Comparing best management practices of community based monitoring between habitats in the literature and in reality.

Honors Thesis
Presented to the College of Agriculture and Life Sciences, Development Sociology
of Cornell University
in Partial Fulfillment of the Requirements for the
Research Honors Program

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May 2008
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Abstract

Community based monitoring projects, often called citizen science, have been on the rise for the last decade. Although they provide the benefit of large data sets from a wide area, the quality of the data is often questioned because they are collected by 'laypeople' with limited field experience. However, there are a number of side benefits of utilizing volunteers in research that may outweigh this concern: increased stewardship of the monitored habitat, educational benefits to participants, and community support for such research. The goal of many of these projects often is restoration or preservation of an area, and these side benefits may aid in meeting the end goal as much as the actual data collected. Many community based monitoring projects publish their results in scientific or technical literature with recommendations for similar future projects. This study determines if these recommendations match the best management practices actually used by programs. Also, this study compares recommendations and practices by habitat to see if more specificity is needed in thinking about improving the data coming from monitoring programs and allowing them to succeed at fulfilling their mission. A series of surveys of program coordinators and primary investigators were compared to recommendations in the literature to determine if published recommendations are a realistic representation of practices that occur in the field. Results showed that although the top recommendations of the literature and survey respondents were similar (championing collaboration with experts, consistent methodology, and presentation of data to policymakers), the means and implications of achieving these goals differs by habitat. Specific habitats were associated with slightly different types of mission statements that have implications for their definition of reliable data and overall success.

Introduction

The value of simple observations in a particular area often provide the most valuable information for scientists on ecosystem dynamics, health, responses to stressors, and changes over time. The United States government (e.g. the Environmental Protection Agency, Fish and Wildlife Service, and the United States Geological Survey) is beginning to put more effort and funding into long-term monitoring projects, realizing the value of such data, but such programs are expensive, labor-intensive and require a career-long commitment by staff members. As a result, there are few such programs, restricted to particular areas of high conservation value or those most drastically threatened such as the coastal rainforest from Oregon to Alaska (Fradkin, pers. comm.). Yet, management decisions depend on placing more specific research projects in a larger context and

understanding broad ecosystem dynamics, especially those in response to anthropogenic change such as climate change, on which regulation can have an immediate effect. As a result, many communities have organized local monitoring programs or connected to national monitoring efforts in order to better understand the habitats in which they live and ensure that the area gets needed conservation or restoration efforts. These programs often aim to fill in the gaps in government programs and result in increased political participation, therefore political response to the data (Overdevest et al. 2004).

Objectives

This study performs an in-depth analysis of the recommendations for best management practices made through the literature and in person, separating the ideas to see if there are any differences by the habitat in which the study takes place. The comparison between published recommendations and those elicited through program managers in surveys will determine if the widely accepted recommendations in the literature are an accurate representation of meeting the challenges of work in the field. Comparisons of the recommendations made by the two venues determined if there is are filters on what points are published based on the demographics of the author groups. In addition, the recommendations from both the literature and the surveys were be separated by habitat to see if thinking about programs by their target ecosystem is a useful practice that may aid programs in success.

Overview of what community based monitoring is

Community-based monitoring, sometimes known as citizen science, has become a recent buzzword among both scientific communities and in the policy arena. The concept, however, is not new, initiated in England with the Riverkeeper tradition, in which anglers would charge someone to watch over the safety and health of the rivers. In the United States, the National Weather Service was the first such program, instituting over 11,000 weather watching stations. The Isaac Walton League followed in 1922, instituting a program much like the Riverkeepers for American streams (Firehock and West 1995). More recently, in the face of human-induced environmental change, there is a demonstrated need for baseline data sets that describe basic environmental health (Stokes et al 1990). Such baseline data is then used to show changes in response to human activities, which allow rapid and effective management. Monitoring indicators encompass measures on individual health, population structure and dynamics, community structure, and overall ecosystem function (Karr 1987). Historically, monitoring programs have focused on chemical and physical factors that were known to cause environmental problems, but recently focus has shifted to the biology at the receiving end, which shows sensitivity to other factors such as land use change and species invasions (Karr 1987).

Professional monitoring programs, usually carried out by government agencies, have rigorous protocols and often seek specific information that is complicated to collect or analyze in a laboratory. These programs generally follow from a government mandate meant to guarantee the health of a certain area and ensure that relevant regulations are upheld. Conversely, community groups have the luxury of many people able to lend a hand in monitoring activities and inform research efforts with a local perspective from

personal experiences. Since such groups generally have limited funding and little expert or professional influence, there is skepticism of the data produced by citizen monitoring programs. However, data collection is rarely ever the sole purpose of a community based monitoring program. Other stated goals include education, expansion of studies into locations important to citizens, identifying areas in need of conservation and restoration, tracking the success of management plans, and providing tools for land use planning and guidance for decision making (Firehock and West 1995). At the core any given citizen monitoring program is likely a balance of several purposes. Attempting to achieve all of these purposes effectively takes a vigilant eye toward the strengths and weaknesses of the program as well as a flexibility to make changes in order to meet these purposes. Community monitoring programs collect large quantities of important data, but the scientific value is often questioned due to skepticism of the reliability of data collected by average citizens. Yet, even if the reliability of the data is not on par with professionals, it often meets the quality necessary to inform policy or compare the health of the system over time. Hence, the benefits and drawbacks of a community monitoring program must be considered in the context of the stated purpose when deciding whether the data is reliable (O'Leary et al. 2004).

Benefits of community based monitoring

There are a number of benefits to volunteer-based data collection, both logistically and socially. Logistically, the amount of data that can be collected is greatly increased, both due to more data collectors and increased access to private lands. Monitoring by professionals is generally limited to public natural areas and small scale

plots because of constraints in committing large amount of professional man-hours to data collection. Monitoring by volunteers can occur at odd hours (especially if people are volunteering near their home) and make the repeated measurements necessary for tracking trends in a changing environment (Smith 2003). For example, spotted owl monitors on the Olympic Peninsula report calls they have heard at night near their homes. Since many of the locals participate in the reporting program, almost the entire area is covered and the regional park staff are saved having to conduct overnight owl surveys (Fradkin pers. comm.). Budget constraints also may limit the amount of professional involvement in each study and perhaps also explain why intermediate levels of expertise are not often utilized. For instance, the numbers of people necessary to complete a comprehensive biodiversity survey and cover the appropriate range and times of day to ensure all animals were counted would require at least three paid staff members at each site, which is far beyond the budget of most studies. This constraint is especially true for the minimally funded programs collecting baseline data. Overall, volunteer data collection is cheap as compared to hiring a professional to do the same work, especially when the hours required for such data collection are not during regular working hours, as is often true in field work (Stokes et al 1990). Also, anecdotal evidence collected by local volunteers has provided scientists with unique insight in regional issues and provided historical perspective in addition to the raw data (Brown et al 2001). The volunteers often help design specific research questions based on observations made from long-term residence in the area and basic day-to-day observations that could not have otherwise been quickly pinpointed, if at all. This questioning strategy allows issues of greatest concern to the stakeholders to be given priority (Danielsen et al. 2005).

The volunteers and their community also benefit, as the relationship between nature and the local citizens shifts from a distanced relationship to one of understanding, responsibility, and ownership (Danielsen et al. 2005). Volunteers may have the chance to gain hands-on experience with organisms that live in the area, yet had not received much attention by the local residents. For example, nocturnal amphibians make well-known vocalizations at night, but surprisingly few people have taken the opportunity to go out and find them. One such humorous story is of a mother and child who were nearly arrested in a local woodlot while searching for salamanders because the local police officer on duty thought they were partying students and did not believe they would spend time searching for the breeding salamanders out at the time (Sullivan pers. comm.).

A personal experience in nature often leads to sympathy and consequent protection of the area that conjures favorable memories. The educational opportunity afforded by these volunteer surveys often creates a sense of ownership and responsibility leading to protection in the local community that may avert future threats (Stokes et al. 1990). Beyond analysis of community managed areas, however, the direct educational effects of volunteer monitoring have not been described. Most connections between the scientific community and volunteers are relatively simple, with specific skills imparted to the volunteers through workshops and data flowing back to the researcher. However, local residents are part of the ecosystem and scientists can gain valuable information from monitoring projects about how locals interact with the habitats they live in and can often inspire and help these residents become involved in local conservation efforts (Brewer 2002). Locals' anecdotes also inform new research questions and lead to more effective management targets (Brown et al. 2001).

Drawbacks of community based monitoring

The main drawback to collecting data using volunteer effort is the concern that the data is not of the same quality as those collected during a professional survey. There has been a recent abundance of articles from researchers verifying their volunteer data by resurveying with professionals, each with varying results. Many find that the volunteers are only reliable to the genus level in diversity surveys and that quality increases with the length of time the volunteer works with the program (Brandon et al 2003). However, depending on the purpose of the program, the data resolution may be accurate enough for the purpose of the study and yield the same conclusions as data collected by professionals (O'Leary et al. 2004). There are many kinds of data taken in the various community monitoring programs, from physical features of the site such as type of rock, amount of rainfall, and turbidity of the water, to chemical factors such as pH, dissolved oxygen, and synthetics introduced by human activities, to biological factors such as species diversity, distribution, and abundance, breeding success, timing of flowering or migration, etc. Some studies compare their own data from year to year, while some are attempting to set up a database of baseline data for others to use to situate their more specific data in a larger context. Depending on the eventual use of the data and the types of factors being tested, volunteers may have differing capabilities to collect accurate data. In addition, few programs have official quality assurance protocols (Pfeffer and Wagenet 2007). The question of quality has led many of these researchers to analyze their programs and make recommendations for future researchers to maximize data quality while using volunteers or at least ensure that the data can be used for the stated purpose.

Research questions and hypotheses

There has been a push within both the policy and research communities to develop a standardized method of monitoring within each habitat so that changes can be compared not just within a site but between similar sites that fall under the same regulation (Smith 2003). Each study published thus far, however, is specific to one kind of habitat such as streams or grasslands, and is not necessarily applicable to other ecosystems despite the authors' broad-ranging recommendations for other monitoring programs. This study identifies what strategies for obtaining reliable data are common across all habitats and which strategies are specific to only one particular habitat. Some strategies are expected to be shared among all habitats, while at the same time it is likely that monitoring teams will have found specific strategies tailored to their individual habitat. These more specific strategies may not have such prevalence in the literature as the more broad recommendations because they are not directly applicable to as many people. However, they are arguably more important for any given individual study in dealing with the challenges that inevitably arise during the first few years. These challenges may determine the success or failure of the program. Forest programs, for example, tend to be focused on private land because most wooded land is privately owned (especially in the more heavily forested eastern United States) and these landowners are often highly educated in forest management, which arms them with the capability to collect highly reliable data but also makes them less likely to want to collaborate nationally because the data is collected about their own land. Considerations such as these are important to consider both during the planning stages of a new program and when leaving avenues for a program to adapt to the challenges that will occur.

Although there are numerous ways of classifying ecosystems into habitats, ranging from the major biomes of the world to the microhabitats of a particular waterfall, this study has focused on four general habitat regions with a relatively high level of citizen engagement: northern plains, northern hardwoods, the Gulf of Maine, and streams from each of these areas.

The northern plains occur in the north-central part of the U.S., Alberta, and Manitoba in Canada. They are formed in the rain shadow of the Rocky Mountians, which creates a semi-arid area perfect for grass species to dominate the landscape. Native grasses are shortgrass and tallgrass prairie species important for bird and insect feeding and migration routes (Molles 2005). Most of the region has been converted to farmland for dry beans, sunflower seeds, and rapeseed, but there are still notable stretches of native land, mostly owned by the US and Canadian governments, and a growing effort to replant native species, which may have economic value in ethanol production.

The northern hardwoods occur from the Great Lakes east to the Atlantic Ocean and as far south as Virginia along the Appalachian backbone north to Nova Scotia. Dominant plants are almost all trees such as red and sugar maples, beech, oaks, ash, eastern hemlock, and white and red pines (Molles 2005). Most of the forest is second growth, having regenerated after nearly all of the land was cleared for agriculture during early settlement. The land is roughly 80% in the hands of private landowners who privately manage their land for personal use and small-scale silviculture (Smallidge pers. comm.).

The Gulf of Maine region is a representative example of the eastern Atlantic coastline, consisting of exposed continental shelf, estuary, and a series of brackish inlets

(Molles 2005), with similar levels of historic development and fishing pressure. The region has been affected by the frequently described overfishing of species such as cod. The citizens have a high degree concern for their local industries and culture, which prompts community groups to spring up and demand protection and monitoring of their coastline. Some of the longest fish stock monitoring records come from the northeastern coastline, as the fisheries service keeps meticulous catch records (Kurlansky 1997), however the area has been affected by humans for so long that no one is sure of what the natural ecosystem looks like.

The final habitat, streams, is representative of the most comprehensive monitoring network in North America, mainly through the EPA and Environment Canada. These government agencies have a number of published protocols and recommendations as well as books of contacts of monitoring groups around the country (www.epa.gov). They encourage groups to take consistent data so that regulations can be made based on the results and that the data sets can be combined for insight into the health of the nation's water sources as a whole. The individual programs have wide-ranging goals, from monitoring the sources of drinking water for chemicals to restoration of salmon habitat in the West. They often involve schoolchildren and have established easily identified indicator species, benthic macroinvertebrates, whose presence is correlated with the degree of health of the stream (Pfeffer and Wagenet 2007).

In addition to comparing the best management practices between the various habitats, this study compares the recommendations made in literature to those elicited through casual surveys of primary investigators and citizen science program coordinators. The researchers making the extra strides to publish recommendations for other programs

in their discussion may have a particular kind of experience, either good or bad, that provokes them to comment on their program rather than simply state that the citizen scientists were used in the data collection.

Although the reliability of the data collected during citizen science projects is rightfully scrutinized and data quality continues to be the primary challenge of these projects, the considerable value of man-hours and community involvement often justify the effort. The researchers and coordinators of such situations often shift the purpose of the study from purely experimental to conservational, which shifts the need of the data from as accurate as possible to as accurate as necessary to meet a conservation end-goal. Thus, this study determines whether the participants in community-based monitoring projects provide data accurate enough to meet the stated mission of the program, even if their accuracy does not match professional efforts. For instance, if the purpose of a given community monitoring group is to track changes in an area in order to present to legislators and inform policy, then the data has to be accurate enough to show the changes but not necessarily so specific as to track each individual species. The projects that have been in existence for a number of years, receiving repeated funding from their backers, are likely to be producing data of enough quality to justify this perpetuation.

Rationale for/importance of research

The various community based monitoring studies around the country have produced a large body of recent literature describing their results, often having unique insight into the natural system of interest because of increased time and spatial access offered by volunteer monitors. The published research offers similar recommendations

and generally falls in line with the EPA quality assurance protocol guidelines. However, challenges that determine the success or failure of a program generally occur in the first few years and likely require specific guidance, a role that universities classically play (Savan et al 2003). These recommendations and practices may be different than those produced at the end of a successful study, especially those reporting sound conclusions at the same time. The recommendations originate from a self-selected successful group of programs that also share the goal of contributing to the scientific literature, which is not necessarily a common goal of all monitoring programs.

Monitoring programs span a wide variety of types, habitats, and goals, including a means to increase local stewardship, to a method to ascertain the range and distribution of certain species, and as a strategy to collect long-term baseline data tracking gradual environmental change (Pfeffer and Wagenet 2007). Although the variety of programs is recognized, no analysis thus far has attempted to compare the different kinds of programs. Those making recommendations for best management practices generally focus on their particular experience or remain within the realm of the more organized water quality programs loosely under the umbrella of the EPA's quality assurance program and therefore differences are not recognized. For instance, Overdevest et al. (2004) describe that participants experienced little gain in technical knowledge from a stream monitoring project, while Brossard et al. (2005) describe a great increase in the knowledge of bird biology through participation in a bird count. However, the bird counts participants did not report an increase in environmental awareness or participation in active conservation while the stream study participants reported significant increases in

stewardship activities. A consideration of habitat is thus necessary in planning and evaluating monitoring programs.

The goal of this study is two-fold: to determine if there are differences between recommendations made in the literature and those made in direct surveys of program coordinators as well as to determine if best management practices differ by habitat. The literature likely only represents a subset of recommendations, mirroring the fact that monitoring programs that publish represent only a subset of the monitoring community as a whole. Similarly, the recommendations are also likely to differ by habitat, as the same set of practices are unlikely to be equally effective in every ecological community. Each habitat presents unique challenges for fieldwork by professionals and therefore probably also does for citizen science teams.

Methods

The methodology of this study was two-fold to in order to address the two research questions. First, a literature review was conducted to characterize the recommendations made in published studies. The goal was to determine the overall best management practices discussed by the authors and to determine if there was a difference by habitat. A survey was then conducted of primary investigators and program coordinators to compare recommendations among program types and with the top recommendations found in the literature.

Meta-analysis of recommendations by habitat

A literature review was conducted to compile a database of tested and validated volunteer methodology (articles listed in Appendix B). The search was conducted in three databases covering education (ERIC), environmental science (Web of Science) and sociology (Sociological Abstracts) to find published studies that address the quality of volunteer data in monitoring studies. Search terms included 'citizen science,' 'volunteer,' 'assessment,' 'monitoring,' 'grassland,' 'stream,' 'coastal,' or 'marine,' and 'forest.' The article collection was considered complete when there were at least 15 from each of the major habitat types in the United States: stream, forest, grassland, and coastal. Each study was reviewed to answer the following and results coded in Statistical Package for the Social Sciences (SPSS) for analysis:

- Was the volunteer force accurate in their identifications as compared to professionals?
    a. Did the author consider the data reliable and useful as determined by the stated purpose of the study?
    b. What level of accuracy was considered adequate in order to use the data?
- What are the recommendations of the authors, if any, for other investigators hoping to use volunteer data collection? Do they mention technical skills, data processing, data sharing and publication, training programs and organization, collaborations, etc?

The literature review identified what the published recommendations are for future volunteer-based ecological studies and if these differ by habitat type. They were then compared to the verbal recommendations collected during the interviews (see below) to see if the published literature corresponds to the practices of those leading such

studies or if those published represent a different subset of recommendations. Articles written by the interview participants were not included in the literature review.

Survey of primary investigators/coordinators using volunteer methods

Primary investigators leading volunteer based long-term monitoring studies were interviewed primarily to determine if they follow similar recommendations to those found in the literature. A target of 10 investigators were chosen from studies in specific regions of each of the four kinds of habitats (stream, forest, grassland, and coastal) through a Google search. The search terms were "volunteer" + "monitoring" + the habitat, followed by systematic random sampling of the search results beginning on a random page. Overall, the response rate was 50%. Some programs may not have responded because the monitoring season has not started yet and some programs only staff an office during the field season. Also, some of the contact information was not updated on the websites and the request for an interview is still filtering to the correct person in 3 cases. The response rate may have favored programs with year-round staff and the smaller programs with personal cell phone numbers as the contact information. However, these are the two ends of the spectrum of monitoring programs, so hopefully represent the mid-sized programs as well.

The interviews were conducted by phone and the person answering the survey had to either be an academic professional running the program or a citizen coordinator taking an equivalent leadership role. Each interview lasted about 20 minutes, longer if the participant was prone to telling stories. The survey questions are included in Appendix A. Specific anticipated answers were coded in SPSS in a worksheet similar to the literature

review for direct comparison, other notes of interest kept for qualitative analysis especially regarding the stated purpose of the program and stories of perceived successes.

The specific regions were northern hardwood, northern plains, Gulf of Maine, and streams in each of these three areas. The initial concern in having such a small number of respondents from each habitat, due mainly to time limitations, was that the investigators willing to spend time to respond to each survey may be the same type of people wanting to publish their recommendations, leading to a bias toward an agreement between the interviews and the literature review. However, the surprised reaction of many, if not most, of the survey respondents to the question asking them to come up with recommendations indicated that there was little basis for this concern.

Results and Discussion

Lit review meta-analysis:

Funding sources varied, with most of the studies funded by academic institutions (fig. 1). Also of note is that all but two of the privately funded studies were authored by an academic collaborator. These collaborators were not the primary investigators or organizers but were the people responsible for applying the data and evaluating the value of the observations. The government studies, though occasionally co-authored by an academic collaborator, had the data publication more directly under the control of their primary investigators.

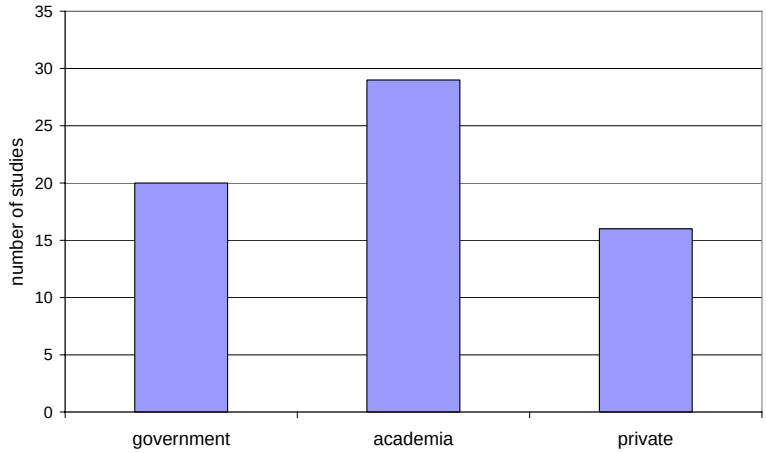

Figure 1. Major funding sources for monitoring programs collecting data for the published studies. n=67.

Most of the studies reviewed were from programs that were older than five years (fig. 2). Some of these studies had chosen to evaluate data from several programs in the same location, covering the overlapping control of that location's community monitoring program. However, the data was essentially continuous for more than five years even if the personnel were not. The one year studies were often more a trial of methodology than publication of results from a monitoring study. The purpose of these studies were almost all, with the exception of two, to inform the development of a citizen science program in a location or habitat of need. Overall, the vast majority of the articles discussed programs that had long-term history and long-term future goals.

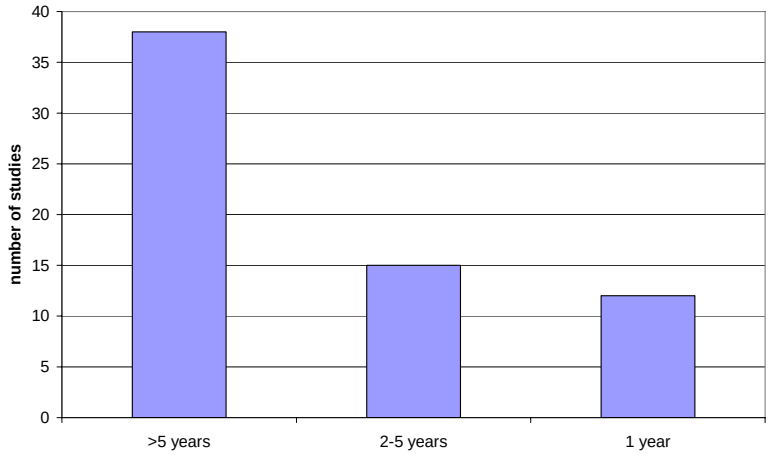

Figure 2. Age of active monitoring program as reported in published literature. n=67.

The literature review yielded the following as the top recommendations:

1) collaborate with experts
2) have a consistent methodology
3) present data to policy influencers
4) have a standardized training program

These recommendations were mentioned by about half of the articles and were clearly more prevalent than the many others, which had at most a quarter of the studies mentioning them (fig. 3). Other notable mentions that have come up in previous review articles (O'Neill et al 2004) but not as prevalent here are the need for data verification, field checks, and a large data set. Few differences appeared by habitat. Coastal studies identified the same strategies and prioritized them in the same order. The forest studies had more total recommendations, placing consistent methodology at the top of their list. After collaboration and standardized training, however, there was a cluster of recommendations including presenting data to policymakers, having a large data set, and data verification by an expert. Grassland studies also placed consistent methodology first, followed by collaboration and presenting data to policymakers. Their last recommendations included standardized methodology, a large data set, and accounting

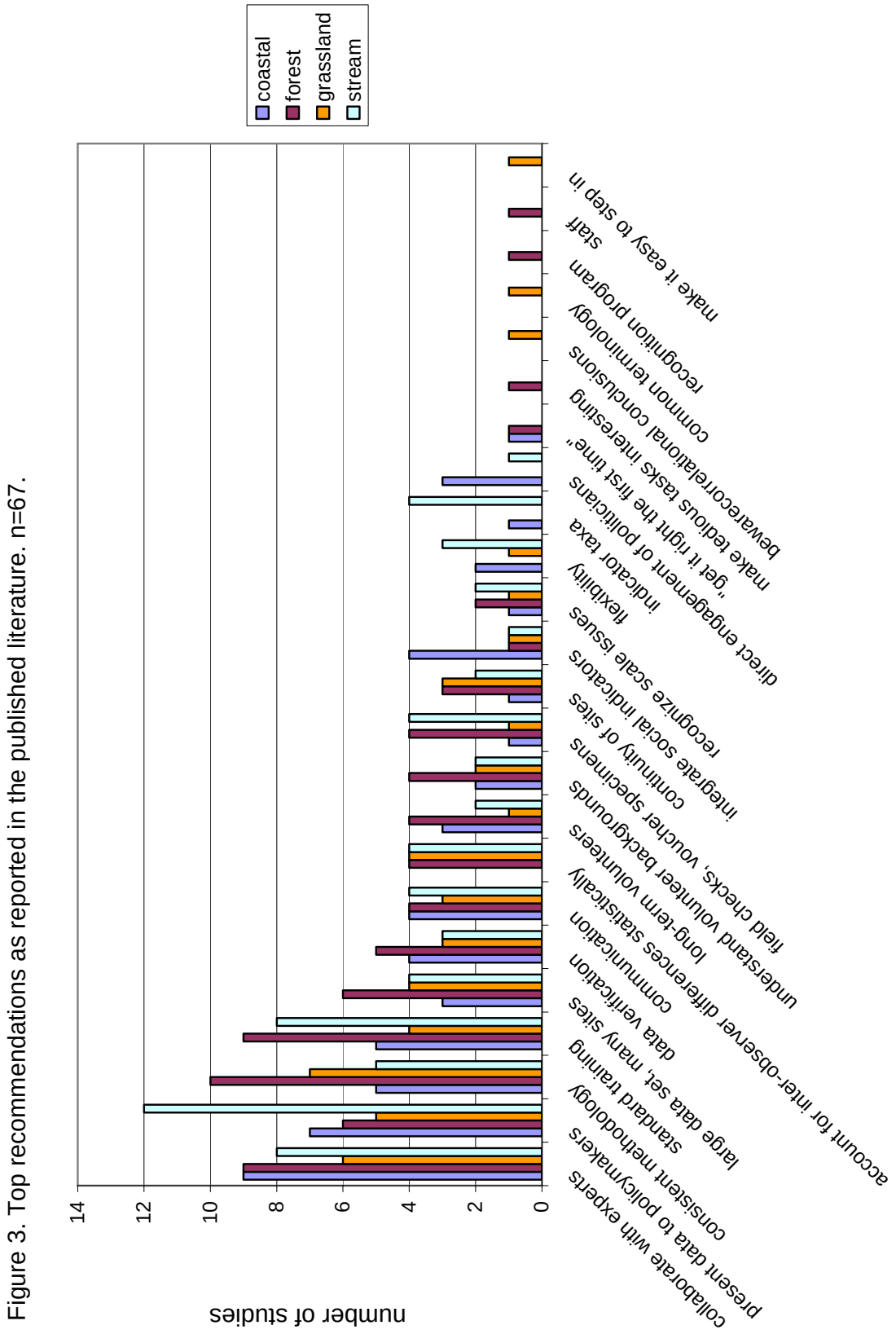

Figure 3. Top recommendations as reported in the published literature. n=67.

for inter-observer differences statistically. The stream studies overwhelmingly mentioned presenting data to policymakers as their top recommendation, followed by standardized training, and collaboration. Consistent methodology then followed with having a large data set, field checks for accuracy, accounting for inter-observer differences, use of indicator species, and communication within the organization.

Primary Investigator Surveys:

The survey yielded the following top recommendations:

1) collaborate with experts
2) have a consistent methodology
3) present data to policy influencers

The most common recommendations from the program coordinators were not as clear cut as those in the literature. In addition, the recommendation of standardized training was only mentioned by one respondent, perhaps because most of the programs had instituted standardized training from the inception of the program and had never really considered the topic an issue. Several forest programs mentioned the need to "get it right the first time," incorporating the idea that initially setting up the program correctly, on a number of facets, is more important than any one aspect. The respondents created a much longer, more varied list of suggestions, than the literature review had revealed, generally more tailored to particular challenges. The sample size between the ecosystems makes statistically determining a difference between recommendations by habitat difficult, but of note is the fact that the coordinators of northern plains surveys never repeated a suggestion. They instead had a variety of recommendations that seemed to link closely with particular problems the program was facing or had dealt with in the

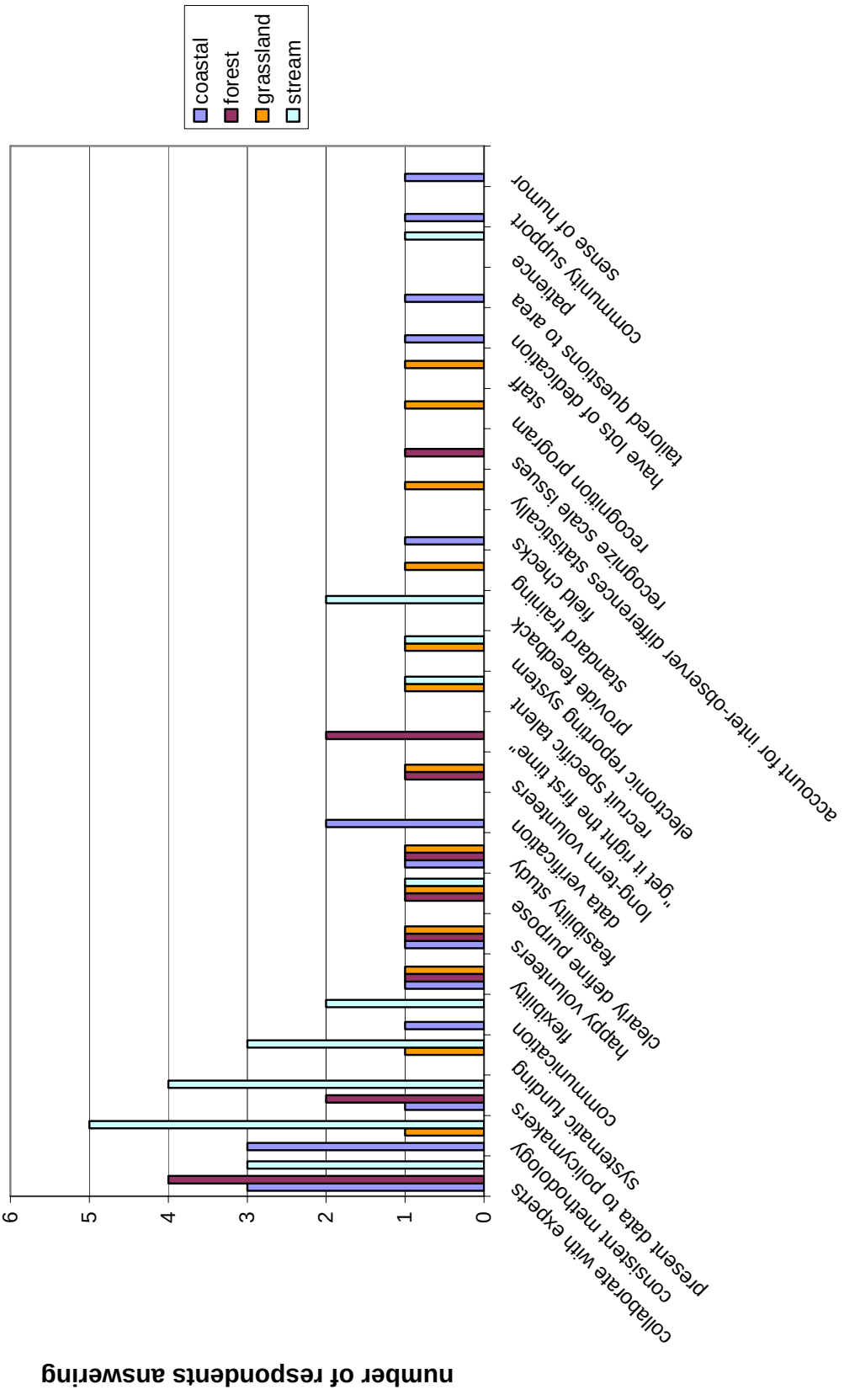

Figure 4. Top recommendations by survey respondents. n=19.

recent past. The other habitats clustered around a few particular pertinent recommendations and drove the list of top recommendations as shown above.

Programs ranged from one to 38 years old with no particular habitat tending to have more recently developed programs than the others (table 1). Theoretically, older programs would have more time to form collaborations and, through trial and error, figure out the strategies that work best for them. The coastal and grassland programs, however, tended to not have a volunteer coordinator and the grassland programs did not tend to have professional collaborations.

	Gulf of Maine n=5	Northern hardwood n=4	Northern plains n=4	Streams n=6	total n=19	χ^2 test
Average age of program	12	7	15	12	n/a	n/a
Volunteer coordinator	1	4	0	5	10	.047**
Professional collaboration	3	3	1	4	11	.484
Paid crew leaders	2	0	0	0	2	.100

Table 1. Demographics of volunteer monitoring programs as reported by program leaders. Statistic with an ** shows significance at the p=.05 level.

The number of volunteers in the program differed by habitat (table 2). The coastal and grassland programs tended to be small, with most having a few hundred people. Grassland had one larger program, a butterfly monitoring program, with a few hundred, while the rest had tens of people. The stream programs, on the other hand, ranged from 15 to nearly 2000, while the forest programs all had around 500 people. Certainly, the number of volunteers in the field affects the amount of data collected, which can act as a substitute for complete accuracy through statistical tests. The training these volunteers received, despite the difference in numbers, isn't all that different. Of note is that the coastal and forest programs tended to have longer training programs while

the grassland and stream programs almost always fell under three hours. This may be related to the complexity of the habitats and the types of research questions asked.

	Gulf of Maine n=5	Northern hardwood n=4	Northern plains n=4	Streams n=6	total n=19	χ^2 test
Average number of volunteers	185	278	146	446	n/a	
Mandatory training	4	3	3	2	12	.336
Standardized training	4	3	3	4	14	.967
Training >3 hrs	4	3	1	0	8	.023**
Handbook	2	4	1	5	13	.071*
Consistent commitment	2.5	3	3	4.5	13	.849

Table 2. Characteristics of volunteers as reported by program leaders. Statistics denoted with ** are significant at p=.05 and with * are significant at p=.1.

All but one program made an effort to make their data publicly available (the one that did not was attempting to protect the endangered species they monitor), many through newsletters and internet databases. Most of these databases were newly constructed and many were still "under improvement". All of the coastal programs published in the scientific literature, many through their collaborators, but less than half of the other programs had ever used their data in such a way.

The stated purposes for the various programs correlated by habitat and each habitat had a slightly different focus (table 3). The coastal programs tended to focus on restoration or tracking changes in the system. Since the Gulf of Maine was developed and under human influence before any monitoring programs were in existence, this may come from the unique needs of such a historic area. This scenario is similar to most coastline of North America, as these were the first areas settled by European immigrants. Grassland areas had a similar pairing of purposes, which may also be rooted in the human impact of the area. The northern plains represent the last of the native grasslands that

have not been turned over to agricultural fields and so represent an important system for conservation and protection of endangered species. The forest programs aimed more toward a description of what was in a given area, from mapping species distribution to collecting basic baseline data. These monitoring programs tend to be young and working with areas that have recovered from abandoned farm fields in the last hundred years that have not yet been fully described. Most of the stream programs had the duel purpose of collecting baseline data and increasing stewardship over the watershed. This last purpose is widely regarded by many researchers who analyze monitoring programs as the primary purpose, but this is apparently only true in stream programs. There are perhaps more stream programs, as they often represent a single creek, and are rapidly becoming common community structures, leading to the impression that monitoring programs are designed to increase stewardship. However, historically this was not the case and the other habitats still seem to follow closer to this original monitoring model.

	Gulf of Maine n=5	northern hardwood n=4	Northern plains n=4	Streams n=6	total n=19	χ^2 test
Database	4	3	3	4	14	.967
Newsletter	3	2	3	4	12	.846
In scientific lit.	5	2	2	2	11	.149
Purpose:						
Map distribution	1	2	0	0	3	.141
Increase stewardship	0	0	0	4	4	.012**
Restoration	3	0	1	0	4	.064*
Baseline data	1	1	0	4	6	.130
Track trends	1	1	2	2	8	.795
Not sure	1	0	1	0	2	.468
Met purpose	4	4	3	5	16	.783
Confident in data	4	3	2	4	13	.795

Table 3. Data presentation information as reported by program leaders. Statistics denoted with ** are significant at p=.05 and with * are significant at p=.1.

Typical survey responses:

Some of the questions asked of the program coordinators commonly elicited a longer response that gives insight into the reason behind the quantitative differences between habitats and into the reality of running a community based monitoring program.

Data was overall not overwhelmingly reliable, but program coordinators seemed to be making the most of the situation and thinking optimistically about the future (table 4). Since the respondents were asked to determine if their data was reliable based on the purpose of their study, most of the responses claimed that they had data that enabled them to meet their purpose, but whether it was sound for scientific studies was a different question. The slight differences in purpose seen in the different habitats are also apparent in whether the coordinator considered the data reliable.

On reliability of data	**Representative quote**	**Associated habitat**
Not always, but improving	"along the right steps"	Coastal
Proud of what they consider successes in the program	"absolutely and exceeded"	Northern hardwood
Not professional, but certain	"yes, from the sheer amount of time out there"	Northern plain
Questionable, but that's not necessarily the primary goal	"data, maybe…education, certainly"	Stream

Table 4. Impressions of the reliability of data from the various habitats.

Collaboration was the most common recommendation from the respondents, but the reasons given for this recommendation were varied and differed slightly by habitat (table 5). The stream programs valued their collaborations for access to nearly all aspects of the monitoring program's success, while other programs specifically cited what benefit they valued most from collaborations. Efficient use of small state grants among all monitoring groups was a common theme, especially among the forest programs. Technique sharing for accuracy was common among coastal programs, which probably

follows from the less-than solidified techniques in many of the coastal programs. Many of the respondents directly viewed collaboration as necessary to create a consistent methodology both within the program and within the larger network. Interestingly, the grassland programs valued collaboration as a way to keep the research questions fresh and make sure that the data would be applied to current issues in the region.

On collaboration	**Representative quote**	**Associated habitat**
Technique sharing	"look at other existing programs"	Coastal
For access to money and ideas	"crucial to pull resources together effectively"	Northern hardwood
Means to keep research fresh	"networking, the way to answer specific questions"	Northern plain
Critical for money, ideas, using the data	"absolutely would not be able to do anything" without partnerships	Stream

Table 5. Impressions of the reasons for the importance of collaboration in various habitats.

When asked if the mission of the program had been met, many respondents hesitated a moment before classifying their response by aspect of the mission statement. Depending on the state of conservation efforts and needs in a particular habitat, programs have different scientific goals, ranging from restoration as is common along the coast to stewardship in the stream programs (table 6). Some of those goals are easier to meet than others. One coastal program coordinator stated that it is "hard to measure success" when watching the floundering success of the lobster nurseries despite their efforts. She knew that they had saved at least six nurseries from development projects, but still had a hard time classifying the last few years of her program as 'successful.' Another coastal program coordinator expressed uncertainty as to "who we should become next…we're at a crossroads". They were attempting to keep their research current and relevant to recent issues, which she stated was critical in maintaining financial support from dwindling state

grants as well as community support. Many of the grassland programs expressed similar sentiments, even relying on their collaborations to ensure that their monitoring was addressing the most pressing questions. One grassland respondent described the work of the group as on an "as we can handle basis," tackling one issue at a time. Conversely, the stream programs seemed to have the goal of affecting conservation through the program itself, not just through presentation of the data to policymakers.

On mission	**Representative quote**	**Associated habitat**
Understand the habitat, and restore it to sustainability	"habitat for future"	Coastal
Get an idea of what's there	"just a snapshot"	Northern hardwood
Answering specific questions or conservation application	"we're actively changing the program based on what the public needs"	Northern plain
Baseline data's nice, but volunteers should learn something in the process	"to get data, but awareness and stewardship"	Stream

Table 6. Impressions of the general mission of the monitoring groups in various habitats.

Common to most programs is a varied volunteer body with a slight overrepresentation of retired volunteers. Most mentioned participation of schoolchildren, either with family or their school classes, when the monitoring protocol allowed for people without higher education. However, no one had readily available demographic information on hand and so the information given represents a best guess by the respondents. Many respondents also mentioned that a better question to ask is how many people from the community are involved. Especially in the coastal programs, which tended to be located in small historic fishing towns, were proud of the fact that nearly every resident participated in some way in the program. This situation creates a different kind of effect even if the same data is collected, by bringing the community together and raising awareness of the status of the particular monitored part of the ecosystem.

On "the typical volunteer"	Representative quote	Associated habitat
Whole neighborhood	"good mix of folks"	Coastal
Depends on program	"typical does not exist"	Northern hardwood
Takes specific skills	"can't take just anyone"	Northern plain
school classes, retirees	"older", "two kinds"	Stream

Table 7. Impressions of the volunteer demographics within monitoring programs in various habitats.

The idea of building community, both inside the program and within the habitat in which the program takes place, was mentioned by a few respondents in different contexts. Many of the stream programs explicitly have building stewardship as a goal in the mission statement, but others alluded to how this process strengthens the program as well. One program held an annual summit, which she described as putting "context to their work" by presenting the efforts to the community and showing the volunteers tangible results to their efforts. They had a political figure speak as keynote and gave awards to notable volunteers as part of the event and made the day both outreach and celebration. Short of an annual summit, data availability was seen as necessary by many people, who cited continual work on their internet databases and websites as well as a need for web-skilled volunteers to help with the efforts. One respondent even cited data availability as their "biggest point to improve on".

Excitement of the volunteers, though only mentioned a few times as a recommendation for success, was a common side comment when respondents were asked about longevity of their volunteers. The strategies of community building and feedback to volunteers were also mentioned in this context as a means to maintain "buy-in" of the volunteers. One forest program coordinator attributed the success of her program as a whole to the fact that "the volunteers love working with these rare plants", describing her program as "wildly successful." Another grassland coordinator described her program as

"in the momentum gaining phase" because there were finally results to present to the volunteers and these results were maintaining volunteer interest and bringing in new recruits. Perhaps the reason that the recommendation of presenting data to policymakers consistently ranks among the top by both literature and surveys is because policy enacted as a result of monitoring work maintains this critical excitement.

Discussion

Separating long term monitoring programs into habitat categories is a novel way of thinking about monitoring programs that are so often lumped into one large category. In both the literature and surveys, the best management practices were slightly different between the habitats, mostly driven by the differing types of mission statements. While stream monitoring programs, for instance, focused mainly on increasing local stewardship and gaining baseline data, the coastal programs emphasized restoration and the grassland programs emphasized specific conservation needs for each area. Forests, with a similar mission of baseline data, had the single goal of characterizing forested land without mentioning the benefits to the volunteers. As such, the grassland program leaders did not repeat a single recommendation, showing that their recommendations were as uniquely tailored to their specific region as their research questions. With this perspective, habitats are a useful categorization when thinking about what is best for the success of community based monitoring programs.

The literature produced from the data collected by monitoring programs often makes blanket statements of strategies for future studies to ensure success and the collection of reliable and useful data. In addition to the need to apply the filter of habitat,

these recommendations also come from a self-selected group of monitoring programs that have reliable results to report. These studies typically came from academic or government supported programs that had existed longer than five years, which is the profile of a successful and established program. At one level (not separating by habitat), the literature produced similar top recommendations to the overall top recommendations as stated by program leaders, but the more specific points were almost entirely different from those stated by program leaders. Thus, the recommendations found in the literature may be helpful when planning the broad aspects of a program, but not as helpful in the first few struggling years that every program goes through.

The top three recommendations (presenting data to policymakers, collaboration, and consistent methodology) are consistent in both the literature review and through surveys despite differing origins of habitat and modes of elicitation because they are applicable to wide audience. The difference lies in the mechanism of achieving that end and the subsequent benefits. Presenting data to policymakers may at first seem tangent to the goals of some of these programs, but through raising excitement in the program, ensures more long-term volunteers that maintain the strength of the program and integrity of the data (Brandon et al 2003). Conversely, for those programs like those along the coast with restoration goals, this recommendation directly ensures the success of the program through the policies enacted continue to support the program.

Consistent methodologies, another of the top recommendations in both the literature and surveys, may at first seem obvious, but achieving that end goal is a major challenge for many programs. Training plays a role in ensuring volunteers have a standard background in the project, but training is only helpful if the volunteers pay

attention, as one of the survey respondents pointed out. He described that some of his elderly birder volunteers, while they came with much excitement and years of experience, they tended to ignore the standardized protocol as written in a handbook in favor of some amendments from their personal expertise. In addition, a coastal respondent mentioned that she requires field tests of the volunteers periodically, especially those that have been with the program for a decade or so, to make sure that they have not made 'personal improvements' to their site's protocol. Therefore, in order to achieve consistent methodology, consideration of the demographics of a volunteer team, which had not been officially enumerated by any of the programs surveyed, may be an important factor.

Collaboration, the final top recommendation in both the literature and surveys, is also implicated in consistent methodology. Knowing what works well and what people are able to realistically achieve in the field from other programs allows the tinkering of the protocol that often accompanies the first few years of a program to be eliminated. In addition, collaboration offers extended access to monetary resources, skilled expertise, tools, etc. The contacts and experience that are achieved through collaboration appear to provide the specific points of help necessary for a particular program to be successful, addressing the specific challenges of habitat or region.

The literature and surveys both showed the same top recommendations for a successful program, but these points only address the big picture for monitoring programs. The more specific recommendations were different in the surveys of program leaders and overall, there were slight but important differences between the programs in various habitats. Programs in different habitats tend to have different purposes, which affects the overall mentality of the program. For instance, stream programs with a focus

on stewardship through scientific participation can accept a higher level of data uncertainty because the end conservation goal is still affected. However, the coastal programs that are diligently monitoring coastal recovery need as accurate data as possible to lobby for continued support of their restoration programs from legislators. Therefore, program planning should take place in the context of the specific habitat that will be monitored in order to fully benefit the habitat of concern and help should be elicited through leaders of similar programs, not just through literature research.

Appendix A : Survey

Organization: _____ Region: _____

Name:_____

Position:_____

1. How long has the program been running?

→ follow-up if longer than 5 years: Have you noticed any trends in the data?

→ if an increase in environmental quality: do you think the program directly affected change?

Length: Trend?: Affecting quality:

- fostering stewardship ___
- use of data ___

2. What type of training, if any, is offered to the volunteers before they collect data?

- mandatory ___ - other:
- handbook ___
- standardized ___ notes:
- more than 3 hours ___

3. What are the demographics of your volunteer force?

- typical ages _____ notes:
- education _____
- number of volunteers_____

4. How long does the typical volunteer remain with the program?

- length of time _____ notes:
- commitment required?

No __ Yes __

amount of time _____

- sporadic ___ or consistent ___

5. What is the organizational structure of your program?

- volunteer coordinator __ - other
- pro. collaboration __
- paid crew leader __ notes:

6. How do you record the data in the field?

- electronic __ - other quality control measures?
- voucher specimens __
- notebook __ notes:
- pro in the field __

7. Is the data publicly available? __ If so, how?

- internet database __ - other:
- newsletters __
- in scientific literature __ notes:

8. Are you confident in the reliability of the data collected? __

→ What was the purpose of the data collection and was that met? __

9. Name the top three recommendations you have for another researcher starting a citizen science program in order to ensure that their data is reliable and useful for comparison to data from similar habitats?

10. Other comments?

Appendix B: Studies used in the literature review

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