data that contributes to CA decision-making, educating the public about environment issues and ecosystem services, promoting the engagement of citizens in the decision-making process and improving the perception of the CA by the public.

One of the managers at TRCA stated “there is a particular opportunity in areas where there’s a real lack of monitoring the information. I… I think that’s the only way to go almost, is citizen science.” A participant from GRCA noted how River Watchers who monitor water levels fill a gap that exists with their instrumentation along the river and stated that while their automated system is “more sophisticated than it used to be and gives us more information, it still is not nearly broad enough.”

For RVCA which does utilize the efforts of citizens in the collection of freshwater monitoring data, free labour is definitely a benefit acknowledged by the participants at this CA; “we wouldn’t be able to cover the area that we cover with staff. So, there’s a lot of free labour; that’s a huge benefit.” Another individual views it not only as “dollars we don’t have to pay as tax payers”, but really the only means of demonstrating a pattern of impact which can then direct effective clean ups. As described earlier by one participant, there are gaps in the sampling network that could be filled by the efforts of citizen scientists. Another participant noted how it could be an important source of local knowledge (i.e. information from local citizens that goes beyond but complements the
data collected through the citizen science program). One staff member, with outreach and stewardship, believes citizen science would be a great way to assess the effectiveness of stewardship projects. If the public is involved in the restoration of a section of stream, he thinks it would be great to get them involved in the pre- and post-monitoring; they can be directly involved in seeing the difference that they made to the health of that stream ecosystem.

Another benefit of citizen science that was discussed by participants was the role of this type of data in decision-making by CAs. City Stream Watch is a great example of how citizen science information can be used to make decisions within the CA. At RVCA, the coordinator of the City Stream Watch program and the Lake Planning/Shoreline Stewardship Program Manager, work together to decide which are the priority areas and the most efficient potential stewardship/restoration projects based on the data collected through the citizen science program. An upper level manager at RVCA explained that they need the data collected by City Stream Watch to do their jobs and that information goes into creating reports that are used to set priorities, to educate the public about what is going on in their area, and to demonstrate trends over time. The education of everyone, promotes the contribution by everyone to watershed health. Along with stewardship, a board member noted that City Stream Watch data could be important for determining the presence of fish habitat in an area proposed for development.

Another benefit of citizen science that was discussed extensively was its role in educating the public about their local, natural environment, about issues facing the health of these ecosystems, and about their role in maintaining the ecosystem services they benefit from. To one participant, stream monitoring citizen science simply makes the stream a reality for volunteers; even that they just know the name of the creek in their community and know that it has fish in it, gives that stream value and hence, makes it worth protecting. Another participant believed that there was an added benefit to the education that volunteers received through benthic monitoring because volunteers have the opportunity to view and learn about “the bottom of the food chain” and its role in all the other components in the stream ecosystem. A number of other participants made the point that
volunteers get an opportunity to learn the organisms that live in streams and what factors (especially human impacts) contribute to stream health.

According to one participant, for some volunteers, this volunteer benthic monitoring of citizen science can provide volunteers with an awareness of how they are impacting their environment and an understanding of the complexity of stream health. Echoing this idea, another participant believed the education this citizen science provides, gives people an opportunity to examine the role their every day actions play on stream health, which may lead them to change their practices. A number of participants mentioned how individuals participating in citizen science will be educated about not only the natural system they are a part of, but begin to make connections between human behaviour, human health and the health of that natural system. As well, some participants have stressed the importance of people gaining awareness and being educated about the complexity of the situation; “it creates an awareness of how they are impacting the environment and the sorts of things that would be required, like whether it be lifestyle changes or you know, and just see the complexity too of the situation. It’s not just one simple ...there is no one simple quick-fix, but you know it’s cumulative effects of all aspects of society and the community.” One manager suggested that protecting watershed health is just too big of a job for a CA to do on its own; these organizations need engaged citizens to contribute to watershed health. The learning that happens through participating in citizen science provides meaning; people then have a vested interest in protecting the ecosystems that provide goods and services that benefit them, their neighbours and their children. Because of the complexity of sampling benthics, one manager believed the purpose of this type of citizen science was as a purely educational tool.

A public engaged in the planning and decision-making of CAs was another potential benefit of citizen science that was discussed by a number of CA participants; that citizen science of aquatic ecosystems leads to education which is critical for engagement and action. As one participant described it, when someone is out there collecting data, they learn why they are collecting it, begin to value the resource they are monitoring, and hence, be much more inclined to advocate for it. As well, they know about what impacts it, how to protect it, and also how they can help it if it becomes degraded. This could
lead to their involvement in its stewardship or its protection via their voices to their municipal counselors. Discussed by a number of participants was how citizens, by being involved in citizen science, could contribute to the planning/decision-making of their CAs. According to one of the managers at the TRCA, the value of monitoring in general is its role in providing information to the decision-making process. The value of volunteer monitoring is how citizens, through their participation, can contribute to this process. She gives the example where “if it improves their [citizen’s] understanding and their expectations of the way decision makers make decisions, then that’s a good thing because it inputs not only in the monitoring phase, but it inputs in the planning phase, and the implementation phase, and the monitoring phase, and all through the whole thing. So citizen monitoring can influence the whole process.”

One ABCA participant described how getting the public involved in citizen science efforts could lead to their understanding of the need for monitoring including determining where in the landscape actions are required to remediate habitats. The public’s understanding of this through citizen science could lead to their involvement in stewardship activities or in making the decisions about where stewardship projects need to take place. She described how ultimately, ABCA is motivated to get people involved in decision-making through advisory committees so that it is the community that is driving what happens on the landscape. The engagement of the public in citizen science, according to one RVCA participant, shows the demands and desires of the public to the political bodies. Through their engagement, they become the voices that direct their municipal councilors to the actions they believe are needed in a particular area.

Another benefit that CAs can acquire through citizen science is a more positive perception by the public of CAs and their activities. CA associated citizen science can foster support for the CA in general which may lead to better funding by the municipalities. At UTRCA, one participant saw how engaging the public in citizen science was an opportunity to modernize the old perception that their organization is full of “…bureaucrats who stop development and you know get in the way of everything…” That there is greater buy-in by the public of the activities of the CA resulting from working with volunteers was echoed by an upper level manager at RVCA; “It’s the
numbers of people and the buy-in and the education and I think that’s how we’re going to achieve our objective of a healthy Rideau watershed in the long run, not by just having another couple of staff people that can do the same amount of work, you know, in the same period of time right now. So there’s a bigger picture than that for sure.”

Another manager at RVCA extended this positive public perception resulting from involvement of the public in volunteer monitoring to the perception of the CA by NGOs. Participation by volunteers from these NGOs in the citizen science program at RVCA often combats the perception by NGOs that the CA should be able to do more. With their connections through the Collaborative members, RVCA can work alongside NGOs on environmental projects; this generally enhances the public’s perception of the CA and its activities. Also echoed was the general idea that their volunteering played a role in improving the public’s perception of the CA stating, “I’m hoping that as we sway people into thinking we’re great, and look at all the good stuff we do, it will get to the others that are potentially thinking the other way, and they’ll see it.”

4.1.1.6 Challenges of VBM that participants believed preclude its use by CAs included lack of interest, lack of CA capacity to support this type of citizen science, and the questionable reliability of VBM data

Participants discussed challenges associated with citizen science, and in particular, volunteer benthic monitoring. These included a lack of interest and availability by the public to produce the necessary data, the lack of capacity of the CA to maintain the appropriate level of involvement in volunteer benthic monitoring, and most commonly, the questionable reliability of this type of citizen science data.

Common topics discussed by participants, when asked about the challenges of citizen science, were volunteer recruitment, retention, and motivation. A challenge noted by one participant is that in rural areas, the smaller populations result in much fewer individuals from which to draw volunteers. One participant described how you may have the same level of interest as in an urban area, but because the population is so much less dense, you would not get enough people to participate in volunteer monitoring to make it feasible. She also saw that benthic invertebrates are not a big draw as far as generating interest and suggested that they would not be nearly as interested in collecting benthos as
they are willing to support the CA’s activities promoting a cleaner lake, for example. One manager described that in a more rural watershed, while there is a difference in community interest and community monitoring, just because you may not have one, does not mean you do not have the other. In her watershed, there is a lot of community interest, and hence input; however, there is little community monitoring and she feels this is because of the rural landscape and smaller populations. Other participants talked about how often there is a small core number of individuals that maintain a high level of dedication to the program until they just burn out. Another CA staff noted that although volunteers seem eager to get into the stream and kick up the bugs, there are few that are interested in identifying them. Among CA participants that talked about their benthic monitoring programs was a consensus that sorting and identifying the collected bugs is the most complicated, time consuming and expensive part of the process of benthic monitoring. They also agree that too much time, training and commitment is needed for volunteers to be able to take part in this part of the benthic monitoring process. CAs either outsource their benthic identification to expert taxonomists or rely on highly trained and certified staff for this task.

The lack of capacity of CAs to support citizen science was also commonly discussed as a reason that such organizations do not often rely on volunteer benthic monitoring data. One manager described the limitations his organization has when it comes to working with citizen science groups using an example of an attempt to partner with a community stewardship group who was interested in doing OBBN protocol based volunteer benthic monitoring. He described how they provided some coaching, a presentation to their members, and equipment on loan. He went on to describe how he felt the program failed to grow because of a lack of coordination within the citizen science group and with his CA’s lack of capacity to provide that coordination. While they can provide some funding for training, loan equipment, and provide technical support and guidance to some degree, in his experience, “the minute it becomes, you know, our task to try and keep those groups running and mobilized, that’s where we fall down a little bit.” Time was a common capacity factor that participants named as a challenge to coordinating a citizen science program. Related factors included the time to schedule, train, and manage volunteers and conduct quality control through supervision. And yet another commented
how the cost of coordinating volunteers due to the time and effort needed to sustain strong commitment, would override the cost saved by collecting the data by using their own expert staff. And from yet another participant “So we’ve tried some of those things, and you need a lot of money, you need a lot of… you know, for Hach kits, and this and that. And somebody who manages that, it’s a full-time job.” Another participant, who spends much of his job collecting benthic data, suggested that a real challenge to coordinating this data collection as a citizen science program was how to store and access the data so that the information is actually used (e.g., a web-based system). Another challenge he mentioned was not getting too caught up in the technical aspect of benthic monitoring and gave the example of how historically the size of mesh for collecting benthos was a huge issue among experts collecting benthic data.

One manager suggested it would just not be possible for volunteers through a community group to collect the amount of data needed by her department - it would be difficult to count on volunteers especially for data that comes from routine monitoring programs that require long-term, consistent data. Hence, the intensity of the monitoring required for benthics would preclude many volunteers since most people are just too busy (i.e. only available some evenings and weekends). More specifically, another participant stated that a CA-coordinated volunteer benthic monitoring program would be vulnerable to the availability and commitment of the volunteers and that only so much could be expected from them, hence, there would be issues of reliability of actually getting the data that they needed collected. Resulting gaps in the data could make it significantly less useful. Relying on volunteers for the data seems to be risky. Summed up by one of these managers: “Data volume and data quality, I think, preclude a lot of what volunteer skill-sets have, at least, been presented to me to date.” and that since she has all the data she needs and has the ability to get large data sets within her own agency or from other government agencies, she likely would not actively pursue or rely on volunteer collected data.
A relatively common discussion I had with CA participants when I asked them about citizens collecting benthic monitoring information was around the **reliability of data** collected by volunteers. Some spoke about having the problem with volunteers not following protocols, others talked about there being bias in how volunteers collect the data. In most cases, the comments were open-ended and somewhat vague, with few individuals providing context and elaborating on those concerns (e.g., discussing the role of quality control, supervision, training and protocol selection etc.). Similarly, some participants are concerned that the experts that could advocate (or not) for the use of that data, are not convinced that citizens collecting benthic monitoring information produces reliable data. One CA participant sharing his thoughts about the use of citizen science by CAs, linked concerns about CA capacity with that of the reliability of volunteer benthic monitoring saying “I think that if there is the process to ensure the results of that community based side of it are defensible and meet objectives and the protocols that would be required scientifically, I see no reason why we shouldn't use that as a resource. But again, in sort of going down that route, would it take more resources to sort of police that process or to administer that process?...[volunteers are] very dedicated and very interested, but they may not have the suitable education to do that.” He also went on to talk about the dependability of citizen science groups because of the precarious funding situation that most are faced with.

It was the opinion of one upper level manager that the person who collects the data should be the individual to do the analysis and reporting so that nothing gets ‘lost in translation’. He summarized his point by stating “So, my belief is to have the quality in that design, collection, storage, analysis and reporting, I have to have professional staff who are committed, trained and accountable to do that. So, from that point of view, I don’t see community volunteers in my understanding being able to fill that role.”

Similarly, a board member and engineer described the validity of collected monitoring data. He described how the philosophy of his CA was that the person collecting the data should be the person to analyze the data in order for the data to be as accurate as possible because that person would have field notes to refer to in order to support the overall conditions of data collection. He went on to state that “we would love to have other
organizations collect on to our behalf, but it doesn't make the data necessarily valid. If we had to spend more time validating that data, we might as well have been collecting it ourselves.”

In response to being asked whether community based monitoring can help mitigate the challenges arising from future changes to the watershed, one board member responded that “generating the additional funding to do this kind of monitoring…is pretty remote. I mean just as much as we can justify it, it ain’t going to happen.” According to one CA manager, monitoring by volunteers is not something they are currently prepared to invest in, stating

Because I believe monitoring is sacred, we put our levy money into it. We fund it and if the funding wasn’t there, if we didn’t have the capacity, I might have a totally different opinion. Because maybe in that instance, I would say “well how can we get this done?” And community volunteers…I shouldn’t say we don’t shut the door on that, I think we’re more comfortable with our own staff.

Another manager stated “For the type of monitoring that we do and what our expectations are for the use of the data, I haven’t seen how community based monitoring meets our needs.” He went on to indicate that he did see some types of volunteer monitoring as very appropriate and referred to the ‘Great Ontario Dip In’ program where volunteers take secchi disc readings at their cottage lakes. One participant suggested that simple pictures of stream condition were valuable sources of information that could be collected by citizens. Another suggested that simple measurements of stream temperature would be usable information that could be reliably collected by citizens. In a more urban watershed, the general manager of a CA suggested that citizen scientist would be helpful for the monitoring required to deal with future challenges; however, only as a supplement to the monitoring already conducted by CA staff. He also expressed his opinion that there are very specific types of monitoring that would be suitable for volunteers to conduct (e.g., water temperature monitoring and rainfall events).
A number of participants described how important they felt science was to the process of monitoring. One manager mused that it is scientists that are required to determine the monitoring frameworks, the protocols and the gaps in knowledge. She felt that scientists need to oversee monitoring with citizens playing a supplemental role, filling in any gaps left after scientists are utilized for this task. According to one board member, in reference to using citizens to collect monitoring data, he stated “That really is not something that we, from a scientific perspective, we would really sort of condone that much. It would be lovely but you know, science is no good if the data suspect.” His argument was that there must be “very strict protocol around the collection of data from a scientific perspective” with specific guidelines and standards. Interestingly, there was one participant who challenged these claims regarding the sanctity of science claiming that this attitude toward science must be tempered if positive progress is to be made in dealing with the environmental issues her organization will certainly face in the future.

There is an emphasis placed on CAs being a science based industry and she described how there is the requirement for the CA to provide the burden of proof when it comes issues about resources under their management. She describes the problem that “science itself can be its own worst enemy” because although the burden of proof is on science to be absolute in its definitive cause and effect context, there are a variety of factors that are often at play in science-based decisions: “where your motivation is, that we need more data... there will always be someone who could always debase something with a different statistic or a different data set or a different context or swing it this way or that way.” She sees this as a problem with the science community, or more specifically, how we embrace the scientific community.

4.1.1.7 Some CA participants were more positive about the potential for their CAs to meet the challenges posed by VBM and discussed conditions of citizen science required in order for CAs to be able to use such data

Some participants, despite the challenges posed by benthic citizen science, were more positive about the potential for their CAs to meet those challenges. “I think it’s great as long as you have somebody that is taking responsibility for it, so that you know that information is sound, it’s authoritative, because if we’re going to use [it], and one of our goals is to provide people and organizations with the best possible science based
information so that they can make appropriate decisions, then it better be right. So as long as you’ve got someone there that can check it and can confirm that the information is right and reliable, then absolutely, it’s a great way to do it.” And from another participant “We’d just have to make a commitment to doing it, and finding the time and space to do it…to get really good quality stuff, we would have to train people, we would have to have a reporting mechanism and we would have to have a commitment that they actually were going to follow these rules. And then we’d have to have somebody sort of tied into that group to manage it from afar.”

In discussions with CA participants about their organizations using citizen science and volunteer benthic monitoring, there were a number of conditions that participants indicated they thought would be necessary for their CA to be able to make use of citizen science. These conditions included the following: data must be rigorous and supported by the scientists/experts using it and/or vetted through a professional organization, it must be compatible with data already being collected, the purpose for the data collection is clear and aligned with those of the CA, appropriate protocols are employed, that volunteers are properly trained and supervised. According to one manager who has experience supervising the coordination of a citizen science group within his CA, the elements of successful citizen science includes a high level of coordination that includes a lot of interaction with volunteers through their training, through field trips and regular follow up. He also noted how important he felt volunteer recognition programs were for maintaining committed participation.

One staff of the CA suggested that creating a volunteer benthic monitoring program was feasible if, among other things, there was single individual that would be responsible for overseeing training and quality of the data that was being collected (especially the bug identification part). One manager mused that her department could use another person as a field technician who spent most of their time outside collecting supplementary data and checking on issues reported to the CA (e.g., how the culvert extension on property X is coming along), and suggested that this might be the person who could coordinate a volunteer benthic monitoring program to assist with that collection of supplementary data.
A couple of participants from the same CA suggested their organization could do a better job of supporting volunteerism, i.e. provide structure for the demand of the public for volunteer opportunities with their CA. To this end one of them suggested creating a full-time volunteer manager that would work with community groups and establish new relationships with other groups. In a more urban watershed CA, one technical staff member suggested that since there was little biological monitoring done by their CA, community members could pick up this task in order to establish some sort of baseline. More than one participant suggested that students were a potential way to incorporate volunteer monitoring in the information that CAs use (either high school, or more preferably, university students).

4.1.2 Citizen science programs

4.1.2.1 Characteristics of citizen science groups: site selection, partnerships and protocols

For all three citizen science groups, the establishment of sites was done in consultation with their local CAs. For URBAN, site selection was an integral part of the group’s inception. The Bay Area Restoration Council (BARC) program, Adopt a Creek, needed more structure and when the director posed the idea of URBAN to BARC members, it was suggested that URBAN take on the BARC monitored streams as part of their program. When considering the other sites to include in the program, even though none of the four CAs in their area (Hamilton, Halton, Niagra and Grand River) were considered partners, sites were selected based on their data needs. While all were consulted, only Hamilton had need for specific site data. According to the coordinator of URBAN, both Conservation Halton and Niagra Conservation Authority had well established benthic monitoring programs already in place. There is only a small portion of the Grand River watershed in the Hamilton city limits and that CA only requested the marsh monitoring data for a couple of the wetlands in that area. The collaboration with CAs began with a meeting that brought representatives of each CA (Halton, Grand River, Hamilton) together to look at maps and discuss areas that would be good for URBAN to sample. Creating connections with the CAs in some cases arose from having a previous
connection with them (e.g., meeting at a conference). The interactions the coordinators of URBAN have are mostly with the ecologists from the CAs in their area.

For Citizen Scientists, it was very important to select sites based on what their partner, the Toronto and Region Conservation Authority (TRCA), was sampling. According to one of the coordinators, they selected new sites that were in locations that would supplement the TRCA’s existing sampling locations but also they adopted TRCA sites that had been abandoned (only had a few years of data). Adopting these sites provided the benefit to Citizen Scientists of providing them with some pre-existing data, and was a benefit to TRCA because Citizen Scientists would not only provide information that TRCA at one point felt was important, but they could provide more detailed data because Citizen Scientists monitor their sites more regularly than the TRCA monitors theirs.

Considered by Citizen Scientists coordinators to be one of their most important partners, TRCA has provided some key assistance in running this group. TRCA helped Citizen Scientists get discounts on training of their crew leaders and the use of TRCA electrofishing equipment is a critical contribution to monitoring efforts of this citizen science group. It is very expensive equipment that costs a lot to maintain and repair. The coordinator of Citizen Scientists stated that without the use of that equipment “we would be very challenged to do any of that aquatic work and our understanding of that system would be a lot different.” He also described a situation when there had been so many rain days that forced the citizen science group to cancel previous attempts to sample a particular site that eventually there were no volunteers to go out. TRCA staff sampled the fish at this site for the Citizen Scientists’ sites because they were in the area. As on other occasions, TRCA provided the equipment and sample bottles. Having access to the expertise within the TRCA has also been of benefit to Citizen Scientists and this access is made easier by the fact that some of both the volunteers and coordinators are employees of TRCA. As for their collaborations with TRCA, there are three individuals that the group deals with; two managers and a field managing assistant.
When asked about the benefits of Citizen Scientists having a partnership with TRCA, one volunteer from the group stated that being associated with the CA

... adds that legitimacy in the public perception and maybe facilitates advancing or expanding the program because the funders love to see that you are collaborating with other organizations. By just having that association with an established, recognized, reputable organization such as TRCA already is a boost in your favor and will put your program in a positive light.

The partnership has been beneficial to TRCA as well. In some cases, Citizen Scientists are really the only organization that has data in particular areas. There have also been instances where data collected by Citizen Scientists was used to help provide estimates that the MNR made about a fish kill incident. As well, a number of volunteers from the Citizen Scientists have been hired by TRCA. One volunteer thought that TRCA’s involvement with Citizen Scientists was really good for the CA’s public relations.

Another staff member that works with the Citizen Scientist director/coordinator at TRCA explained that “TRCA has recognized that they’re, you know, they’re contributing information that, you know, we can all use.” He also described how TRCA provided Citizen Scientists the opportunity to look at sites within the Rouge watershed that TRCA would also like to have a better understanding of and since the volunteers are OSAP trained, they could assist TRCA with their monitoring on occasions when the needed an extra person.

For City Stream Watch, one of RVCA’s program managers provides the program with technical support and supervision of the coordinator. She also established the sampling regime, deciding which sites to sample and the cycle on which these sites would be visited. The 23 creeks are monitored on an approximate five year cycle. The individuals streams completed each year were determined based on their geography; each year the monitoring of one east, one south and one west stream is conducted. This was planned in order to have all three parts of the city included in the monitoring each year. This would ensure that individuals from the public in each area of the city could participate every year, increasing the likelihood of maintaining interest from the public across the entire city each year.
The coordination of City Stream Watch by RVCA provides a number of benefits as well as some challenges. Among the benefits is what one coordinator described as the ability to “tap into funding sources that we wouldn’t have been able to get if it was just us [City Stream Watch].” It seems that a quasi-government organization that is willing to work with a citizen science group provides the group with more credibility to funders. Other reasons one coordinator believed this association provides credibility include the fact that the program is well established with consistently high numbers of volunteers, they work with an established protocol and their volunteers are always supervised by the CA’s trained staff. Another benefit of the coordination that RVCA provides to the City Stream Watch group is the operating space and equipment it gains from RVCA. Unlike an NGO, the group does not have to worry about renting space, the cost of storing, maintaining and repairing equipment. As well, operating out of the CA provides the project with a wealth of information through collaborations with other CA employees. This was particularly important for acquiring permission from some of the land owners; CA staff in other departments were able to provide history of previous interactions with particular landowners and so the CA provided context for the interaction City Stream Watch would then have with the owner in asking permission to establish a monitoring site on their land. Tapping into the knowledge of the CA provided the coordinator with greater knowledge of the streams they were preparing to sample; location of the stream, other work by consultants that might have been conducted there due to proposed developments, and also whether there is a potential for compensation areas resulting from development of say subdivisions on another part of that system. Also, the integration that City Stream Watch is building with the Stewardship group at RVCA is seen by one of the coordinators as an incredible benefit that may not be possible without the group being a part of RVCA.

There seem to also be benefits of the CA partnership/coordination from a volunteer’s perspective. One volunteer noted that he felt that being associated with the CA gave him some authority when approached by the public. He also noted that the City Stream Watch was a great way to educate the public about what the RVCA is about. A member of the collaborative noted that being associated with a relatively small CA allows them the flexibility to adjust and adapt to change. One of the challenges that a City Stream Watch coordinator described about having the program coordinated by a CA was how it
was difficult to fit the program, which is so unlike many of the CA’s other programs, into the work time frame that most CAs follow. Most of the hours put into the program are accumulated in a period of six months and since there are evening and weekends involved because of working with the publics’ schedules, coordinating those activities and creating the resulting output (reports and information) can result in the accumulation of a lot of overtime hours. Another challenge arose from the lack of autonomy from the CA; the public automatically sees the volunteers as part of RVCA instead of City Stream Watch. Two situations were described in which this association creates a challenge: the public automatically lumps CAs in with the other government organizations that regulate the activities that landowners can conduct on their property (e.g., MNR deals with species at risk regulations and so may prevent certain types of activities by landowners if their lands support species at risk). Another challenge with being lumped in with the government agencies is that the public sometimes believes that the City Stream Watch people can deal with things that they actually cannot deal with. Collaborating with CAs so closely is also a challenge for CAs as well; for the CA to back a project where volunteer data is collected, they need to provide a lot of support and commitment; the CA decision makers need to support to both the principles of the group and provide committed funding to ensure the data that is collected (and that will be used for CA decisions) is rigorous and reliable. For organizations that are already stretched in their ability to execute their mandates, providing the funds for staff time is an especially big commitment.

While URBAN uses the OBBN protocol without any modifications, they use the optional sample-picking method (Jones et al. 2007) where the bugs are picked live from the sample in the field, visually unaided using the bucket method of randomization. When volunteers were asked about the rigor and validity of the data they were collecting, they all had high confidence given the fact that they were so well supervised with particular quality control placed on the sampling of bugs from the stream kick net. For the benthic data collected, OBBN gets the data after URBAN staff sort and identify the bugs collected.
Citizen Scientists use the OSAP protocol which is simplified in order for the group to be able to monitor all of the seven sites over a season. One of the coordinators indicated that the full OSAP protocol was very specialized requiring highly trained individuals to conduct them. One of the CA staff that work closely with the data collected by Citizen Scientists described the significance of the qualifications of the director/coordinator of Citizen Scientists; since he is a member of TRCA staff, she described how

…he is a qualified biologist with a license in, well, it's a certification in electrofishing. I know his work. I know what he is doing. And he also knows, he follows the same protocols that TRCA does which makes the data he collects from the Rouge contextualized within the regional data sets. So I can bring it in to make the regional set a little bit more robust.

The program manager of City Stream Watch developed the protocols for that program (macro stream assessment) which are updated and slightly modified from the monitoring program that MNR used called ‘Macro Streams’. An entire length of a stream is monitored with measurements on water quality, physical characteristics and stream habitat taken every 100 m and their fish sampling follows OSAP protocols. Although City Stream Watch monitoring does not include the systematic sampling of benthic macroinvertebrates, the program has an annual benthic invertebrate demonstration event to help people understand more about the ecology of stream ecosystems and their food webs. When asked about the sufficiency of the macro stream assessment, while there were no comments provided by the volunteers, one of the coordinators commented about the protocol. She indicated that while there was quite a bit of subjectivity (e.g., visual estimates of habitat), the level of information they were collecting was completely sufficient for planning remediation and restoration activities. She also noted how much more weight their fish sampling provided to the macro data.

According to participants, because the process involves collecting benthos, there are challenges to having complete volunteer participation in all aspects of this type of monitoring. While they all agree that the collection of the specimens is really no problem for supervised volunteers, most found the prospect of having volunteers sort/identify bugs from their samples problematic. At the one extreme were participants (particularly coordinators), who believed that to get reliable and rigorous data, the samples collected
for the streams needed to be sorted and identified by experts (be they the coordinators themselves who all possessed graduate degrees in a biology related field, or certified taxonomists that specialize in identifying stream bugs). One explanation given for this was the need to identify to at least the level of family in order to get meaningful information from the monitoring. To identify to family (or lowest possible level) is a “such a big resource draw because it takes a lot of time to identify down to that level...we just go down to family because we don’t have the resources to take it down any further,”, according to one coordinator. She went on to describe how one day of field collections translates into two weeks of identification. The coordinator of City Stream Watch noted that although having the benthic information would add a great deal of understanding to their volunteer macro stream assessments, identifying the invertebrates is “a huge amount of resources and it’s big bucks at the lab”.

There were also some individuals, however, who believed that with enough funding (for space, equipment and people), and under the supervision/tutelage of an expert, at least some of the sorting/identification could be accomplished with the assistance of volunteers. The issue with this, however, that one coordinator raised was that while “it’s definitely within our overall capability,... people with different life circumstances are not interested in doing that part of it – they want to be out in the field and doing that work and being with the birds and maybe identifying plants. They’re not interested in identifying the bugs.” She felt the only real interest for identification would come from students who are interested in getting work related experience in that field. When volunteers were asked about the data they were collecting, they indicated they were relatively confident that their data was rigorous given how well they were trained, supervised and the points of quality control conducted by their supervisors during benthic sample collection, bug sampling and identification.

The volunteers of citizen science groups talked about how they felt that often there appears to be perceived issues of credibility with data that volunteers collect. Those that spoke about this gave reasons why these issues do not apply to the citizen science group that they volunteer with. One volunteer of Citizen Scientists indicated that the associations between TRCA and the group’s coordinator (also a TRCA employee), went
a long way towards their data gaining credibility with TRCA. Also, TRCA contributes their support to training the crew leaders at Citizen Scientists. One of the volunteers indicated that this is what attracted her to the group; the fact that they used established protocols approved by the Ministry and used by CAs (OSAP) and the training members of Citizen Scientists received was quite robust. Another volunteer indicated that with the supervision they got in the field, there was little potential for unobserved volunteer errors. One URBAN coordinator also commented on how their group gained credibility in the data they collected because of their use of Ministry approved protocols that were used by CAs in their region (OBBN). Generally when volunteers were asked about the data they were collecting, they indicated they were relatively confident that their data was rigorous given how well they were trained, supervised and the points of quality control conducted by their supervisors during benthic sample collection, bug sampling and identification.

4.1.2.2 Citizen science groups see a real need for the work they accomplish and seem successful at attaining their desired outcomes (education and collecting useful data)

There were a number of reasons that the participants, who were involved with the citizen science groups of this study, thought these programs are needed. Two of these reasons commonly mentioned related to education and to a need for the data. Education was noted as being a very important reason for the existence of citizen science programs that conduct stream monitoring and benthic monitoring, and both coordinators and volunteers shared this opinion. One of the volunteers noted that “There’s so much education that needs to be done, and there’s no one fulfilling that…” She suggested that the program she was involved with played an important part in fulfilling that role while another suggested getting out into streams and collecting data was “good for the human brain” and provided health benefits. One volunteer thought the program she was involved in was providing people the opportunity to learn about how humans impact ecosystems; “I think that’s a huge part of what they do and a huge part of why they are important and why they are a really cool organization because it means that people like me… who are students, who want to learn about these things and have to learn about these things can actually go and see them.” Also mentioned by a volunteer was the importance of his citizen science group in engaging citizens, and he described how the activities of the
group empower people; the public has an opportunity to contribute to something being accomplished since there appears to be a lack of funding for scientists to do the job; “you have a bunch of volunteers and it [monitoring] might not have been done if it wasn’t for the volunteers so that’s, that’s really important.”

The coordinators of the citizen science program felt **education** was a central objective of their group. One coordinator noted that her program creates change in people and that more than just presenting facts, you need to do something that can “influence everyday actions by people” in order to achieve watershed protection. Another stated that “…we’re trying to get that across to people that there’s fundamental connections between the environment and living.” A number of them expressed their hopes that by providing knowledge about and experiences in their local environment, citizens would learn the importance of natural local systems on their wellbeing, and in understanding that importance, those same individuals would take pride in maintaining or improving their local environment. The ultimate goal of educating citizens is to not only change their attitude toward their natural surrounding but to change their behaviour toward it as well (e.g., prevent littering in streams, change lawn mowing practices to provide a buffer along a creek/stream, etc.).

**Collecting useful data** appeared to be an objective of all the citizen groups. Data collection was noted by a number of participants as an objective of their citizen science group. Among the characteristics described for this data was that it be usable; not only rigorous, but also span a long enough time period to be of some use in decision-making. One of the citizen science participants thought an ideal outcome of their group’s work would be to contribute to changing policy. He summed it up stating

> We ultimately would like to see our work going to other research that would help…get into some government policy to change habitat regulation that affects more effective protection of an ecosystem or an animal; or something that’s useful in helping us to preserve our ecosystem services that seem to get run down all the time.

A couple of participants felt that it was really important for the data generated from these programs to be available in a way that would allow different users to examine the
information in different ways to suit their particular needs; so making the information not only available through published reports, but accessible in a more raw format so that it can be used to answer different questions. A participant from City Stream Watch’s collaborative stated: “It’s publishing information, getting everything readily accessible and then finding better ways to slice and dice it so you can really see more pictures.” One of the groups’ directors indicated that an objective of his group was to “create scientifically-based monitoring data…tangible and usable by someone, if not by us, someone else after us…” Similarly, another director indicated that a main goal of her group was getting good data to the organizations and people who can report on the environment and for another participant, the creation of a relational database for use by other groups, was one of his group’s hoped-for outcomes. One coordinator noted that much of the data his program collects is unique and that it is “ultimately useful to wildlife managers or someone out there like other researchers”. Many of the participants commented on how valuable the citizen science data their groups collect is for resource managers given the amount of cutbacks to government organizations that are responsible for freshwater monitoring. One coordinator stated that “there’s a huge need for it, especially because there have been cutbacks and citizens need to be engaged; not only the fact that citizens need to be engaged but that there are just lots of areas that need to be monitored, and if we don’t have the data for these areas, then it’s a problem, it’s a huge problem.”. The coordinator of one group indicated that the data her group collects is highly useful for identifying impaired stream sites, and that the resource managers in her region actually use that information to examine the opportunities for potential remediation projects.

All three citizen science group seemed to achieve their desired outcomes with respect to providing the public with education and with providing quality data that could be used for decision-making. Interestingly, the group that had the most active education program was also the program that provided the fewest examples of their data being used for making decisions about the resources they monitored (and vice versa). URBAN’s education and outreach program is relatively extensive. The stream data they collect is analyzed and reported in the form of report cards for each of the streams and are available to the public and can be accessed from an interactive map on the website. Also on the
website is a pictorial guide to the benthic invertebrates found in the streams they monitor. As well, the coordinators host a reception for anyone who was involved in the group including the partners, sponsors and volunteers. That evening’s activities consisted of a keynote address on a relevant topic and then the coordinators’ presentation of the findings for that year’s sampling. URBAN was also invited to a watershed monitoring day by the CAs as part of the Remedial Action Plan for Hamilton Harbour. They, along with a number of other groups doing monitoring, went to the event and gave a presentation. Another education and reporting venue for URBAN was a kiosk at the bay front that was manned by students a couple of days a week in the afternoon/evening to be available to talk with the public about the program and learn about the publics’ concerns. Finally, through their extensive outreach program, URBAN staff led interactive seminars with students from grades 9-11 at a number of high schools in the Hamilton area which were often supplemented by a field trip (Cartwright et al. 2013).

Citizen Scientists present their monitoring results in a newsletter that’s available on their website. To date, however, only the 2009 report is available. They also analyze and create data summaries that they use for reference and that are provided to funders that request them. Their plan is to create a 10 year “roll up” that reports all the data and presents any trends that exist. As well, the coordinator/director has set up a booth at the ROM for the Shad Gallery, an event where volunteer groups can go in and talk about what they do in the Biodiversity area of the museum.

City Stream Watch provides educational demonstrations during the summer months. The benthic demonstration is extremely popular; it brings the public out who may not themselves actually participate in the volunteer stream survey work conducted by this group and gets them interested and gives them a better understanding about who RVCA is and what the City Stream Watch is trying to accomplish.

The data collected by these citizen science groups was seen as both a motivation for the groups’ creation and as a goal and desired outcome. In their interviews, participants discussed what they believed the data their groups collected was needed for and contributed to. Some of the uses participants cited included: providing species at risk
information to MNR and contributing to their watershed information system, inclusion of their data in a larger regional database (e.g., OBBN) that was being drawn from to make decisions about conservation and resource management, considered in the management of development projects, and for reporting on the health of stream ecosystems. There were no examples given by the coordinators of the direct use of URBAN data in decision-making; however, one coordinator mentioned that due to the length of time they had been collecting data (only three years at that point), it would be difficult to discover many trends in the data.

According to a manager at TRCA, the benthic invertebrate information collected by Citizen Scientists for Rouge watershed has been used as a metric in their watershed report cards and also to determine the impacts on the stream ecosystem as a result of an industrial spill. The TRCA manager also used the volunteer data in the fish management plan for the Rouge watershed; it was used qualitatively, i.e. for characterization of the sub-watershed rather than in calculating the indices, and was considered a bonus rather than something relied on. In another situation however, where there was an industrial spill, the data from Citizen Scientists was the only information that existed about the system before the spill and the MOE requested that information for their investigation. Data collected by Citizen Scientists is provided to their TRCA partner and managers from the TRCA have at times requested specific data from Citizen Scientists. The data was incorporated into the thermal and fisheries data for the streams in the 2007 Rouge watershed plans.

City Stream Watch stream assessment and fish data are provided through their mini-reports to consultants conducting Environmental Impact Assessments. Their fish data is submitted to the provincial database for OSAP data overseen by MNR. Although benthic monitoring is not conducted as part of the macro stream assessment done by City Stream Watch, the macro stream assessment could be an adequate tool for choosing benthic sampling sites because it indicates where every riffle in the stream occurs. The program manager, who also oversees RVCA’s benthic monitoring program, suggested that with more resources, she would consider increasing or moving some of the OBBN sites given the information they have acquired through the monitoring done by City Stream Watch.
As well, this group works with the Stewardship program; the citizen science program actually produces maps of potential enhancement projects based on the data they have collected and provides these to the stewardship team. The two groups then work together pooling their volunteers and resources to, for example, do a shoreline naturalization project or to clean up garbage or uproot invasive yellow irises from a site.

4.2 Survey of Ontario conservation authorities

4.2.1 Characteristics of conservation authorities

Table 4.1 summarizes the information acquired from CO for the CA cases in this research study. These data were provided for all the CAs and this information was used for this research to supplement the data collected in the information questionnaire. Initially, the population of the watershed served by each CA was included in an ordination with other physical characteristics of the CA watershed (LAND; Figure 4.1). However, initial plots indicated that all of the variation in CAs was being driven by population size. Even when TRCA (which appeared to be the driver of this pattern) was removed, all the CAs lined up in the graph space in order of population. Population was therefore removed from the ordination. The amount of land holdings seems to be the main variable separating the CAs with GRCA owning the most land (20,101 ha) and MRCA, MVC and KCCA among those CAs that own the least amount of land (362, 430 and 528 ha, respectively). Other features that distinguish CAs include the land jurisdiction of their watershed compared to the amount of land owned or held in conservation areas; GSCA has 79 conservation areas totaling 11,481 ha and a jurisdiction of only 3,146 km$^2$, whereas MRCA has five conservation areas totaling 270 ha but with a watershed jurisdiction of 11,060 km$^2$. 
Table 4.1  Summarized data for the CA cases in this research provided by Conservation Ontario (Conservation Ontario 2011b, unpublished data). Acronyms for CAs are given on page xxii.

<table>
<thead>
<tr>
<th>Conservation Authority</th>
<th>Lowest</th>
<th>ABCA</th>
<th>RVCA</th>
<th>UTRCA</th>
<th>GRCA</th>
<th>TRCA</th>
<th>Highest</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watershed Area (km²)</td>
<td>283</td>
<td>2,500</td>
<td>4,243</td>
<td>3,432</td>
<td>6,800</td>
<td>3,467</td>
<td>11,060</td>
<td>3,074</td>
</tr>
<tr>
<td># of Municipalities</td>
<td>1</td>
<td>16</td>
<td>23</td>
<td>22</td>
<td>38</td>
<td>20</td>
<td>38</td>
<td>13</td>
</tr>
<tr>
<td>Population size</td>
<td>11,173</td>
<td>47,925</td>
<td>989,789</td>
<td>535,783</td>
<td>951,863</td>
<td>4,314,876</td>
<td>4,314,876</td>
<td>351,912</td>
</tr>
<tr>
<td>Full-time equivalent</td>
<td>7</td>
<td>29</td>
<td>60</td>
<td>109</td>
<td>162</td>
<td>583</td>
<td>583</td>
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<tr>
<td>Part-time equivalent</td>
<td>0</td>
<td>7</td>
<td>16</td>
<td>88</td>
<td>63</td>
<td>311</td>
<td>610</td>
<td>50</td>
</tr>
<tr>
<td># Board Members</td>
<td>5</td>
<td>9</td>
<td>22</td>
<td>15</td>
<td>26</td>
<td>28</td>
<td>28</td>
<td>14</td>
</tr>
<tr>
<td>Revenues ($)</td>
<td>825,784</td>
<td>3,718,569</td>
<td>8,417,893</td>
<td>12,763,589</td>
<td>29,932,682</td>
<td>84,319,059</td>
<td>84,319,059</td>
<td>8,383,875</td>
</tr>
<tr>
<td>Expenses ($)</td>
<td>788,192</td>
<td>3,552,172</td>
<td>8,158,078</td>
<td>12,763,589</td>
<td>29,198,957</td>
<td>83,901,613</td>
<td>83,901,613</td>
<td>7,947,035</td>
</tr>
<tr>
<td>Total Land (Ha)</td>
<td>362</td>
<td>3,942</td>
<td>2,498</td>
<td>5,967</td>
<td>20,101</td>
<td>17,804</td>
<td>20,101</td>
<td>4,068</td>
</tr>
<tr>
<td># of Conservation Areas</td>
<td>1</td>
<td>7</td>
<td>9</td>
<td>3</td>
<td>12</td>
<td>8</td>
<td>79</td>
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<td>Conservation Area Land (Ha)</td>
<td>100</td>
<td>1,000</td>
<td>1,271</td>
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<td>11,800</td>
<td>1,450</td>
<td>11,800</td>
<td>2,010</td>
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<tr>
<td># Benthic sites</td>
<td>0</td>
<td>30</td>
<td>55</td>
<td>136</td>
<td>14</td>
<td>185</td>
<td>185</td>
<td>31</td>
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<td># Surface Water sites</td>
<td>4</td>
<td>86</td>
<td>66</td>
<td>41</td>
<td>82</td>
<td>44</td>
<td>88</td>
<td>32</td>
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<tr>
<td># Ground Water sites</td>
<td>0</td>
<td>17</td>
<td>15</td>
<td>41</td>
<td>29</td>
<td>21</td>
<td>41</td>
<td>13</td>
</tr>
</tbody>
</table>
Table 4.2 Table showing the number of iterations, the final stress values, and the non-metric and linear goodness of fit values for the nonmetric multidimensional scalings (NMDS) calculated for each of the data subsets.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Data Subset</th>
<th>NMDS Stress</th>
<th>Number of Iterations</th>
<th>Non-metric Fit</th>
<th>Linear Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation</td>
<td>NUMMON</td>
<td>0.114</td>
<td>80</td>
<td>0.987</td>
<td>0.972</td>
</tr>
<tr>
<td>Ontario</td>
<td>STAFF</td>
<td>0.009</td>
<td>99</td>
<td>1</td>
<td>1</td>
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<tr>
<td></td>
<td>BOARD</td>
<td>0.059</td>
<td>141</td>
<td>0.997</td>
<td>0.991</td>
</tr>
<tr>
<td></td>
<td>LAND</td>
<td>0.042</td>
<td>64</td>
<td>0.998</td>
<td>0.996</td>
</tr>
<tr>
<td>Information</td>
<td>PERMON</td>
<td>0.075</td>
<td>49</td>
<td>0.994</td>
<td>0.975</td>
</tr>
<tr>
<td>Questionnaire</td>
<td>IACTIVITY</td>
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<td>114</td>
<td>0.995</td>
<td>0.986</td>
</tr>
<tr>
<td></td>
<td>RACTIVITY</td>
<td>0.019</td>
<td>70</td>
<td>1</td>
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</tr>
<tr>
<td></td>
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<td>45</td>
<td>0.989</td>
<td>0.947</td>
</tr>
<tr>
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<td>BMREPORT</td>
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<td>41</td>
<td>0.987</td>
<td>0.939</td>
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<td></td>
<td>BMDetail</td>
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<td>77</td>
<td>0.996</td>
<td>0.985</td>
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<tr>
<td>Opinion</td>
<td>MONTIME</td>
<td>0.076</td>
<td>65</td>
<td>0.976</td>
<td>0.897</td>
</tr>
<tr>
<td>Questionnaire</td>
<td>VININPUT</td>
<td>0.114</td>
<td>49</td>
<td>0.987</td>
<td>0.944</td>
</tr>
<tr>
<td></td>
<td>VLABOUR</td>
<td>0.153</td>
<td>92</td>
<td>0.973</td>
<td>0.907</td>
</tr>
<tr>
<td></td>
<td>VMON</td>
<td>0.115</td>
<td>53</td>
<td>0.987</td>
<td>0.951</td>
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<tr>
<td></td>
<td>VBENMON</td>
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<td>0.990</td>
<td>0.952</td>
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<td></td>
<td>COMINPUT</td>
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<td>0.996</td>
<td>0.993</td>
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<tr>
<td></td>
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<td>0.996</td>
<td>0.983</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>VMOBSDATA</td>
<td>0.137</td>
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<tr>
<td></td>
<td>VBMScenarios</td>
<td>0.041</td>
<td>80</td>
<td>0.998</td>
<td>0.994</td>
</tr>
</tbody>
</table>
Figure 4.1 NMDS ordination showing the dissimilarity among CAs based on their land holdings (LAND). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together. For example, MRCA is very dissimilar to GRCA, compared to CVC which is not very dissimilar to NPCA.

Diagnostic values for the NMDS are given in Table 4.2 listing the stress, number of iterations performed for the scaling, and the non-metric and linear goodness of fit measures for each of the data subsets (Tables 3.3 to 3.5). All values indicate excellent representations of the distances among the CAs for the data subsets. For the staff and board data subsets, initially values relating to the different types of both staff and board members were included in the ordinations. It was apparent though, that the variation observed was driven by the number of total staff members per CA. Therefore, staff numbers and board numbers were ordinated separately. Figure 4.2 shows a prominent clump in the ordination plot for the staff numbers (STAFF) of the CAs due to two outliers (TRCA and HRCA). When these two CAs are removed from the ordination the variation in the remaining CAs is clearer. Spread along the x-axis is based on the total number of equivalent full and part time staff and along the y-axis is based on the number of part-
time staff, especially seasonal staff. For example, despite both having relatively high numbers of total full time and part time equivalent staff, HCA has 185 and 59 seasonal and seasonal full time equivalent staff respectively whereas GRCA has 31 and 16 seasonal and seasonal full time equivalent staff, respectively. The variation in the CAs with respect to the number and composition of board members (BOARD; Figure 4.3) is due mostly to total number of non-elected board members where MRCA’s board consists completely of non-elected individuals in their municipalities.

Figure 4.2 NMDS ordination showing the dissimilarity among 34 CAs (TRCA and HRCA excluded) based on their staff complement (STAFF). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
Figure 4.3 NMDS ordination showing the dissimilarity among 36 CAs based on characteristics of their board complement (BOARD). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

4.2.2 Activities of conservation authorities

When asked about the importance of different CA activities, all CA respondents considered both ‘flood protection’ and ‘permits and approvals’ to be either very or somewhat important activities of their CA (Figure 4.4). Similarly, they considered ‘source water protection’, ‘public outreach and education’ and ‘monitoring and indicators’, ‘remediation and restoration’ and ‘conservation areas management’ either very or somewhat important, with a few of the CA respondents having a neutral opinion about the importance of these activities. One respondent indicated that their CA does not conduct ‘remediation and restoration’.
Figure 4.4 Responses by staff from each of 27 CAs from information questionnaires to questions regarding the importance of various activities conducted by their CA (a) flood protection, b) reservoir management, c) permits and approvals, d) source water protection, e) remediation/restoration, f) integrated water resource planning/management, g) monitoring and indicators, h) public outreach/stewardship, and i) conservation areas management).
Two activities showed a broader range of opinions on their importance to CAs; while the majority of respondents indicated ‘integrated water resource management’ as a very or somewhat important CA activity, five respondents were neutral, one thought it was not very important and another indicated their CA does not conduct this activity. Similarly 16 of the CA respondents considered ‘reservoir management’ as a very or somewhat important activity of their CA; however, four individuals felt neutral about the importance of this activity and three felt it was not very important and four respondents indicated their CAs did not perform this activity.

The ordination of CAs based on these 10 CA activities (IACTIVITY) shows a cluster of six CAs in the middle bottom of the plot (Figure 4.5) whose respondents felt that all of the activities that were asked about in the questionnaire (‘flood protection’, ‘permits and approvals’, ‘source water protection’, ‘education and outreach’, ‘reservoir management’, ‘monitoring and indicators’, ‘remediation and restoration’, ‘conservation areas management’, ‘integrated water resource management’) were all extremely important. There’s another cluster at the far left side corresponding to the responses of participants who believed all activities to be extremely important except ‘reservoir management’ which their particular CAs do not conduct. There is separation of CAs with respect to how important their respondents found ‘reservoir management’ to be and also on how important their respondents felt that ‘integrated water resource management’ is to their CA (e.g., SCA and MVCA do not find it very important whereas QC and the cluster of six at the centre bottom find it extremely important).
Figure 4.5 NMDS ordination showing the dissimilarity among 27 CAs based on the responses to questions regarding the importance of different activities to the functioning of the CA (IACTIVITY). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

When asked to rank the 3 highest priority activities conducted by their CA, it was evident that the two highest priority activities are ‘flood protection’ and ‘permits and approval’ (Figure 4.6). Only seven respondents ranked an activity other than ‘flood protection’ as the highest priority CA activity. Of those seven, five ranked ‘permits and approvals’ as the highest priority activity. While the majority of respondents ranked ‘permits and approvals’ as the second highest priority activity of their CA, there were a number of other activities that were ranked as second highest priority by respondents.

Finally, there was a lot of variation in which activity ranked as the third highest priority CA activity. One respondent included ‘natural heritage system planning’ as their third highest ranking priority CA activity.
Figure 4.6 The opinion ranking, by survey respondents, of the three highest priority activities in the CAs. ‘Flood Protection’ and ‘Permits and Approvals’ are consistently ranked highest among the respondents.
Another suggested that three top priorities was not enough and stated that their CA has 7 priority activities. Similarly, a respondent stated that many of the listed activities are part of the key mandates of CAs and therefore rank very important. Finally, one respondent lumped ‘reservoir management’ as the same thing as ‘flood protection’ because they go hand in hand. Participants were asked to rank the three most important CA activities from a selection of nine activities. The variation in these ordination data (RACTIVITY) is mostly a result in differences in what CAs ranked as the 3rd most important activity to their organization (Figure 4.7); CVC respondent chose ‘watershed planning’ compared to the respondent at RVCA who ranked flood protection as the third most important activity (this was most often ranked 1st or 2nd).

**Figure 4.7** NMDS ordination showing the dissimilarity among 25 CAs based on the responses to questions regarding the ranking of the importance of different activities (1st, 2nd, or 3rd) to the functioning of the CA (RACTIVITY). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
Another factor creating separation among the CAs on the ordination plot is from the choice of their respondents when deciding the 2nd most important activity of their CA. Near the bottom of the plot are CA respondents that reported the second most important activity to be one of the two most commonly ranked as most important (‘permits and approvals’, ‘flood protection’), and near the top are CAs that ranked other activities as second in importance (e.g., ‘monitoring and indicators’, ‘conservation areas management’). In a ‘Comments’ section at the end of this question set, one respondent stated that everyone at the CA thinks that monitoring is important but it is one of the first things that gets cut when there are stresses on the budget. Similarly, another respondent stated that while their CA understands the importance of monitoring, because it takes so long to uncover trends, and only if there is good data of the right kind being collected, managers tend to put less emphasis on monitoring.

4.2.3 Monitoring programs of conservation authorities

There were a number of questions asking about characteristics of each CA’s monitoring program. The earliest CA benthic monitoring programs were established in the early 1990’s and the most recent was established in 2009. Of the 27 CAs that participated in the fact-based questionnaire, 22 indicated their CA had an in-house benthic monitoring program. Considering the data that CO provided (Conservation Ontario 2011b, unpublished data), the total number of CAs with in-house benthic monitoring programs is actually 29. From the CO data it appears that most of the CAs use OBBN protocol or a modification/combination of it for their benthic monitoring. Two CA participants indicated they use both OBBN and OSAP. Another participant indicated its CA uses both BioMAP and OBBN. When asked about changes to their benthic monitoring programs over the past five years, 20 of the respondents indicated that changes had been made. The most common change made was to the number of sampling sites, closely followed by the location of sampling sites. Similar numbers of respondents reported changes to the frequency of benthic sampling and in the protocols used for sampling. With respect to these four changes, the median number of changes to the benthic sampling program by CAs was two. When asked to what level the invertebrates collected through their benthic monitoring program were identified, most of the CA respondents (nine) indicated they
identify to the Family level. The lowest possible level was next most common response (five), followed by OBBN (three), Order (two) and Various (one).

With respect to number of sites sampled, some respondents stated their CAs increased the number of sites they sampled while others indicated their sampling was reduced because of budgeting or because the time allotted for benthic monitoring decreased (in one case, fisheries and temperature monitoring took priority over benthic sampling). The ordination of the number of surface, ground and benthic monitoring sites of each CA reported to CO in 2011 (NumMon) shows a cluster of CAs to one side of the graph (Figure 4.8). Most of the variation among CAs with respect to how many monitoring sites they have in each of three categories (surface water, ground water and benthic) is due to the variation in the number of benthic monitoring sites relative to the other types of monitoring sites (e.g., TRCA has 185 benthic sites compared to 44 and 21, surface and ground water monitoring sites, respectively). The cluster of CAs on the graph farthest from TRCA are those with under 20 benthic sites. Within this cluster, GRCA and ABCA have the most distance between them which appears to be due to their differences in ground water and benthic monitoring sites with GRCA having more ground water sites but fewer benthic sites than ABCA. Their numbers of monitoring sites are GRCA: 82, 29, and 14 and ABCA: 86, 17, and 30 (surface, ground and benthic sites respectively). With respect to frequency of sampling, only a decrease in frequency was reported.
Figure 4.8 NMDS ordination showing the dissimilarity among 36 CAs based on the number of ground, surface and benthic monitoring sites (NUMMON). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

A couple of respondents indicated that number, location and frequency of sampling changes annually due to the use of a random survey design. Most respondents indicated that the highest percent of monitoring time was devoted to surface water quality monitoring compared to ground water quality monitoring and benthic monitoring. Two CA respondents indicated that more time was devoted to benthic monitoring than either ground or surface water quality monitoring. Seven of the CA respondents indicated that the percent of monitoring time was divided equally among the three types of water quality monitoring. Ground and benthic monitoring performed by CAs (PERMON), CAs are separated on the ordination plot (Figure 4.9) mostly based on their relative percent of surface water monitoring (e.g., NBMCA reports 70% of their monitoring is surface water while the cluster of CAs in the bottom right of the plot report 10% for all three types of monitoring). As well, the amount of benthic monitoring CAs reported doing created
distance among CAs in the ordination plot (e.g., HCA estimates that about 50% of their monitoring consists of benthics, while LTVCA reports no benthic monitoring).

Generally the ordination plot does not show much clumping in a single location indicating there is not a convergence to a particular combination of responses.

Figure 4.9  NMDS ordination showing the dissimilarity among 26 CAs based on the responses to questions regarding the relative percentages of different types of water quality monitoring (PERMON). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

When respondents were asked about their perception of the amount of time allocated to water quality monitoring by their CA, for each of surface water, ground water and benthic monitoring only one respondent indicated they believed that ‘a bit too much’ time was allocated to monitoring (Figure 4.10). Twice as many respondents believed that more time should be allocated to both surface water and benthic monitoring by their CA than did those who thought that enough time was being allocated to these types of monitoring. Equal numbers of respondents believed that their CA should allocate more
Figure 4.10 Opinions from 76 questionnaires about the amount of time spent doing each of three types of water quality monitoring (a) surface water monitoring, b) ground water monitoring and c) benthic monitoring).
time to ground water monitoring as those who believed their CA allocated enough time on this type of water quality monitoring. Generally most CA respondents felt that enough of their organization’s time is allocated to surface water quality monitoring (MONTIME; Figure 4.11), with exceptions shown at the left hand side of the ordination: CRCA, CVCA, and HCA respondents believed that much more time should be allocated to surface water quality monitoring. On the other extreme is the respondent from NPCA who believed that a bit too much time is allocated by their organization on surface water monitoring. CA respondents generally felt the same about to the time allocated to ground water monitoring as they did for surface water monitoring although no respondents felt that too much time was allocated to ground water monitoring.

Only one group of CA respondents believed that enough time was allotted by their CA to benthic monitoring: RVCA, SNCA, SCA and KCCA respondents felt enough time was allotted to all types of monitoring. All other CA respondents felt that either a bit more or much more time should be allocated to benthic monitoring by their organization. The plot seems to separate those CA respondents who feel the time allocated to all monitoring types is insufficient (left side of plot) compared to CA respondents who felt that time allocated to all monitoring types is sufficient (right side of the graph). SSMCA was unique in that its respondent did not provide an opinion on the amount of time their CA spent on benthic monitoring but felt that monitoring of both surface and ground water by their CA was sufficient.
Information about the CAs’ benthic monitoring programs was given by respondents in a 12 question set (BMDDETAIL; Figure 4.12). The pattern of the ordination is based the date of the CAs’ benthic monitoring programs’ creation. From left to right on the graph, CAs are arranged from older to younger benthic programs. When this variable is removed, the remaining variation in the pattern of ordination is based on the taxa level to which the CA identifies its collected macroinvertebrates.

**Figure 4.11** NMDS ordination showing the dissimilarity among 29 CAs based on the opinion of respondents to questions regarding the amount of time their CA spends monitoring surface water, ground water and benthos; MONTIME). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
Figure 4.12  NMDS ordination showing the dissimilarity among 19 CAs based on the responses to questions regarding various characteristics of their in-house benthic monitoring program (BMDetail). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

All respondents believed that benthic monitoring findings were important for ‘monitoring and indicators’ (Figure 4.13). Most respondents believed that benthic monitoring was important to ‘public outreach and stewardship’ and ‘remediation and restoration’ and ‘integrated water resource planning/management’ activities of their CAs. Slightly more respondents believed that benthic monitoring was not important to ‘conservation areas management’ and ‘permits and approvals’ compared to respondents who thought benthic findings were important to these CA activities. Equal numbers of respondents found benthic monitoring important and not important to ‘source water protection’. Finally, the majority of respondents felt their CAs’ benthic monitoring programs were not important to ‘reservoir management’ or ‘flood protection’.
Figure 4.13 Responses by staff to questions regarding the importance of information collected from their in house benthic monitoring program to various activities conducted by their CA (a) flood protection, b) reservoir management, c) permits and approvals, d) source water protection, e) remediation/restoration, f) integrated water resource planning/management, g) monitoring and indicators, h) public outreach/stewardship, and i) conservation areas management).
Interestingly, when asked whether benthic monitoring was important to ‘Other’ activities not listed, a couple of respondents indicated that Watershed Report Cards was such an activity. The same respondents indicated that Watershed Report Cards were an important method of reporting benthic monitoring data suggesting that they view Watershed Report Cards as both a CA activity and a reporting method. Other activities listed by respondents included ‘coastal wetland monitoring program’ and ‘development application plan input’. Under ‘Comments’ for this question set, one respondent indicated that there was a desire to use benthic monitoring to evaluate the success of restoration projects but was unable to because the level to which their CA’s staff could identify the invertebrates collected was not detailed enough.

The ordination of the importance of nine CA activities with respect to the importance of their in-house benthic monitoring programs (BM\text{BENEFIT}) is given in Figure 4.14. While there is relatively little clustering, the separation between HCA and ABCA seems to relate to their rank of importance of benthic monitoring in ‘reservoir management’, ‘flood protection’ and ‘permits and approvals’. The respondents at these two CAs indicated that benthic monitoring was rather more important to these activities than did most of the other CAs. In fact, the activities that the HCA respondent thought that benthic monitoring was important to were the activities that the SCA respondent generally considered benthic monitoring not very important to. The separation between KC and HRCA is the opposing importance their respondents placed on their CA’s benthic monitoring to ‘permits and approval’, ‘source water protection’, and ‘conservation area management’ (HRCA = low, low and high whereas KC = high, high, and low).
Figure 4.14  NMDS ordination showing the dissimilarity among 21 CAs based on the responses to questions regarding the importance of their in-house benthic monitoring program to various CA activities (BM\textsubscript{BENEFIT}). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

It appears that for the majority of the CA respondents, ‘internal reports’ and ‘public presentations’ were most important methods for reporting their CA-run benthic monitoring findings (Figure 4.15). More respondents indicated ‘community meetings’ were either somewhat important or very important while the number of respondents that considered ‘board meetings’, ‘monthly reports’, ‘staff meetings’, and ‘presentations to municipalities’ important was almost equal to the number of those that felt these methods were unimportant for reporting benthic monitoring findings. Surprisingly, 21 of the 22 respondents indicated they believed benthic data collected by their CA were not very, or not at all important to ‘watershed report cards’.
Figure 4.15 Survey responses from the information questionnaire asking for a member of each CA to assess the importance of different methods of reporting their benthic monitoring information.
When commenting on their responses to this question set, a couple of respondents indicated that their CA had not collected enough data for them to be used in many of the types of reporting listed. In the comments section for this question, one respondent stated that “The data collected seems to be underutilized. More interdepartmental and public education should be produce to help those not directly involved with the program understand why it is so important and such a good tool to complement water quality data as an indicator of stream health.” In a similar vein, another respondent stated that “Benthic data is used to answer specific questions related to the health of a specific watercourse/watershed, or to identify changes, sensitivity etc. so is sometimes part of information provided for meetings, reports etc. but not always.” A couple of respondents commented on the utility of benthic monitoring – one indicated it was important for “presenting water quality”.

The ordination showing patterns in opinion about benthic monitoring reporting (BMREPORT; Figure 4.16), shows that NVCA stands alone because its respondent ranked benthic monitoring as very important for every type of CA reporting listed. MVCA and CLOCA respondents on the other hand, ranked benthic monitoring as not very important to the types of reporting listed. HRCA seems to be off by itself because its respondent ranked benthic monitoring as very important in almost all reporting except for ‘monitoring reports’; they considered it not at all important in this type of reporting.

From the 11 CAs that indicated they utilize the benthic monitoring information from other organizations for their CA activities, six indicated they used these data provided by either the MOE or MNR, three used the data from their municipalities, two used the data from consultants, one used the data from their own CA coordinated VBM program, and two used VBM data from volunteer community groups that collect this data. The three CAs that stated they used VBM data, were also the only three of the CAs responded ‘Yes’ to the question “Does your CA conduct volunteer benthic monitoring?” Other than TRCA, which collaborates with Citizen Scientists, only Conservation Halton and Kawartha Conservation had respondents who indicated their CA used the information collected by volunteer benthic monitoring for their organizations’ activities.
Figure 4.16 NMDS ordination showing the dissimilarity among 20 CAs based on the responses to questions regarding the importance of their in-house benthic monitoring program to various CA methods of reporting (BMREPORT). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

There was no description for the VBM utilized by Kawartha Conservation but the respondent from Conservation Halton described their use of VBM:

We utilize volunteers to help us in the field collecting any monitoring data. They are never sent out alone and always have a minimum of 1 trained staff member go out with them. We have volunteers come out for a few reasons. 1) So the staff member is not out in the field alone - goes with our policies of working alone. 2) to teach/give a learning opportunity to students or graduates who are interested in aquatic/terrestrial monitoring but have little/no experience with field work. Then hopefully they will be able to add volunteering to their resume and possibly find a job in their field. Volunteers rarely speed up the process of field work with the exception of volunteers who come out for multiple weeks and understand the protocols.”
Hence, this individual indicated that VBM was not at all important at all to most of their CA’s activities except for ‘monitoring/indicators’, for with their opinion on the importance of VBM was neutral (i.e. neither important nor not important). The other two CA respondents indicated that their CA’s VBM activities were extremely important to ‘stewardship and outreach’ and important for ‘remediation and restoration’ and ‘monitoring/indicators’. Volunteer benthic data were considered not important (or at all) for ‘flood protection’, ‘source water protection planning’, ‘conservation areas management’, ‘remediation and restoration’, and ‘reservoir management’.

4.2.4 Attitudes of conservation authorities toward citizen science

When respondents were asked about their opinion about various types of community input (‘volunteer input’, ‘volunteer labour’, ‘volunteer monitoring’ and ‘volunteer benthic monitoring’), almost all respondents agreed that ‘volunteer input’ was ‘useful’, ‘used by other staff of their CA’, and ‘used by other CAs and government agencies’. While more respondents agreed that this type on community contribution was ‘available’, ‘trustworthy’, and ‘program and policy relevant’ than disagreed, a fair proportion also somewhat disagreed that ‘volunteer input’ was ‘available’, ‘trustworthy’ and ‘overall preferable’ to other types of community contribution. A large proportion of respondents had no opinion about the trustworthiness, relevance to CA program and policy and the preference of volunteer input to other types of community contributions (Figure 4.17).
The opinions of CA staff about the characteristic and quality of volunteer input as a form of community contribution to their CA’s activities (a) useful, b) available, c) trustworthy, d) program and policy relevant, e) used by other CA staff, f) used by other CAs and government agencies, and g) overall preferable to other types of community input). Dark bars are used to emphasize directional opinions.
The ordination shows that with respect to ‘volunteer input’ (input in the form of opinions, ideas, and knowledge), most of the CAs fall relatively spread out along the plot (VI\text{INPUT}; Figure 4.18). The factor that appear to separate ERCA/SSMRCA from MVCA, is that the MVCA respondent either does not know or has no opinion on whether ‘volunteer input’ (in the form of opinions, ideas and knowledge) is trustworthy, reliable or preferable to other types of community input. What appears to separate GCA and HCA on the plot is that the respondent of GCA agreed/strongly agreed with most of the adjectives listed, whereas the only characteristic of volunteer input that the HCA respondent slightly agreed with, was its usefulness. This respondent slightly disagreed that it was preferable over other types of community input. Another general separation in the plot is between GCA and CVC. Generally the respondent from GCA agreed/strongly agreed with the adjectives presented to describe volunteer input whereas the respondent from CVC either disagreed or had no opinion on how well the adjectives described volunteer input.
With a few exceptions, respondents overwhelmingly agreed (or strongly agreed) with the attributes listed (‘useful’, ‘available’, ‘trustworthy’, ‘program and policy relevant’, ‘used by other CA staff’, ‘used by other CAs and government agencies’, and ‘overall preferable to other types of community input’) to describe ‘volunteer labour’. There was a fair proportion of respondents who had no opinion on whether ‘volunteer labour’ is program and policy relevant or whether it is overall preferable to other types of community input. Similarly, a number of respondents ‘didn’t know’ whether volunteer labour was program and policy relevant or used by other CAs or government agencies (Figure 4.19).

**Figure 4.18** NMDS ordination showing the dissimilarity among 27 CAs based on the opinion of respondents to questions regarding the characteristics (useful, available, trustworthy, program and policy relevant, used by other CA staff, used by other CAs and government agencies, and overall preferable to other types of community input) of volunteer input (input in the form of opinions, ideas, and knowledge; VINPUT). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
Figure 4.19 The opinions of CA staff about the characteristic and quality of volunteer labour as a form of community contribution to their CA’s activities (a) useful, b) available, c) trustworthy, d) program and policy relevant, e) used by other CA staff, f) used by other CAs and government agencies, and g) overall preferable to other types of community input). Dark bars are used to emphasize directional opinions.
Most CA respondents either agreed or strongly agreed with the majority of the characteristics presented to describe ‘volunteer labour’ (input in the form of labour/work, e.g., tree planting). The variation in the main cluster of CAs in the ordination plot is a result of each CA respondent slightly disagreeing with a different adjective describing volunteer labour – it corresponds to which characteristic the CA respondent happened to disagree with (VLabour; Figure 4.20). The responses of some of the CA participants are preferable over other types of community input. The LPRCA respondent agreed/strongly agreed with all adjectives but strongly disagreed that volunteer labour was used by other staff in their CA and did not know how extensively volunteer labour was used by other

Figure 4.20 NMDS ordination showing the dissimilarity among 27 CAs based on the opinion of respondents to questions regarding the characteristics (useful, available, trustworthy, program and policy relevant, used by other CA staff, used by other CAs and government agencies, and overall preferable to other types of community input) of volunteer labour (input in the form of labour/work, e.g., tree planting; VLABOUR). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
CAs and government agencies or how preferable it was over other types of community input. Similarly, the respondent from ERCA and UTRCA did not know how extensively volunteer labour is used by other CAs and government agencies but UTRCA and MVCA also did not know how reliable volunteer labour is. MVCA also did not know how preferable volunteer labour is to other types of community input although they agreed/strongly agreed with most other characteristics describing volunteer labour.

With respect to ‘volunteer monitoring’ (of any kind), there was much more variation in the opinions of respondents about how well the attributes listed in the questionnaire correspond to this type of community input (Figure 4.21). More respondents agreed that volunteer monitoring ‘useful’, ‘available’, ‘trustworthy’, ‘program and policy relevant’, ‘used by other CA staff’, and ‘used by other CAs and government agencies’. This difference was the smallest for the attribute ‘trustworthy’. As many respondents agreed that volunteer monitoring was ‘overall preferable to other types of community input’ as disagreed and for this attribute, the majority of respondents either had no opinion, or did not know whether this attribute corresponded to volunteer monitoring. In fact more respondents indicated ‘neither agree nor disagree’ or ‘didn’t know’ for this attribute as those that either agreed or disagreed. Similarly, as many respondents either had no opinion or did not know whether volunteer monitoring was ‘program and policy relevant’ or ‘used by other CAs and government agencies’ as there were that had some opinion about the attribute.
Figure 4.21 The opinions of CA staff about the characteristic and quality of volunteer monitoring as a form of community contribution to their CA’s activities (a) useful, b) available, c) trustworthy, d) program and policy relevant, e) used by other CA staff, f) used by other CAs and government agencies, and g) overall preferable to other types of community input). Dark bars are used to emphasize directional opinions.
The cluster of CAs at the mid-lower right side of the ordination plot consists of CAs whose respondents either agreed or had no opinion on the how the adjectives described ‘volunteer monitoring’ (input in the form of monitoring, e.g., measuring stream temperature), and in some cases there was disagreement with one or two of the characteristics presented (VMON; Figure 4.22). It appears that CA respondents on the right side of the plot (ERCA, RVCA, SCRCA, KC) generally show more agreement with the adjectives describing volunteer monitoring than those on the left side of the plot (SSMRCA respondent didn’t know about any of the adjectives and UTRCA only agreed that volunteer monitoring is useful while the LPRCA respondent that that volunteer monitoring was only trustworthy and program and policy relevant). The respondents at the top of the plot had almost opposite responses to the respondents of CAs at the bottom of the graph (e.g., LPRCA and UTRCA respondents had opposite opinions for all adjectives except they both disagreed that volunteer monitoring was used by other staff in their CA).
Between 30 and 60% of respondents ‘didn’t know’ or felt they ‘neither agree or disagree’ with whether the attributes listed describe ‘volunteer benthic monitoring’ (Figure 4.23). When respondents did have an opinion on volunteer benthic monitoring, they generally agreed that it was ‘useful’, ‘policy and program relevant’, and ‘used by other CAs and government agencies’. Equal numbers of respondents agreed as disagreed that volunteer benthic monitoring was ‘available’, ‘used by other CA staff’, or ‘overall preferable to other types of community input’. More respondents, however, disagreed that this type of community input was trustworthy.

**Figure 4.22** NMDS ordination showing the dissimilarity among 27 CAs based on the opinion of respondents to questions regarding the characteristics (useful, available, trustworthy, program and policy relevant, used by other CA staff, used by other CAs and government agencies, and overall preferable to other types of community input) of volunteer monitoring (input in the form of monitoring, e.g., measuring stream temperature; VMON). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
Volunteer Benthic Monitoring

Figure 4.23 The opinions of CA staff about the characteristic and quality of volunteer benthic monitoring as a form of community contribution to their CA’s activities (a) useful, b) available, c) trustworthy, d) program and policy relevant, e) used by other CA staff, f) used by other CAs and government agencies, and g) overall preferable to other types of community input). Dark bars are used to emphasize directional opinions.
There was a range of opinions from CA respondents to the adjectives describing volunteer benthic monitoring (VBENMON; Figure 4.24). Most respondents felt both agreement and disagreement with some of the adjectives but there was little consistency in which adjectives were agreed upon and by which respondents. Some of the outliers in the plot highlight this variation. For example, the UTRCA respondent didn’t know about all but two of the adjectives which he/she slightly disagreed with (its availability and use among other staff of the CA). On the other side of the plot, are CA respondents who agree with many of the adjectives describing volunteer benthic monitoring with disagreement with for only one of the adjectives. The MVCA respondent agreed with 4 of the 7 adjectives and didn’t know about the other 3 whereas LPRCA had almost opposite opinions about the descriptions of volunteer benthic monitoring except both CA respondents agree that volunteer benthic monitoring was useful.
When asked about the importance of any type of community contribution to their CAs’ activities (Figure 4.25), for most CA activities (‘flood protection’, ‘permits and approvals’, ‘reservoir management’, ‘source water protection’, ‘public outreach and education’ and ‘monitoring and indicators’, ‘remediation and restoration’ and ‘conservation areas management’, ‘integrated water resource planning/management’), more respondents believed that community contributions were important for these activities than did those that believed community contributions to not be important. For ‘source water protection’, ‘remediation and restoration’ and ‘public outreach and

Figure 4.24 NMDS ordination showing the dissimilarity among 26 CAs based on the opinion of respondents to questions regarding the characteristics (useful, available, trustworthy, program and policy relevant, used by other CA staff, used by other CAs and government agencies, and overall preferable to other types of community input) of volunteer benthic monitoring (input in the form of monitoring benthic macroinvertebrates; VBENMON). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
stewardship’, all the respondents who had an opinion about the importance of community contribution, believed it was important to these activities (few respondents either had no opinion or had no community contributions to these activities of their CA). Similarly, only very few respondents believed that community contributions were not important for ‘integrated water resource planning and management’, ‘conservation areas management’. The differences between the number of respondents finding community contributions important vs not important was much smaller for the following activities although still more than triple the number of respondents felt community contributions were important to these activities: ‘flood protection’, ‘permits and approvals’, ‘reservoir management’ and ‘monitoring and indicators’. The ordination in Figure 4.26 shows the distance between CAs regarding how relevant their respondents find any type of community contribution to various activities in their organization (COMINPUT). The main cluster on the plot represents CA respondents that agree to some extent that community contributions are important to the CA activities listed. The variation in the cluster reflects the degree of agreement (strong agree versus somewhat agree) and which activities they felt neutral about. The outliers on the graph represent CA respondents that feel that community contribution of any kind has no importance to most of the CA activities listed.
Figure 4.25 Opinions of the CA staff regarding the importance of any type of community contributions to various activities conducted by their CA (a) flood protection, b) reservoir management, c) permits and approvals, d) source water protection, e) remediation/restoration, f) integrated water resource planning/management, g) monitoring and indicators, h) public outreach/stewardship, i) conservation areas management). Dark bars are used to emphasize directional opinions.
The SCA respondent felt that community input was important for Source Water Protection, Remediation and Restoration and Outreach and Stewardship. The CVCA respondent believed that community input was only important to Reservoir Management and Conservation Areas Management.

Respondents were given seven scenarios and asked how beneficial collaborations between VBM groups and CAs were for these scenarios (Figure 4.27). All but three respondents believed that VBM/CA collaborations were beneficial for ‘the promotion of enhanced public relations’ (13 respondents felt neutral). This pattern of responses was
also observed when asked whether VBM/CA collaborations were beneficial for ‘public education on the significance of human actions on the quantity or quality of freshwater resources’, ‘the promotion of community contribution to other CA activities and initiatives’, ‘increasing the number of sites sampled or the frequency of sampling of sites’ and for ‘increasing the social capital (i.e. connections within and between social networks) of the CA’. There were only two scenarios that were slightly more ambiguous in the division of opinions. There were still more than twice as many respondents who found VBM/CA collaboration to be beneficial than not beneficial ‘for cost-effective labour’ and ‘for finding better solutions to problems through of the input by the individuals directly affect by the CA’s management decisions’.

The ordination of the CA respondents’ feelings on the benefit of volunteer benthic monitoring to CAs shows that SCA’s respondent found VBM very beneficial for enhancing public relations for the CA and for increasing social capital of the CA and agreed that VBM was beneficial for public education (VBMBEREFIT; Figure 4.28). This respondent thought VBM was not (or at all) beneficial to any of the other listed statements: For the promotion of community contribution to other CA activities and initiatives, for cost-effective labour, for increasing the number of sites sampled or the frequency of sampling of sites, for finding better solutions to problems through of the input by the individuals directly affect by the CA’s management decisions.
Figure 4.27 Responses of CA staff regarding the benefit of collaborations between their CA and VBM groups for a) public relations, b) public education, c) community engagement, d) labour, e) social capital, f) increased monitoring and g) enhanced problem solving. Dark bars are used to emphasize directional opinions.
At the other extreme is ERCA whose respondent believes VBM is very beneficial in all of the situations provided. At another extreme is the SNCA respondent who had no opinion on the benefit VBM to most statements but felt VBM was beneficial as cheap labour, increasing sampling and for find better solutions to problems. The respondent of CCCA found little benefit of VBM to most of the statements except they felt a slight benefit of VBM to increasing the breadth of sampling.

Figure 4.28 NMDS ordination showing the dissimilarity among 25 CAs based on the opinion of respondents to questions regarding benefit of their CA’s collaboration with VBM programs to various aspects of the CA (enhancing public relations, improving public education, increasing social capital, promote community contributions to other CA activities, provide cost-effective labour, increasing the number of sites and frequency of benthic sampling, find better solutions to problems their CA deals with; VBMBENEFIT). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
Respondents were asked for their agreement with certain statements regarding the factors that pose obstacles to collaboration between VBM groups and CAs (Figure 4.29). There was strongest agreement with the following statements: ‘lack of capacity to provide support (financial, technical or in kind) to VBM groups’ and ‘lack of confidence in the volunteers ability to adhere to the protocols the VBM group uses to collect their data’ with only 4 and 5, respectively, respondents disagreeing that these were obstacles to VBM/CA collaboration. A similar pattern was observed with the statements ‘lack of confidence in the protocols used by VBM groups to collect their data’ and ‘lack of individuals available for or interested in volunteering for the VBM group’. For these statements a greater proportion of respondents stated they ‘neither agree nor disagree’ than for the two former statements (32 and 37% versus 14 and 22%). Relatively similar numbers of respondents agree as disagreed with the following statements: ‘lack of training or experience of CA staff in dealing with or coordinating volunteers in a VBM group’, ‘lack of desire of CA staff or board members to use data collected by VBM groups’, and ‘lack of confidence in the protocols used by VBM groups to collect their data’. The proportion of respondents responsible for these opinions is much lower than for the other statements; the proportion of respondents that answered that they ‘neither agree or disagree’ was 24, 32, and 56%. For only one of the statements were the number of respondents disagreeing higher than for those that agreed; three times the number of respondents disagreed than agreed that a lack of need for the data collected the VBM group was an obstacle to VBM/CA collaborations.
Figure 4.29  Levels of agreement of CA staff to statements regarding the factors that may pose obstacles to collaborations between their CA and VBM groups including: a) lack of training or experience of CA staff in dealing with or coordinating volunteers, b) lack of CA’s need for the data collected by the VBM group, c) lack of desire of CA staff or board members to use data collected by VBM group, d) lack of CA’s capacity to provide support (financial, technical or in kind) to VBM, e) lack of confidence in the protocols used by VBM groups, f) lack of confidence in the volunteers ability to adhere to the protocols, g) lack of cooperation in site selection and h) lack of individuals available for, or interested in volunteering for the VBM group. Dark bars are used to emphasize directional opinions.
Regarding the potential obstacles for partnerships between CAs and VBM groups, the MVCA respondent disagreed (or was neutral) on all of the potential obstacles presented in the questionnaire (Figure 4.30; VBMObscollab). Contrary to this, the

![Figure 4.30](image)

**Figure 4.30** NMDS ordination showing the dissimilarity among 27 CAs based on the opinion of respondents to questions regarding obstacles to the collaboration of their CA with VBM groups (lack of training or experience of CA staff in dealing with or coordinating volunteers, lack of CA’s need for the data collected by the VBM group, lack of desire of CA staff or board members to use data collected by VBM group, lack of CA’s capacity to provide support (financial, technical or in kind) to VBM, lack of confidence in the protocols used by VBM groups, lack of confidence in the volunteers ability to adhere to the protocols, lack of cooperation in site selection and lack of individuals available for or interested in volunteering for the VBM group; VBMObscollab). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
GCA respondent agreed that all of the items are obstacles to collaboration but was neutral about whether the lack of confidence in the protocols used by VBM and whether a lack of cooperation in site selection were obstacles to collaborations between CAs and VBM groups. Along the other axis, are CA respondents that agree that some of the items are obstacles to collaboration and disagree that others are and opinions on the right side of the graph seem to be opposite to the opinions on the left side of the graph (e.g., SNCA agrees that 3 of the items are obstacles and SCA respondent agrees that 4 of the items are; however, only both respondents strongly agree that CAs have a lack of capacity to support collaborations with VBM groups). Another separation is that only MVCA, KC and NPCA respondents disagreed that the lack of CA capacity to support VBM groups was an obstacle to collaboration. The respondents of LPRCA and NPCA both disagreed and agreed with certain items in the questionnaire; however, the items that the respondent from LPRCA strongly agreed were obstacles to collaboration (the lack of training of CA staff to coordinate volunteers and the lack of capacity of CAs to support VBM groups), the NPCA respondent disagreed were obstacles. As well, where the NPCA respondent felt strongly that a lack of volunteer availability or interest was an obstacle to collaboration, the LPRCA respondent strongly disagreed that this was an obstacle.

When asked to state their agreement with a number statements regarding the obstacles preventing the use of VBM collected data in CA decisions regarding freshwater management (Figure 4.31), less than 20% of the respondents with an opinion disagreed that lack of VBM data use by CAs was because of ‘lack of resources for CA staff to coordinate their own VBM program’ and ‘lack of resources to provide support (technical, in kind or funding) to the VBM group’. Similarly, there were few respondents that disagreed that the ‘discrepancy between the data collection protocols used by the VBM group and those used by the CA’ was an obstacle to VBM data use by CAs.
Figure 4.31 Levels of agreement of CA staff to statements regarding the factors that may pose obstacles to the use of VBM data by CAs including: a) lack of resources for CA staff to coordinate their own VBM program, b) lack of need for the data collected by the VBM group, c) lack of resources to provide support (technical, in kind or funding) to the VBM group, d) lack of desire by CA staff or board members to use data collected by VBM groups, e) lack of training or experience within the CA for evaluating the quality of volunteer collected data, f) discrepancy between the data protocols CA uses and those for which the VBM group uses and g) discrepancy between the sites that the CA requires data for and those for which the VBM group has collected data. Dark bars are used to emphasize directional opinions.
For three statements the number of respondents agreeing and disagreeing was almost equal: ‘lack of desire by CA staff or board members to use data collected by VBM groups’, ‘lack of training or experience within the CA for evaluating the quality of volunteer collected data’ and ‘discrepancy between the sites that the CA requires monitoring for and those for which the VBM group has collected data’. For the last statement, however, less than half of the respondents had an opinion (i.e. 54% responded that they neither agree nor disagree). Only one statement had more respondents disagree with this than agree with it; 25% of the respondents with an opinion disagreed that ‘lack of need for the data collected by the VBM group’ was an obstacle for the use of VBM data by CAs.

The variation in the ordination plot (Figure 4.32) relating to the obstacles to use of VBM data (VBMBSDATA) by CAs is due to the strength of opinions regarding the obstacles listed. In the centre are a cluster of CA respondents that have either moderate or no opinion on the statements regarding obstacles to data use by CAs. The further from the centre of the plot, the more extreme the opinions of the CA respondents are and their location around the central cluster and how different they are from the other extreme opinions of CA respondents (e.g., the respondent at LPRCA strongly disagreed that all but 3 items were obstacles to VBM data use: no resources for staff to coordinate their own VBM, no CA capacity to support the VBM group, inability of CA to assess the quality of the VBM data).
The SCA respondent agrees strongly with all but three of the obstacles; this respondent strongly disagreed that discrepancy between VBM and CA data collection protocols, ability of the CA staff to assess VBM data quality and discrepancy between CA and VBM data collections sites are obstacles to the use of VBM data by CAs.

Given four scenarios and asked under what circumstances a CA should consider replacing its benthic monitoring program with one that uses volunteers to collect benthic monitoring data, the median number of selections by respondents was 2.5 scenarios and there is not much variation in the number of times the four scenarios were chosen. The scenarios were chosen as follows: ‘funding that was allocated to your benthic monitoring program’.

![Figure 4.32 NMDS ordination showing the dissimilarity among 28 CAs based on the opinion of respondents to questions regarding obstacles to the use, by their CA, of data collected by VBM groups (lack of resources for CA staff to coordinate their own VBM program, lack of need for the data collected by the VBM group, lack of resources to provide support (technical, in kind or funding) to the VBM group, lack of desire by CA staff or board members to use data collected by VBM groups, lack of training or experience within the CA for evaluating the quality of volunteer collected data, discrepancy between the sites that the CA requires data for and those for which the VBM group has collected data; VBMOSDATA). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.

The SCA respondent agrees strongly with all but three of the obstacles; this respondent strongly disagreed that discrepancy between VBM and CA data collection protocols, ability of the CA staff to assess VBM data quality and discrepancy between CA and VBM data collections sites are obstacles to the use of VBM data by CAs.
program was no longer available’ (43 times), ‘funding is available to your CA staff to identify the benthic invertebrates collected by the VBM group your CA collaborates with’ (37 times), ‘funding is available for your CA to coordinate a Volunteer Benthic Monitoring (VBM) program’ (31 times), ‘funding is available to collaborate with a VBM group that exists in your watershed (i.e. provide technical, in kind or funding support)’ (31 times). Only six of the respondents felt that none of these scenarios was an appropriate circumstance for replacing their CA’s in-house benthic monitoring program. Surprisingly, there were slightly more individuals that felt all four scenarios were appropriate compared to the number of individuals that felt that only one of the scenarios was appropriate for replacing their CA’s benthic monitoring program (20 and 18 individuals, respectively). Approximately half that many individuals chose two or three of the scenarios (10 and eight, respectively).

Generally there is a relatively uniform spread in the CA positions on the ordination plot (Figure 4.33) relating to the scenarios that CA respondents chose to replace their CA benthic monitoring programs (VBMSCEANRIOS) with the exception of a few clusters. There is a cluster on the right side of the graph consisting of 7 CA respondents who selected all the scenarios. As you move further left, the number of scenarios chosen by CA respondents decreases with HCA and SCA respondents selecting none of the scenarios. The spread along Axis 2 of this plot relates to the variation in which scenarios were chosen by CA respondents that chose the same number of scenarios.
Figure 4.33 NMDS ordination showing the dissimilarity among 29 CAs based on the opinion of respondents to which of four scenarios they found to be acceptable circumstances under which their CA would replace their in-house benthic monitoring program with VBM (funding for the CA’s program was no longer available, funding was available for their CA to coordinate their own VBM program, funding was available to collaborate with VBM programs that were independent from the CA, and funding became available for staff to identify the invertebrates collected by VBM programs; VBMScenarios). CAs that are more distant from each other in the plot space are more dissimilar than CAs that are closer together.
Chapter 5

5 Discussion

5.1 Conservation authorities

5.1.1 The role of CA capacity in supporting citizen science

Participants from CAs discussed a number of the indicators of capacity both internal and external to their organizations, first generally, and then in some instances with respect to their organizations’ abilities to implement or support VBM. The indicators of capacity internal to their organization that seem most relevant included those related to resources (human, information and financial), and organizational dynamics including flexibility social learning and partnerships. The indicators of capacity external to their organizations include links to the community and community support, and partnerships and collaborations with other organizations.

From the comments and examples provided by the interviewees, all of the CAs demonstrate a great capacity to accomplish their organizational tasks due to the qualities of their human resources. In most cases board of directors were viewed as supportive and “environmental types” that want what is right for the watershed and for its people. More importantly, staff appears to be dedicated, flexible and motivated to accomplish the work of their conservation authorities and have excellent interpersonal skills that allow them to work effectively not only with co-workers but also with individuals outside the organization. Staff were also considered by all individuals interviewed, to be highly skilled with the education and technical expertise to conduct all CA activities.

Surprisingly though, there was a split in agreement by respondents regarding whether a lack of training or experience of CA staff in dealing with, or coordinating volunteers would be an obstacle to collaboration. So while the participants of the case research unanimously extolled the capabilities of their human resources, almost half of the survey respondents thought a lack of training or experience of CA staff to deal with volunteers was a factor that might preclude getting involved in VBM. While the CAs in the case studies appear to have the type of staff that will provide the capacity to achieve
organizational goals, in all the cases, it seems there are just not enough of them to tackle the amount of work that exists to fulfill all of the CA goals completely. This would pose a significant challenge for finding the staff time to allot to either coordinating a citizen science program or liaising with citizen sciences groups coordinated outside of their CA. According to the staff at RVCA who coordinate and manage the City Stream Watch program, each year even they have a difficult time finding the soft funding to support the associated staff to accompany the volunteers into the field for the stream monitoring they do. For successful citizen science, coordination is vital (Pollock et al. 2003; Pollock and Whitelaw 2005; Bonney et al. 2014; Loos et al. 2015), and if a CA considered coordinating their own VBM program, at least one staff member would need to be dedicated to this task. If a CA was merely to liaise and provide support for a collaborating citizen science group, it seems that some significant dedication of staff time would be required as well.

Most participants were satisfied with the information resources they have access to and while none complained that lack of access to the needed information interfered with them completing their tasks, a couple of suggestions for improvement were offered. The first relates to the lack of time to access up-and-coming information, i.e. the time to explore new developments in the general fields which their tasks are related (an example given by one staff member was green energy), and the second was one wish list item for more up-to-date technology for information access. Both of these are relevant to the capacity of CAs to implement or support citizen science. Sheikheldin et al. (2010) examined science use for policy making by nine CAs and found that lack of time, limited financial resources and the and lack of available relevant and credible science tended to be somewhat, or moderately, viewed as impediments to the use of science. In considering the lack of time for exploring their fields of practice, unless staff happen upon some literature about citizen science in their search for ‘need to know’ information, it is not likely that most staff have the opportunity to sufficiently acquire the background or context on the topic with which to assess the costs/benefits of this activity for their organization. Not only is most of the useful literature about citizen science in peer-reviewed academic journals (as opposed to grey literature including government reports), this field is still in its infancy compared to say a topic like ‘climate change’ which is
commonly featured in the mainstream media, government reports and other gray literature. As one participant noted, staff often have little time to explore information that is not absolutely relevant to the tasks they are currently dealing with. This lack of capacity to explore the relevant literature on citizen science may also play an important role in their attitudes toward the potential value of VBM to CAs; it may limit their ability to develop an informed opinion on the potential viability of either implementing their own VBM group or collaborating with one already in existence. Therefore despite the growing body of literature that presents VBM as a form of citizen science that can produce viable data concordant with that collected by professionals (e.g., Moffett and Neale 2015), without access to this information CA staff and managers may hold on to more dated views of volunteer data’s inferiority to that collected by experts.

None of the participants felt they experienced a deficit of opportunities for professional development, and most indicated that sought out and received most of the training they felt was needed to do their jobs effectively. Many participants cited conferences as sources of professional development, and in particular, the annual A.D. Latornell Conservation Symposium organized by Conservation Ontario and the University of Guelph were often mentioned. Having attended and presented a poster at this conference in both 2010 and 2011, I have experienced the range of topics that CA participants are exposed to. As well, I used my attendance as an opportunity to network and seek both the CA and citizen science cases for this study. Given the breadth of topics presented at this event, including community collaboration and citizen science, attendance by CA staff at this symposium would significantly enhance the capacity for CAs to consider implementing or supporting citizen science in their management activities.

From the interviews of the 34 CA participants it was clear that the lack of financial resources was a major constraint in their capacity to complete their organizations’ tasks. As a testament to the perceived effectiveness of their employees, most participants thought the best investment of finances would be for the hiring of more staff. In fact one wish list item presented during interviews was for finances to support an individual to work directly with the community as a volunteer manager that could provide support for citizen science. These interview findings are supported by the survey results; 50 of the
67 respondents agreed that lack of CA’s capacity to provide support (financial, technical or in kind) to VBM is an obstacle to collaboration of CAs with VBM. As well, 48 agreed that this lack of capacity to support VBM was an obstacle to their organization using the data collected by VBM groups. The lack of stable long-term funding poses a major capacity problem for CAs, not only because it prevents the ability of managers to hire more staff, but it takes some significant time away from the high quality staff they already have; instead of undertaking the tasks of the CA, staff are spending up to 30% of their time applying for external, short-term and unreliable funds. This is an example of how an organization is not capitalizing effectively on the specialized skills and knowledge of their employees.

Some consider the organization’s ability to acquire external funding a demonstration of reduced capacity (Grindle and Hilderbrand 1995), whereas, others it as a good indicator of capacity (Timmer et al. 2007). All of the participants that discussed this topic regarded their CAs as highly accomplished at seeking external funding. de Loë et al. (2002) describe how relying on such sources of funding can reduce an organization’s capacity since funding priorities often change causing a reduction or an end to the flow of funds. A study by Cervoni et al. (2008) found that the most often cited barriers to Integrated Water Resources Management (IWRM) by CAs in Ontario were related to capacity, primarily due to lack of financial resources, and that a key concern was that many core CA programs (e.g., development of water strategies) are executed without any provincial government funding. Other management studies in Ontario also speak to such insufficient investment in CAs by government (Carter et al. 2005; de Loë and Kreutzwizer 2005; Shrubsole 1996). Not only did all 31 individuals interviewed by Cervoni et al. (2008) indicate that investment would increase capacity and aid in managing resources more effectively, a number of the Ontario participants (consisting of CA and CO staff, government employees and academics) emphasized the importance of sustained and long term funding to “ensure continued and consistent management of water resources” (pg. 343).

**Organizational dynamics** play an important role in capacity, and one important element of such dynamics is flexibility and organizational learning. CAs demonstrate a lot of
flexibility in their individual staff (see previous discussion) as well as by their organizations as a whole. Despite the revolutionary change experienced by CAs in the mid 1990s, most participants in this research ultimately see their organizations as more capable at succeeding in their task and doing so more effectively, than before the change. As one participant noted, it forced them to realize who their real client is (the municipalities) and build stronger ties at a more local scale. As well, the case CAs in this study seemed to do a tremendous job of finding external funding to complete their tasks, even if the funding is not central to their core suite of activities. This shift to pro-activity in seeking funding was an example of organizational learning that resulted from the 90s funding cuts which was observed by the research done by Michaels et al. (2006). They examined the organizational learning associated with focusing events and their research also uncovered stories by a number of their interviewees about how their CAs turned their emphasis to partnerships – “with local communities, other conservation authorities, government agencies and private enterprises” (pg. 989, Michaels et al. 2006).

Many participants in this research discussed how especially in their permits and regulations departments, there was a move by the organization to focus more on assisting land owners to take the appropriate actions by concentrating on compromise, incentives, education and stewardship rather than simple enforcement. This seems like it has been an important adaptation for how CAs are redefining their organizations. As stated by Michaels et al. (2006), “This experience of collaboration has led conservation authorities to define themselves in terms of how they do business as much by what their business is” (pg. 990). As well as organizational learning, the changes made by CAs in response to the focusing events of the Harris cuts and Walkerton tragedy demonstrate ‘adaptive flexibility’ – the ability to adopt new strategies to solve a problem or overcome an impasse (Georgsdottir and Getz 2004). While the qualities of the staff and management strategies of the case CAs suggests these organizations possess ‘spontaneous’ flexibility (finding diverse solutions when there is no external pressure to be flexible), both interviews and the surveys suggest that a solution consisting of adopting VBM could really only emerge with the development of another focusing event (e.g., more cuts to the their stable funding sources; discussed below).
While CAs have demonstrated high capacity through their **flexibility and capability for organizational learning** as a response to focusing events, on a daily basis, it was noted by some of the participants that more could be done in the practice of strategic planning. This line of discussion developed in a number of interviews after asking questions on the topic of the future changes that might affect CAs and the work that they do. Participants believed it was vital to take time to “stand back and say ‘Why are we doing this?’ ‘Can we do it more efficiently?’” in order to be “always on top of what are the essential tasks that we need to do and then having the resources to back them up.” A couple of the participants noted that understanding their community’s needs and knowledge, and focusing on the relationships they have with the public, was central to the strategic planning process. While this strong focus on community that I observed in the case CAs would promote capacity for the adoption of citizen science, a deficit of strategic planning may preclude the opportunity for CAs to really take the opportunity to examine the challenges and benefits their organizations might experience in implementing or supporting citizen science programs. Similarly, such a deficit in opportunities for more routine exercises in strategic planning would seem to also diminish the organizations’ potential for spontaneous flexibility (Georgsdottir and Getz 2004), and hence, diminish the opportunities to consider citizen science as a potential solution to some of the problems CAs commonly face in incorporating community in executing the tasks of their organizations.

With respect to the **flexibility of individual staff**, a number of participants have described their managers supporting staff in their creativity and innovation, allowing them to feel comfortable taking risks regardless of the outcome. This type of management goes beyond just providing the training and education experiences for staff to develop their skills and abilities, it allows them to ‘safely’ use their new knowledge and expertise (Franks 1999; Crisp et al. 2004). This promotes individual learning. At the organizational level, all of the top managers describe how their job is managing people and so a constant learning process (i.e. assessing daily how staff are dealt with, policies are made and partnerships are maintained). This type of management would increase the capacity of CAs in general, and more specifically, the capacity of a CA to find solutions.
and adaptations in the process of incorporating citizen science effectively into their activities and management tasks.

Another important element of organizational dynamics contributing to the capacity of CAs is their ability to form networks, partnerships and collaborations both within and outside their organization (Kean 2008). From the interviews of this research the case CAs demonstrate enhanced capacity through these types of collaborative behaviours. Most participants stated that they work extensively with a number of individuals in other departments within their CA (and they do so effectively as well, given their comments on the strong interpersonal skills their CAs staff are described to have). All CA participants emphasized the importance of external partnerships to their ability to achieve their goals. Their capacity is also significantly enhanced by their partnerships with other CAs and CO, academia, governments, NGO’s and community. A few potential ways that these networks would serve CAs well in their attempts to incorporate citizen science and VBM into their organizational activities, are by providing knowledge and expertise (e.g., protocols, coordination best practices and advice etc.), resources (e.g., financial, in kind), potential to access a greater range of funding sources, and a volunteer base – interested community members willing to volunteer their time for the collection of data.

The external indicators of capacity that this research examined included community support, as well as political support and guidance (Kean 2008). CA participants placed a really strong emphasis on working with community in achieving their organizational goals. They all discussed how important community support is in accomplishing the tasks they undertake by providing numerous examples of the types of community contributions their organizations utilize; from simply using volunteers for their labour potential in stewardship and restoration events (e.g., tree planting, invasive species removal etc.), and in a few cases, ongoing data collection (i.e. citizen science), to valuing their input on planning and strategy committees, collaboration with the public occurs across the continuum of community contributions. This strong support for community involvement was echoed by the 67 survey respondents who were associated with 29 of the 36 CAs in Ontario. They mostly agreed that these volunteer activities were useful, available, trustworthy, program and policy relevant, used by other staff in their CA, and
used by other CAs and government agencies. CA participants in the case research viewed all types of community contributions as a vital avenue for educating the public not only about the specific issues that their watershed is experiencing, but about how CAs are working to improve watershed conditions. As well, in many of the types of community contributions, CA participants viewed information flowing both ways – participants gave examples of their CAs gaining valuable local knowledge about characteristics of the watershed, a better realization of the comprehension the community has about watershed issues, as well an opportunity to understand needs of the public. Day et al. (2014) acknowledges that there is a “trend away from unilateral communications approaches to more dialogue and interactivity” which is a key element of effective communication (pg. 232).

Creating such strong community ties would significantly enhance the capacity of CAs to support or implement citizen science. These links to community would provide CAs with an understanding of the concerns that the public might volunteer their time for (i.e. the types of issues they would be willing to help collect data to address). They would also provide CAs with a better understanding the gaps in knowledge the public may have, and how particular types of citizen science might contribute to educating community around conservation or water issues that may be more poorly understood/recognized by the public. One participant emphasized how important it is for CAs to really understand the perceptions of the public - their attitude toward, and value they place on the environment - so that CAs can properly market and advertise in order to get the public more enthused about getting involved with the work that CAs do. This link between the public and environmental management has been addressed in the literature and examined from a number of perspectives. For example, in examining the role of communication in marine protection, research by Day et al. (2014) highlights the importance of understanding your audience (e.g., values, motives, knowledge) in connecting with, and inspiring a response by the public. DeCaro and Stokes (2013) developed a framework to assess how well environmental institutions match human expectations and local behavioral patterns in order to improve the effectiveness of public participation in the activities of these institutions.
Despite the high level of input case CAs sought from the public, some participants discussed the challenge they have maintaining a positive impression with the public which they believed was a throwback from the poor reputation that developed from their permitting and regulations activities of the past. While this would reduce capacity of the CAs to support or implement citizen science, all the CA participants that discussed this issue provided examples of effective ways that they have been changing their practices in order to combat this poor impression. Citizen science can also provide organizational capacity in the form of community support and enhanced social capital. The participants at RVCA discussed how the activities of City Stream Watch garner interest by the public in the activities of the CA as well as provide more of the watershed’s population with an understanding of the work that RVCA does and also about what this CA hopes to accomplish. One of the CA participants in the recent study conducted by Murphy-Mills (2015) also commented how in community based monitoring, the monitoring is almost secondary to the benefits it provides to community relations and that involvement influences the buy-in of the community in the activities of the CA. Cervoni et al. (2008) interviewed a staff member of UTRCA who indicated that not all members of the public understand what a watershed is and even municipal officials had difficulty with this concept. They went on to suggest that with the challenges that CAs are faced with in “linking social systems with the natural environments that people inhabit”, education as an activity of watershed management is vital (pg. 342, Cervoni et al. 2008).

**Political support and guidance** can by evaluated through the institutional arrangements an organization has. For CAs, these predominantly refer to the relationships they have with various levels of government. At the federal level, some CAs held DFO agreements to monitor the potential for threats to at-risk fish species and their habitats during their assessments for permitting and for development proposals. While not compensated by DFO for this service, this arrangement provides noted benefits to CAs; they have the opportunity to streamline the permitting process for the public they service, reducing the work and potential frustration of their clients in dealing with multiple permitting institutions. Since cuts in the 1990s, the institutional arrangements between CAs and the provincial government has both created clarity in the roles and responsibilities of the CA as well obliterated a significant source of continuous and reliable funding. However,
despite the lack of financial support, most CA participants felt they were supported in their activities by provincial offices. One participant noted that support by provincial departments in CA activities was essential since “mandates with regards to hydrology, water quality/quantity, those sorts of things were still a responsibility of say for example, the Ministry of the Environment”. As well, with the loss of provincial funding came an autonomy that allowed CAs to lose the “filter through which new perspectives must pass” (pg. 136, Naess et al. 2005), enabling them to be proactive and creative in their solutions for rebuilding after the funding collapse. Finally, the institutional arrangements between the CAs and municipalities were strengthened by the Harris cuts; CAs now work closely with municipalities in providing the watershed management services. While most participants noted that they felt they received good guidance and support from their municipalities, some also discussed the difficulty in improving the financial support they receive from these entities through levy increases – some participants noted that often the most pushback to levy increases was by the smaller municipalities within their watershed. Generally it seems from this research, that within the institutional arrangements that CAs have with each level of government, the mandates, tasks and goals of the different organizations are well enough delineated to provide CAs clarity regarding what their responsibilities are. However, Cervoni et al. (2008), after an interview with a Conservation Ontario staff stated that “The lack of clarity in water resources management roles and responsibilities results in confusion regarding the responsible authority, a loss of efficiency, and a duplication of effort” (pg. 340).

I observed an exercise at one board meeting I attended where the CA managers were attempting to re-evaluate what their organization’s core activities should be. It seems that when questions do arise on how to focus the mandates of their organizations, it is not as much about who should do what, but more about which of the myriad of important things can their organization afford to do and be most effective and efficient at, while at the same time considering which are most important for the health of the watershed and its inhabitants. The support and guidance from the institutional arrangements that CAs have with governments would probably provide some capacity to enable CAs to consider supporting and implementing citizen science in their activities. CAs have enough autonomy to examine the costs and benefits to their organization; however, with the
myriad of other tasks pulling at their time and resources, it may be difficult for them to take the opportunity to fully examine the potential that citizen science may have for their organizations. Murphy-Mills (2015) found that government cutbacks have pushed CAs to work more closely with community groups to fill monitoring gaps left by reduced capacity and staff; she examined cases where CAs depended on continued support of volunteers to sample sites that they would not likely be able to sample without the use of volunteers. A CA participant in her research, however, also cautioned that the role of CA staff in community initiatives was highly dependent on the CAs capacity since there is a requirement of having the staff to deal with all aspects of the implementation of a citizen science program (Murphy-Mills 2015).

Generally, it seems that CAs have high capacity at the organizational level including human resources, flexibility and collaborations and externally with their community support and most of their institutional arrangements. However, the effect of low capacity resulting from a lack of resources is significant. The quality of their staff, the style of their management and the flexibility they have demonstrated both through their people and as organizations, suggests these watershed management agencies have a high capacity for implementing or supporting a successful VBM programs. However, as described by the three citizen science groups in this research, these programs require the investment of resources including staff to coordinate the volunteers and manage the data, all of which may involve data validation, analysis and reporting, equipment and supplies, and possibly space and equipment for the processing of samples collected in the field. While the consensus is that CAs do extremely well given the financial resources they have to work with, they are constantly struggling for the funds to achieve all of the goals that they would like to achieve. Hence, in order for CAs to use what capacity they do have for the support or implementation of citizen science, it is the attitudes that need to change in order for say, VBM to become a reality.

5.1.2 The role of CA attitude in supporting citizen science

CA participants discussed their monitoring programs which were considered critical activities of their organizations. One manager called monitoring the foundation of his organization and the basis of everything his CA does. Not only is realizing the value of
monitoring information critical for the support of citizen science, I argue that support for strong monitoring programs enhances the capacity of CAs – gaining information is a critical step in the process of adaptive management and being more adaptive (i.e. learning from and acting on gathered information) enhances an organization’s ability to perform their tasks and achieve their goals.

Monitoring, however, can be held in such high regard that there is little consideration of other potential ways to acquire this information other than through its collection by experts. The same CA manager, described monitoring as “sacred” and as with most of the case CAs, his CA’s monitoring programs (including biomonitoring) are supported using core funding (often with the levies provided by the municipalities). Hence, it seems there would be little incentive to make any sort of move away from expert monitoring without assurances that the data collected by any non-expert is of the same or better quality as that collected in-house by CA employees. The attitudes of the CA staff and board members play an important role in whether there can be support for water quality citizen science and in particular, VBM. Participants expressed a mix of opinions citing both the benefits and challenges they associated with the implementation of citizen science within their CA.

The benefits of citizen science were acknowledged by all participants, even those that discussed the challenges, and included public education about ecosystem services, increased awareness by the public about how their individual actions impact natural systems, increased monitoring locations and intensity resulting in a greater ability to make effective management decisions, a public that is more engaged in the planning and decision-making associated with the resources being monitored, that has a better understanding of the need for monitoring and public that better understands of the role that CAs play in managing the anthropogenic activities that impact freshwater systems. This better understanding of the CAs’ roles, activities and responsibilities would ultimately enhance the publics’ perceptions about CAs, hence, fostering more support for the work these organizations do. The survey data support these observations. Overwhelmingly, respondents felt that any type of community input would enhance all of the different types of activities conducted by their CA and that collaboration with VBM
groups in particular, would be beneficial to public relations and education, community engagement, social capital and as cost-effective labour for increasing the amount of data in their CAs’ monitoring programs. Some of the community based monitoring and NGO participants interviewed by Murphy-Mills (2015) believed that CAs should do more to foster the activities of community based monitoring through their provision of technical support and their expertise, while others believed that CAs limited by “time and manpower and funding” could benefit from the production of data through community based monitoring ( pg. 82). While this perspective suggests that CAs should provide support to CBM, other CA participants believed that CAs play a central role in creating community based monitoring programs that are a supplement to their own monitoring (Murphy-Mills 2015). This distinction aside, a majority of their interviewees believed that community based monitoring fits well with the mandates and community focus of CAs. They also thought that CAs, as quasi-governmental agencies, could play a unique role in connecting, like a “really awesome hub”, the community, local municipalities with which they work closely with, and the higher levels of government through their partnerships (particularly with the provincial ministries) (pg. 84, Murphy-Mills 2015).

Some of the benefits mentioned by CA staff were also benefits that the citizen science group participants experienced through their programs. Among the directors, coordinators and volunteers in these groups, participants observed (or experienced) the education and engagement of the volunteers, the increase in knowledge about water resources through the collection of quality data that might not otherwise be acquired, and for some, the use of the data in coordinating restoration and stewardship activities. Branchini et al. (2015) demonstrated that citizen science projects have an important and effective education value. Administering a questionnaire before and then several days after participation in citizen science activities (i.e. collecting data on the presence and abundance of key coral reef taxa), resulted in a significant increase both in volunteers’ knowledge of coral reef biology and ecology, and in their awareness of human behavioural impacts on the environment (Branchini et al. 2015). The experiences of volunteers and coordinators in this case research support Cuthill’s (2000) argument; citizens that take part in community based monitoring, experience positive attitudes and behaviours towards their environment. The volume and extent of data that can be
collected by volunteers was examined by Theobald et al. (2015) who focused on citizen science projects that collected data on biodiversity; from 326 projects, over 67% collected information at a regional scale (100 - 10,000 km or more) and these projects were on average, seven years longer than an average National Science Foundation grant. There has also been an explosion of publications demonstrating the application of citizen science to environmental understanding and management (for recent reviews see Theobald et al. 2015; Roy et al. 2015; Powney and Isaac 2015; and Dickinson et al. 2012). From learning more about the distribution of small plastic debris on beaches (Hidalgo-Ruz and Theil 2013), to better understanding population trends and ecology of the Secretarybird (Hofmeyr et al. 2014) and monarch butterfly overwintering in the USA (Howard et al. 2010), to gaining a better understanding of how dung beetles decompose cowpats (Kaartinen et al. 2013), scientists and research and resource managers are gaining valuable information through the use of citizen science. A number of participants in this study who expressed their support for the implementation of citizen science and VBM by their CAs, also held the common opinion was that the monitoring data collected by volunteers should merely supplement the programs already in place the CA. Murphy-Mills (2015) observed two types of support for community based monitoring by CAs: CAs with limited resources of their own doing what they could to support community based monitoring groups in providing supplementing their CAs’ databases versus community based monitoring groups supporting CAs as a program within their organization.

CA interviews often mentioned the **challenges working with volunteers** (particularly in recruiting sufficient numbers of volunteers and the ability of the CA to recruit and retain volunteer benthic monitors), their limited capacity, and the reliability of the data that could be collected through citizen science. In both rural and urban based CAs, participants believed that volunteers could not be counted on to supply the needed benthic monitoring data. In rural areas, one participant believed that the small population size of their watershed would preclude their ability to sustain interest in such programs; that they could not recruit enough volunteers to maintain VBM programs. In urban areas, it was argued that despite the high population from which to draw volunteers, there was just too much information required to be able to consistently depend on volunteers to
provide the data. These opinions about volunteer recruitment and retention were echoed in the results of the survey; there was an almost even split in how the respondents felt about the availability of VBM, with as many agreeing it was available as those disagreeing. As well, almost half of the respondents agreed that the lack of individuals available for, or interested in volunteering for the VBM group, was an obstacle to the collaboration between CAs and VBM groups. Participants from all of the citizen science cases in this research had something to say regarding the challenges working with volunteers. Some talked about the extra effort in coordinating resulting from volunteers with “less commitment” to the project; some volunteers do not show up or need to leave early without notice, often a number of individuals have very low flexibility with regards to scheduling etc.

Another challenge in implementing and supporting VBM that many CA participants noted was the limited capacity of the CA itself. One of the CA managers described how they just lacked the capacity to support coordination beyond some coaching, training and loaning of equipment. In their review of documented citizen science projects in hydrology and water resources, Buytaert et al. (2014) identify resource intensity as a major research and implementation challenge for citizen science; it is human resource intense particularly in coordination, training/education, and in maintaining an acceptable level of participation (Gura 2013). A number of the CA participants in Murphy-Mills (2015) research cited their organization’s capacity as an obstacle for becoming involved in community based monitoring as well.

As well as lacking the human resources for the coordination of VBM programs, another major capacity concern for most CAs that is associated with this type of citizen science, is the time and cost of sorting and identifying the benthos. While citizen science could be used to increase (in some cases) the number and extent of benthic sampling areas, it appears that few CAs would have the capacity to process those samples; a lot of time and effort is required to train volunteers, the cost of the time for staff to sort and identify that many more samples was considered by a few participants as impossible, and the high cost of expert taxonomy services would preclude their ability to out-source the identification of the benthos from that many samples. Both URBAN and Citizen Scientists coordinate
and supervise their volunteers sorting of benthos from samples. The samples are ‘picked’ for live bugs the same day that the samples are collected. In the case of Citizen Scientists, as well as sending the sample away for expert sorting and identification to the lowest possible level, the program supervises the identification of the stream bugs to the Order level (Citizen Scientists 2015b). URBAN staff which have been trained and certified through the OBBN, distinguish 27 taxa groups (a mixture of Classes, Orders, sub-Orders, and Families) that comprise the minimum taxonomic precision for the Ontario Stream Assessment Protocol (OSAP) and Ontario Benthos Biomonitoring Network (OBBN) (Stanfield 2013).

One of the most common challenges discussed by CA participants was their lack of confidence in the reliability of the data that VBM groups collect. Some of the reasons cited were the biases that volunteers would have collecting the data and their inability to follow protocols. Both of the VBM groups used protocols and identification methods that were developed and vetted by provincial departments and are the same as those used by most of the in-house CA benthic monitoring programs and in both cases, their conclusions are drawn from identification of the invertebrates by an expert. According to the director of URBAN, not only do they lack the resources to set up a lab with microscopes to support the identification of benthos by volunteers, she thought that there was only a certain type of volunteer (i.e. mainly students looking for marketable experience), that was interested in this aspect of the project and that many others just were not that interested in identifying the bugs. As for Citizen Scientists, perhaps the time and effort to train volunteers to identify the bugs was deemed just not worth the resources, or perhaps the data quality was also a consideration in this decision (the director of Citizen Scientist is also a staff member of a CA), but unfortunately, I did not specifically ask about the reasoning behind the decision to use an expert taxonomist. Murphy-Mills (2015) found that there was a mix of CAs (from the nine within the Oak Ridges Moraine) that participated in community based monitoring of any sort and one participant from a CA indicated that while they used to include volunteers in benthic monitoring program, since they adopted the OBBN protocol, the increased resolution precluded their continued use of volunteers.
VBM is one of the most validated avenues of citizen science inquiry (Penrose and Call 1995; Fore et al. 2001; Navis and Gillies 2001; Engel and Voshell 2002; Nerbonne and Vondracek 2003; Gowan et al. 2007; Nerbonne et al. 2008; Medeiros et al. 2011; Moffett and Neale 2015). Engel and Voshell (2002) found that it was one of the metrics from the protocol that had been designed for use by the citizen science group that resulted in discrepancies between conclusions derived from this data compared to that collected by the experts; it was not the abilities of the volunteers to follow protocols since when the data collected by volunteers was analyzed with the revised metrics, the discrepancies between expert and volunteers conclusions were minimized. Engel and Voshell (2002) concluded that

> If volunteer biological monitoring programs are carefully analyzed, modified where necessary, validated, and then strictly adhered to, professional biologists and others in regulatory and natural resource agencies should accept the results, be confident about using them, and be grateful for the assistance. (pg. 176)

Nerbonne and Vondracek (2003) also examined the biases of untrained volunteers in sorting and identifying benthos and made some specific recommendations pertaining to how volunteers could best be trained to most effectively reduce their biases and increase their agreement with expert sorting and identification. Most recently, Moffett and Neale (2015) found concordance in long-term benthic monitoring trends, assessments of stream health as measure by a biotic index and an index of composition, despite the spatial and temporal differences between volunteer and professional sites examined. Among the most common recommendations to improve the quality of data from citizen science programs includes: training volunteers, using standard protocols, performing data quality control and validation (e.g., Nerbonne and Vondracek 2003; Riesch and Potter 2014).

As part of the issue with data quality, some CA participants felt that the cost of ensuring the quality of volunteer collected data would be higher than just depending on their own expert staff to collect and analyze the samples. One of the government staff in Murphy-Mills (2015) study observed that some of the CAs that have the resources to support their own monitoring feel that it is not worth their effort to engage citizens in monitoring due to the time commitment and lower quality data that results, and so use community based
monitoring purely for outreach. In this research, not only did CA participants themselves appear concerned for the quality of the data that could be collected by volunteers, they worried that even if their own concerns regarding the data quality issues could be addressed, it may not be possible to convince other potential users of these data that VBM has the potential to produce high quality, reliable information. Reish and Potter (2014) interviewed a number of scientists who were involved in citizen science programs and also found that individuals were often as concerned about how their use of volunteer data would be viewed by their peers, as they were about the actual quality of the data. Murphy-Mills (2015) reported on only one participant’s positive comments regarding the potential quality of community based monitoring data; this government employee stated that volunteers can collect data of the same quality as professionals provided appropriate training. For the most part, she found that “Even when community members are trained appropriately and use approved monitoring protocols, the data are still dismissed by decision-makers because of the stigma that is attached to data collected by community volunteers.” (pg. 103, Murphy-Mills 2015)

These observations relating to the mistrust of citizen science data by decision makers was echoed in Murphy-Mills’ (2015) document analysis; while some of the Oak Ridges Moraine (ORM) CAs were not involved in community based monitoring and this fact was reflected in the lack of its mention in their grey literature (e.g., reports, documents), there was also a lack of reference to community based monitoring in reports by CAs that were involved in community based monitoring; “Although interviews with CA staff indicated that many of the CAs had some involvement in CBM, with a few CAs having extensive interactions with community members to monitor water resources, there was no mention of CBM in any of the documents from CAs.” (pg. 73, Murphy-Mills 2015) Similarly, despite the explicit mention of community based monitoring being an integral part of the ORM Conservation Plan, and this fact being outlined in the technical documents of the Conservation Plan, she found only a few government organizations in the ORM that were directly and overtly involved in community based monitoring, “with the majority only peripherally involved and choosing to downplay the involvement in their grey literature.” (pg. 77, Murphy-Mills 2015)
The general credibility of citizens collecting rigorous and objective scientific data is often in question. A couple of the CA participants believed that the collection of the data must be strongly tied to its processing and analysis so that in order to get the most accurate data possible, a single individual needs to do both in order to avoid information getting “lost in translation”. Such rigor would certainly preclude the use of volunteers for whom it would be completely impossible to uphold this condition. Despite these opinions, there were more individuals among the survey respondents that disagreed that there was a lack of need by CAs for VBM data; this pattern was observed both when respondents were asked about the obstacles to collaboration between VBM groups and CAs and when they were asked about obstacles to the use of VBM data by CAs. According to Buytaert et al. (2014) who reviewed the role of citizen science in hydrology and water resources, this approach to data collection is in fundamental contrast with citizen science where data quality needs to be compromised due to logistical factors such as availability of equipment, and the availability and training of an inherently transient workforce (Cohn 2008; Devictor et al. 2010). They argue that citizen science requires the use of technically simplified procedures to collect consistent samples and it must therefore also draw conclusions from a larger volume of potentially lower quality data. This therefore necessitates a quite different approach to data analysis (Cohn 2008). Echoing this, Murphy-Mills (2015) state that “the challenge for CBM programs has become figuring out what community volunteers can monitor reliably given their resources (i.e. what variables to examine), what are the ways to collect those data (i.e. methodologies and equipment), in order to ensure that the collected data are useful to agencies to involved in decision-making.” (pg. 102)

The opinions of many of the CA participants suggest a very strong regard for the importance of science in providing “real knowledge” of a system through the conduct of the “objective” expert-scientist (Buytaert et al. 2014). This is not surprising given the observations by Michaels et al. (2006) from their interviews with CA staff; participants realized after Walkerton that with the protection of source water falling to CAs, all CAs needed to perform at a high level of technical competence in order to maintain their autonomy and allow them to build and use their local knowledge in order to reassure the public that they were able to protect source water adequately.
In their review, Buytaert et al. (2014) note that when the decision-making around hydrology, water resource management and technology occurs almost exclusively by scientists, it may be difficult for citizen science to be used in this process even when that knowledge is being collected through an institutionalized process. Despite the provincial (OBBN and OSAP) and national Canadian Aquatic Biomonitoring Network (CABIN) networks that support the collection of benthic data by professional and volunteers alike through standardized protocols and other forms of support, there is still a strong reluctance by many of the CA staff to accept VBM as a valid avenue for acquiring meaningful watershed information. These observations are supported by the results of the survey where 67% of the respondents believed the lack of confidence in the protocols used by VBM groups, and 50% believed a lack of confidence in the volunteers’ ability to adhere to the protocols were obstacles to CA-VBM collaboration. As well, approximately 80% of the respondent with an opinion agreed that discrepancy between the data protocols CA uses and those used by the VBM group is an obstacle to the use of VBM data by CAs. Some CA participants in Murphy-Mills (2015) study also expressed concerns over the quality of the data collected by volunteers; “Despite the fact that many of the CAs interviewed had participated in some form of CBM, and provided training to the community volunteers, these results suggest that there is an inherent distrust in the data collected by volunteers, regardless of the training and support that is being provided.” (pg. 101) Another issue with use of citizen science data and monitoring information, in general, was that there was little impact by community based monitoring in decision-making because of the nature of monitoring being a long term process and there not being enough of it generated by these groups to show any trends (Murphy-Mills 2015). This is a challenge associated with any monitoring data which makes getting funding specifically for monitoring “really, really hard to get” according to a government staff in Murphy-Mills’ (2015) study; “it’s the last thing on the agenda, and the first thing to get slashed” (pg. 104).

But citizen science data are indeed being used by CAs in planning and decision-making. Data from the RVCA coordinated City Stream Watch program is used for determining stewardship programs, restoration projects, and other planning and management activities. Murphy-Mills (2015) found that when CAs “had control over the data
collection, and thus data quality, they were more likely to include it in planning decisions” (pg. 95). Data collected by Citizen Scientists is used by TRCA because it does not overlap with their sites, but fills in gaps by adding to the extent of the data available to TRCA in their decisions. TRCA staff admitted having high confidence in those data because the coordinator of Citizen Scientists works at TRCA and is certified in data collection methods that TRCA utilizes. One TRCA manager stated that it “makes the data he collects from the Rouge contextualized within the regional data sets – so I can bring it in to make the regional data sets a little bit more robust”. Rouge watershed data has been used in the qualitative aspects of watershed characterization in the fish management plan for the Rouge watershed, and in one particular case, it was the only information that existed for a site that could give a sense of what the stream was like before a spill. These are two examples of what Buytaert et al. (2014) describe as a feedback loop that is possible when “scientists are involved in a process of knowledge co-generation, where they combine locally collected data by citizen scientists with other existing datasets to add value to that information, and make the results accessible for individual and collective decision-making arenas.” (pg. 11) It is not clear from this study how the stream data collected by URBAN might be used for decision-making by either CAs or other government agencies.

One of the survey questions summed up the question, ‘How do the attitudes of the people in CAs limit the implementation or support for VBM by their organization?’ There were four scenarios provided in the survey question and respondents were asked to select any or all of the circumstances under which CAs should consider replacing their in-house benthic program to VBM. Most of the respondents selected more than one scenario (36% selected all four scenarios, 32% selected three scenarios, 18% selected two scenarios, and 14% selected only one scenario). Half of the respondents that selected only one scenario chose: ‘Funding that was allocated to your benthic monitoring program is no longer available’. This was also the most commonly selected scenario overall. These results support the idea that with the capacity CAs have, they would rather invest in their own expert benthic programs and in many cases would only consider moving to VBM if it were absolutely necessary for acquiring the monitoring data they needed for their activities. From those that selected two of the scenarios, as many respondents chose this
scenario: ‘Funding is available for your CA staff to identify the benthic invertebrates collected by the VBM group your CA collaborates with’ as the funding cut scenario. The selection of this scenario attests to the importance they place on gaining scientifically rigorous, high quality data. There was no preference by the respondents between the following scenarios: ‘Funding is available for your CA to coordinate a Volunteer Benthic Monitoring (VBM) program’ and ‘Funding is available to collaborate with a VBM group that exists in your watershed (i.e. provide technical, in kind or funding support)’. It appears that were CAs to consider moving from in house benthic monitoring to VBM, for most organizations it would be under dire circumstances of funding cuts to their programs. It also seems that if they did adopt VBM, there was no preference for a CA coordinated program versus an independent group, provided the most technical aspect of this sort of monitoring (the sorting and identification of the invertebrates), be executed by the expert staff of the CA.

Arguing the need to move from a “technocratic-expert view” on decision-making, to a “joint creation-knowledge exchange model”, Buytaert et al. (pg. 4, 2014) see this move away from the objective or neutral scientist-initiated approach in constructing the problems and frameworks that will dictate what types of data are needed, to an approach that takes into account these multi-stakeholder processes and the relationship between “knowledge”, “scientific knowledge”, “decision-making” and “actions”. They go on to state that “The application of citizen science in a water resources management context is clearly in its infancy in this regard” (pg. 4), but that citizen science can help to shift the typically key and central role of scientific process in the course of knowledge production; this is important to ensuring citizen science feeds into democratic institutional structures and is considered equally in deliberative decision-making (Buytaert et al. 2014).

Interestingly, one of the CA managers echoed these ideas stating that it was time for CAs to start understanding their community better – what motivates them, influences their decisions and how they perceive value – ending her comment with the claim that “we all need to be social scientists more so than technocrats”.
5.2 Citizen science groups

The variation among the citizen science groups’ type of monitoring and the strength of their collaborations with their local CAs seem to be connected to the level of contribution their volunteer collected data made to local decision-making about aquatic habitats. Both URBAN and Citizen Scientists conduct VBM whereas City Stream Watch does not. As well, City Stream Watch is coordinated by RVCA, a structure not unlike the ‘government-led’ community based monitoring described by Whitelaw et al. (2003) which complements government monitoring priorities and often involves long-term monitoring with the engagement of citizens. Both URBAN and Citizen Scientists seem like a mix of ‘collaborative’ community based monitoring which involves multiple agencies and groups (government, citizen groups, academia and business), and ‘educational’ community based monitoring which simply engages volunteers in learning about the environment through the activity of monitoring (Whitelaw et al. 2003). While neither have really strong collaborations with the agencies that could make decisions based on the data their groups collect, these two citizen science groups, do provide high quality information by using trained volunteers, standardized protocols, quality control measures for their data collection, as well as experts for their sorting and identification of invertebrates. These actions go beyond those of simple ‘education’ monitoring.

Interestingly, while there is significant and important collaboration between TRCA and Citizen Scientists, the data that the volunteer group provides to the CA is not vital and simply is a nice supplement to the data their organization is already collecting (like icing on a cake). While TRCA seems to connect with Citizen Scientist through their training of volunteers and loan of equipment and knowledge, URBAN is strongly connected to McMaster University; it receives the direction, coordination and funding from the grants and academics within the institution and compared to the other two groups, has a much heavier mandate for outreach and education of their local community. All three groups conform most closely to the ‘consultative’ approach, one of four approaches to community based monitoring organized by Lawrence (2006) and described by Conrad and Hichley (2011). In this approach, the public contributes information to a central authority; City Stream Watch to RVCA, Citizen Scientists to TRCA and URBAN to the research lab at McMaster University and their government led network (OBBN). None
of these groups either implement decisions or decide collaboratively with government on what is needed (as in the ‘functional’ and ‘collaborative’ approaches) or in the case of the transformative approach, consist of “local people make and implement decisions with support from “experts” where needed” (pg. 276, Conrad and Hichley 2011).
Chapter 6

6 Conclusions, recommendations and future research

6.1 Conclusions

Most of the literature supports citizen science as an important part of protecting and managing ecosystems. My research answers the call for “more case studies showing the use of citizen science data by decision-makers or the barriers to linkages and how these might be overcome” (pg. 273, Conrad and Hichley 2011). This research sought to answer the question “Why is the use of volunteer benthic monitoring (VBM) by CAs not more common?” with the objectives of examining the role of both capacity of CAs and the attitudes of their people to either support or implement VBM by their organization. Given how the close associations with communities play an important role in the work by CAs, and the fact that not only do CAs make resource management decisions, they are closely linked to levels of government that develop policy, I had assumed going into this research that VBM and CAs were a perfect fit. However, this research demonstrates that those few CAs that do use the data collected by their local citizen science groups, do so in a limited way. Only the non-benthos collecting citizen science program, under the coordination of a CA, used the data extensively to make decisions about stewardship and restoration activities (RVCA and City Stream Watch). Hence, this research answers the call by Stepenuck and Greene (2015) for research that presents “the role that such aspects as monitoring program design, characteristics of participants, and surrounding political environment may play in effective citizen participation in decision-making processes.” (pg. 13). As well, this research presents negative or null results by examining cases where both the attitudes and capacity likely affect not only the prevalence of VBM use by CAs, but also for those independent groups that are conducting VBM, the limited use of that data by local managers in their decision-making (e.g., URBAN). Such knowledge, according to Stepenuck and Greene (2015), “affords others the opportunity to learn from reported outcomes and avoid pitfalls” and hence, citizen science efforts can save considerable time and expense in program development by knowing in advance about program concerns (pg. 12). Related to this, it is clear from this research that the models
currently used by groups for conducting VBM could not be used to replace to any significant extent, the benthic monitoring conducted by the CA. In order to acquire the equivalent level of information currently collected by expert staff of the CAs, a significant increase in capacity would be required to collaborate more full with, or coordinate such citizen science programs.

Through the in-depth case research of five CAs, I examined issues of capacity and attitudes of their staff toward monitoring, community contributions and citizen science. These qualitative data provided a rich narrative of how CAs view their capacity in general and what their thoughts and attitudes were regarding the usefulness of VBM to their organizations. Using a combination of gatekeeper and snowball sampling to acquire interview participants within the CAs may have introduced some bias. For example, for some CAs, there was little choice in the participants that I was given permission to interview. In these cases, results may have been biased toward the attitudes held by the individual deciding the participants – the gatekeeper may have chosen staff and board members who would most closely share similar views to their own.

While CAs appear to have substantial capacity with respect to their organizational dynamics, community connections and institutional arrangements, for the purposes of utilizing VBM, this is outweighed by their reduced capacity resulting from a lack of sufficient financial resource. I also examined the structures, protocols, data collected, coordination and partnerships of the few citizen sciences groups who collaborate with CAs. It appears that particularly with respect to the sorting and identification of the invertebrate samples, the methods of the VBM groups are just too labour intensive for these groups to supply a greater proportion of the benthic monitoring information at the level currently collected by expert CA staff.

To determine whether the findings of the case research could be generalized to the rest of Ontario CAs, I conducted a survey asking about CA activities and monitoring, and their opinions about the value of community contributions and in about their capacity for, and attitudes toward VBM in particular. These data were both summarized to examine general trends and ordinated via nonmetric multidimensional scaling. Although the latter
on their own provided some depth and detail (i.e. actually visualizing how CAs 
responded similarly or differently to groups of questions), one of the goals of this 
analysis was to attempt to correlate survey responses to attributes of the CAs (i.e., those 
summarized in Table 4.1). An attempt was made to use Mantel tests to achieve this by 
examining the correlation between two distance matrices (e.g., are the groups of 
responses among CAs regarding attitudes towards volunteer labour somehow related to 
the group of variables that describe their watershed size and land holdings?). There were 
190 total possible Mantel test correlations computed for all combinations of distance 
matrices. Thirty-one tests showed significant correlations between two distance matrices. 
None of these, however, compared the attributes of the CAs to the survey responses. 
While examining the correlations among two response distance matrices could also 
potentially provide some interesting insight, interpreting where the correlations exist was 
like trying to interpret a multiway regression interaction because of the multiple factors in 
both matrices. Thus, these results were not considered in the interpretation of the survey 
results.

Another issue with these data was that there were large numbers of questionnaires 
completed by two of the CAs, and biases due to these heavy returns were minimized by 
calculating the median responses for each CA. However, in doing so, there was 
potentially some interesting information lost. Further analysis of these data could be 
conducted to see how much variation existed among individual opinions within a given 
CA. As well, calculating the medians also resulted in basically only having a single 
opinion from each of the CAs that participated in the survey, putting to question the 
ability of these conclusions to be generalizable to CAs as a whole. Ideally, acquiring 
more respondents from each CA would enable analyses to incorporate variation both 
within and among CAs providing a richer understanding of how capacity and attitudes 
towards VBM are viewed by CAs.

This research shows that there is a lack of capacity in CAs to support or implement 
VBM, primarily due to lack of adequate and stable financial resources. The consensus 
among CA participants was that the best use of staff was for acquiring more of the high 
quality staff they currently support. Such human resources would be invaluable for the
critical task of coordinating or liaising with the participants of citizen science programs. Probably more significant as a factor precluding the widespread adoption of VBM by CAs are the attitudes held by CA participants. As science-based organizations (Sheikheldin et al. 2010; Michaels et al. 2006), there is a distinct mistrust by CAs of the potential for a non-science layperson to collect credible and rigorous benthic monitoring data. Since monitoring is considered a vital component of their activities, they support it with what little stable funding they receive. Despite the fact that the majority of CA participants in this research identified and acknowledged the same benefits of citizen science that are echoed throughout the literature, I believe the combination of these factors (capacity and attitude) make VBM an unlikely form of citizen science to be adopted by CAs anytime soon.

6.2 Reflections on the potential for CAs supporting VBM and other citizen science

With the capacity issues (especially the lack of staff) facing CAs, one of the major potential benefits and motivations for supporting or adopting VBM would be the contribution of data that may not otherwise be collected (i.e. expanding the monitoring program both spatially and temporally). Due to certain logistics, current models of VBM being conducted (i.e. those of URBAN and Citizen Scientists) would not provide such an expansion for CA monitoring programs. There are two distinct components to benthic monitoring: the collection of the field data and benthic sample, and then the sorting and identification of benthic invertebrates from the sample. Examining these components separately can provide insights into why the current VBM models might not be able to fulfill the data needs of CAs.

For the purposes of quality assurance and quality control, a staff or expert is required for supervision of the collection process. In my participation of both VBM and CA benthic monitoring, it is clear that unless the supervising expert is volunteering their time to lead field collection activities, no time is saved by paid CA staff overseeing the collection of volunteers. Where CA staff could collect the field data and samples from three or four sites a day (even taking into account driving time between sites), both URBAN and Citizen Scientists could complete only one site per day. This is understandable
considering that the individuals volunteering are usually looking for a unique and educational nature experience, as much as they are dedicated to assisting the CA in obtaining high quality, useful data. What changes to these VBM would need to be made for them to emulate the efficiency of CA field monitoring? VBM groups would need to be led by volunteer experts to ensure the quality of the collected data and the multiple crews would need to consist of dedicated volunteers that could contribute multiple field days for data collection. These types of volunteers are rare and consist mostly of students who are attempting to gain valuable and marketable field experience to improve their future job prospects. The crews of volunteers would need to be able to collect at least as much data as can be collected by the CA staff within a season for VBM to be a valuable supplement to the CA’s monitoring program.

The next component to benthic monitoring and a major technical factor affected by both capacity and attitude in limiting VBM is the time, effort and expertise associated with sorting and especially identifying the collected benthic macroinvertebrates. For the VBM to benefit the CA through the expansion of their monitoring program, volunteers would need to complete the work of either one or two expert staff or a professional taxonomist. This would require individuals to devote a number of hours, for their training and for completing the large volume of samples that could be potentially collected (in the above described scenario). Much of the literature examining VBM has examined the abilities of volunteers to effectively conduct these tasks and it is generally heralded as the most time consuming and complicated part of benthic monitoring. Moffett and Neale (2015) found that volunteer data were limited for assessment of taxonomic richness due to the higher level of identification they used and concluded the volunteer monitoring they studied had limited ability to detect biodiversity trends. Despite this, a modified protocol where some taxa were identified at species or genus level while other were only identified to family, was still successful in detecting trends in stream health while being simple enough to be done onsite without in depth taxonomic knowledge (Moffett and Neale 2015). Perhaps, this type of simplified identification could be adopted/developed for Ontario’s aquatic habitat with biodiversity trends assessed using the DNA information from the ethanol the invertebrate sample was preserved in (Hajibabaei et al. 2012).
The modifications to both components of VBM would require the efforts and dedication of a significant volunteer base. It would also require the time and effort of staff for training, coordination and quality assurance. Unless CAs were able to acquire such a volunteer base, it seems that the time and effort required by CA staff to conduct VBM at the same levels being conducted by the two VBM groups in this research, would be prohibitive. There are much more affordable ways for CAs to engage and educate their communities as well as involve them in the activities of their organization. Stewardship programs that could support large groups of volunteers and require little to no training time (e.g., invasive species removal or tree planting), as well as providing interested community members seats on CA planning/implementation committees are both options, and CAs seem to have enthusiastically adopted these tactics.

Despite the benefits of these various forms of participation in CA activities, there still some unique benefits provided by citizen science that cannot be met by either stewardship activities or advisory committee work. I believe that the right type of citizen science must be chosen that avoids the complexity of VBM and the heavy training requirement (and level of dedication to be efficient in expanding CA monitoring programs). Such a program should involve large numbers of volunteers (like the numbers that could be supervised for stewardship activities) in order to maximize the number of people that can be engaged in the experiential learning that comes from doing science, and that are educated about the purpose and function of the data they are collecting for their CAs’ management and for conservation purposes in general. This citizen science program should provide sufficient volumes of high quality data for CAs to be able to use the information in their water resource management and CAs would report to the citizen scientists collecting these data, how the information is being used in CA decision-making. RVCA’s City Stream Watch is a good example of a citizen science program that accomplishes these goals by possessing the following attributes: it is well coordinated, uses standard and expert vetted protocols, is supervised by staff who ensure quality data are collected, engages a large number of volunteers in the scientific process and educates them about the water resources and human impacts on their degradation, generates sufficient volumes of data which are welcomed and used by RVCA in the process of conducting stewardship and remediation programs. More research is needed
to be able to determine how to modify current VBM programs to acquire these same attributes. Finally, an important component of the ideal citizen science program for use by CAs is one which maximizes the participation of the people who volunteer and have a vested interest in what data are collected and how it gets used in decisions about their livelihoods. This could take the form of a community-based steering committee to work closely with CAs technical and scientific expertise to determine the questions that the data are needed for, where the data collection is needed, and what decisions will be made with the data being collected.

6.3 Future research

Citizen science takes on a multitude of forms based on a number of factors including the activity being conducted (Wiggins and Crowston 2011), the size of the program (Theobald et al. 2015; Bonney et al. 2014), and the level of participation by volunteers in the process of science and its application (Whitelaw et al. 2003; Bonney et al. 2009b; Conrad and Hichley 2011; Shirk et al. 2012; Couvet and Prevot 2015). While there are an ever increasing number of publications documenting the application of these myriad of types of citizen science programs to the understanding of science or management, when it comes to examining the theory of citizen science itself (e.g., the factors for success, challenges to overcome) most of the literature focuses on large scale programs that include many volunteers over broad geographical ranges where participants play little or no role in the process of science other that of data collection. More of this type of research is needed on the smaller, more regional community based monitoring programs (but see e.g., Pollock and Whitelaw 2005; Conrad and Hichley 2011). This information could provide better insight into what the important structural factors of citizen science might be when examining the feasibility of citizen science use by CAs. For the promotion of implementation and use of VBM by resource managers, future research could examine the methods for identifying macroinvertebrates; how these may be streamlined to cater to volunteer activities that occur completely in the field (i.e. determine a valid identification protocol that can be done by the same volunteers in the field that have collected the sample), as well as examine the potential for DNA barcoding for the assessment of biodiversity of invertebrate samples. While there are certainly
challenges associated with citizen science, I agree strongly with Conrad and Hichley (2011), who argue that these challenges should not be used to devalue such community initiatives, because the benefits of citizen science far exceed the challenges.
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Appendices

**Appendix A:** Ethics approval granted for the conduct of research involving humans (signatures and contact information have been removed).
Appendix B: Example of email correspondence inviting participation and providing study information.

Dear ABCA Board Members,

I’m a 3rd Biology PhD student in the Environment and Sustainability Program at The University of Western Ontario. My research examines the role of Community Based Monitoring on freshwater management by Ontario’s Conservation Authorities. ABCA has agreed to be a case in my research and I’m looking for a second volunteer from ABCA’s Board of Directors to conduct a recorded interview. I’m hoping this volunteer will have at least a year of experience as a member of ABCA’s board. If you fit this criterion and are interested in being interviewed, I look forward to hearing from you. I will be attending the May 19th board meeting at ABCA. You are welcome to chat with me after the meeting, send me an email anytime (xxxx@uwo.ca), or call me at (xxx) xxx-xxxx. For more information, I’ve attached below a more detailed description of my research as well as the letter of information for research participants.

Sincerely,
Sonja Teichert

Community based monitoring (CBM) of ecosystems is where citizens and community groups participate substantively and constructively in the monitoring of status and trends in ecosystem health. Regional, Provincial, Federal, and First Nations government agencies cannot meet the increased need for such monitoring due to changing priorities and limited resources. There is great demand for sound ecosystem monitoring in Canada because of enhanced awareness of environmental stressors (e.g., climate change, invasive species, development) and the perceived threats these changes can bring on valued components of the ecosystem (e.g., streamflow regimes, biodiversity). There is also a recognized benefit to more inclusive processes leading to government decisions regarding environmental protection and sustainability. Volunteers across the country already spend thousands of hours participating in monitoring programs, but their contribution is often devalued by the common view that scientific experts provide the only credible input into environmental monitoring and decision-making. Exploring and challenging this fundamental assumption in the context of Ontario stream ecosystems is the basis of my research.

CBM that provides quality information while broadly engaging the community will be a critical tool in the development of collaborative, locally-driven, science-based environmental protection plans. Biomonitoring of freshwater ecosystems in Ontario commonly uses macroinvertebrates as indicators of ecosystem health (called benthic biomonitoring) due to their behavioural, physiological, population, and community level
responsiveness to environmental degradation. Ontario’s 36 Conservation Authorities (CAs) are responsible for watershed management activities including monitoring, stewardship and environmental advisory services. CAs have the potential to use CBM data for management purposes since they collaborate at the local level with governments, private industry and community members. While many of Ontario’s CAs maintain ongoing monitoring programs, most of the partnerships between CAs and community groups interested in the state of their local watershed, do not involve the collection of benthic biomonitoring data by volunteer citizens.

This research will focus on the role of CBM on freshwater management by Ontario’s CAs. My objectives are to examine the factors that contribute to the creation and maintenance of partnerships between CBM and CAs and when these partnerships exist, examine the factors that influence if and how CAs use data collected by CBM programs. Using a case study approach, I will use qualitative methods (surveys, interviews) to assess the relative contributions of experts and community members to decision-making about Ontario streams, as well as to explore issues of priority, conflicts and constructive ideas related to the use of CBM information in decision making. For each case, I will conduct recorded interviews with at least 3 CA staff members: general manager, community liaison, freshwater manager, and potentially up to 3 more depending on the CA and suggestions from individuals, spend time observing the daily operations of the CA and having informal conversations with staff, acquire documents (watershed and management reports, meeting minutes, internal documents, and press releases), administer a questionnaire to all board members and recruit 2 interviewees, attend 2 board meetings, observe/participate in the CA’s monitoring program (through all steps including choice of collection site, data collection, data use etc.). This research will provide a valuable contribution to the field of applied aquatic ecology by addressing the organizational and social barriers related to the integration and use of information collected by volunteer community groups in decision making.

My interest in CBM developed from having over six years of experience working in various capacities with CBM projects - projects that brought diverse volunteers together to monitor and respond to issues regarding the sustainability of ecosystem goods and services. I have experienced the power and utility of these projects, and acquired a deep appreciation for the relationships and public education necessary to foster stewardship. These professional experiences led me to return to academia to pursue a PhD in a Biology program with a strong interdisciplinary component in Environment and Sustainability. I am currently in my third year of this program - I have completed all of its course requirements, and have been successful with both my Proposal Assessment and my Comprehensive Examination. I’m currently working on acquiring participation by my chosen CA cases and the CBM groups that they are partnered with.

Appendix C: Letter of Information for research participants.

INFORMATION LETTER FOR RESEARCH PARTICIPANTS

Sonja Teichert
PhD Student, Department of Biology
The University of Western Ontario, London
Phone: xxx-xxx-xxxx ext. xxx
Email: xxxxx@uwo.ca

Re: Community Based Monitoring, Conservation Authorities and freshwater management

Study purpose: I am a PhD student in the Department of Biology at The University of Western Ontario undertaking a study to learn about the factors that influence the existence of partnerships or collaborations between Community Based Monitoring groups (where volunteers collect freshwater monitoring data) and Conservation Authorities. Where these partnerships exist, we would like to find out what factors facilitate the use of this volunteer collected data by the partner Conservation Authorities in their daily management of freshwater resources in their respective watershed. Identifying issues of priority, conflicts and constructive ideas related to the use of CBM information may contribute to the integration of expert application of freshwater benthic biomonitoring with the more holistic perspective of Community Based Monitoring.

What is involved: If you agree to participate in the study, you will be asked some questions about your experience working in either a Conservation Authority or Community Based Monitoring group. You will be asked your opinion of some of the challenges or obstacles Conservation Authorities and Community Based Monitoring Groups face in trying to work together, as well as your opinion about the benefits that such collaborations can provide to the community and to effective freshwater resources management. The interview should take approximately one hour. You may keep this letter for your records.

Risks and Benefits: No adverse physical effects are expected to result from this research. Emotional distress may arise during the interview process as some of the
questions asked may elicit sensitive information. For instance, issues such as working conditions, monetary and human resource capacity within the organization they are employed by may be particularly difficult to discuss. Research participants may benefit from the outlet that the interview provides them in voicing their opinion about how business within the organization is conducted and from feeling that their opinion is valued. It is hoped that this research will provide insights into how volunteer monitoring data might be of benefit to the management decisions that are made about community freshwater resources.

Confidentiality: Your name will not be used in the study. Only the researchers will be able to access the information that we collect today. If we publish or present the findings of this study, we will not use your name. Data collected will be entered in the graduate student’s personal computer and converted to numerical code, such that identifying data will not be in any reports or works to follow. This file will be encrypted. Raw data will be stored in a locked cabinet in graduate student’s home office.

Freedom to withdraw: Participation in this study is voluntary. If you decide to participate, you may tell the interviewer at anytime that you wish to stop the interview. You do not need to answer any questions you do not want to answer.

Questions or concerns: If you have any questions about this study, you can contact Sonja Teichert at xxx-xxx-xxxx ext. xxx.

I have read the letter of information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Signature of Research Participant: _______________________________________

Printed Name: __________________________________________________________

Date: _________________________________________________________________
Appendix D: Topic checklist referred to for the interviews of individuals of the CAs.

RESPONDENT I.D.  ____________________________________________
SEX of PARTICIPANT  __________________________________________
AFFILIATION  ____________________________________________
JOB TITLE  ____________________________________________

COMPLETION TIME  START TIME _____ END TIME _____
DATE  ____________________________________________

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Questions</th>
</tr>
</thead>
</table>
| 1       | Participant’s roles and responsibilities within the conservation authority. | - Tell me what your job with this CA involves?  
- What are your key duties?  
- Tell me about a typical day?  
- What kind of daily decisions do you make in your job?  
- How do these decisions affect other work conducted in the CA?  
- How long have you been with the CA?  
- What is your background and how has it led to this position?  
- Did your educational background prepare you for this job? |
| 2       | Information required for this position                              | - What kinds of information do you need to do your job?  
- How do you access this information?  
- Are there any challenges in getting this information? |
<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Questions</th>
</tr>
</thead>
</table>
| 1       | e.g., give examples of info: journals, reports, data from other staff/departments in CA, info from government or other institutions | - Are you getting the information you need to make your daily decisions?  
- What is the quality of the information like?  
- What other resources do you need to do your job?  
- Can you think of an example of a situation where you had difficulties doing your job because you couldn’t access the information and/or resources necessary to complete a particular task?  
- What happened? What did you do? |
| 3       | Upgrading                    | - Are there opportunities for staff to upgrade their education and training?  
- Are you encouraged to upgrade? |
| 4       | Job Satisfaction             | - Are you being challenged in your position? If so, how?  
- Are you satisfied with the level that you’re being challenged in your position?  
- Can you give me an example of how you were challenged and how you felt about it?  
- Are you encouraged to take on new tasks, beyond your job description? In what way? How do you feel about this?  
- Are you supported in these new tasks? If so, how? |
| 5       | Collaboration within the CA  | - Do you collaborate with other employees and/or departments in your CA? How?  
- Can you identify the departments and provide some examples of projects you have collaborated on.  
- If no, can you explain why? |
<table>
<thead>
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<th>Topic</th>
<th>Questions</th>
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<tbody>
<tr>
<td>6</td>
<td>Consultation with other organizations</td>
<td>- Do you consult with experts from other organizations for the work that you do?</td>
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<tr>
<td></td>
<td></td>
<td>- If so, can you describe an example of a situation where you sought a consultant?</td>
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<td></td>
<td></td>
<td>- Which organizations do you commonly collaborate with?</td>
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<td></td>
<td>- What is the nature of these collaborations (i.e. formal or informal)</td>
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<tr>
<td></td>
<td></td>
<td>- Have you encountered any challenges in securing external consultants?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- If so, have you encountered any challenges in interpreting the information they provide?</td>
</tr>
<tr>
<td>7</td>
<td>Collaborations with local/municipal government</td>
<td>- How do you collaborate with the local government(s) in the watershed?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Can you describe some of these collaborative efforts?</td>
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<tr>
<td></td>
<td></td>
<td>- Do you feel that adequate guidance and support is provided to the CA from the local government?</td>
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<tr>
<td></td>
<td></td>
<td>- Could you elaborate?</td>
</tr>
<tr>
<td>8</td>
<td>Provincial government</td>
<td>- Can you describe your relationship with the provincial government?</td>
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<tr>
<td></td>
<td></td>
<td>- What kinds of support does the provincial government provide (financial, information, technical) for your specific position?</td>
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<tr>
<td></td>
<td></td>
<td>- Do you feel that the provincial government provides the CA with adequate guidance and support for watershed management? Explain.</td>
</tr>
<tr>
<td>Section</td>
<td>Topic</td>
<td>Questions</td>
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</tbody>
</table>
| 9       | Future challenges| - Can you identify any emerging or future challenges or issues that may become important in your job at the CA?  
- Can you explain why these are important?  
- Are you aware of any of the strategies that this CA currently has in dealing with these challenges?  
- Have you discussed with other staff members how to approach these challenges in the future?  
- If so, have they been informal or formal discussions?  
- What kinds of resources do you believe the CA will require coping with these challenges?  
- Do you think this CA currently has the capacity to manage these challenges? |
| 10      | Community        | - Do you have more experience working with groups or individuals?  
- Which community groups do you have experience working with?  
- What, if any, were some of the challenges or difficulties that you experienced when working with community?  
- What were some of the benefits or rewards that you experienced when working with community?  
- Outline the education programs available for the community, to increase their awareness about water quality and water quantity issues in the watershed.  
- Outline the programs available to encourage community/public participation in watershed protection. |
<table>
<thead>
<tr>
<th>Section</th>
<th>Topic</th>
<th>Questions</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>- How does the public communicate and raise issues and concerns with the conservation authority?</td>
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<td></td>
<td>- What kinds of issues have been raised by the local community since you have been with the conservation authority?</td>
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<td></td>
<td></td>
<td>- Are their partnerships between this CA and community groups? Are they formal or informal?</td>
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<tr>
<td></td>
<td></td>
<td>- Can you give me an example of one?</td>
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<tr>
<td>11</td>
<td>Community based monitoring</td>
<td>- Have any of the community groups you’ve worked with collected freshwater monitoring information?</td>
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<td></td>
<td></td>
<td>- What kind of information was collected?</td>
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<td></td>
<td></td>
<td>- How was/is this information used by the conservation authority?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- What are some of the obstacles to maintaining partnerships with these groups</td>
</tr>
<tr>
<td>12</td>
<td>Funding</td>
<td>- How does the conservation authority seek external sources of funding? Explain this process.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- How does the conservation authority work together with other organizations to secure new funds for watershed management activities?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Can you provide examples of recent applications for funding for current and/or future projects?</td>
</tr>
<tr>
<td>13</td>
<td>Partnerships</td>
<td>- Can you provide examples of partnerships between the CA and other organizations?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- How do these partnerships benefit the conservation authority’s watershed management activities?</td>
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<tr>
<td></td>
<td></td>
<td>- What are the biggest obstacles to maintaining these partnerships?</td>
</tr>
<tr>
<td>Section</td>
<td>Topic</td>
<td>Questions</td>
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</tbody>
</table>
| 14 | Future changes to watershed | – Is there a defined mission, or collective values of where the organization should be in 5 yrs?  
– The world is changing and around some things pretty quickly (e.g., the economy). What are some of the changes that you think will be most important for this CA to consider in its strategic planning?  
– What kinds of resources/skills do you think this would require?  
– Do you think the CA has the capacity (skills, data, financial) resources to adapt to the changes that you mentioned?  
– Has the local/provincial government addressed the importance of considering the above changes?  
– What role, if any, do you see CBM playing in helping to mitigate some of the challenges that may arise from change?  
– Can you identify some particular challenges the CA may face?  
– How do you define watershed management? |
| 15 | Satisfaction with CA/Suggestions for improvement | – If you could create a wish list for this CA, what would it include?  
– In what areas do you feel this CA could improve?  
– In what areas do you feel this CA excels? |
| 16 | | – Other comments / questions / concerns? |
Appendix E: Additional questions for interviews with CA board members.

Board Member Questionnaire

- Which municipality do you serve on this CA board?
- How long have you acted as an elected councilor for this municipality?
- How long have you served as a board member for this CA?
- What is your current and/or past profession?
- Are you retired?
- What is your educational background?
- How are decisions made by the board (e.g., consensus or majority vote)?
- What types of decisions are made by the board of the CA?
- What information do CA staff provide you with to aid you in your decision making?
- From your current knowledge, how many community groups does this CA collaborate with?
- From your current knowledge, are there any community groups that are collecting data that they share with this CA?
- How does this CA use the data collected by that community group?

Appendix F: Topic checklist used for interviews with citizen science group participants.

RESPONDENT I.D. ________________________________
SEX of PARTICIPANT ________________________________
AFFILIATION ________________________________
TITLE ________________________________
COMPLETION TIME START TIME _____ END TIME _____
DATE ________________________________
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<tr>
<th>No.</th>
<th>Questions and filters</th>
<th>Prompts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describe your roles and responsibilities within the community group.</td>
<td>– How long have you been with the group?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Can you tell me a bit about your background and how it led to this position?</td>
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<tr>
<td></td>
<td></td>
<td>– How have your roles and responsibilities changed during your involvement with this group?</td>
</tr>
<tr>
<td>2</td>
<td>What personally is your primary motivation for being involved with this community group?</td>
<td>– Did you have some past experience that led you to become involved with this group?</td>
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<tr>
<td></td>
<td></td>
<td>– What is the most rewarding outcome that has resulted from your participation with this group?</td>
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<tr>
<td></td>
<td></td>
<td>– Does an example of a particularly rewarding experience resulting from your participation with this group come to mind? Explain.</td>
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<td></td>
<td></td>
<td>– What has been the biggest disappointment that you’ve experienced from your participation with this group?</td>
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<tr>
<td></td>
<td></td>
<td>– Can you provide me with an example of an instance when you found it particularly challenging to complete a particular task?</td>
</tr>
<tr>
<td>3</td>
<td>Describe the organizational structure of this community group.</td>
<td>– Is there a steering committee?</td>
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<td></td>
<td>– How many positions of leadership are there?</td>
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<td></td>
<td></td>
<td>– How many people are responsible for the decisions made by your community group?</td>
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<td>No.</td>
<td>Questions and filters</td>
<td>Prompts</td>
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<tr>
<td>4</td>
<td>What is the primary motivation of this community group?</td>
<td>- Is there a specific need driving the existence of this community group?</td>
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<td></td>
<td></td>
<td>- What are the specific objectives of this community group?</td>
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<tr>
<td></td>
<td></td>
<td>- What are the specific outcomes that this community group hopes to achieve?</td>
</tr>
<tr>
<td>5</td>
<td>How does this community group collaborate with the local conservation authority?</td>
<td>- What is the role of the local conservation authority in this partnership/collaboration?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Are there particular employees of the conservation authority that work closely with your group?</td>
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<tr>
<td></td>
<td></td>
<td>- What types of support does the local conservation authority provide to your community group?</td>
</tr>
<tr>
<td>6</td>
<td>What are some of the challenges and benefits resulting from your collaboration with the local conservation authority?</td>
<td>- How do you define watershed management?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Can you provide an example of a situation where your collaboration with the local conservation authority was a benefit to the goals of your community group? Explain.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Can you provide an example of a situation where your collaboration with the local conservation authority was a detriment to the goals of your community group? Explain.</td>
</tr>
<tr>
<td>7</td>
<td>What type of information does your community group collect?</td>
<td>- What information do you collect and how do you collect it? Who collects the information?</td>
</tr>
<tr>
<td>No.</td>
<td>Questions and filters</td>
<td>Prompts</td>
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<td></td>
<td></td>
<td>- Who established your protocols?</td>
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<td>- Who established the sites to be monitored by your community group?</td>
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<td></td>
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<td>- Was there any resistance to collaboration? Why?</td>
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<tr>
<td>8</td>
<td>What types of support does the local conservation authority provide to your community group?</td>
<td>- Do they provide staff for consultation or information collection?</td>
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<td></td>
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<td>- Do they provide training?</td>
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<td></td>
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<td>- Do they provide information management support?</td>
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<td>- Do they provide promotion of your community group?</td>
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<td></td>
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<td>- Do they provide assistance with fundraising and grant writing?</td>
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<td>- Do they provide equipment, either donated or on loan?</td>
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<tr>
<td>9</td>
<td>How does the conservation authority use the information collected by your community group?</td>
<td>- If they don’t use your information, why don’t they?</td>
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<tr>
<td>10</td>
<td>Does this community group partner with other organizations or governments?</td>
<td>- What is the nature of that partnership?</td>
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<tr>
<td></td>
<td></td>
<td>- Is the information collected by your group used by these organizations? If so, how?</td>
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<td>11</td>
<td>Volunteers</td>
<td>- Where did you hear about this CBM program?</td>
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<td></td>
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<td>- What sort of training do you receive?</td>
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<td>- List any workshops/events coordinated</td>
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<td>Prompts</td>
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<td>by the program that you’ve attended.</td>
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<td>- What activities have you participated in with this group?</td>
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<td>- Approx. how many hours have you volunteered for this program?</td>
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<td>- What data have you collected?</td>
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<td>- What have you learned during your involvement with this program?</td>
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<td></td>
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<td>- How long do you plan on volunteering for this program?</td>
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<td>- What value do you place on the program?</td>
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<td>12</td>
<td></td>
<td>- Other comments / questions / concerns?</td>
</tr>
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**Appendix G:** Coding hierarchy developed during the open coding phase of the qualitative analysis of interviews ([+] beside a node indicates there are sub-nodes within).

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<td>more buy in</td>
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<td>behavioural &amp; value changes</td>
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<td>get work done that would otherwise not</td>
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<td>20</td>
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<tr>
<td>be possible</td>
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<td>3</td>
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### Future Issues

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### [+] Golden Quotes

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### Monitoring

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<td>cost of identifying benthos</td>
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### Partnerships-Collaboration

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Appendix H: Conservation Authority Survey: Questionnaire 1 - Water quality monitoring.

Questionnaire 1: Water Quality Monitoring

Conservation Authority activities and initiatives

For which Conservation Authority (CA) are you responding to this survey?

Using the scale provided in the drop down menu, please indicate how important the following activities currently are to your Conservation Authority (CA).

0 – not carried out by CA
1 – not at all important
2 – not very important
3 – neutral
4 – somewhat important
5 – very important

A) Flood Protection
B) Reservoir Management
C) Permits & Approvals
D) Source Water Protection Planning
E) Remediation
F) Integrated Water Resource Planning/Management
G) Monitoring/Indicators
H) Public Outreach and Stewardship
I) Conservation Areas’ Management
J) Others (Please specify)

Comments:

Please rank the three highest priority activities conducted by your CA:

A) Flood Protection
B) Reservoir Management
C) Permits & Approvals
D) Source Water Protection Planning
E) Remediation
F) Integrated Water Resource Planning/Management
G) Monitoring/Indicators
H) Public Outreach and Stewardship
I) Conservation Areas’ Management
Please fill the following table indicating the percent of total monitoring time by your CA that is devoted to each type of water quality monitoring, and for each also indicate whether your CA should be devoting more time to each.

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<th>Type of water quality monitoring</th>
<th>Total monitoring time devoted (%)</th>
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<tr>
<td>Ground Water Quality Monitoring</td>
<td>0-20  21-40  41-60  61-80  81-100</td>
</tr>
<tr>
<td>Benthic Monitoring</td>
<td>0-20  21-40  41-60  61-80  81-100</td>
</tr>
<tr>
<td>Other (Please specify)</td>
<td>0-20  21-40  41-60  61-80  81-100</td>
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</table>

Does your CA have a benthic monitoring program (loosely, a series of sampling sites at which individuals associated with your CA collect benthic data that is the property of your CA)? (Y/N)

What year was your CA’s benthic monitoring program established? ____________

Please indicate which, if any, of the following changes were made to your CA’s benthic monitoring program in the last five years (Please select all that apply.):  

- _____ Number of sampling sites  
- _____ Location of sampling sites  
- _____ Frequency of sampling  
- _____ Protocols used to sample  
- _____ None of the above  
- _____ Others (Please specify) ___________________________________________

Please use the space below to provide any details on how exactly your benthic monitoring program has changed in past five years.

________________________________________________________________________

To what level are the invertebrates collected through your CA’s benthic monitoring program identified?  

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Lowest possible level</th>
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<tr>
<td>Other (Please specify) _____________________________</td>
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</tbody>
</table>
Using the scale provided in the drop-down menu, please indicate how important the information collected through your CA's benthic monitoring program currently is to each of the following methods of reporting carried out by your CA.

1 – not at all important
2 – not very important
3 – neutral
4 – somewhat important
5 – very important

A) For Watershed Report Cards  
B) For internal CA reports  
C) For public presentations  
D) For presentations to Municipalities  
E) For community meetings  
F) For monthly reports  
G) For staff meetings  
H) For board meetings  
I) Other (please specify)_____________________________________________________

Comments: ____________________________________________________________________

Using the scale provided in the drop-down menu, indicate how important the information collected through your CA's benthic monitoring program currently is to each of the following activities carried out by your CA.

A) For flood protection  
B) For reservoir management  
C) For permits and approvals  
D) For source water protection planning  
E) For remediation and restoration  
F) For integrated water resource planning/management  
G) For monitoring/indicators  
H) For public outreach and stewardship  
I) For Conservation Areas' management  
J) Other (please specify)________________________________________________________

Comments: ____________________________________________________________________
Regardless of whether your CA has its own benthic monitoring program, does your CA currently use or report benthic monitoring data that has been collected, analyzed or compiled by any of the following? Please select all that apply.

____ Community volunteer group
____ Non government organization
____ Provincial government organization (e.g., MOE or MNR)
____ Federal government (e.g., DFO)
____ Municipality
____ None of the above
____ Others (Please specify)____________________________________________________

☐ None of the above

Comments: ______________________________________________________________

Are volunteers used to collect any of the benthic monitoring data used by your CA (Y/N)? If 'N' please scroll to the bottom of the survey and click 'Submit' to complete the survey.

Using the scale in the drop-down menu provided, please indicate how important the information arising from Volunteer Benthic Monitoring (VBM) currently is to the following activities carried out by your CA.

A) For flood protection
B) For reservoir management
C) For permits and approvals
D) For source water protection planning
E) For remediation and restoration
F) For integrated water resource planning/management
G) For monitoring/indicators
H) For public outreach and stewardship
I) For Conservation Areas’ management
J) Other (please specify)________________________________________________________

Comments: ______________________________________________________________
Appendix I: Conservation Authority Survey: Questionnaire 2 - Community Input and Benthic Monitoring

Questionnaire 2: Community Input and Benthic Monitoring

For which Conservation Authority are you responding to this survey?

In what capacity are you associated with this CA? Staff/Board Member

Using the scale provided, indicate your opinion of the time allocated by your CA toward the types of water quality monitoring

0 – N/A
1 – much more time should be allocated
2 – a bit more time should be allocated
3 – enough time is allocated
4 – a bit too much time is allocated
5 – too much time is allocated

A) Surface water quality monitoring
B) Ground water quality monitoring
C) Benthic monitoring
D) Other (please specify): __________________________

Comments: __________________________

Community contributions to Conservation Authority activities and initiatives.

Volunteer contributions from the community to your CA activities and initiatives can be made in a variety of forms. Community can provide input in the form of opinions, ideas and knowledge. For example individuals may sit on a committee that CA representatives (staff/board) also sit on or facilitate, or they may provide input on environmental assessments (Volunteer Input - VI). Individuals may also volunteer their time to stewardship activities coordinated by your CA. For example, volunteers may provide the labour in restoration projects including tree planting or invasive species removal (Volunteer Action - VA). As well, community members may also volunteer their time to monitoring efforts – the collection of scientific data which your CA may use to make management decisions (Volunteer Monitoring - VM).

VI – input in the form of opinions, ideas and knowledge
VL – input in the form of labour (e.g., tree planting)
VM – input in the form of monitoring (e.g., turbidity measurements)
VBM – input in the form of benthic monitoring
Using the scale provided, indicate your agreement with each of the following statements:

0 – don’t know
1 – strongly disagree
2 – slightly disagree
3 – neither agree or disagree
4 – slightly agree
5 – strongly agree

<table>
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<tr>
<th>This type of community contribution is:</th>
<th>Useful</th>
<th>Available</th>
<th>Trustworthy</th>
<th>Policy and program relevant</th>
<th>Used by other staff in your CA</th>
<th>Used by other CAs and gov’t agencies</th>
<th>Overall preferable</th>
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<td><strong>VI</strong> (volunteer input) – input in the form of opinions, ideas and knowledge</td>
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<tr>
<td><strong>VL</strong> (volunteer labour) – input in the form of labour (e.g., treeplanting)</td>
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<tr>
<td><strong>VM</strong> (volunteer monitoring) – input in the form of monitoring e.g., turbidity measurements</td>
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</table>
Using the scale provided, please indicate how important community contributions (any type) currently are to the activities of your CA.

0 – no community contributions
1 – not at all important
2 – not very important
3 – neutral
4 – somewhat important
5 – very important

A) Flood Protection
B) Reservoir Management
C) Permits & Approvals
D) Source Water Protection Planning
E) Remediation
F) Integrated Water Resource Planning/Management
G) Monitoring/Indicators
H) Public Outreach and Stewardship
I) Conservation Areas’ Management
J) Others (Please specify)  

Comments:  

Using the scale provided, please indicate how beneficial you feel collaborations between Volunteer Benthic Monitoring groups (VBM) and CAs are to the following.

1 – not at all beneficial
2 – not very beneficial
3 – neutral
4 – somewhat beneficial
5 – very beneficial

A) For the promotion of enhanced **public relations** between community members and CAs
B) For **public education** on the significance of human actions on the quantity or quality of freshwater resources
C) For the **promotion of community contribution** to other CA activities and initiatives
D) For increasing the social capital (i.e. connections within and between social networks) of the CA
E) For cost-effective **labour**
F) For increasing the number of sites sampled or the frequency of sampling of sites
G) For finding better solutions to problems through of the input by the individuals directly affect by the CA’s management decisions
H) Other (please specify)  

Comments:  

In your view, under what circumstances should a CA consider replacing their benthic monitoring program with one that uses volunteers to collect benthic monitoring data? (Please select all that apply.)

- Funding that was allocated to your benthic monitoring program is no longer available
- Funding is available for your CA to coordinate a VBM program (i.e. CA staff coordinate, train and supervise volunteers)
- Funding is available to collaborate with a VBM group that exists in your watershed (i.e. provide technical, in kind or funding support)
- Funding is available for your CA staff to identify the benthic invertebrates collected by VBM group your CA collaborates with
- Funding is available for your CA staff to identify the benthic invertebrates collected by VBM group your CA coordinates
- None of the above
- Others (Please specify)

Comments: ________________________________________________

In your view, to what extent do you agree that the following factors are obstacles to the collaboration between Volunteer Benthic Monitoring (VBM) groups and CAs?

1 – strongly disagree
2 – slightly disagree
3 – neither agree or disagree
4 – slightly agree
5 – strongly agree

A) **Lack of training or experience of CA staff** in dealing with or coordinating volunteers in a VBM group
B) **Lack of need for the data** collected the VBM group
C) **Lack of desire** of CA staff or board members to use data collected by VBM groups
D) **Lack of capacity** to provide support (financial, technical or in kind) to VBM groups
E) Lack of confidence in the **protocols** used by VBM groups to collect their data
F) Lack of confidence in the **volunteers ability** to adhere to the protocols the VBM group uses to collect their data
G) Lack of cooperation in **site selection** between the VBM group and the CA
H) **Lack of individuals** available for or interested in volunteering for the VBM group
I) Other factors that are obstacles to the collaboration between VBM groups and CAs (please specify)? ________________________________________________

☐ None of the above

Comments: ________________________________________________
In your view, to what extent do you agree that the following factors are obstacles preventing the use of Volunteer Benthic Monitoring (VBM) collected data in CA decisions regarding freshwater management?

1 – strongly disagree
2 – slightly disagree
3 – neither agree or disagree
4 – slightly agree
5 – strongly agree

A) **Lack of resources** for CA staff to coordinate their own VBM program
B) **Lack of need** for the data collected by the VBM group
C) **Lack of resources to provide support** (technical, in kind or funding) to the VBM group
D) **Lack of desire** by CA staff or board members to use data collected by VBM groups
E) **Lack of training** or experience within the CA for evaluating the quality of volunteer collected data
F) Discrepancy between the data collection **protocols** used by the VBM group and those used by the CA
G) Discrepancy between the **sites** that the CA requires monitoring for and those for which the VBM group has collected data
H) Other factors that are obstacles to the use of VBM collected data in decisions made by CAs (please specify)? □ None of the above

Comments: ____________________________________________
Curriculum Vitae

Sonja Teichert

EDUCATION

Ph.D. (Biology and Environment & Sustainability) Western University, London, ON
Apr 2016

M.Sc. (Biology) Acadia University, Wolfville, NS
Thesis: Habitat use and population spatial structure of the Forked Fungus Beetle (Bolitotherus cornutus Panzer)
Oct 1999

H.B.Sc. (Zoology) Western University, London, ON
Thesis: Seasonal patterns of arboreal nest use by the White-footed Mouse (Peromyscus leucopus noveboracensis)
Apr 1995

PUBLICATIONS

Refereed
• Teichert, S. 1999. First reported flight of Bolitotherus cornutus Panzer (Coleoptera: Tenebrionidae). The Coleopterists Bulletin 56(3): 293-295

Non-Refereed
• Mallik, A.U. and Teichert, S. 2009. Effects of forest management on water resources in Canada: a research review. National Council for Air and Stream Improvement (NCASI), Technical Bulletin No. 969
CONFERENCES PRESENTATIONS & INVITED LECTURES

Conferences

- 3MT: Three Minute Thesis Competition, Apr 2012, Western University, London, ON
- The role of Community Based Monitoring in freshwater ecosystem management by Ontario's Conservation Authorities. March, 2012, Western Forum, London, ON
- The role of Community Based Monitoring in freshwater ecosystem management by Ontario's Conservation Authorities. November, 2010, A.D. Latornell Conservation Symposium, Alliston, ON (poster)
- The role of Community Based Monitoring in freshwater ecosystem management by Ontario's Conservation Authorities. June, 2010, Joint Annual Meeting of the North American Benthological Society (NABS) and American Society of Limnography and Oceanography, Santa Fe, New Mexico
- Spatial population structure of the bobcat (Lynx rufus) in Nova Scotia. September, 1999 at Atlantic Society of Fish and Wildlife Biologists Annual Meeting, Sydney, NS
- The Role of Space in Patterns and Processes: The ecology of the forked fungus beetle, Bolitotherus cornutus (Panzer). February, 1999 Northeastern Wildlife Research Graduate Conference, Orono, Maine
- Population dynamics and movement of the forked fungus beetle Bolitotherus cornutus. March, 1997 Northeastern Wildlife Research Graduate Conference, Montreal, Quebec

Invited Lectures

- The use of citizen science in freshwater management by Ontario Conservation Authorities. Oct, 2014 Ecosystem Health (graduate course), Western University, London, ON
- Public participation and the use of Citizen Science in freshwater management by Ontario's Conservation Authorities. May, 2013, Retiring with Strong Minds Program, Western Schulich School of Medicine, London, ON
- The use of watershed-level studies to assess the effects of forestry practices on water quality and quantity. Graduate Seminar and Tutorial Series, 2006 Lakehead University, Thunder Bay, ON
- Long-term survey data: Ring-necked Pheasant (Phasianus colchicus) crowing as an index of their relative abundance. November, 1999 Methods in Ecology, Acadia University, Wolfville, NS
- Spatial pattern and ecological analysis: The ecology of the Forked Fungus Beetle Bolitotherus cornutus; an example. February, 1999 Tutorial in Animal Ecology (graduate course), Acadia University, Wolfville, NS
• Time series analysis of the relative abundance of the Ring-necked pheasant (*Phasianus colchicus*) in Kings County, Nova Scotia. February, 1998 Methods in Ecology, Acadia University, Wolfville, NS

**Scholarships & Awards**

- 2013 Community Involvement Scholarship, PSAC Local 610, Western University
- 2012 QEII Graduate Scholarship in Science & Technology, Western University
- 2012 David E. Laudenbach Scholarship, Western University
- 2012 Award for Research Excellence - 2nd place, Society of Graduate Students - Western Research Forum, Western University
- 2012 Graduate Thesis Research Award, Western University
- 2012 A.D. Latornell Conservation Symposium Grant
- 2012 A.D. Latornell Conservation Symposium Student Sponsorship, Canadian Water Resources Association (declined)
- 2012 Soil and Water Conservation Association Award of Merit
- 2011 Student Travel Scholarship, Ontario Association of Impact Assessment (declined)
- 2011 Ontario Graduate Scholarship, Western University
- 2011 Green Award, Western University  
  Honourable Mention for work on Interdisciplinary Forum Committee  
  Nominated personally & for work on Earth Day Colloquium Organizing Committee  
- 2011 Award of Excellence, Environment and Sustainability Collaborative Program, Western University
- 2010 Travel Award, Environment and Sustainability Collaborative Program, Western University
- 2010 Award of Excellence, Environment and Sustainability Collaborative Program, Western University
- 2010 Ontario Graduate Scholarship, Western University
- 2009 Ontario Graduate Scholarship, Western University
- 2009 Entrance Scholarship, Environment and Sustainability Collaborative Program, Western University
- 2009 Student Travel Scholarship, Ontario Association of Impact Assessment
- 1998 Carl H. McCarthy & Margaret Godfrey McCarthy Scholarship, Acadia University
- 1996 Alden B. Dawson Award, Acadia University
- 1995 Dean Russell Limited, Western University
- 1995 Dean’s Honour List, Western University
**PROFESSIONAL EXPERIENCE**

**Western University, London, ON**  
Sep 2008 - Dec 2015  
*Department of Biology*  
- Tutorial Leader for General Biology  
- Teaching Assistant for Restoration Ecology, Evolution  
*Centre for Environment and Sustainability*  
- Teaching Assistant for Engineering Solutions, Ecosystem Health, Environmental Issues, Natural Science of Environmental Problems  
*Faculty of Science*  
- Graduate Fellow in Learning Development

**ALS Laboratory Group**  
Thunder Bay, ON, May 2007 - Dec 2007  
*Analyst (Microbiology Department)*  
analyzed water samples for bacteria (e.g., Total coliforms, *E. coli*, *Clostridium*, *Psuedomonas*, *Aeromonas* etc.) using presence/absence and filtration methods

**Lakehead University**  
Thunder Bay, ON, Oct 2005 - July 2007  
*Research Associate (to Dr. Azim Mallik)*  
- 2006/2007 contract: collected, read and organized literature; wrote literature review on the use of watershed-level studies in examining the impacts of forestry practices on water quality and quantity in Canada  
- 2005/2006 contract: collected, read and organized literature; wrote literature review on the effects of buffer zones on maintaining the ecological functions of riparian areas of forested streams

**Cape Breton University**  
Sydney, NS, Aug 2001 - Jul 2005  
*Senior Laboratory Instructor (Department of Biology)*  
- prepared laboratory materials for instruction and maintained equipment, supplies and specimens  
- developed new laboratory experiments and procedures and their corresponding manuals and handouts  
- developed and graded laboratory assignments and exams, and maintained a record of student’s grades and attendance  
- successfully initiated collaboration between environmental biology students and Environment Canada’s Canadian Aquatic Biomonitoring Network (CABIN), where students collected physical and biological stream data to submit to CABIN’s database
Acadia University
Wolfville, NS, Apr 2000 - Aug 2001
Project Coordinator (Nova Scotia Herpetofaunal Atlas Project)
- recruited and trained volunteer atlassers throughout the province to submit sightings of amphibian and reptiles
- established and maintained contacts with individuals, clubs, NGOs and Government agencies involved in project
- maintained and developed the website and online submitted atlas data
- produced newsletters, prepared and help to administer the yearly budget, and helped to secure project funding
- gave presentations, workshops and interviews to promote the project and train volunteers

Dalhousie University
Halifax, NS, Jan 2001 - Apr 2001
Research Assistant (to Dr. Ransom A. Myers)
- analyzed trends in the by-catch of the world’s longline fisheries using SAS and SPPLUS

Self-employed Research Consultant
Wolfville, NS, Sep 1999 - Apr 2000
- spatial and temporal analysis; over 20 years of bobcat harvest data from across NS
- spatial analysis of 2 years of bird and arthropod data from Gros Morne, Nfld.
- effects of burying seeds on the germination of plants in the genus Vaccinium.

Acadia University
Wolfville, NS, Sep 1996 - May 1999
Biology Department
Teaching Assistant for Principles of Biology, Terrestrial Ecology and Population Ecology

PROFESSIONAL AFFILIATIONS, WORKSHOPS AND CERTIFICATES
- Soil and Water Conservation Association of Ontario: Jan 2012 - Jan 2013
- Society of Freshwater Science: Mar 2009 - Mar 2013
- Canadian Water Resources Association: Feb 2009 - Mar 2013
- Western Certificate of University Teaching: July 2014, Western University
- Integrating Complexity - Environment and History: interdisciplinary workshops exploring challenges to scientific understanding, Oct 2010, Western University
- Site 41 Symposium: An interdisciplinary best practice case study of waste management, Sep 2010 at UWO
- Media Relations Workshop: Department of Biology, Feb 2010, Western University
• Fall Perspectives on Teaching: Sep 2009, Western University
• Spring Perspectives on Teaching: Apr 2009, Western University
• Graduate Teaching Assistant Conference: Sep & Feb 2008, Sep 2009, Western University
• Social Responsibility: A Road Map to Sustainability: Nov 2008, Tavares Group Consulting
• Teaching Assistant Training Program: Aug 2008, Western University

**COMMITTEE INVOLVEMENT**

**Western University**

• Student Representative on Environment and Sustainability (E&S) Collaborative Committee: Sep 2011
• Student Sustainability Collaborative: Sep-Dec 2012
• Member and Chair of SOGS Sustainability Committee: member Jun 2009 - Apr 2012, chair Mar 2010 - Apr 2012
• Member of SOGS Grad Club Committee: Aug 2010 - Jan 2012
• Member of the President’s Advisory Committee on Environment and Sustainability: Sep 2010 - May 2012
• Executive Member of the Environment and Sustainability Society (ESS): Sep 2010 - Jan 2012
• Graduate Student Representative for Society of Graduate Students (SOGS): Jun 2009 - June 2011
• Executive Member of Society of Biology Graduate Students (SOBGS): Sep 2009 - June 2011
• Member of the Earth Day Colloquium Organizing Committee: 2009, 2010, 2011 & 2012
• Member of the ESS Interdisciplinary Forum Organizing Committee: 2011
• Member of the E&S Outreach Committee: Sep 2009 - Aug 2010
• E&S Outreach Volunteer: 2009-2011
• Volunteer Graduate Facilitator for the Leadership Education Program: 2008-2010
• Member of the Ontario Association on Impact Assessment Education Liaison Committee: 2009-2010

** Acadia University**

• Volunteer for Teaching Assistance by Graduate Students: Sep 1997 - Aug 1998
• Member and Vice-President of the Biology Seminar Club: Sep 1997 - Aug 1998
VOLUNTEER WORK

- Foster Parent for Progressive Animal Welfare Service (PAWS): Feb 2014 - present
- Event Organizer: Building a vermicomposter workshop given to grade 3 students of St. George’s School, London, ON (Feb 26, 2013)
- Feline Foster Parent for the Animal Rescue Foundation of Ontario (ARF Ontario): Apr 2009 - Jul 2010
- Western Serves (Chelsey Park Home): Sep 2008, annual Western University service learning
- Volunteer for the Thunder Bay and District Humane Society: Sep 2005 - Dec 2005