Miistakis Institute

Using Citizen Science to Advance Environmental Research and Monitoring in Alberta

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Document prepared for Environmental Monitoring and Science Division, Alberta Environment and Parks

Innovative research. Engaged communities. Healthy landscapes.

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Executive Summary

On June 30, 2016, the Environmental Monitoring and Science Division (EMSD) was created within the Department of Environment and Parks (the Department). EMSD is led by the Chief Scientist, whose role and delegated responsibility for delivering Alberta's environmental science program is established under s. 15 of the *Environmental Protection and Enhancement Act* (EPEA). One of the core business priorities for EMSD is planning, coordinating and conducting environmental monitoring, which includes the establishment of citizen science and community based monitoring programs.

This report establishes a foundation for the Chief Scientist and EMSD to understand the state of citizen science in Alberta and beyond, and to demonstrate the value of citizen science in supporting and advancing the development and implementation of an environmental science program.

Citizen science is research and monitoring where volunteers engage with a scientist to answer real questions. From collecting grizzly bear scat, to listening to amphibian calls, to reporting on groundwater levels, many Albertans are already participating in citizen science. The role of volunteers can be diverse, from citizens contributing field observations, to sorting or classifying images from their home computers, to identifying relevant research questions to address a local issue of concern. In addition, citizen science projects can range in scale from a local conservation challenge (e.g., pollution in a local water body) to global in scope (e.g., tracking monarch butterflies across North America).

Recently, the White House endorsed US federal agencies to support citizen science and provided three guiding principles:

1. Citizen science must be held to the **same standards as western science**. Scientific research projects should follow standard scientific practices in design, implementation, data quality assurance, data management, and evaluation.
2. Data worth collecting and using are also worth preserving and sharing. An **open source policy** means project data, applications, and technologies should strive to be transparent, open, and available to the public.

3. “Of the people, by the people, and for the people.” Projects should **engage the public** in ways that maximize both the value volunteers provide to the project and the value volunteers derive from participating.

Citizen science has strong potential to contribute to monitoring the condition of Alberta’s environment while also meaningfully engaging communities in knowledge generation and sharing. McKinley and associates (2015) identified two reasons environmental management agencies invest in citizen science: 1) to enable research and monitoring that might not otherwise be possible because of scale or other practical issues; and 2) to engage volunteers in new knowledge production, scientific learnings, and decision-making relating to the science. These pathways are not mutually exclusive, but reinforce each other as volunteers participate in a project.

Citizen science can help generate datasets over large geographic and temporal scales - a limitation for most scientists for practical reasons. Citizen science can help speed up field detection due to large numbers of individuals participating, and it can help with the classification of large datasets. These benefits are exemplified through the discovery of significant scientific results associated with citizen science projects including documenting species range shifts, assessing vulnerable species, anticipating effects on water resources, species management, and disaster and conflict resiliency.

In addition, the value proposition of citizen science includes the ability of programming to advance societal outcomes including environmental stewardship, community capacity, and environmental justice, and the co-production of knowledge.

There are limitations to citizen science that need to be considered and understood to ensure volunteers are involved appropriately and programs are designed effectively. Some of the concerns associated with citizen science projects include: the ability of volunteers to collect high quality information, the potential to engage volunteers in the subject matter, the potential for volunteer bias, the program sustainability, and data access and interoperability. Many of these concerns can be addressed through appropriate program design. However, some research and monitoring projects require specialized knowledge, equipment, training, and time commitments that make citizen science unsuitable. Other agencies, such as the Scottish Environmental Protection Agency, have developed frameworks to help staff determine when citizen science is an appropriate approach to consider.

There is a strong trend among government agencies and other organizations to incorporate citizen science as a tool to realize science, monitoring, and citizen engagement objectives. Interviews with citizen science practitioners from the United States Geological Survey (USGS), United States Environmental Protection Agency (EPA) and Tribal Health Alaska Project LEO provided lessons learned and outlined the role these agencies have played in supporting citizen science programming. Both the EPA and USGS support citizen science programing through small grant opportunities, development of standard protocols, supporting training sessions, auditing programs, calibrating and loaning technical equipment, and development of sharable tools and resources to support programming. Alaska Tribal Health developed and implemented Project LEO which documents strange phenomena, such as algae blooms, parasites in fish, and strange weather occurrences likely associated with climate change, and encourages the link between local traditional knowledge and traditional science through dialogue exchange and development of shared research questions.

Monitoring agencies reported that citizen-supported research and monitoring projects have strong, multifaceted societal impacts. The programs increase science literacy, encourage life-long learning, and connect people with the outdoors. Projects realize these impacts while completing high quality research and organizing data for use, and reuse, by future generations. Additional lessons shared by monitoring agencies include the importance of clearly outlining the role of citizen science within the agency mandate, addressing legal/ownership issues at the outset of program development, careful consideration of program goals and desired outcomes in program design, and investment in citizen science through providing support, resources and training to staff and partner organizations.

In Alberta there were 87 citizen science programs documented through the creation of a citizen science inventory. Sixty-nine of these projects were biodiversity related. They ranged in scale from local (e.g., Glenbow Ranch citizen science species checklist) to global (e.g., eBird). Fewer than half the documented citizen science programs are national or international in scale, and it was difficult to discern how well utilized many of these programs were in Alberta, or how easy it would be for a provincial monitoring agency to acquire the data.

A workshop highlighted many of the opportunities and concerns from an environmental monitoring and science staff perspective relating to citizen science. The workshop was attended by 20 participants, including Alberta Environment and Parks staff from a variety of disciplines such as air and water monitoring, community based monitoring, science and modelling, and data management. In addition, representatives from the Alberta Biodiversity Monitoring Institute and Nature Alberta were in attendance.

For citizen science to add value to environmental monitoring efforts in Alberta, a series of recommendations and actions were developed. The following broad recommendations were derived from a literature review, case study assessment, and staff feedback at the workshop:

1. Develop clear agency policy, procedures, and guidance to provide clarity to agency staff and partners.
2. Invest in citizen science through proper resourcing of staff and building of internal capacity.
3. Explore coordination within and between provincial government agencies on citizen science programming, and identify opportunities for citizen science to support each other's mandates and interests.
4. Develop a citizen science hub to share resources and widely promote citizen science in Alberta.

Project Background

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This report establishes a foundation for the Chief Scientist and EMSD to understand the state of citizen science in Alberta and beyond, and to demonstrate the value of citizen science in supporting and advancing the development and implementation of an environmental science program.

What is Citizen Science?

Citizen science refers to research cooperation between scientists and volunteers to expand opportunities for scientific data collection, and to provide access to scientific information by community members. Citizen science has a long history of collecting, storing, and sharing environmental data. The genesis of ecological and environmental science owes much to the efforts of amateur naturalists (Barber 1980, Keaney 1992, Merrrill 1989). These citizen scientists were engaged in the praxis of natural history throughout the Victorian era and their efforts laid the foundation for the more specialized areas of knowledge and expertise (e.g., ornithology, mammalogy, ecology) There is a long and continuous history of public engagement in the collection of information and data that contribute to science and management. For example, the annual Christmas Bird Count and Breeding Bird Surveys have been conducted continuously since the 1880s (Butcher and Niven 2007, Greenwood 2007).

In the last two decades, citizen science approaches to gathering biodiversity and natural resource information have proliferated (Roy et al. 2012; Shirk et al. 2012; Bell et al. 2008). The status of species, natural communities, or systems (like the state of water quality in a region) (Latimore and Steen 2014), the presence and extent of invasive species (Crall et al. 2011; Gallo and Waitt 2011), or the use of habitats by species (Sullivan et al. 2014; Erb 2012) have all been the focus of efforts to collect data using volunteers.

Researchers (Silvertown 2009) have identified three factors leading to the recent proliferation of citizen science programs: 1) the evolution and accessibility of technical tools to improve communication, dissemination of information, and data collection; 2) appreciation by professional scientists and others that the public represents a valuable source of labor, skills, computation power, and funding; and 3) the increased value realized by improving the public's understanding of research and monitoring through engagement in the scientific process. From a volunteer's perspective, there are many reasons why citizen science might be attractive, such as a desire to: contribute to scientific research and monitoring, participate in an enjoyable leisure activity, use new technologies, or address concerns about a local issue. Research on volunteer motivations revolves around a complex framework of factors and changes over time (Rothman et al. 2012). In addition, citizens are demanding the incorporation of principles of accessibility, transparency, and accountability within government agencies and decision-making. A recent poll in the US found that 40% of people did not trust, or only trusted a little, what scientists say about the environment[1]. Citizen science projects have the ability to change the way information is generated and shared, improving accessibility, transparency, and credibility of the information.

Citizen science initiatives have been responsible for the discovery of significant scientific results including documenting range shifts (Wilson 2013), assessing vulnerable species (Westgate 2015), anticipating effects on water resources (e.g., CoCoRaHS), human-wildlife conflicts (Lee, Quinn, and Duke 2006), species management (Delaney et al. 2007), and disaster and conflict resiliency (Tidball and Krasny 2012). Miistakis sees tremendous opportunity to use citizen science to advance understanding of the condition of the environment in Alberta. .

In addition, citizen science has been shown to advance both individual and societal outcomes including environmental stewardship (Evans et al. 2005), community capacity (Ballard and Belsky 2010), environmental justice (Wing et al. 2008), and co-production of knowledge and practice (Ballard & Belsky 2010).

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[1] http://www.huffingtonpost.com/terry-newell/who-cares-what-the-expert_b_569672.html

The Challenge of Defining Citizen Science

Over the last decade, citizen science has become widely discussed as an approach to expand meaningful engagement in science and understanding of science in society (Riesch & Potter 2014; Follett & Strezov 2015). The term citizen science has been coined twice. Alan Irwin, a UK social scientist, used the term as the title for his book that explored the relationship between science and volunteers (Irwin 1995). Irwin stressed the relationship between citizen science and environmental citizens, and noted the production of knowledge needs to be opened up to the public to help build sustainable futures and to solve environmental challenges. The argument here is that a volunteer is more likely to understand and engage in stewardship of the environment. The term was also coined by Richard Bonney, from the Cornell Lab of Ornithology (CLO), to refer to the growing number of scientist-driven public research projects supported by CLO (Bonney et al. 2009).

There are important differences in the Irwin and Bonney approaches: one is focused on increasing engagement of the public (i.e., laypersons) with a focus on democratization of science[2], while the other is more about scientists engaging volunteers in scientific research, driven by the need to obtain data. In essence, the approaches can be distinguished as bottom-up, driven by citizens' concerns (such as water quality in a local water body), versus top-down, driven by scientists, who need access to big data sets that would be difficult to collect on their own (Science Communication Unit 2013). The true breadth of citizen science lies between these two approaches, and the strength of the concept lies in its ability to achieve science, monitoring, and engagement goals.

A recent paper authored by many highly regarded citizen science practitioners defined citizen science as "the practice of engaging the public in a scientific project – a project that produces reliable data and information usable by scientists, decision makers, or the public and that is open to the same system of peer review that applies to conventional science" (Mckinley et al. 2015). The newly formed Citizen Science Association[3] defines citizen science as "involvement of the public in scientific research – whether community-driven research or global investigations." Lastly, the European Citizen Science Association[4] defines citizen science as

[2] Democratization of science: to expand the way knowledge is created and shared, as well as the creation of institutions and practices that fully incorporate principles of accessibility, transparency and accountability.
[3] http://staging.citizenscience.org/
[4] http://ecsa.citizen-science.net/

"organized research where the balance between scientific, educational, societal, and policy goals varies across projects. Citizen Science is an expanding field experimenting with alternative models of public knowledge production and democracy. That includes strengthening the scientific research by engaging with a variety of knowledge domains and introducing new perspectives and information as well as new partnerships. Citizens create knowledge – knowledge creates citizens."

The following characteristics are common between the different definitions of citizen science:

- Collaboration goes beyond institutional boundaries where there is a common agenda between multiple actors or stakeholder groups;
- Data collected is useful and usable; and
- Volunteers are engaged in the scientific process (Haklay 2015).

There are many other models of citizen science that have influenced the dialogue around the field, such as volunteer monitoring, participatory action research, and community based monitoring (Chambers 1994; Whitelaw et al. 2003). These other models tend to derive research questions based on community concerns, and typically represent a bottom-up approach to science. For example, community based monitoring is defined as "a process where concerned citizens, government agencies, industry, academia, community groups, and local institutions collaborate to monitor, track, and respond to issues of common community concern" (Whitelaw et al. 2003). Although some citizen science programs would fit this definition, many citizen science programs occur at a very broad scale and are not designed to address a local community concern. The lines between the models tend to blur, and attributing programs to one model or another can be challenging (Bonney et al. 2009). It is likely more important to define programs based on their model of participation or, in other words, by asking how the public are involved in the research or monitoring. Due to the breadth of citizen science programming, developing a citizen science typology will help to provide clarity when describing and evaluating citizen science programs.

Citizen Science Typologies

Typologies are helpful for quickly understanding the intent of the program, scope, and degree of participation. There are generally three different ways citizen science projects are classified: the model of participation, the geographic scope of the program, or the primary program goal and desired outcome (Shirk et al. 2012; Wiggins & Crowston 2011).

Volunteers can engage at different points in the scientific process, although the majority of projects typically involve volunteers reporting on some defined attribute, such as a species observation or a landscape change. Shirk et al (2012) describe three different models of participation:

1. Contributory projects which are designed by scientists and for which volunteers primarily contribute data;
2. Collaborative projects which are generally designed by scientists and for which volunteers contribute data and help to refine project design, analyze data, and/or disseminate findings; and
3. Co-created projects which are designed by scientists and volunteers working together and at least some of the volunteers are actively involved in most or all aspects of the research process.

The vast majority of citizen science papers in the literature represent contributory projects (Riesch & Potter 2014). Table 1 lists the different stages of scientific inquiry volunteers can be involved in, highlighting the diversity in degree of participation and types of activity, from defining the research question to disseminating the results.

Table 1: Types of volunteer activities

Stage of Inquiry	**Model of Participation**		
	Contributory	**Collaborative**	**Co-created**
Define question			X
Gather information			X
Develop hypothesis			X
Design study		(X)	X
Data collection	X	X	X
Analyze samples		X	X
Analyze data	(X)	X	X
Interpret data		(X)	X
Draw conclusions		(X)	X
Disseminate results	X	(X)	X
Discuss results and ask questions			X
(X) sometimes			

The model of participation is an important consideration in relation to desired outcomes: as the degree of volunteer participation increases (level of involvement of volunteers throughout the scientific process), the ability of the project to achieve science and social-ecological outcomes also increases. Contributory projects tend to show strengths in the development of science outcomes and gains in content knowledge for volunteers, while co-created projects tend to show strengths in increasing volunteer engagement in decision-making and building capacity for on-the-ground actions (Shirk et al. 2012; Mckinley et al. 2015). For example, Gardenroots, a co-created citizen science program in Arizona, assessed the risks posed by potential metal contamination to community gardens. Volunteers were engaged in all aspects of the research and monitoring program (as identified in Table 1). The authors noted that both individual learning and community outcomes were achieved (Ramirez-Andreotta et al. 2015). The study concluded that the co-created project improved communication around exposure risk, flow of information within the impacted community, and improved environmental health assessments (Ramirez-Andreotta et al. 2015).

The type of participation model is an important consideration at the project design phase, when the intended outcomes and impacts are defined. Wiggins and Crowston (2011) developed a different typology that focuses on the primary goal of the program with the understanding that citizen science programs often have multiple goals. They classify programs into five categories:

1. Action: locally rooted in place with primary goal to support a civic agenda;
2. Conservation: locally rooted in place with primary goal to support stewardship and natural resource management;
3. Investigation: tends to be regional or international in scale and primary goal is focused on scientific research;
4. Virtual: projects that are technologically mediated with no physical elements and tend to have an investigative research goal; and
5. Education: the primary goal is related to education and outreach.

The goal-oriented typology has not been as well utilized as the model of participation typology, but it is helpful for enabling practitioners to think carefully about the intended outcomes of a program. Citizen science programs often have more than one goal, and there can be tensions between goals that need to be considered.

The Miistakis Institute considered these two different classification systems, the model of participation, and geographic scope of the program as fields for the Alberta Citizen Science Inventory, to help citizen science practitioners and the public learn about citizen science programs relevant to Alberta.

Citizen Science Principles

As citizen science continues to grow and develop, public institutions such as the White House, Zurich University (Appendix A), and the European Citizen Science Association (Appendix B) have developed guiding principles to ensure appropriate program design and achievable impacts.

Given the diversity of definitions for citizen science and program types, developing guiding principles is a helpful step for ensuring effective program design. In 2015, the White House released a memorandum to federal agencies, entitled "Addressing Societal and Scientific Challenges through Citizen Science and Crowdsourcing." It outlined three principles that federal agencies should abide by[5]:

4. Citizen science must be held to the **same standards as western science**. Scientific research projects should follow standard scientific practices in design, implementation, data quality assurance, data management, and evaluation.
5. Data worth collecting and using are also worth preserving and sharing. An **open source policy** means project data, applications, and technologies should strive to be transparent, open, and available to the public.
6. "Of the people, by the people, and for the people." Projects should **engage the public** in ways that maximize both the value volunteers provide to the project and the value volunteers derive from participating.

These citizen science principles are consistent with the responsibilities identified in s. 15.2 of EPEA including:

1. "To collect, store, manage, analyze, evaluate and assess environmental monitoring data and to ensure the information is scientifically credible,

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[5] The White House. 2015. Accelerating Citizen Science and Crowdsourcing to Address Societal and Scientific Challenges. On-line URL: https://www.whitehouse.gov/blog/2015/09/30/accelerating-use-citizen-science-and-crowdsourcing-address-societal-and-scientific

including through prior peer review where the Chief Scientist considers it appropriate."

This goal is similar to the White House citizen science principle 1, which focuses on the scientific rigor of data collection. This principle stresses that citizen science is research or monitoring that should follow rigorous scientific standards, and produce data that is credible and useable by scientists and decision makers.

2. "To make environmental monitoring data and related scientific evaluations and assessments available to the public and to the Science Advisory Panel established under section 15.2(1)."

   This goal is similar to the White House citizen science principle 2, which focuses on an open source policy, where citizen science tools and resulting data is openly shared. This citizen science principle stresses that resulting data and results are to be shared with key stakeholders and the public.

Guiding principles provide direction to staff pursuing a citizen science approach. Here Miistakis provides draft guiding principles for consideration by the Chief Scientist and EMSD. These were developed by Miistakis and discussed with Department (EMSD) staff (although the guiding principles have not been approved).

1. Citizen science must be held to the same standards as conventional science. Citizen science research and monitoring projects should follow standard scientific practices in design, implementation, data quality assurance, data management, and evaluation.
2. Citizen science should operate in an open and transparent manner, and projects should strive for project data, applications, and technologies to be shared.
3. Citizen science should be inclusive and encourage active, meaningful, and productive participation of volunteers.
4. Citizen science should provide mutual benefit to both conventional scientists and participating volunteers.

Citizen science practitioners should strive to demonstrate the value of science through the efficient use of public funds, and to improve public support and individual interest in research and monitoring programs.

The Value Proposition: what is the role of citizen science in research and monitoring programs?

Citizen science has strong potential to contribute data to scientific evaluations and assessment on the condition the environment in Alberta while also meaningfully engaging communities in knowledge generation and sharing. McKinley and associates (2015) identified two reasons environmental management agencies invest in citizen science: 1) to enable science that might not otherwise be possible because of scale or other practical issues (rare events), and 2) to engage volunteers in new knowledge production, scientific learnings, and decision-making relating to the science. These pathways are not mutually exclusive, but reinforce each other as volunteers participate in a project. Careful program design is important to ensure desired outcomes are achieved. Here, Miistakis highlights the value associated with investment in citizen science programming.

Citizen science can occur at large geographic scales and often for longer temporal scales than conventional science

Citizen science can operate on a large geographic scale, generating datasets that can inform ecological questions at scales relevant to species range shifts, spread of infectious disease, and impacts on environmental processes like climate change and landscape change (Dickinson et al. 2010). eBird is one of the most well-known examples of a global citizen science program. As of 2013, eBird had collected over 140 million volunteer observations, for 150,000 different species, reported during 10.5 million volunteer hours. This data has been used extensively to document species distributions, and to understand the implications of climate change on avian ecology (Sullivan et al. 2014).

A recent survey of 388 biodiversity-related citizen science projects from around the globe estimated that between 1.36 and 2.28 million people are contributing to biodiversity-related citizen science projects. These contributions result in an in-kind contribution value between $667 million to $2.5 billion USD (Theobald et al. 2015). In France, citizen science programming contributed to monitoring of biological indicators agreed to under the Convention on Biological Diversity. Researchers valued the contribution from volunteers as the equivalent to 31 full-time staff, which would have cost 670,000 to 4.4 million Euros (Levrel et al. 2010).

The point here is not the real or potential cost savings; rather, it is that in order to effectively monitor at large spatial scales, many states, countries, and monitoring institutions have benefited from volunteer collected data. Citizen science has made large-scale assessments, research, and monitoring possible.

Citizen science can lead to early detection and reporting of rare events
Volunteers, with many eyes on-the-ground, can be effective at detecting change and reporting on rare events (e.g., road kill, diseased wild animals, algae blooms, or phenology changes in species) which are often impractical for a scientist to study (Pocock et al. 2013). A good example of early detection and real-time monitoring results is volunteers reporting the spread of house finch conjunctivitis across North America through Cornell Lab of Ornithology's FeederWatch program (Hosseini et al. 2006). Also, citizen science data has contributed to our understanding of avian migratory phenology shifts due to climate change (Hurlbert and Liang 2012). Reporting of strange phenomena or rare events may be an important objective of a monitoring agency responsible for reporting on environmental conditions. In addition, quick identification could enable a faster response by decision makers.

Citizen science can speed up image classification and analysis
Volunteers have proven to be effective at classifying photos, video, and audio files from research and monitoring programs, as well as reporting on secondary information, greatly speeding up data processing and analysis (Mckinley et al. 2015). The best examples of these types of citizen science projects occur through an on-line citizen science portal called Zooniverse where volunteers can: help sort images from the African Serengeti to inform wildlife management; review images to find plankton from California ocean current as an indicator of ecosystem health; or upload photos and transcribe archived orchid records from the UK to help researchers understand the impacts of climate change[6]. Volunteers can greatly speed up the process of classification and reduce costs associated with processing data. Again, cost savings and processing time of data are important variables for consideration by monitoring agencies that have an aim to report in a timely and efficient manner.

Citizen science can lead to better research questions
Science can sometimes benefit from integrating local and/or Traditional Ecological Knowledge (TEK) into the development of the research questions or monitoring program. A successful example is the Local Environmental Observer (LEO) project

[6] https://www.zooniverse.org/projects?discipline=nature&page=1

developed by the Alaska Tribal Health Initiative, where volunteers are encouraged to report rare phenomena, such as wildlife disease, algae blooms, or flooding occurring in northern aboriginal communities. The observations are assessed and, if appropriate, shared with conventional scientists for input. For example, if a local community member finds a fish with a parasite it might be shared with a scientific lab to ensure it is safe for consumption. Sometimes this activity results in the need for further research. Then scientists meet with the local community and develop the research questions together[7].

Citizen science can spread knowledge

Volunteers participating in a citizen science program are likely to share their experiences with family, friends and other community members. This changes how information flows through a community, and can lead to positive behavioral changes by others who may be motivated by the participant's shared knowledge. Road Watch in the Pass, a citizen science project that enabled volunteers to report wildlife observations along a busy transportation corridor, reported over 80% of participants sharing information with other community members about the project, including location of wildlife-vehicle collision hotspots and where you should slow down and drive cautiously (Lee et al. 2010). Citizen science therefore represents another mechanism for a monitoring agency to get its message and important monitoring results on the condition of the environment out to the public.

Citizen science can promote the flow of information between government agencies and the public

Information is generally passed from an agency to the public via outreach and education mechanisms. Citizen science programs differ in that volunteers participate in the research and monitoring program and generate knowledge through participation, thereby changing how information flows. This could lead to increased public participation in decision-making and better outcomes. The Great Koala Count in Southern Australia surveyed participants after their involvement and found improved understanding of koala management issues, with some participants changing their opinion on koala management strategies. The study found the citizen science program improved dialogue between volunteers interested in koalas and policy makers (Hollow et al. 2015).

Ultimately, the desired outcome of monitoring programs is to provide information necessary to understand environmental conditions and inform environmental

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[7] http://leonetwork.org/en/leo/about

decision-making by policy makers, regulators, planners, researchers, communities, industry, and the public. A more open flow of information and dialogue through increased participation and understanding of issues will benefit the monitoring agency and participating volunteers.

Citizen science can foster stewardship

In some cases stewardship actions by participants may be a desirable outcome of the citizen science program. There are examples of volunteers undertaking stewardship activities as a result of what they learned through their participation in a citizen science program. For example, a recent study assessed two backyard citizen science programs and reported management activities undertaken by participants for an invasive species (the common house sparrow) (Larson et al. 2015). Results indicated that all citizen science volunteers engaged in some form of management (both lethal and non-lethal) for invasive house sparrows, as this species is negatively impacting native songbird populations.

Citizen science can increase collaboration

There are numerous case studies where citizen science programming has helped to explore community concerns that may have been overlooked by scientists. For example, a citizen science program in Maine engaged landowners and municipal staff to develop a database of seasonal wetlands across the landscape. Seasonal wetlands are under threat from development and play an important role in providing habitat for smaller animals, such as amphibians and birds. The project resulted in improved acceptance of proactive planning for seasonal wetlands, improved knowledge among community members of best management practices, and increased dialogue between land owners and municipal staff (Jansujwicz et al. 2013).

Citizen science can build awareness and trust about an organization's mission

Engaging volunteers in citizen science projects can raise the public profile of the organization developing the project. Through project participation, volunteers learn about the organization's mission and may develop a better appreciation of management issues (Mckinley et al. 2015).

Thinking through Challenges

There are limitations to citizen science that need to be considered and understood to ensure volunteers are involved appropriately and programs are designed effectively. Involving volunteers in research and monitoring programs is not always appropriate, so understanding when and where involvement can be effective is an important first step (Mckinley et al. 2015). In the following section, key challenges of citizen science are identified, as are key steps for addressing these limitations.

Ability to engage volunteers

Research and monitoring program methodology may be too time intensive for volunteers or not occur often enough to hold interest. For example, a methodology may be highly specialized, involve complex equipment, or require intensive training limiting the value of citizen science. In addition, the subject matter may not capture volunteers' attention, limiting the value of engagement.

Ability to collect high quality data

From a scientist's perspective, one of the main concerns has been the ability of volunteers to collect data to the same quality of professional scientists. Quality control measures are an important consideration in citizen science, and can be addressed through proper and sufficient training, collection of duplicate samples, and testing for biases and outliers during data analysis (Mckinley et al. 2015). There have been numerous studies which compare volunteers' ability to collect accurate data to the abilities of a professional scientist. In the majority of cases, volunteers were able to collect data that scientists were able to use (Gollan et al. 2012; Jackson et al. 2015). To a certain extent, the ability of volunteers to collect high quality data can depend on the attribute under study. For example, a comparison between volunteers and professional scientists monitoring pollinators found a strong correlation between the two datasets for monitoring abundance and trends in higher level taxonomic composition but not for species specific identification. Therefore, the authors noted that citizen science could play a role in detecting community changes in abundance over space and time, but not for specific pollinators (Kremen et al. 2011).

An interesting new approach is to develop a hierarchical method of data collection to accommodate different levels of volunteer engagement. For example, a shore crab monitoring program developed for tropical coastal ecosystems consists of two levels: a rapid methods protocol for independent volunteers and a more detailed method which requires extensive training by scientists to accommodate different types of users (Vermeiren et al. 2016). During the citizen science program design phase, it is important to consider the level of data quality needed and the ability of volunteers to collect the information.

Perception of data quality
A survey of 41 scientists involved in the OPAL[8] citizen science project in England noted one of the biggest concerns in relation to data quality concerns was the perception of how other scientists will perceive research where volunteers are involved (Riesch & Potter 2014). This indicates that there is still a need to showcase successful citizen science programs to the scientific community and to help scientists understand the value proposition of citizen science to achieving science goals, including the way other programs have addressed quality assurance and quality control (QA/QC).

Challenges with large opportunistic data-sets
Citizen science enables data collection over large geographic scales that can help scientists assess changes in species distribution and abundance over time, track spread of wildlife diseases or invasive species, and understand changes in weather and climatic patterns. In general, these datasets tend to be opportunistic as volunteers report an observation or sighting to a large database along with hundreds of other users.

One of the key issues with opportunistic datasets is that the effort of the volunteer in data collection is often unknown. This can lead to the following challenges (Isaac et al. 2014) with analyses to understand trends over time:

- Uneven recording intensity over time: In this situation, the frequency of sampling is unknown because zero values are not recorded. For example, an area might be intensely sampled and a species was not recorded, or alternatively an area might have only been sampled once and the species was not recorded. If the sampling effort is known, better conclusions on species presence could be made;
- Uneven spatial distribution: The distribution of sampling effort is unknown; therefore some areas may have been extensively sampled by volunteers while other areas had no sampling effort; and
- Uneven detectability of attribute due to differences in skill sets of volunteers.

These concerns can lead to biases in data analysis limiting the potential for modeling change of an attribute over time. Recently there have been efforts to use opportunistic data in models that are integrated with smaller scale systematic surveys of the same attribute (Isaac et al. 2014; Giraud et al. 2014). For instance, Giraud and associates (2014) used birding datasets from France to develop a

[8] http://www.opalexplorenature.org/

statistical framework to combine a large-scale opportunistic dataset with a systematic dataset where sampling efforts were known to model trends in species abundance over time.   Another approach has been to incorporate sampling effort into volunteer monitoring to enable more robust modeling of the data (Bonardi et al. 2011; Dickinson et al. 2010).

Although opportunist datasets present challenges, monitoring agencies engaging volunteers in data collection need to consider how the data will be used in the program design phase to determine if information on volunteer sampling effort needs to be collected (Pimm et al. 2014).

Access and interoperability of citizen science data

Data collection by volunteers tends to focus on the need of the organizing agency and not necessarily on data sharing with other researchers and participants. This may limit the potential for the citizen science program to be open and accessible, compromising the guiding principles of citizen science. Citizen science data and metadata should be publically accessible, unless security concerns or privacy concerns prevent open access.

Interoperability between programs and datasets is another challenge that limits the potential for large-scale data analysis. Although there are recent efforts in the United States to standardize similar attribute data between datasets, this is an area of citizen science that could greatly enhance its long-term value and will require investment by the citizen science community (Fleming & Billman 2003). Supporting interoperability between programs collecting similar attributes is a potentially important government agency role. Data standards and protocols for different monitoring attributes need to be agreed upon to enhance large geographic scale data collection.

Volunteer bias

Recently citizen science was featured in Nature in an editorial entitled "Rise of the Citizen Scientist[9]." The editorial was complimentary to the overall values of citizen science, but it proposed that citizen science's main limitation is the potential for conflict of interest. The editorial surmises that some volunteers are likely to participate to advance their political objectives, which could bias how they participate. For example, volunteers who participated in the Great Koala Count project had stronger views on koala protection than did the general public.

[9] http://www.nature.com/news/rise-of-the-citizen-scientist-1.18192

The European Citizen Science Association responded to the editorial with the following statement, “Instead of seeing public engagement with citizen science as an asset - one that channels public concerns into asking targeted questions and obtaining sound scientific evidence - the editorial saw this as cause for concern and conflict of interest. Conventional science also struggles with issues related to transparency of motives, conflict of interest, and integrity. Citizen science is not special in this regard, but by singling it out, the Nature editorial casts undeserved doubt upon the integrity of citizen science data. Statistical testing and good design are already used to identify and minimize bias in citizen science projects.”[10]

This exchange highlights the importance of program design that considers standard scientific practices, quality assurance, evaluation, and reporting. There are numerous resources that aim to help practitioners develop optimal citizen science programs (Tweddle et al. 2012; Bonney et al. 2009). The Chief Scientist should consider adopting or adjusting one of these resources to help staff design effective programs.

Program sustainability

Citizen science requires investment in program design, development, data collection tools, data management, and collaboration between monitoring agencies and volunteers. Often research and monitoring programs are designed to cover large geographical areas over long temporal periods, thus requiring long-term funding and support. Program sustainability can be a big challenge and needs to be considered before project inception to ensure appropriate funding is secured (Fleming & Billman 2003).

When is Citizen Science Appropriate?

Some research and monitoring projects require specialized knowledge, equipment, training, and time commitments that make citizen science unsuitable (Dickinson et al. 2010), but when should citizen science be considered? The following information and figure were extracted from a report prepared for the Scottish Environmental Protection Agency (SEPA) and from lessons learned by University of Florida Extension Services[11] (Pocock et al. 2013). Figure 1 depicts characteristics to consider when assessing if a citizen science program is appropriate.

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[10] http://ecsa.citizen-science.net/node/142

[11] https://edis.ifas.ufl.edu/fr359

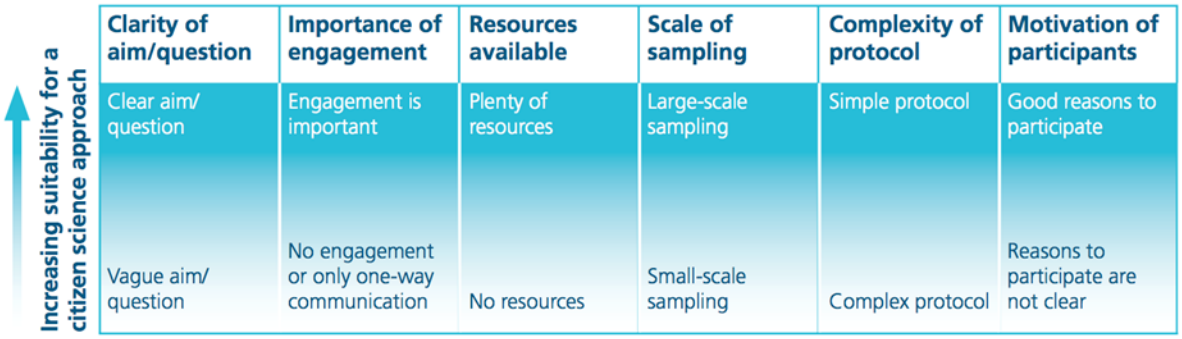

Figure 1. Characteristics for assessing appropriateness of a citizen science approach

These characteristics are defined as:

- **Clarity of aim/question**: as with all science programs, careful documentation of the research aim, objectives, and outcomes is important for ensuring there is a need for volunteers and that volunteers are to contributing meaningful and useful data. Well-defined research and monitoring programs: will improve the volunteer's experience; ensure high quality data is collected; and are more likely to lead to improved understanding of science and the issue being investigated.

- **Importance of engagement**: A key strength of citizen science is its ability to improve engagement in science, decision-making and stewardship activities relating to the project. There must be value provided to the participant, and the program must include a science component (data collection) for it to be considered citizen science. If the monitoring agency is trying to educate the public on a program or environmental concern, then the program should focus on outreach and education objectives not the creation of a citizen science program. If there is a need to collect data and the agency wishes to enhance engagement opportunities, then citizen science should be considered as an option. If the program is focused on a local community concern or if there is a community that the monitoring agency wishes to engage, then citizen science may be especially desirable.

- **Resources available:** Consider what the program needs to be successful and if those resources already exist. Does the project need a website, database, or data collection tools, and are these readily available? Can the project adopt existing QA/QC protocols used in research and monitoring programs?

- **Scale of sampling**: Citizen science offers great strength in large-scale data collection over long periods of time. Some research and monitoring projects are not practical without contributions from volunteers. These projects rate higher as potential for the development of citizen science programming.

- **Complexity of protocols**: The most effective citizen science programs have simple protocols to follow, reducing volunteer error and the amount of training required. Programs with complex protocols require more investment in training and might only be appropriate for small-scale programs with a lower number of volunteers.

- **Motivation of participants**: Citizen science requires volunteer engagement and sustained interest over time. A recent analysis of the Global Biodiversity Information Facility (GBIF), a species database, found that although citizen science has contributed an increase in birding data, other taxa continue to have large knowledge gaps (Amano et al. 2016). These knowledge gaps may be partially explained by how interested volunteers are in the topic. It is important to understand the motivation of volunteers and the diversity of reasons volunteers choose to participate. For instance, does a project address a topic of interest, provide a sense of place (in one's backyard or community park) or a sense of community, involve a concerning topic, or enable participants to discover something new? It is also important to consider the level of engagement in data collection. For example, if there is too much data to enter it could be overwhelming for a volunteer, however if data entry happens rarely, then volunteers are likely to forget about it.

SEPA developed a decision-making framework to guide staff on identifying appropriate citizen science opportunities (Pocock et al. 2013). The framework is specific to SEPA goals and objectives, and considers the characteristics outlined above.

The Department could benefit from the development of a decision support framework that enables staff to assess if citizen science is appropriate, while also classifying the projects based on typologies around scale and degree of participation. The Chief Scientist should consider how the program helps in addressing knowledge gaps or meeting science objectives.

How Are Other Monitoring Agencies Using Citizen Science?

There is a strong trend among government agencies and other organizations to incorporate citizen science as a tool to realize research, monitoring and citizen engagement objectives. In order to explore how citizen science could help fulfill the responsibilities identified under s.15 of EPEA, Miistakis felt it would be helpful to share three case studies of agencies and organizations that have used citizen science to carry out their work.

Miistakis selected these case studies based upon the website search that informed the citizen science inventory, and professional knowledge of citizen science programs. Miistakis selected the United States Geological Service (USGS), the United States Environmental Protection Agency (EPA) and the Local Environmental Observer Network (LEO) for case studies. Miistakis completed interviews with personnel from each agency/organization. Miistakis interviewed three people from the EPA: Alice Mayio (Head Office, past lead for volunteer monitoring efforts), Edward Washburn (Head Office, Citizen Science Program) and Tina Laidlaw (regional volunteer monitoring lead). Miistakis interviewed Dave Govoni from the USGS and Mike Brubaker from the LEO Network. Miistakis had hoped to include a case study of the National Oceanic and Atmospheric Administration (NOAA)[12] as this agency has a rich tradition of supporting citizen science. However, Miistakis was unable to secure an interview in a timely fashion.

Introduction to Agencies

The Local Environmental Observer Network

Arctic communities were among the first to experience significant impacts from climate change. In 2009, the Alaska Native Tribal Health Consortium (ANTHC) established the Center for Climate and Health to help describe connections between climate change, environmental impacts, and health effects. In 2012, the LEO Network was launched as a tool to help the tribal health system and local observers share information about climate and other drivers of environmental change.

[12] http://www.oesd.noaa.gov/leadership/citizen_sci.html

The LEO Network is a network of local observers and topic experts who share knowledge about unusual animal, environment, and weather events. These observations are based on local and traditional knowledge, and the experience of network members. With LEO, individuals can connect with others in their community to help detect, monitor, and find answers about environmental events. Community members can also engage with topic experts in many different organizations and become part of a broader observer community[13].

United States Environmental Protection Agency (EPA)

The mission of the EPA is to protect human health and the environment. EPA's purpose is to ensure that:

- all Americans are protected from significant risks to human health and the environment where they live, learn, and work;
- national efforts to reduce environmental risk are based on the best available scientific information;
- federal laws protecting human health and the environment are enforced fairly and effectively;
- environmental protection is an integral consideration in U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade, and these factors are similarly considered in establishing environmental policy;
- all parts of society -- communities, individuals, businesses, and state, local, and tribal governments -- have access to accurate information sufficient to effectively participate in managing human health and environmental risks;
- environmental protection contributes to making our communities and ecosystems diverse, sustainable, and economically productive; and
- the United States plays a leadership role in working with other nations to protect the global environment[14].

United States Geological Service (USGS)

The USGS is a science organization that provides impartial information on the health of the United States' ecosystems and environment, the natural hazards that

[13] https://www.leonetwork.org/leo/about
[14] https://www.epa.gov/aboutepa/our-mission-and-what-we-do

threaten the US, the natural resources people rely on, the impacts of climate and land-use change, and the core science systems that help provide timely, relevant, and useable information. The mission of the USGS is to serve the US by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect quality of life[15].

Synthesis of Interviews

Interviews with each agency were structured around three questions:

- What is the value of citizen science to your agency?
- What role did your agency play in supporting citizen science? and
- What were the challenges and lessons learned?

A synthesis of these interviews is provided below. Notes from the interviews are included in Appendix C.

Why Citizen Science? (Value proposition & meeting monitoring objectives)

The EPA and USGS have long-standing engagement with citizen science, traditionally referred to as volunteer monitoring, and report a number of realized benefits.

Democratization of Science

- Citizen science is about the democratization of science and recognizes the need to engage others in the scientific process to strengthen evidence-based decision-making.
- The local environment surrounds us. People live in a place, know it, and can observe it changing. Citizen science builds on this dynamic and connects people to the environment.

Integrating TEK and Trust Building

- In the case of the LEO Network, citizen science helps to integrate academia, government agencies, and local communities. ANTHC noted that the LEO Network helped to build a team environment around a local issue of concern. The program helps to mesh Traditional

[15] http://www.usgs.gov/aboutusgs/

Ecological Knowledge with western science around a specific event and focused everyone on a defined issue.

Enhanced Engagement Improves Credibility and Understanding of Monitoring Agency

- When people are engaged, they become better citizens who are more likely to advocate. Further, volunteers tend to be supportive of environmental action which represents a win for environmental agencies.
- Citizen science enables groups to understand different agencies' priorities.
- Citizen science enables groups to potentially access grants to address environmental issues in their communities.

More Data Enables Better Decisions

- The use of citizen science has addressed large data gaps and increased agencies' ability to gather data across long temporal spans and wide geographic scopes, which all three monitoring agencies could not do on their own. Citizen science is a comparatively cost-effective way to obtain large datasets.
- More boots-on-the-ground, more eyeballs, more helping hands, and more actionable data (data of sufficient quality to meet agency research aims).
- Data and results have been submitted to decision makers at the state level so they could make more informed decisions.

Faster Identification of Local Problems

- With more people reporting observations, issues are likely to be identified more quickly. In the case of LEO, program developers noted that there were numerous strange phenomena that were going unreported. LEO enables volunteers to report these phenomena to scientists who can help to determine if any action needs to be taken.

In conclusion, agencies reported that citizen-supported research and monitoring projects have strong, multifaceted societal impacts. The programs increase science literacy, encourage life-long learning, and connect people with the outdoors. Projects realize these impacts while completing high quality research and organizing data for use, and reuse, by future generations.

Agency Role in Supporting Citizen Science

Agency staff were asked how the agencies supported citizen science programming. Both the EPA and USGS play support roles as opposed to developing their own programs. Specific roles of the agency included:

- Both the EPA and USGS belong to the Federal Crowdsourcing and Citizen Science Community of Practice[16]. As a result, agencies have helped to develop new policies and legislation to support citizen science.
- Agencies have played a technical support role, including protocol development and creation of data standards.
- Federal agencies have engaged with state, local, and tribal governments and other organizations to promote the use of citizen science data.
- Agencies have provided training to foster improved data collection and use of data. For example, the EPA trained communities on monitoring protocols and reporting prior to ANTHC developing the LEO Network.
- Agencies have been involved in the collaborative development of tools and organizational strategies (e.g., Federal Crowdsourcing and Citizen Science Toolkit[17])

Lessons Learned

Agency staff were asked to reflect on challenges in using citizen science and to share lessons learned.

Citizens Science Requires Agency Commitment and Investment

- The USGS and EPA staff both noted that institutional commitment is important and it needs to be clearly communicated.
- Both the USGS and EPA staff report increasing emphasis on tool development (e.g., low-cost sensors, smartphone apps) to help inform large-scale national interests with less emphasis on local issues most likely to spark citizen interest and engagement.
- There has been a shift from grassroots groups receiving support from regional agency staff, with local groups dictating the research needs, to a top-

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16 http://www.digitalgov.gov/communities/federal-crowdsourcing-and-citizen-science/

17 https://crowdsourcing-toolkit.sites.usa.gov/

down approach where citizen science programming is supported by head office when it best serves the agency's interests.

- Program sustainability is critical: up-front investment is important, but must be sustained to realize long-term outcomes.
- Infrastructure (data collection and management tools) for citizen science needs to be set up properly and receive continual investment for its upkeep.
- Investment in community is important and enables a citizen science project to be more successful. For example, EPA supported the One Health Initiative in Alaska – Project LEO which is growing into Canada. Without the EPA investment in community and capacity building, the program would not have been as successful. The EPA made a ten year investment in capacity building and training in those communities.

Citizen Science Requires Careful Program Design

- The key questions or objectives for the citizen science program need to be defined clearly.
- Build programs to be scalable to other areas and geographies.
- Just because you can doesn't mean you should: not all research and monitoring programs can benefit from citizen science. Agencies need to understand when to consider citizen science and when to use a different approach.
- Community engagement can be challenging, and volunteer motivations need to be carefully considered.

Citizen Science Needs to be Considerate of Data Quality Concerns

- There is still work to be done to change the perceptions in the science community regarding cost-effectiveness and data quality for data collected by volunteers.
- Quality assurance (QA) of data is important. QA includes confirming validity of data, data management, and a data collection training program.
- The level of rigor for data collection depends on how the data is being used: regulatory data needs to have a higher level of QA than data collected for educational purposes.

Citizen Science Needs to be Considerate of Liability/Legal Concerns

- Practical concerns, including questions of liability for injury, protection of privacy, level of access to government computer systems and data, and the implications of access to or contact with rare, endangered, or dangerous organisms, may prevent or severely limit the effective employment of volunteers in research and monitoring programs.

- Scientists wishing to meet all the necessary requirements for the legal and ethical use of volunteers' time and data are confronted with a myriad of complex, often outdated, and sometimes contradictory regulations pertaining to the employment of volunteers.

Citizen Science Relies on Building Credibility and Trust between Partners

- Building trust with partner organizations is critical. The goal is not competition but collaboration.
- Agencies supporting citizen science or developing programs need to be clear about their intent to share information.
- Collaboration via citizen science programming is desperately needed to answer research and monitoring questions across jurisdictions (e.g., inter-provincial).

In conclusion, government agencies should clearly outline the role of citizen science within the agency mandate, address legal/ownership issues at the outset of program development, carefully consider program goals and desired outcomes in program design, and invest in citizen science through providing support, resources and training to staff and partner organizations.

Alberta Citizen Science Initiatives

Understanding the state of citizen science in Alberta is important to determine the breadth of programs taking place and how citizen science programs are contributing to environmental monitoring across the province. Miistakis created an inventory of all citizen science initiatives that contribute to environmental monitoring, reporting, and evaluation in Alberta. For each program, key characteristics were identified including purpose, scale, longevity, type of data collection, data collection methods, model of participation, and desired outcomes.

The purpose of the inventory was two-fold:

1. Build understanding of the state of programming where volunteers are contributing to science and monitoring that may be relevant to the Department's science and monitoring priorities; and

2. Enable EMSD to support a growing community of citizen science practitioners engaging Alberta's public in research and monitoring initiatives through sharing of an on-line citizen science inventory.

A Citizen Science Inventory could: support engagement in citizen science by characterizing the diversity of programs occurring in Alberta; encourage collaboration and coordination of programs with similar purpose and outcomes; and facilitate public engagement in citizen science programming.

Approach

The Alberta-based citizen science inventory was informed by two US-based inventories: 1) the Citizen Science Association's "PPSR_CORE Metadata Standard"[18] and 2) the Wilson Center's "Commons Lab database"[19]. Metadata standards are being developed to improve interoperability between citizen science programs. Fields from both databases were combined and additional fields deemed important for Alberta were also included. The following 14 fields were used (fields from the PPSR_CORE Metadata Standard are in bold text):

1. **ProjectGUID** - A globally unique identifier (GUID) for each project (not yet generated for the AMERA Citizen Science Inventory)
2. **ProjectName** - Name of project
3. **ProjectDataProvider** - Name of data provider/source/initial first registry
4. **ProjectDescription** - Description of project related to aspects such as goals, objectives, purpose, vision, etc.
5. **ProjectDateLastUpdated** - Date the project information was last updated (ISO 8601 - e.g., 2015-11-29)
6. ProjectContactName - Primary contact first and last name
7. **ProjectStatus -** Current status of the project activity
8. AgencySponsor - All agencies that provide financial or in-kind support
9. ModelofParticipation - Contributory, collaborative or co-created (Bonney et al. 2009)[20]
10. GeographicScope - International, national, provincial/state, local
11. Theme - Air, water, biodiversity; please note that weather-focused projects (e.g., CoCoRaHS) were grouped under the air theme
12. ProtocolsUsed - Description of program protocols
13. ContactDetails - Contact details to learn more about the project
14. Notes - Additional notes or question about the project

[18] http://citizenscienceassociation.org/2015/10/09/ppsr_core-metadata-standard/

[19] https://ccsinventory.wilsoncenter.org/about.html

[20] Bonney et al's (2009) report breaks citizen science into three categories based on how many stages of the scientific process are participatory: 1) Contributory: volunteers participate largely in data and sample collection but leave project design and data analysis to the professional scientists. This is the most common form; 2) Collaborative: volunteers provide input for method development and help analyze and distribute results. This often emerges from volunteers in collaborative projects who want to be more involved; and 3) Co-created: scientists and volunteers have equal contributions to the project, negotiating each step of the scientific process from the first idea for the project through deciding what comes next.

Nature Alberta's "Citizen Science in Alberta" [21] and the Government of Alberta "Citizen Science Programs"[22] documents were used as a starting point. Next, a Google search was carried out using the search terms "citizen science Alberta." Miistakis processed the results until saturation was achieved (no new projects appeared). Finally, the Miistakis team incorporated additional projects with which they were familiar.

A potential next step is to broadly share this initial inventory with individuals and organizations involved in environmental science and monitoring in Alberta. This will enable Miistakis to fill in missing fields and to add new projects that were not discovered through this approach.

General Observations

- There are 87 citizen science projects captured in the inventory.
- Projects are primarily contributory and have a focus on biodiversity (69 of the 87 projects are biodiversity projects).
- Projects range from being very specific to a local geography (e.g., Glenbow Ranch Citizen Science Checklist) to international in scope (e.g., eBird).

To highlight program diversity, Table 2 summarizes the programs based on environmental media (water, air, and biodiversity) and scale of the programming.

Table 2: Summary of inventory findings

	Air	Water	Biodiversity	**Total**
Local	1	4	13	18
Provincial	0	4	17	21
National	2	2	16	20
International	4	1	23	28
Total	7	11	69	**87**

21 http://naturealberta.ca/wp-content/uploads/2013/02/Promoting-Citizen-Science-in-Alberta.pdf

22 http://environment.gov.ab.ca/info/library/8808.pdf

Challenges

- Miistakis was not able to cross-check which programs already have a generated unique global ID. Miistakis is still in the process of following up with the Citizen Science Association (which has generated an inventory of programs) to prevent duplication.
- A number of categories were problematic to populate based simply on a web search. For instance, ProjectDateLastUpdated wasn't readily available for most projects and ProjectStatus wasn't always self-evident from a website.
- Some of these projects have been in existence for many decades (e.g., Christmas Bird Count), while others are currently in development (e.g., NatureLynx).
- Miistakis discovered some citizen science projects that appeared international in scope but did not have any observations submitted in Alberta (e.g., Project BudBurst). Miistakis did not include projects that lacked Alberta observations.
- Some of the projects aren't an exact fit for environmental media (air, water, and biodiversity). There may be the potential to add a climate category for projects relating to phenology or weather.
- A project may have a model of participation that is more involved than contributory, however if that wasn't clearly articulated on the website it was listed it as contributory project.

Considerations for Next Steps

To ensure the inventory is comprehensive and the fields are accurate, Miistakis suggests the following steps:

- Share the inventory at the citizen science workshop, and request feedback (feedback from the staff workshop was incorporated into the inventory following the workshop); and
- Engage a summer student to call coordinators of programs occurring locally and provincially to complete empty fields and confirm accuracy of information.

In addition, Miistakis recommends EMSD consider sharing the inventory on-line and enabling groups to edit their programs. This action will support citizen science practitioners while also enabling Albertans to learn where, and how, they can contribute to monitoring and evaluating Alberta's environment.

Citizen Science Staff Workshop

A citizen science workshop was held on March 17, 2016 with Department staff[23] to foster a better understanding of citizen science and to explore the value of citizen science, its opportunities and challenges, and the role citizen science can play in contributing to an environmental science program to monitor, evaluate and report on the condition of the environment in Alberta.

The workshop objectives were:

1. To introduce staff to citizen science as an approach to meeting science and monitoring objectives.
2. To seek staff input on how citizen science could help meet science and monitoring objectives.
3. To seek staff input on the role of a government agency in supporting citizen science programming and practitioners in Alberta.

The workshop outcomes informed the development of recommendations in this report on how to build internal capacity and support for citizen science. The workshop was attended by 20 participants, including staff from a variety of disciplines such as air and water monitoring, community based monitoring, , science and modelling, and data management. In addition, representatives from the Alberta Biodiversity Monitoring Institute (ABMI) and Nature Alberta were in attendance.

The morning's workshop sessions included presentations aimed at providing background information on the value of citizen science, citizen science case studies from other monitoring agencies (EPA and USGS), and examples of citizen science programming in Alberta. Afternoon sessions focused on facilitated discussion with three break-out groups to understand staff perceptions of the opportunities and challenges associated with citizen science, and the role staff could play in supporting citizen science programming in Alberta. The workshop agenda and notes from the workshop breakout sessions can be found in Appendix D.

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[23] At the time of the workshop, staff were working in an arms-length agency that was part of the Ministry of AEP that transitioned to a business area in the Department of AEP.

Synthesis of Staff Workshop Findings

1. There is a good understanding of the value of citizen science from an engagement perspective, including building relationships, improving credibility, and fostering understanding of Alberta's environment.
2. There is general support for, but less understanding of, the value of citizen science from a science and monitoring perspective; some concerns were expressed about the ability of volunteers to produce the rigorous, high quality data required for a scientifically credible environmental science program.
3. EMSD needs to clearly define the role of citizen science in helping meet its business objectives, identifying what the monitoring gaps are, and how citizen science can help address these gaps.
4. It is important that staff understand when it is appropriate to consider citizen science. Therefore, EMSD would benefit from a framework to help identify which citizen science programs should be supported and promoted.
5. Citizen science programming will require resources and expertise, and should be resourced appropriately within the monitoring agency.
6. Data management and reporting must be well thought out, so that data is operable and accessible.
7. Citizen science could be helpful to EMSD for addressing data gaps, particularly for air and water monitoring in connection with Watershed Planning and Advisory Councils and airshed groups. There are varying opinions as to the ability of volunteers to provide high quality data, so further discussion on monitoring objectives and quality of data needed to meet desired outcomes is necessary.
8. EMSD should leverage and support existing citizen science programming when it helps meet their mandate instead of developing their own citizen science programs.
9. EMSD could play a strong support role to citizen science practitioners in Alberta by:
    - developing standardized protocols;
    - organizing training sessions;
    - performing equipment calibration;
    - auditing citizen science monitoring data;

- developing a hub to share resources and tools, and to promote programs on the Alberta Environment and Parks website;
- hosting citizen science workshops; and
- providing funds to existing programs or to develop new programs.

Recommendations

To harness the value of citizen science in monitoring environmental conditions, a series of recommendations and actions are shared below. Recommendations were derived from a literature review, case study assessment, and feedback at the staff workshop.

Develop clear agency policy, procedures, and guidance to provide clarity to agency staff and partners.

- Clearly articulate the role of citizen science in meeting agency science and monitoring objectives (e.g., address data gaps,).
- Approve principles to guide staff to develop and support citizen science programs in Alberta.
- Develop a framework for considering the appropriateness of citizen science.
- Develop or support an existing framework for project design.

Invest in citizen science through proper resourcing of staff and building of internal capacity

- Create a PowerPoint presentation outlining what citizen science is, and highlighting the value to a monitoring agency, case study examples and resources available to staff.
- Develop and share case studies focused on the value of citizen science in supporting research and monitoring goals and provide examples of how volunteers have been able to collect scientifically rigorous research and monitoring data.
- Identify agency monitoring gaps and assess if citizen science is appropriate.
- Identify where it is possible build off existing citizen science programs (use the Alberta Citizen Science Inventory).

Invest in the skill sets necessary to support citizen science programming through training of existing staff or hiring of individuals with relevant backgrounds. **Explore coordination within and between provincial government agencies on citizen science programming, and identify opportunities for citizen science to support each other's mandates and interests.**

- Identify citizen science programs (use the Alberta Citizen Science Inventory) occurring in Alberta that meet different provincial agency mandates.
- Explore where appropriate data interoperability occurs within and between agencies.
- Explore program expansions where appropriate through multi-agency support.
- Invest in citizen science staff positions that coordinate within and between agencies to support the generation of citizen science programs of shared value.

Develop a citizen science hub to share resources and widely promote citizen science in Alberta.

- Publically share the Alberta Citizen Science Inventory and enable people to edit their program profiles and to add programs.
- Build the capacity of citizen science programming in Alberta through a variety of mechanisms:
    - Provide small grants to help support and diversify citizen science programming;
    - Provide resources (e.g., standards and protocol development, equipment library) and staffing support;
    - Develop technologies and/or scientific instrumentation; and
    - Provide data quality audits.
- Host conferences and workshops with citizen science practitioners to advance the field of practice and interoperability between projects.

References

Amano, T., Lamming, J. & Sutherland, W.J., 2016. Spatial gaps in global biodiversity information and the role of citizen science. , XX(X), pp.1–8.

Barber, L. 1980. The heyday of natural history, 1820-1870. Doubleday and Co., New York.

Ballard, H., and J. Belsky. 2010. “Participatory Action Research and Environmental Learning: Implications for Resilient Forests and Communities.” *Environmental Education Research* 16 (5): 611–627.

Bell, Sandra, Mariella Marzano, Joanna Cent, Hanna Kobierska, Dan Podjed, Deivida Vandzinskaite, Hugo Reinert, Ausrine Armaitiene, Malgorzata Grodzińska-Jurczak, and Rajko Muršič. 2008. “What Counts? Volunteers and Their Organisations in the Recording and Monitoring of Biodiversity.” *Biodiversity and Conservation* 17 (14) (March): 3443–3454. doi:10.1007/s10531-008-9357-9. http://link.springer.com/10.1007/s10531-008-9357-9.

Bonardi, A. et al., 2011. Usefulness of volunteer data to measure the large-scale decline of “common” toad populations. *Biological Conservation*, 144(9), pp.2328–2334. Available at: http://www.sciencedirect.com/science/article/pii/S0006320711002382.

Bonney, R., H. Ballard, R. Jordan, E. McCallie, T. Philips, J. Shirk, and C. Wilderman. 2009. “Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report.” *Science Education*. Washington, D.C.

Butcher, G.S. and D.K. Niven. 2007. Combining data from the Christmas Bird Count and the Breeding Bird Survey to determine the continental status and trends of North America birds. National Audubon Society, Washington.

Chambers, R. 1994. “The Origins and Practice of Participatory Rural Appraisal.” *World Development* 22 (7): 953–969.

Crall, Alycia W, Gregory J Newman, Thomas J Stohlgren, Kirstin A Holfelder, Jim Graham, and Donald M Waller. 2011. “Assessing Citizen Science Data Quality: An Invasive Species Case Study.” *Conservation Letters* 4 (6): 433–442.

doi:10.1111/j.1755-263X.2011.00196.x. http://dx.doi.org/10.1111/j.1755-263X.2011.00196.x.

Delaney, David G, Corinne D Sperling, Christiaan S Adams, and Brian Leung. 2007. "Marine Invasive Species: Validation of Citizen Science and Implications for National Monitoring Networks." *Biological Invasions* 10 (1) (May): 117–128. doi:10.1007/s10530-007-9114-0. http://dx.doi.org/10.1007/s10530-007-9114-0.

Dickinson, Janis L, Benjamin Zuckerberg, and David N Bonter. 2010. "Citizen Science as an Ecological Research Tool: Challenges and Benefits." *Annual Review of Ecology, Evolution, and Systematics* 41 (1) (December): 149–172. doi:10.1146/annurev-ecolsys-102209-144636. http://www.annualreviews.org/doi/abs/10.1146/annurev-ecolsys-102209-144636.

Erb, Peter Lowell. 2012. "Landscape and Anthropogenic Effects on Mammal Occupancy in the Appalachian Trail Corridor." *ProQuest Dissertations and Theses*. Ann Arbor: University of Colorado at Boulder. https://ezproxy.royalroads.ca/login?url=http://search.proquest.com/docview/1112071609?accountid=8056.

Environmental Protection and Enhancement Act, Revised Statutes of Alberta 2000, c. E-12. http://www.qp.alberta.ca/documents/Acts/E12.pdf

Evans, C., E. Abrams, R. Reitsma, K. Roux, L. Salmonsen, and P.P. Marra. 2005. "The Neighborhood Nestwatch Program: Participant Outcomes of a Citizen-Science Ecological Research Project." *Conservation Biology* 19 (3): 589–594.

Fleming, L.C. & Billman, L.W., 2003. *Green Paper on Citizen Science*,European Commission.

Follett, Ria, and Vladimir Strezov. 2015. "An Analysis of Citizen Science Based Research: Usage and Publication Patterns." *PloS One* 10 (11): e0143687. doi:10.1371/journal.pone.0143687. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0143687#sec003.

Gallo, Travis, and Damon Waitt. 2011. "Creating a Successful Citizen Science Model to Detect and Report Invasive Species." *BioScience* 61 (6): 459–465. doi:10.1525/bio.2011.61.6.8.

http://www.bioone.org/doi/abs/10.1525/bio.2011.61.6.8.

Gollan, J. et al., 2012. Can volunteers collect data that are comparable to professional scientists? a study of variables used in monitoring the outcomes of ecosystem rehabilitation. *Environmental Management*, 50(5), pp.969–978.

Giraud, C., Calenge, C. & Julliard, R., 2014. Capitalizing on opportunistic data for monitoring biodiversity. *arXiv*.

Greenwood, J.J.D. 2007. Citizens, science and bird conservation. *Journal of Ornithology* 148:S77–124

Haklay, Muki. 2015. "Citizen Science and Policy : A European Perspective by Muki Haklay." Vol. 4. Woodrow Wilson International Center for Scholars, Washington, DC.

Hollow, B. et al., 2015. Citizen science for policy development: The case of koala management in South Australia. *Environmental Science & Policy*, 47, pp.126–136. Available at: http://www.sciencedirect.com/science/article/pii/S1462901114001993 [Accessed January 7, 2015].

Hosseini, P.R., A.A. Dhondt, and A.P. Dobson. 2006. "Spatial Spread of an Emerging Infectious Disease: Conjunctivitis in House Finches." *Ecology* 87 (12): 3037–3046.

Hurlbert AH, Liang Z (2012) Spatiotemporal Variation in Avian Migration Phenology: Citizen Science Reveals Effects of Climate Change. PLoS ONE 7(2): e31662. doi:10.1371/journal.pone.0031662

Irwin, Alan. 1995. *Citizen Science: A Study of People, Expertise and Sustainable Development*. New York: Routledge.

Isaac, N.J. et al., 2014. Extracting robust trends in species' distributions from unstructured opportunistic data: a comparison of methods. *bioRxiv*, p.006999. Available at: http://biorxiv.org/content/early/2014/07/10/006999.abstract.

Jackson, M.M., Gergel, S.E. & Martin, K., 2015. Citizen science and field survey observations provide comparable results for mapping Vancouver Island White-tailed Ptarmigan (Lagopus leucura saxatilis) distributions. *Biological Conservation*, 181, pp.162–172. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0006320714004352 [Accessed

December 8, 2014].

Jansujwicz, J.S., Calhoun, A.J.K. & Lilieholm, R.J., 2013. The maine vernal pool mapping and assessment program: Engaging municipal officials and private landowners in community-based citizen science. *Environmental Management*, 52(6), pp.1369–1385.

Keaney, E.B. 1992. The botanizers: amateur scientists in nineteenth century America. University of North Carolina Press, Chapel Hill.

Kremen, C., Ullman, K.S. & Thorp, R.W., 2011. Evaluating the Quality of Citizen-Scientist Data on Pollinator Communities. *Conservation Biology*, 25(3), pp.607–617. Available at: http://dx.doi.org/10.1111/j.1523-1739.2011.01657.x.

Larson, L.R., Cooper, C.B. & Hauber, M.E., 2015. Emotions as Drivers of Wildlife Stewardship Behavior: Examining Citizen Science Nest Monitors' Responses to Invasive House Sparrows. *Human Dimensions of Wildlife*, 1209(DECEMBER 2015), pp.1–16. Available at: http://www.tandfonline.com/doi/full/10.1080/10871209.2015.1086933.

Latimore, Jo A., and Paul J. Steen. 2014. "Integrating Freshwater Science and Local Management through Volunteer Monitoring Partnerships: The Michigan Clean Water Corps." *Freshwater Science* 33 (2) (June 15): 686–692. http://www.jstor.org/stable/10.1086/676118.

Lee, T., M. Quinn, and D. Duke. 2006. "Citizen Science, Highways Nd Wildlife: Using a Web-Based GIS to Engage Citizens in Collecting Wildlife Information." *Ecology and Society* 11 (1): 11. http://www.ecologyandsociety.org/vol11/iss1/art11/.

Levrel, Harold, Benoît Fontaine, Pierre Yves Henry, Frédéric Jiguet, Romain Julliard, Christian Kerbiriou, and Denis Couvet. 2010. "Balancing State and Volunteer Investment in Biodiversity Monitoring for the Implementation of CBD Indicators: A French Example." *Ecological Economics* 69 (7): 1580–1586.

Merrill, L. 1989. The romance of Victorian natural history. Oxford University Press, New York.

Mckinley, Duncan C, Abraham J Miller-rushing, Heidi L Ballard, Rick Bonney, Hutch Brown, Daniel M Evans, Rebecca A French, et al. 2015. "Investing in Citizen Science Can Improve Natural Resoruce Management and Environmental

Protection." *Issues in Ecology*.

Pimm, S. et al., 2014. The biodiversity of species and their rates of extinction, distribution, and protection. *Science*, 344.

Pocock, M.J.O, D. Chapman, L. Sheppard, and H.E. Roy. 2013. "Developing a Strategic Framework to Support Citizen Science Implmentation in SEPA."

Ramirez-Andreotta, M.D. et al., 2015. Building a co-created citizen science program with gardeners neighboring a superfund site: The Gardenroots case study. *International public health journal*, 7(1), pp.1–18. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4420190&tool=pmcentrez&rendertype=abstract.

Riesch, Hauke, and Clive Potter. 2014. "Citizen Science as Seen by Scientists: Methodological, Epistemological and Ethical Dimensions." *Public Understanding of Science* 23 (1): 107–120. doi:10.1177/0963662513497324.

Roy, H.E., M.J.O. Pocock, C.D. Preston, D.B. Roy, J. Savage, J.C. Tweddle, and L.D. Robinson. 2012. "Understanding Citizen Science & Environmental Monitoring. Final Report on Behalf of UK-EOF." London, UK.

Science Communication Unit. 2013. "Science for Environment Policy. Indepth Report: Environmental Citizen Science." http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR9.pdf.

Shirk, Jennifer L, Heidi L Ballard, Candie C Wilderman, Tina Phillips, Andrea Wiggins, and Rebecca Jordan. 2012. "Public Participation in Scientific Research : A Framework for Deliberate Design." *Ecology and Society* 17 (2).

Silvertown, Jonathan. 2009. "A New Dawn for Citizen Science." *Trends in Ecology & Evolution* 24 (9) (September): 467–471. doi:10.1016/j.tree.2009.03.017. http://www.ncbi.nlm.nih.gov/pubmed/19586682.

Sullivan, Brian L, Jocelyn L Aycrigg, Jessie H Barry, Rick E Bonney, Nicholas Bruns, Caren B Cooper, Theo Damoulas, et al. 2014. "The eBird Enterprise: An Integrated Approach to Development and Application of Citizen Science." *Biological Conservation* 169 (January): 31–40. doi:10.1016/j.biocon.2013.11.003. http://linkinghub.elsevier.com/retrieve/pii/S0006320713003820.

Theobald, E. J., A. K. Ettinger, H. K. Burgess, L. B. DeBey, N. R. Schmidt, H. E. Froehlich, C. Wagner, et al. 2015. "Global Change and Local Solutions: Tapping the Unrealized Potential of Citizen Science for Biodiversity Research." *Biological Conservation* 181: 236–244. doi:10.1016/j.biocon.2014.10.021. http://dx.doi.org/10.1016/j.biocon.2014.10.021.

Tidball, K.G., and M.E. Krasny. 2012. "Civic Ecology: A Pathway for Earth Stewardship in Cities." *Frontiers in Ecology and the Environment* 10 (5): 267–273.

Tweddle, J.C. et al., 2012. *Guide to citizen science: developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK*, Available at: www.ukeof.org.uk.

Vermeiren, P. et al., 2016. Hierarchical toolbox: Ensuring scientific accuracy of citizen science for tropical coastal ecosystems. *Ecological Indicators*, 66, pp.242–250. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1470160X16000455.

Westgate, Martin J. 2015. "Citizen Science Program Shows Urban Areas Have Lower Occurrence of Frog Species, but Not Accelerated Declines." *PloS One (1932-6203)* 10 (11).

Whitelaw, GS, H Vaughan, B Craig, and D Atkinson. 2003. "Establishing Environmental, the Canadian Community Monitoring Network." *Monitoring and Assessment* (88): 409–418.

Wiggins, Andrea, and Kevin Crowston. 2011. "From Conservation to Crowdsourcing: A Typology of Citizen Science." *System Sciences (HICSS), 2011 44th Hawaii International Conference on*: 1–10. doi:10.1109/HICSS.2011.207.

Wilson, Scott. 2013. "Citizen Science Reveals an Extensive Shift in the Winter Distribution of Migratory Western Grebes." *PloS One* 8 (6).

Wing, S., R. Horton, S. Marshall, K. Thu, M. Tajik, and L. Schinasi. 2008. "Air Pollution and Odor in Communi- Ties near Industrial Swine Operations." *Environmental Health Perspectives* 116 (10): 1362–1368.

Appendices

Appendix A – Zurich University Citizen Science Guiding Principles

Ten principles of citizen science

Citizen science is a flexible concept which can be adapted and applied within diverse situations and disciplines. The statements below were developed by the *'Sharing best practice and building capacity'* working group of the **European Citizen Science Association**, led by the Natural History Museum London with input from many members of the Association, to set out some of the key principles which as a community we believe underlie good practice in citizen science.

1. Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding.
   Citizens may act as contributors, collaborators, or as project leader and have a meaningful role in the project.

2. Citizen science projects have a genuine science outcome.
   For example, answering a research question or informing conservation action, management decisions or environmental policy.

3. Both the professional scientists and the citizen scientists benefit from taking part.
   Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence e.g. to address local, national and international issues, and through that, the potential to influence policy.

4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process.
   This may include developing the research question, designing the method, gathering and analysing data, and communicating the results.

5. Citizen scientists receive feedback from the project.
   For example, how their data are being used and what the research, policy or societal outcomes are.

6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for.
   However unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratisation of science.

7. Citizen science project data and meta-data are made publicly available and where possible, results are published in an open access format.
   Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this.

8. Citizen scientists are acknowledged in project results and publications.

9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.

10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data sharing agreements, confidentiality, attribution, and the environmental impact of any activities.

Appendix B – European Citizen Science Association Guiding Principles

STANDARDS FOR CITIZEN SCIENCE

PRINCIPLES AND GUIDELINES FOR CITIZENS SCIENCE PROJECTS AT UNIVERSITIES AND OTHER RESEARCH INSTITUTIONS

Version dating 10th November 2015

proposed for discussion during a workshop on 17th November 2016 in Zurich

Questions to be discussed during the workshop:

- Do these Standards safeguard the quality of citizens science projects?
- Do these Standards address the critical points and provide for adequate mechanisms to mitigate them?
- Are the proposed Guidelines concrete and complete enough?
- Are the respective rights and duty issues between research institutions, researchers and citizens scientists adequately described?
- Do we need stricter safeguarding of compliance like a register?
- Who are the relevant stakeholder organisations to `parent` these Standards?
- Do we need an explicit list of expectations and rights that the projects maintain and share openly a light version of this?

PREAMBLE

For a long time, citizens have been involved in science. The evolution of universities and other research performing organisations, the complexity of research questions, and the distance from every day experience as well as the necessity to maintain expensive and complicated equipment have generally limited participation of citizens in the last century, although some projects depend on the contributions of citizens.. Today, research universities conduct research project largely without the participation and influence of citizens. This situation is however changing rapidly. The advent of new information and communication technologies has led to growing availability of scientific results for large groups of people. As a consequence, the involvement of citizens in science - citizen science - is increasing and will become more important with the emergence of well-informed knowledge societies and the ever-growing information and communication technology. Citizen Science gives interested people the possibility to participate in scientific projects and thus contributes to education and awareness of the public. The research is often guided by topics of general interest and concern, like environment or monitoring of capital accidents (Texas Oil spill). A large variety of initiatives exist, including, at various degrees, amateur scientists and 'professional' researchers. These projects might sometimes be detached from mainstream academic research, but may open up new research questions that are otherwise not addressed. They may not require formal academic recognition, but may become the seed for professionalised science later on. Using such technologies, organisations that focus on facilitating citizens participation in science (European Citizen Science Association, etc.). have been established. They are mostly focused on coordinating citizen science practice, being a community of practice that shares lessons, experiences etc.

On the other hand, citizens are also involved in the scientific processes within academia where they usually contribute to a research projects defined by academic researchers. As recognized by many, such involvement is beneficial for research. Citizen scientists often bring novel points of views. Although the usual academic procedures are efficient and have proven themselves, people from outside the specific discipline in which the research started may help overcome blind spots. The collaboration between academia and citizens fosters innovation, unravels novel research areas, advances technology and facilitates collecting farther-reaching data. Furthermore, involving citizens promotes public education and understanding of science, supports the transition to the future digital society and connects people and academics worldwide. Existing projects range from involving few to millions of non-specialist participants in such diverse areas as the classification of astronomical objects, birdwatchers producing and analysing quantitative data in distribution, or collecting medical data of one self or others.

DRAFT

PURPOSE

The purpose of these Standards is to provide academic researchers, their institutions and funding bodies with principles and guidelines how to run citizen science projects in the academic setting. They give the answers to pertinent questions, thus making citizen science projects more attractive to researchers and bringing them recognition and legitimacy. The Standards address specific issues of citizen science and offers ways to tackle them. They give answers to questions such as how to involve citizens in setting science agendas; how to involve them in a research project and how to make their contributions visible. Ultimately, the purpose of these Standards is to provide a basis for the recognition of the quality and solidity of the research results of citizen science.

These Standards thus provide definitions and non-regulator principles and guidelines to be applied when defining, deciding, funding, executing and evaluating citizens' science projects. They aim to clarify the roles of the parties involved and to provide a framework for citizen science as robust science rather than as public engagement.

By setting the framework for involving citizens, these Standards ideally encourage academic researchers to welcome citizens as serious and respected partners in their endeavours and open the doors for citizens to contribute substantially and creatively to science.

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DEFINITIONS

Citizen science generally refers to the general public engagement in scientific research activities when citizens actively contribute to science either with their intellectual effort or surrounding knowledge or with their tools and resources. Various notions of citizen science, mostly addressing the degree to which academic (professional) scientists (**researchers**) and citizen scientists participate are in use. These Standards deal with research projects where academic and citizen scientists work together. The lead and organisation lies with the research institution of the academic scientists.

Research institutions initiate and support these citizen science projects in the same way they supports any other project, for example with basic resources. The projects involve the citizens in several ways. The goal of the project leaders is to enhance the quality and scope of the project by including academic and non-academic researchers to pursue new scientific insights.

Citizen scientist refers to anyone involved in research and not related to a research institution. Everyone can become a citizen scientist if the person fulfils the criteria of the research project in terms of basic skills and abilities.

APPLICABILITY

Academic Researchers may use these standards to plan, organise and seek funding for citizen science projects. Adhering to these Standards provides them with a solid base to set up, to seek recognition within their institution and to provide the funding agencies with a tool to judge their projects.

Citizens may consult these standards to learn about their rights and duties and to develop an understanding of working in research projects. Generally, the Standards enhance the role played by citizens in science.

Research institutions may use these standards to ascertain that their citizen science projects satisfy a set of recognised principles and guidelines.

Funders may use these Standards and the adherence thereto by research institutions to judge the quality of citizens' science projects and their outcomes. These Standards allow the comparison of different projects, increase reproducibility and prevent repetitions.

Policy makers may require the proper application of these Standards when funding citizen science projects.

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PRINCIPLES

1. Excellence all the way

Citizen science projects must adhere to general international standards of science, the relevant international standards specific for the academic discipline (-s) of the projects and these Standards for citizen science. This includes aspiring for objectivity and assessing it, transparency of methodology, proper citations and avoidance of wasteful repetitive studies.

2. Participation all the way

Citizen science projects should aim to develop an active and productive participation of citizens' scientists in all the different phases of the research project, by acknowledging a large variation in their participation. Citizens might possibly contribute to topic selection and development, research design, execution, dissemination of results and funding. Expertise of citizen science shall be used in the best possible way implying flat hierarchies and the possibility of citizen scientists to take over responsibilities if they wish, once encouraged.

3. Clear motivation

The goal of a citizen science project must be clearly and realistically stated. Citizen Science is often cross disciplinary and the governance of such project should take this into account. The projects must be designed to encompass in a wide way the various aspects of a research topic.

4. Openness and diversity

Citizen science projects should be open to anyone. Projects may not discriminate on any personal grounds. In fact, cross-cultural approaches and diversity are often needed for optimal and unbiased scientific quality. Project should not just opt for passive diversity (not stopping anyone from joining) but have a clear engagement strategy that is suitable for the context of the research.

5. Transparency

Citizen science projects must operate in a fully transparent way. Either all data etc. are open to all members of a team or there shall be an agreement reached to why this is impossible.

6. Maintaining public and personal interest

Research institutions should ensure the public investments into citizen science are spent effectively and efficiently and empower citizens and institutions to explore new ways for science.

7. Sustainability

Research institutions and their researchers should provide access to citizens to their research projects, including to e-infrastructures. The research institutions and researchers should ensure the continuity in project support and the dissemination of knowledge and support participants who want to continue and develop their knowledge.. The development and maintenance of the community of citizen scientists should have high priority.

8. Education and training

Citizen science projects shall contribute to education and training of scholars and citizens alike. Importantly, researchers must properly instruct and train citizen scientist concerning all standards and ethics involved in the respective research project. It is recommended to work closely with science communicators, to make the information clear and suitable for a wide range of participants.

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GUIDELINES

Recruitment and training of citizen scientists

Researchers must recruit citizens' scientists in an open and transparent way and take into account their competences carefully. The selection of the citizens must be unbiased and research institutions and researchers may not discriminate on any personal grounds. It must guarantee that the citizen science project complies with scientific standards, such as open outcome. Depending on the research foreseen and the amount of work involved, the research institution, researcher and the citizen scientist may conclude an agreement describing the respective rights and duties or an informed consent procedure.

Governance

Research institutions must ensure that citizen science projects have a governance structure that guarantees best practise rules for research projects. For this, the researchers must provide a written document to everyone involved stating the rules and procedures. Research institutions should appoint a person to monitor the compliance with scientific standards[1]. The researchers must allow for open transparent discussions in dedicated regular meetings where everybody can voice concerns and make suggestions. The university should provide the necessary infrastructure for carrying out the project.

Quality control

As for all research projects, research institutions, researchers and citizens scientists should undertake the necessary actions to adhere to the relevant codes of conduct and ethical behaviour in scientific research when conducting citizens science projects and using and disseminating research data and findings. Research institutions and their researchers must put measures in place such as protocols and quality control guaranteeing the quality of the work of citizen scientists so their effort is not lay to waste. This includes the training and use of appropriate protocol design, instrumentation and analysis methods. Importantly, such quality assurance measures also include measures for the storage or curation of data. Finally, it includes encouragement of citizen scientists, inviting them to participate at a higher level, by analysing data or managing groups of other citizen scientists.[2]

[1] list scientific standards

2 Gura, Trisha, "Citizen Science: Amateur experts," Nature 11 April 2013 / vol. 496, 261–262; Schnoor, Jerald L., "Citizen Science," *Environmental Science & Technology*, September 1, 2007, 5923

Ethical oversight

Researchers take the necessary steps to insure the rights and welfare of the citizen scientists involved and that their individual rights, included privacy, are respected and protected. If the projects involve the generation/collection of personal data of citizens (e.g. health data), research institutions should legally protect such data should and seek agreement on their use with those from whom the data has been generated. Where relevant, an informed consent process should be designed to allow participants to understand what will happen with the information that they collect. Depending on the project, necessary approvals from ethical oversight bodies (such as an ethics review committee) should be sought. However, ethical oversight mechanisms specifically designed for citizen science projects should also be considered as they emerged within the communities of practice such as the Citizen Science Association or the European Citizen Science Association.

Sustainability

Research institutions should attempt to ensure sufficient funding safeguarding the continuity of and support to a citizen science project and the adequate dissemination of the results obtained.

Intellectual property rights and acknowledgement[3]

Intellectual property rights derived from citizen science projects must be dealt with and agreed upon in the agreement regulating the respective rights and duties. Researchers shall provide feedback to the citizen scientists on for example how their data are being used and what the research, policy or societal outcomes are. Citizen science projects data and meta-data are made publically available, and results are published in an open access format. Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this. Researchers always should acknowledge the contribution of citizen scientists to their scientific results and publications.

Costs

The research institutions and their researchers should make sure that the costs for the citizen science projects are covered properly from a variety of funding sources, including crowd funding. The eventual sharing of benefits must be regulated in the agreement. The research institutions and their researchers must provide free access to the research work for citizen scientist and may not require fees. Research institutions and their researchers must insure that citizen scientists do not lose money.

[3] TYPOLOGY OF CITIZEN SCIENCE PROJECTS FROM AN INTELLECTUAL PROPERTY PERSPECTIVE, by Theresa Scassa and Haewon Chung February 2015

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Health, safety, security and environment

Research institutions and their researchers should undertake the necessary measures to ensure the health, security and safety of any citizens' scientist contributing to a research project as well as to take the necessary actions to minimise the impact on the environment. Where applicable, citizen's scientists must be made aware so that they can comply with security, safety and environmental rules and with procedures in force at the research institution, in particular concerning the notifications on introduction of material and instrumentation that could induce risks or ethical issues to the research project.

ASSESSMENT AND APPLICATION

The research institutions and their researchers must provide mechanisms to implement these Standards safeguarding a low administrative burden. The relevant stakeholder organisations regularly assess the relevance and applicability of these Standards and, whenever appropriate, propose and decide upon needed amendments.

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Appendix C – Case Study Notes

The Local Environmental Observer (LEO) Network

www.leonetwork.org/leo/about

Mike Brubaker, Alaska Tribal Health Campus, Anchorage, Alaska

1. **When did LEO form and why?**
    - The tribal health council was informed by leadership (tribal health system), that there were sporadic reports of strange phenomena occurring (weather, wildlife diseases, die-offs) that are likely linked to climate change. During climate change community assessments, they ask the local communities about events of interest and found there was lots of information that was not being documented or shared. For example, people see an extreme weather event, but no-where to report.
    - So the tribal council developed LEO to enable communities to report events of interest, and then to be able to connect in experts to help understand the phenomena.
    - The tribal council then helps address what next. Does there need to be a research team formed. A collaborative team is established that integrates the local and western perspectives.
    - Local and traditional knowledge grounded and reporting of observation – these observations help form the problem statement.
    - Additionally, LEO could lead to a more intensive community based monitoring program based on referral.
    - LEO was built to be scalable to other areas. – set up as hubs, from a management perspective, but linked to the each other via mapping tools.
    - Careful about terminology – community based effort – providing a tool that somebody with exceptional local knowledge can identify unusual change – share their observations to alert others.
    - Examples of Leo process – Wildlife health
        - Through a series of community assessments of an important river system, LEO had a round table conversation and the fisherman talked about a high number of salmon that had symptoms of something. This wildlife health issue was posted and posted and asked should be concerned about safety? LEO participant took photos which were forwarded to Alaska Fish and Game, who

determined there were two different types of parasites – not a human health issue, and parasites have been found in Alaska before. But people did not want to eat the fish. In addition through LEO other groups also reported same disease like symptoms. People were interested in why is it occurring here and why so much? What should LEO do next to understand the cause of these phenomena?

  - A Leo reported that 60% of grouse catch had worms in breast meat that she has not seen before – she froze the tissue, and took pictures and shared on LEO. The worms were then sent to a lab, preserved and removed worms to Colorado State University. The LOE observer, and researchers partnered in a paper together. There was no health significance, but a change in the worms' distribution or range.
  - Other examples included an article published in an International journal – Circumpolar Health – on a algal bloom that was un-president in North.

2. Where there foundational pieces in place to enable CS to take off?

- There was heavy investment in the communities from EPA:
  - There has been gradual capacity development for people who might engage in LEO, including:
    - Training – Environmental protection Agency has provided grants to tribal governments to increase the environmental capacity. That means there are trained people, with computers and salaries working on and understanding need for LEO.
    - Network - Building of a community network
  - Technology - Development of tools to help with data collection
  - Managers of LEO have been engaged regionally on health issues for a long time –and have built trust.
  - Focus on health, which is important to the community
  - Partnerships with many difference organizations to support LEO's work.

- There has are efforts to provide education for people on how to post a good observation due to diversity of observations (earth quack impacts to seas bird die off).
    - Monthly webinar to coach people on how to collect accurate information.

3. In what way has CS being valuable?

- ONE HEALTH – community health and wildlife and environmental conditions is coordinated.
- Grassroots ID of health issue – collaborative approach to building a team to address issue.
- Great way to meshing local and traditional knowledge – around specific events and focus everyone around a defined issue.

4. Describe any challenges in the process?

- Community engagement can be challenging, finding the right people, those that are concerned. Not every place has someone who is participating in LEO.
- Originally engagement included mostly Tribal Environmental Managers, but LEO is slowly working on building capacity to engage broader public.
- Building trust with partner organizations (goal is not competition but collaboration)
- Public information - be clear that LEO is sharing information. It can't come from anonymous. There needs to be trust between tribal health council and LEO.
- Build a system where there is not abuse – registration process necessary
- Concerned about scale - so what changes are happening next store (BC, AB), if you have a die off of some wildlife species, LEO would like to know about it. Collaboration is desperately needed.

5. Lessons Learned

- There is great power in connecting local knowledge keepers and Western Scientists.
- Developing effective long-term research and monitoring approach from the LEO approach.

- Things in the North are changing quickly and keeping an eye on events reported by communities is important for response. LEO is a bottom up approach and builds credibility within the community.
- Enables next step to identification of a problem – collaboration of research team
- Investment (EPA funders of program) of training in communities, tribes need to want to be engaged. Corporative process.

In conclusion: Interested in partnership in Alberta. Last one health group meeting; ticks are a major concern for them right now. There is a new species showing up in Alaska – mule deer – and currently moose and caribou do not have ticks, so concern about winter ticks.

Case Study Environmental Protection Agency (EPA)

Alice Mayio: Head office, was the national lead for volunteer monitoring efforts
Edward Washburn: Head office, citizen science program
Tina Laidlaw: volunteer monitoring, EPA 17 years ago, hired to work in one region to help with volunteer monitoring efforts and statewide environmental groups

Call objectives

- Understand from a monitoring agency perspective the role citizen science has played in your organization.
- How your agency has supported CitSci?

Questions

1. When was CitSci first introduced into the agency/org? And why?

Started with Volunteer Monitoring in 1990s and was implemented from field offices

- Volunteer monitoring, supporting VM since 1990, EPA role to encourage standardized protocols, networking, outreach opportunities (hosting national meetings). Alice defines VM efforts at EPA as growing from the bottom up and specific to a water body of concern EPA Encouraged states to develop state wide long term monitoring programs. Quality assurance a key push from EPA.
- The value added from this approach is it enables monitoring of water bodies not included in state monitoring, and volunteers play a role in identification of red flags as far as water health.
- Volunteer data not necessarily used specifically by EPA, but encouraged to use by state who needs to make decisions.
- EPA Regions are independent – so some regions have done more than others.
- One of the key roles was a focus on quality assurance, and development of an equipment loan program.
- EPA used to support volunteer coordinators, regional meetings, and technical review of quality assurance plans.
- Recently, the EPA has not supported initiatives anymore. The main support was in the 90’s.

- Now support has transitioned into citizen science, it is the new thing! Model is same as volunteer monitoring. The main change is the use of technology.
- There was a notion that citizen science is being driven from the top down driven – head office of EPA – and is not focused on grassroots like VM was. One of the key focuses now has been getting a grip on data quality is the big concern here. There was not agreement about this between EPA staff on the phone – some felt CS is not top-down. It is more coming from both directions – see below.
- Grappled with the data management and quality assurance issues – these are big issues that need to be addressed. QC checks as a federal agency.

Now shifted to Citizen Science and spearheaded by EPA Office of Research Development

- Edward, role with Citizen Science, EPA – citizen science has been a new buzz word, matter of technology, geographic mapping, hand-held smart devices, computing power, internet access, social media, innovative of people. Passion for volunteering in science – this mix, movement that is growing from the top and bottom – organically. Culture and timing and suddenly things take off.
- EPA Office of Research and Development (ORD) started to get involved in citizen science, with a focus on 2 region office – NW, NJ, regional administrator – made a top down priority- harnessing the public that were interested in environmental issues. Sometimes comes from the communities, not always scientists, can be driven by community.
- CS works across academic, government and communities – it helps to integrate
- EPA is engaged in the Community of Practice group over the last five years, that contributed to the White House initiative

Why – value added of CS

- Data – people talk about data as if it is homogenous, but everyone should recognize that they come into the data with one point of view and think that everyone is talking about the same sort of data. This leads to confusion. There are three dimensions of data:

    - The What (is it something observing, instrument that is observing);
    - The Why (motivation, how will be it used); and
    - The How (end to end process, quality assurance)
  - Initial concern about citizen science about data quality? Depends on why you are using the data – regulatory is different than education for example and requires different levels of assurance.
  - CS is about the democratization of science – need to engage others in process.
  - **Progress** on trying to bridge the gap – VM community who are also representing us within larger EPA.
  - Key questions or objectives needs to be defined clearly. Reasons why they are collecting the data.

2. Who specifically uses/applies/works with CitSci (e.g., field staff, scientists, head office…) and how often?
   - In the past it is up to regional office, some do more than others, Encourage monitoring but only one component of their job. It tends to still vary a lot depending on regional leadership.
   - Currently an opportunity to get more support in region from ORD.

3. What have been the outcomes of a CitSci approach?
   - EPA has not measured the outcomes, as was originally more organic. They used to track successes when first started supporting VM, referenced a old national newsletters where numerous examples of successes where shared including uses of the data,
   - A few examples, improved local awareness of the impacts from cattle on riparian and stream systems, results of monitoring resulted in farmers fencing off important areas – many examples where it lead to stewardship actions
   - Lately have not had time to collect these outcomes.

4. In what ways has CitSci been valuable to your agency/org? What's worked?
   - Local environment surrounds us, people live in a place, and know it and can see change. It connects people to the environment

- Because of VM engagement watershed groups connected the local issues and understand the priorities, used to award grants to statewide groups.
- Provides opportunities to educate, fill data gaps, and engage people to make decisions that may influence listing of impaired waters, local actions by groups.
- Addressed large data gaps, help collecting data in QA way
- Data and results were submitted to decision makers at state level so they could make more informed decisions.
- When people engaged they become better citizens, more likely to advocate. Volunteers tend to be supportive of environmental action. Win for environmental state agency. Comparative cost effective way to get more data.

5. What hasn't worked? (i.e., challenges /barriers)?
    - VM lessons learned – kick start a program, maintaining funding, EPA went from giving out 100,000 dollars to groups, analytical support, communication, outreach, lessons learned to no support. Program Sustainability is important!
    - Quality Assurance (QA) of data, how do you know it is valid, data management, training program.
    - Investment in community is important. For example, EPA supported One Health Initiative in Alaska – Project LEO which is growing into Canada – what they learned is that without the EPA investment in community, capacity building, the program would not have been as successful. Gap funding helped get this going. EPA 10 year investment, capacity building, training in those communities. New tool that could connect those people quickly.
    - **Prior investment in a community – more likely to see the citizen science project be successful.**

6. What lessons have you/your agency learned from integrating CitSci into your approach to achieving you're monitoring and engagement goals?
    - 319 grants EPA, educational grants
    - 106 grants for monitoring EPA

- Support for VM within EPA has been dropping – need commitment because it is valuable
- Technical support role
- Protocol development needed
- Vision important

7. What roles have your agency played in supporting CitSci initiatives?
   - VM issue guidance to state –EPA supported the notion that volunteer data is valuable and can be used to make decisions– this started agencies using the data.
   - Intuitional commitment is important and needs to be made clear.
   - Agency should be prepared to use the data – if a state will not use the data, EPA can step in a use it.
   - In the past EPA has provided guidance on standards - but very old.

8. How are you able to sustain CitSci over time?
   - Office Research Development, RARE - Regional Applies Research Effort, enables collaboration with the regions. Look at the projects that have been funded over the past 10 years – starting to fund citizen science programs from ORD.
   - Infrastructure needs to be set up and is important; investment is needed in the community.
   - Examples of successful programs:
     - Data management – **data one** – guide in 2013 data management guide, primer on data management
     - CSA – eBird – learned early on – made transition to enable people to see their own data it took off.
     - National Geographic – Malaria - swarm intelligence, P 146 – decentralized approach – simple rules of thumb – (e.g., ants evolution).

United States Geological Service

Dave Govani

When was CS first introduced into the agency, and why?

- North American bird phenology program began in 1880s and continued through 1970; it was called volunteer monitoring back then
- The program collected a lot of observations; in order to preserve and rescue the data the USGS starting crowdsourcing to transcribe the data form
- Stream gauge monitoring is another means of engaging volunteers
- Our use of volunteers is long-standing and it is fair to say that EPA has valued that kind of interaction as an extension of our ability to gather data across long temporal and wide geographic spans; EPA couldn't do it on its own
- More boots on the ground, more eyeballs, more helping hands = more 'actionable data' (i.e., data of sufficient quality to meet the aims of our research as an organization which "serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.")

In what ways has CS been valuable to your agency? What has worked?

- See above + "perpetual fact sheet" ((included in resource package) -- Many applications across all USGS Mission areas.

 Increasing emphasis on tools (e.g., low cost sensors, smartphone apps), software, visualization – via challenges & prize

What roles has your agency played in supporting CS initiatives?

USGS has provided support for/participation in:

 Multi-agency initiatives (Federal);

 Development of new policies/legislation;

 Engagement with state, local, tribal, entities and with Federal and other communities of practice, e.g., Federal Crowdsourcing and Citizen Science, Citizen Science Association; Cornell Lab of Ornithology, National Water Research Institutes

- USGS Citizen Guidebook (in development)
- Collaborative development of tools and organizational strategies, e.g. Federal Crowdsourcing and Citizen Science Toolkit and U.S. Fish & Wildlife Service Citizen Science Framework (included in resource package)

What hasn't worked (i.e., challenges/barriers)?

- Excerpted from 2012 USGS Citizen Science Workshop report - http://pubs.usgs.gov/of/2013/1234/
- Practical concerns, including questions of liability for injury, protection of privacy, level of access to government computer systems and data, and the implications of access to or contact with rare, endangered, or dangerous organisms, may prevent or severely limit the effective employment of volunteers in USGS research programs. Scientists wishing to "do the right thing" and meet all the necessary requirements for the legal and ethical use of volunteers' time and data are confronted with a myriad of complex, often outdated, and sometimes contradictory regulations pertaining to the employment of volunteers.
- Federal research focus on big national concerns rather than on the kinds of local issues most likely to spark volunteer enthusiasm and engagement may inhibit volunteer recruiting. Uneven or unreliable post kickoff funding to assure long-term research project viability, though not unique to citizen science-oriented projects, may impact them by devaluing results and discouraging volunteer retention.
- Other constraints imposed on Federal application developers relating to government-commercial sector contractual relationships (for example, Terms of Service (TOS) agreements for software application deployment) have often proven to be significant impediments to distributing and making effective use of modern tools, such as simple smartphone-based data collection applications.

What are the lessons learned from integrating CS into your approach to achieving your monitoring and engagement goals?

- Just because you can doesn't mean you should (not all science research activities can profit from CS&C; cost/effectiveness, esp. when activities require deployment of costly instrumentation; data quality requires consistent protocols, training, and monitoring of volunteers).

- Care must be taken to ensure sufficient engagement over the long haul, particularly when temporal aspect of research is a focus.
- Still have work to do to change perceptions in the 'Academic/Research Guild' regarding cost-effectiveness and especially data quality. Promote internal support through CSWG, talks, e.g., at workshops.

Other Notes

- USGS has CS programs that are primarily contributory for participants (not advanced CS) and that are embedded in specific funded projects driven by the organizational needs of the Department of the Interior
- USGS scientists who are able and willing engage in CS , however field staff are typically the ones who engage with participants
- USGS is an intermediary partner that works with local, state or tribal entities to do things; now that the US Administration has regularized and promoted CS and crowdsourcing for various policy goals, USGS interacts with other federal and state agencies. Additionally, there is a mandated USGS federal CS coordinator who works with the White House (Dave filled that role). Sophia Liu (sophialiu@usgs.gov) is now filling that role.
- The US Office of Science and Technology Policy (OSTP) has a community of practice (COP) of federal agencies for CS
- USGS has their own internal COP called the USGS Community for Data Integration - http://www.usgs.gov/cdi/
- The federal government has played a strong role in promoting and setting policy for CS and crowdsourcing through informing federal agencies that using CS is encouraged
- USGS is currently working on a federal inventory of CS
- Everything USGS does is open source using publicly available software – this is a big directive from a philosophical point of view
- Administration has encouraged agencies to seek “work-arounds” when legislation and old policies are problematic to advancing CS
- The stated priority of USGS is to support other bureaus with scientific information and data so that the agency can make land-use decisions. USGS needs the data of sufficient quality to meet that mission. Our focus

is not on education but the agency encourages it when possible. USGS does education in the context of making sure that volunteers can provide the agency with that good data. USFWS has more of an education focus for their CS programs

- The USGS CS demographic is typically technologists or retired scientists – people who have an understanding of the scientific process
- All data has to be quality assured/quality checked

Appendix D –Workshop Agenda and Results

Citizen Science Workshop, March 2016

Workshop Purpose

To foster an understanding of citizen science including how citizen science is defined, what programs exist, and how citizen science could help accomplish agency science and monitoring goals.

Workshop Objectives

1. To introduce staff to citizen science as an approach to meet science and monitoring objectives.
2. To seek staff input on how citizen science could help meet science and monitoring objectives.

3. To seek staff input on the role of a government agency in supporting citizen science programming and practitioners in Alberta.

Workshop Agenda
March 17 2016, 9:00am to 4:00pm
Edmonton Marriott at River Cree Resort

9:00 am Introductions

9:10 - 9:15 **Welcome and review of workshop objectives**, Krista Tremblett Ministry of Alberta Environment and Parks

9:15 -9:45 **What is Citizen Science and How Can it Help Advance Environmental Monitoring in Alberta?** Tracy Lee, Senior Project Manager, Miistakis Institute

9:45 - 10:30 **EPA's Citizen Science Activities: Past and Present**. Tina Laidlaw, EPA Region 8 Nutrient Coordinator and Hilary Snook, Senior Scientist, United States Environmental Protection Agency

10:30 – 11:15 BREAK

11:15 -11:45 **Advancing Science Through Citizen Engagement: The USGS Experience.** Dave Govoni, Physical Scientist, United States Geological Survey, Office of Enterprise Information.

11:45 -12:05 Project Findings - Tracy Lee

- Review CitSci principles
- An Alberta Citizen Science Inventory

12:05 – 12:30 Citizen Science in Alberta

- **Nature Lynx Demonstration**, Tara Narwani, Communications Manager, Alberta Biodiversity Monitoring Institute
- **Citizen Science: Engaging Albertans in the Science of Nature**, Jenna Curtis, Stewardship Program Coordinator, Alberta Land Stewardship/ Nature Alberta

12:30-1:30 LUNCH (provided)

1:30-2:30 Workshop Discussion – facilitated break out groups

- Discussion 1: Given what was shared this am, when thinking about the mandate to measure, assess and inform the public on the condition of the environment;
    - What do you see as the biggest challenges for CitSci?
    - What do you see as the greatest opportunities for CitSci?
- Discussion 2: In relation to the following questions provide specific examples relating to air, water, biodiversity, wildlife health and community engagement.
    - How can CitSci help produce relevant credible data on Alberta's environment?
    - How can CitSci help provide data to public and stakeholders in an open, timely and efficient manner?
    - How can CitSci approach engage key stakeholders in provincial monitoring?

2:30 – 2:45 BREAK

2:45-3:15 Discussion 3: What role could a government agency play in supporting CitSci in Alberta?

3:15-3:45 Report back from breakout groups

4:00 pm Closing remarks and next steps, Krista Tremblett, Ministry of Alberta Environment and Parks

Presenters

What is Citizen Science and how can it help advance environmental monitoring in Alberta? Tracy Lee, Senior Project Manager, Miistakis Institute. This presentation will provide a general overview of the field of Citizen Science, including diversity of programming, typologies, guiding principles and models of participation. I will discuss the benefits and challenges of Citizen Science and the potential value to environmental monitoring in Alberta.

Bio: Tracy is a senior project manager at the Miistakis Institute, a research institute affiliated with Mount Royal University, which brings people and ideas together to promote healthy communities and landscapes. Tracy acquired her MSc from the University of Calgary, Resources and the Environment Program. Tracy's graduate work, in association with the Miistakis Institute, focused on the development and assessment of a citizen science project to monitor wildlife movement across a major highway. Tracy has helped to establish and implement a number of citizen science programs in Alberta with communities, government and industrial partners including Road Watch BC, Collision Count, GrizzTracker and Wild Watch.

Advancing Science Through Citizen Engagement: The USGS Experience. David L. Govoni, Physical Scientist, USGS Office of Enterprise Information
The U.S. Geological Survey (USGS) has, for many years, made effective use of the skills and energies of citizen volunteers to advance its research mission. It is regarded as a leader in the creative application of citizen science and crowdsourcing techniques within the U.S. Department of the Interior. Many of its citizen science projects have been undertaken in partnership with a range of national and international governmental, educational and non-governmental organizations and institutions. Following a brief introduction to the USGS, the presentation will be divided into four parts. To provide context to the main elements of the presentation, part one will consist of a brief review of basic terminology, history, and the technological and societal enablers of modern citizen science. Part two will provide a synoptic review of citizen science projects at the USGS to illustrate their breadth of approach and application. Based on the USGS's experience Dave will, in part three, review some of the benefits of incorporating citizen science into its program of research, as well as the key barriers and constraints encountered in doing so. From this discussion, Dave will lay out some lessons learned in designing and implementing successful USGS projects. Finally, time permitting, Dave will summarize current USGS and Federal-level policies and

activities designed to encourage and facilitate the use of citizen science, as well as opportunities to collaborate.

Bio: David Govoni is a Physical Scientist in the U.S. Geological Survey's Office of Enterprise Information. He earned a B.A. in Geology at Rutgers University and M.S. in Paleobiology and Stratigraphy from The George Washington University. Dave joined the USGS in 1990, where he focuses on improving science information discovery, delivery, and management. He co-founded the USGS Community for Data Integration's Citizen Science Working Group to promote effective use of citizen science in the conduct of USGS research and to foster cooperation between the USGS and broader Federal citizen science community. He is currently helping to develop and coordinate plans and processes to implement Federal policies on open data and public access to Federal scientific research. He actively participates in several local and national citizen science projects including the Cornell Lab of Ornithology's eBird and the Audubon Christmas Bird Count.

EPA's Citizen Science Activities: Past and Present. Tina Laidlaw, EPA Region 8 Nutrient Coordinator and Hilary Snook, Senior Scientist, United States Environmental Protection Agency.

EPA will discuss the Agency's support to volunteer monitoring / citizen science efforts since the 1990s. Historically, EPA has provided financial and technical assistance to organizations nationally to help them meet their local monitoring objectives while collecting quality data that can be used by states and EPA to make management decisions. Tina will describe the logistical details of supporting and implementing citizen science programs across the country, identify challenges with maintaining support and highlight lessons learned. Tina will present several activities previously supported in EPA Region 8 (Rocky Mountain West) and move into a discussion of current citizen science efforts being led by EPA Region 1 (New England). Over the past couple of years, the New England Regional Laboratory has convened a region-wide cyanobacteria monitoring and "bloom watch" workgroup that consists of public water suppliers, state environmental water quality and beach monitoring programs and departments of public health, tribes, NGOs, volunteer monitoring groups, and academics, to collaboratively establish a uniform and consistent regional approach to monitoring cyanobacteria. This program can provide useful information to a broad range of entities; from lake associations to large drinking water suppliers. Tina will discuss the methods, tools, and data produced from the workgroups efforts to date and briefly highlight factors leading to success, lessons learned and the role of EPA.

Bios:
Tina Laidlaw received her B.A. from Davidson College, North Carolina and a Masters of Science from the University of Georgia. Prior to joining EPA, she worked for Alabama Water Watch and the Colorado River Watch volunteer monitoring programs. Tina began her EPA career in Denver, Colorado, in 1999. Her primary duties included providing technical support to states, tribes and volunteer groups on monitoring and assessment issues. In 2002, she moved to the EPA Office in Helena, Montana and joined EPA's water quality standards program. Currently, she serves as the EPA Region 8 Nutrient Coordinator and continues to oversee state and tribal monitoring programs.

Hilary Snook is a scientist for USEPA's New England Regional Laboratory. He holds a bachelor's of Science degree from Montana State University and a Masters degree in civil and environmental engineering from Tufts University. His work involves the coordination and management of water quality and aquatic biological monitoring surveys for the region, and provides a supporting role for national aquatic resource surveys presently being initiated by the EPA. He has implemented ecological assessments of condition for wadeable streams, large rivers, lakes and ponds, and near coastal waters for the past twenty years with a focus on development of biological indicators for assessing aquatic resource condition, emerging contaminants, and the transport of contaminants through food webs and the environment. He has spent the past 25 years working on water quality and other hydrologic issues and problems.

Nature Lynx Demonstration. Tara Narwani, Communication Manager, Alberta Biodiversity Monitoring Institute (ABMI).
From budding nature enthusiast to established naturalist, NatureLynx is a mobile and desktop application designed by the Alberta Biodiversity Monitoring Institute (ABMI) to empower Alberta's citizen scientists of all stripes. Building off a basic "spot, snap, post" platform, NatureLynx allows users to upload biodiversity sightings, have their posts verified by experts, and share their data through its mapping portal and social network. Users with specific biodiversity-related questions can participate in "missions" to collect hypothesis-driven data and share the results of their effort broadly.

Bio: Tara Narwani is a scientist by training, but a science communicator at heart. After winning the Herb Lampert Emerging Journalist Award and the Alberta Innovates Health Solutions (AIHS) Media Fellowship during her doctoral studies at the University of Alberta, she began writing extensively about medical research for

AIHS as a freelance writer. Science communication and engagement became her full-time gig when she joined the Alberta Biodiversity Monitoring Institute in 2012.

Citizen Science: Engaging Albertans in the Science of Nature. Jenna Curtis, Stewardship Program Coordinator, Land Stewardship Centre.
Land Stewardship Centre and Nature Alberta have been working with Alberta's stewardship community for over 65 combined years. Through their respective programming, which includes the Watershed Stewardship Grant, Living by Water, Important Bird Areas, and Bird Conservation, they have seen and supported citizen science in action throughout the province.

Bio: Jenna Curtis is the Stewardship Program Coordinator for Land Stewardship Centre. She manages the Watershed Stewardship Grant program, which funds community based stewardship projects up to $10,000, and the Alberta Stewardship Network Program, a program that support Alberta's stewardship community through tools and resources such as the Stewardship Directory, Grassroots Newsletter and the Stewards in Motion events. She also coordinates Living by Water, a program of Nature Alberta, which promotes beneficial practices and proper shoreline management with lakefront property owners.

Workshop breakout notes

Tracy Workshop Group

SESSION 1:

Opportunities

- The agency is currently examining monitoring framework, CitSci as a consideration is timely
- Enables us to build trust with stakeholders and public
- Increase amount of data and peoples understanding of data as a means of what is happening on the landscape
- Agency could play a connection role between CitSci practitioners
- Agency could develop standard protocols
- CitSci can help promote the value of monitoring agenda
- Existing standards to draw from (EPA, USGS)
- Engage citizens to understand issue of importance to Alberta
- Can contribute to understanding beyond Alberta if tied to larger national or international projects
- Ability to span intergenerational interests and cross culture

- Can help to build an environmental ethic
- Increase stewardship ethic
- Address monitoring gaps
- Enable data collection on private land
- Enable Agency to engage the DYI community

Challenges

- There is a need to define Agency role and for us to stay within this role
- Resourcing needs – including funding, man-power of existing staff to take this on (need explicit expertise)
- Development of a framework is needed
- Clear understanding of the end use – is this for education, policy, science outcomes?
- Addressing liability issues (safety of volunteers)
- Addressing quality assurance
- How does citizen science get reported? How are results evaluated?
- Currently no protocols in place for many of the monitoring variables
- Biases associated with volunteer engagement
- How do we manage expectations in our support of citizen science
- Interoperability - the ability of a system or a product to work with other systems or products without special effort.
- Discoverability - is the ability of something, especially a piece of content or information, to be found.
- Agreement of definition between CitSci and CBM

Participants were asked if any of these barriers were prohibitive to using CitSci, in other words are they all solvable.

- One staff member expressed concern about the ability of volunteers to collect credible data.

SESSION 2: How can CitSci help
Air quality data gaps

- Airsheds currently operate independently of each other
- Engage students in data collection – learning techniques to monitor air quality (colleges, technical schools)
- Development of standards or use of standards already developed to encourage Albertan’s to monitoring air quality.

- Concerns expressed about the low vs high tech equipment and what low tech can tell us. Suggest that low tech (CitSci) could help with early warning signs (red flag) and help with specific placement in areas. Possibility that CitSci could help with detecting change.
- Two programs were mentioned as examples
  - Airbeam, measures PM2.5 - http://www.takingspace.org/
  - Sampler canister –volunteers smell something and then collect and air sample which is analyzed in a lab
  - iSpex, measuring aerosols using Citizen Science - http://ispex.nl/en/
    - Journal article: http://onlinelibrary.wiley.com/doi/10.1002/2014GL061462/abstract

WPACS

- Is there an opportunity to work with WPACs to improve province wide data collection? If so a government agency could help by:
  - Establishing agreed on provincial standards for monitoring
  - Act as central repository for data
  - Provide training
  - Audit water monitoring data
  - Provide funding support
  - Provide equipment to groups
  - Help disseminate data results – sharing of data and results

General Opportunities

- Play the role of knowledge broker (social media, hosting workshops, blogging, using data in state of environmental reporting)
- Develop Citizen Science toolbox

Groups to connect with:

- Environment Canada
- Municipalities
- Industry
- Alberta Lake Management Society
- Aboriginal groups

SESSION 3: How can a government agency help CitSci

- Consider partnerships and support what is already happening
  - Remember does not have to be high tech (i.e., ice, phenology)
  - Build off of existing tools – not necessarily build new tools
  - Example where app developed but does not seem to be a data collection component: ifish app; http://www.ifishalberta.com/
- Encourage standards to monitoring
- Provide training (monitoring methods, calibrating equipment)
- ID data gaps to better understand agency role and which programs to support
- Help to ID partners
- Develop an equipment library or even sell equipment
- Play an data auditing role
- Play a role as a hub for CitSci, including data accessibility and inventory of CitSci
- Host a citizen science forum
- Provide an understanding of what can be done with the data
- Should keep simple

Where are you as an agency already supporting CitSci?

- Provided support to Alberta Lake Management Society – invasive aquatic monitoring
- Water gauge readers – hydrometric network
- Provided support to Alberta Biodiversity Monitoring Institute – Naturelynx

Groups to engage in CitSci

- Hunters and anglers
- Recreationists
- Farmers
- Ducks unlimited (wetlands)

Next steps generated from workshop

- Define CitSci and CBM, include a list of characteristics

Danah Workshop Group

SESSION 1:

Opportunities

- A new organization and still figuring our roles/priorities – can insert CitSci at the front end
- CitSci might enhance credibility/buy in and social capital.
- How can use CitSCi to work with outside partners
- An opportunity to engage schools/parents in collecting data and monitoring
- Creates a bottom up approach – getting info into hands of people who care (communities) and efficient pathway for information
- Opportunity for corporate or non-government funding.
- How to incorporate concerned citizens into monitoring
- CitSci could support emerging priorities and support integration of monitoring priorities

Challenges

- Data management and data platform – how is data housed and shared
- Who is the champion for Citizen Science – which staff, department have the mandate?
- Finding direction for Citizen Science
- Retaining commitment from volunteers can be a big time and resource investment
- CitSci might compromise credibility/buy in and social capital
- Consistent data standards
- Mistrust of government by landowners, might have trouble engaging people
- Funding limitations

Session 2: How can CitSci help the government agency?

Air quality data gaps

- Can CitSci help fill in data gaps associated with air quality monitoring? Think this through on a pro-active basis, where there are different classes of data (education to regulation)
- Must be able to have non-scientists to collect useable data

Coarse data collection

- The need for specific vs. coarse data needs to be articulated.
- The final use of the data needs to drive the type of data needs, what are the data quality objectives.

- How confidence are you in the data, and what can you provide back to stakeholders

Collaborative Citizen Science Network – role for government agency

- Develop resources
- Networking
- Take advantage of current GOA partnership in support of CitSci
- Evaluating CitSci

Session 3: What role can government agency play in CitSci
Role of a CitSci hub:

- Tool development (tools for analyzing data)
- Develop standards
- ID data gaps
- Provide resources
- Data delivery mechanism

Promote existing CitSci programs, through social media

- It is important to know which CitSci projects should be supported/promoted

Can provide a provincial perspective
Ensure best of class – and no reinventing the wheel
Funding new/existing CitSci programs, prioritize groups that share and provide needed data.
Important to understand that CitSci is not appropriate in all areas
Play a collaboration mode
Act as a link to GOA departments
Integrate throughout the organization as opposed to a branch– what does this look like?
Provide training of CitSci, like ALMS
There needs to be time and upfront money to fund the integration of CitSci
Start small – build on success

Krista Workshop Group

SESSION 1:

Opportunities

- Generate public interest (in the unknowns)
- Engage with new communities/groups
- Tapping into known interests (i.e. replicating EPA BloomWatch Program)

- Turn complaints into observations
- Strengthen relationships between the agency and other organizations (partnerships – cross training)
- Filling gaps (geography, data, people
- Discovery and innovation (technique, technology)
- Reporting and storytelling

Challenges

- Managing data
- Collecting credible data (data quality)
- Ownership of data
- Volunteer engagement (connecting to projects)
- Buy-in from scientists to use the data
- Recognized/acceptance of QAQC
- Funding and or resources
- CitSci training (uses resources)
- Generating public interest
- Risk/liability of volunteers
- Volunteer recognition of efforts and impact
- Publically accessible an sensible
- Knowledge translation
- Data evaluation and reporting
- Aligning individuals and organizational interests

Session 2: How can CitSci help the government agency?

- Produce relevant/credible data on
    - Lake Level observer network (water quantity), lake level database
    - Air sensor distribution- PM monitors (air quality eggs)
    - Increased geographic coverage – provincial trends, coarse scale analysis
    - CitSci could be used to validate modeling, through ground-truthing
    - Leveraging what is already out there – interests can help agency priorities
- Provide data to public/stakeholders efficiently and transparently

    - Metadata is important for comparison studies;
    - National and international CitSci orgs; and
    - TECH/IT gaps, Fish and Game, Nature AB.
- Engage key stakeholders in provincial monitoring
    - Small watershed stewardship groups
    - Municipalities
    - Natural history groups
    - Connect stakeholders with relevant groups

Session 3: What role can the government agency play in CitSci?

- Provide sustainable funding
- Technological evaluation
    - Developing relevant standards and protocols
- Training
- Improved understanding of scientific process
- Strategic monitoring program design
- Maintaining database
- What is the goal/role of CitSci, as this will influence role the agency can play? Does the agency want better data or changing behaviors?
- Need to identify what the agency doesn't have data on? CitSci can help us fill the gaps, for example
    - Ice melt on lakes (ice watch)
    - Algae blooms
    - Drought (widespread data is missing)
- Leading role in evaluating data, identifying relevance of environmental indicators
- Partnerships to fill gaps
    - Ground-truthing support (e.g., training municipal employees to sample water)
    - Invasive species programs
- Both top down and bottom up approaches are important.