

Community and Citizen Science at the UC Division of Agriculture and Natural Resources

Final Report

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Executive Summary

Community and citizen science (CCS) refers to scientific research conducted, in whole or in part, by amateur or nonprofessional scientists. As both a field of research and an evolving area of scientific practice, CCS has grown rapidly in recent years. The University of California's Cooperative Extension system – the Division of Agriculture and Natural Resources (ANR) – has been engaging with the public and a variety of clientele communities for more than a century, and much of this engagement has involved clientele participating directly in research. This project has aimed to take stock of CCS in the ANR context, consider its particular strengths, identify gaps and challenges, and think carefully about what the future of CCS at ANR could look like.

We have found many examples of CCS already underway across ANR. There are also real opportunities to support and grow CCS activities at ANR. Our recommendations are focused on some general guidelines that ANR can follow, and explicit next steps that if taken, can better support and foster CCS that aligns with ANR's mission and vision, and the public value realized through a University connected and committed to the people of California.

Approach and Methods

We conducted 16 semi-structured interviews with a broad range of ANR personnel, representing a mix of focal areas and roles across the system. We also administered a short survey during the ANR Statewide Conference, which received 74 responses. These sources, combined with online research, many informal interactions, and the experience of the authors, inform the recommendations and insights presented in this report.

Defining CCS at ANR: Gray areas and institutional considerations

Cooperative Extension raises interesting questions about the definition of CCS, and the gray areas between CCS and other extension activities that typically engage the public, such as outreach, social science, clientele interactions, and self-assessment. Directly addressing these can be helpful to ANR and inform the field of CCS.

Recommendations

- R1. Develop a definition of CCS that fits the ANR context**, matches its goals for recognizing, supporting, and growing CCS, and allows for specific programs to advance particular approaches that fit within the ANR umbrella.
- R2. The definition of CCS at ANR should avoid conceptual overreach.** A definition that includes all forms of engagement with the public will ultimately confuse and dilute both the CCS work and the other kinds of essential engagement work ANR undertakes.

Status of Community and Citizen Science at ANR

ANR is already home to a rich and diverse array of CCS projects and programs that fit within a broad definition of CCS, and which engage many different audiences in many kinds of activities. This points to a variety of opportunities for leadership and innovation in California and beyond. There is a feedback in which CCS projects draw on ANR resources such as technology and volunteer networks, and at the same time bolster those resources. There also appears to be

strong enthusiasm for, and experience with, CCS approaches across ANR, as well as in the national land-grant community.

Recommendations

- R3. Foster existing enthusiasm, experience, and capacity for CCS.** This involves building awareness of the many options and approaches to CCS available as tools.
- R4. Articulate the wide range of goals and potential benefits of CCS.** This can help more people find their way into this kind of work.
- R5. Inventory and develop a guide to existing resources,** including off-the-shelf tools, and in-house capacity for developing new tools and resources.
- R6. Track, report, and reward contributions to CCS.** This would add a new dimension to our understanding of how ANR is creating impact through research.
- R7. Strengthen connections between UC researchers and ANR networks.** A first step would be to convene a working group involving network coordinators, volunteers, researchers who have worked with them, and other interested parties to devise plans for encouraging further collaboration.
- R8. Leverage existing ANR networks, county-based offices and volunteer programs** to expand the geographic scope of UC research. Statewide networks of volunteers are a significant and arguably unique asset for ANR and should be a centerpiece of an ANR CCS strategy.
- R9. Evaluate and develop a strategy for addressing equity and inclusion through CCS** to determine whether and how CCS at ANR is advancing more inclusive programs.
- R10. Train and support UC researchers to work with volunteers.** Such professional development should consider the broad range of ways that clientele and the public can participate in research.
- R11. Support low-tech CCS.** Not all CCS is online or app-based. An institutional framework for supporting CCS at ANR should explicitly include low-tech and in-person approaches to CCS.
- R12. Promote online crowd-sourced processing** for datasets that need human engagement. Online crowdsourcing and gamification appear to be underutilized approaches in ANR.

Challenges and Barriers for CCS at ANR

It is important to be realistic about challenges associated with doing CCS well, whatever model a researcher might be pursuing. CCS takes time, money, and particular skills, and will not always be an appropriate approach. We found that sustaining and scaling up successful programs is a common challenge. Some also report persistent challenges in legitimizing CCS, alongside other activities in the world of cooperative extension.

Recommendations

- R13. Address practical and professional obstacles to initiating, sustaining, and growing successful CCS projects.** ANR can take actions to explicitly recognize and support cases where CCS projects are making great strides to advance its mission and deliver public value.
- R14. Leverage the example of CCS at ANR to foster CCS in California and beyond.** ANR can be a leader in academia, among land grant universities, and for cooperative extension by continuing to foster CCS, to look closely at what that means and how it can improve.

Looking Ahead: Vision statements for CCS at ANR

Beyond our specific recommendations, a broader, more forward-thinking rationale for CCS at ANR is needed. CCS is already advancing ANR strategic objectives in multiple ways. What might that look like if steps are taken to address the above recommendations?

V1. Opportunities to participate in ANR research are more pervasively available, equitable, and impactful throughout California.

V2. UC Researchers who want to engage communities in their work can gain skills and access support structures for doing this effectively.

V3. CCS Networks at ANR are providing a unique statewide resource to researchers, state and federal agencies, and others striving to understand and address large scale environmental challenges.

V4. CCS is expanding awareness of, and appreciation for, the role of ANR in California's environment, economy, and communities.

Concluding Recommendations

How can ANR work toward the vision expressed above? We offer the following broad concluding recommendations:

- 1. Develop a shared understanding of CCS.** This can take place through a gradual process, using approaches such as advisory groups, conference workshops, and evaluation or other assessment activities. (R1, R2)
- 2. Embrace the diversity of CCS happening at ANR.** Some examples show the promise of scaled up research that can address big challenges facing the state; others show how science in communities can open doors to a variety of positive outcomes in a local place. Some involve new technology, and some involve little technology at all. These models are not mutually exclusive, but they can look very different and lead to different kinds of benefits. ANR can welcome, support, and foster the full breadth of CCS. (R4, R5, R6)
- 3. Better equip and prepare researchers with skills, technology, and administrative support needed for CCS.** ANR may be ahead of many other research institutions when it comes to the skills needed for CCS, but more can be done to support the community in taking on this work. (R3, R8, R10)
- 4. Continue to foster inclusive volunteer networks, expand volunteer opportunities, and think big about how they can yield data and insights that would be otherwise impossible.** While Master Gardeners, California Naturalists, and 4H might be powerhouses of CCS in California, they are for the most part locally focused. How can this resource work for CCS at larger scales? (R7, R9, R11, R12)
- 5. Strategically invest in capacity that helps sustain and scale valuable projects.** Evaluation and reporting can help to identify promising opportunities to “level-up” ongoing CCS at ANR. Training programs, technology platforms, and expert staff are needed to capitalize on those opportunities. (R10, R13)

6. **Seek and support creative partnerships that expand participation, and ensure meaningful learning through that participation.** CCS is built on partnerships, often at multiple scales. Innovative CCS partnerships with government, industry, and non-profit groups throughout the state can advance CCS that specifically improves ANR's performance with respect to its mission and vision. (R14)

Introduction

Community and citizen science (CCS) refers to scientific research conducted, in whole or in part, by amateur or nonprofessional scientists. Also known as public participation in scientific research (PPSR), volunteer monitoring, crowd-sourced science, civic science, or community science, these efforts can take many forms, and can advance scientific research in a variety of ways.

As both a field of research and an evolving area of scientific practice, CCS has grown rapidly in recent years. It has been identified as a priority goal for the National Science Foundation (NSF n.d.) and called out as an interagency priority in recent Congressional legislation (Gardner 2017). Publications focused on CCS have ramped up significantly in recent years with many journals dedicating special issues to the topic, and a new journal – *Citizen Science: Theory and Practice* – having recently been established. Several new professional associations have been formed, including the Citizen Science Association, which attracts hundreds of scholars and practitioners to its biannual meetings. Many other professional associations, such as the American Geophysical Union, Ecological Society of America, Society for Conservation Biology, and the American Association for the Advancement of Science, have begun to focus on CCS in their publications and conferences.

The recent rapid growth in CCS is part of what motivated the project described in this report. Many science institutions with societal missions struggle to engage the public in a meaningful way and foster the change needed to move toward sustainability. Federal and state resource agencies see CCS as an important way to engage the public in stewardship of land and water resources as well as communicate and educate others. Collaborating on CCS projects offers opportunities for people to work together in a variety of settings, and this can result in social learning that fosters communities of practice and increase social resilience to rapidly changing conditions. CCS can also enhance science literacy and other learning outcomes. And with the right approach, CCS can also foster agency – the ability to use experiences in environmental science to make positive changes (Ballard, Dixon, and Harris 2017).

Of course, ANR has been engaging with the public and a variety of clientele communities for more than a century. Much of this engagement has involved clientele participating directly in research. The proliferation of new practices, new tools, and new networks of scholars and practitioners focused on CCS as a field provides an opportunity to build on this experience, and for ANR to bring this experience to bear on projects throughout the UC system and beyond.

This project has aimed to take stock of CCS in the ANR context, consider its particular strengths, identify gaps and challenges, and think carefully about what the future of CCS at ANR could look like. This effort supports several of the goals identified in ANR's 2016-2020 Strategic Plan, most directly *Goal 1: strengthen research and extension partnerships* by creating a new arena of potential partners; *Goal 2: increase ANR's reach* by expanding to and deepening the relationship with more communities (discussed in greater detail later in this report); and *Goal 15: tell ANR's story*, by both expanding the audience, and the community of storytellers. Further, the increased utilization of CCS can benefit from *Goal 9: improve volunteer management*, and *Goal 12: modernize technology*. In addition, it relates closely to several of the public value statements and contributes to condition changes developed as part of the strategic planning process, particularly *improved access to positive built and natural environments*, by inviting

communities to interact in these spaces in new ways; and *increased civic engagement*, as many of the issues addressed by CCS directly empower stakeholders to understand, investigate, and make informed decisions through the application of knowledge they have a hand in generating. This conversation about extension's relationship with CCS is also taking part on the national stage, evidenced by a recent paper from extension personnel in New Hampshire, Virginia, and Florida (Clyde et al, 2018), and a workshop at the 2019 Citizen Science Association Conference.

In the rest of this document we report on insights gathered from ANR personnel through semi-structured interviews from a selected sample of key people, a brief survey, and a variety of informal conversations, all focused on developing a broad understanding of how the public and clientele communities are participating in ANR research. We provide examples of the many different forms this work is taking, and provide recommendations. In addition to this report, and to a session at the 2018 ANR Statewide meeting, this project has initiated a special issue of *California Agriculture* dedicated to the topic of community and citizen science. Titles and abstracts of articles in process for that publication (as of April, 2019) are listed in Appendix A.

An overriding assumption of our analysis and reporting has been that there are real opportunities to support and grow CCS activities at ANR. Thus, to flesh out that idea, **our recommendations are focused on some general guidelines that ANR can follow, and explicit next steps that if taken, can better support and foster CCS that aligns with ANR's mission and vision, and the public value realized through a University connected and committed to the people of California.**¹

What is Community and Citizen Science?

Over the course of this project we have defined community and citizen science broadly and have actively explored gray areas of that definition as examples arise that push boundaries. We use the term “community and citizen science” as an explicit acknowledgment that there are different traditions in this broad field (Ottinger 2017). Projects vary in terms of the nature and level of participation by non-scientists, the focus of the research, the role of professional scientists, and many other factors. One commonly used framework delineates contributory, collaborative, and co-generated projects (Shirk et al. 2012). **Contributory** projects are what people often think of first when they hear “citizen science.” These projects are typically developed by a team of professional investigators with the intent for the public to collect and sometimes analyze data, from local to global scales. **Collaborative** efforts involve a deeper level of engagement by the non-professional participants, including designing data collection methods, and exploring potential explanations for observed trends. Some projects are led by scientists, with volunteers playing any number of roles, while others may be led by community members, with scientists playing a limited advisory or supporting role. The vast network of water quality monitoring “stream teams” is a good example of this type. Projects can also be **co-created**, where both professional and non-professional scientists are involved in defining the research questions, discussing and disseminating results – in many cases, environmental problems, such as high lead levels in water in Flint, Michigan are brought to scientists by community members asking for assistance. This model should be familiar at land grant institutions, where research is often instigated by producers needing to address new problems they face.

Below, we discuss these considerations further and place them in the context of what we found about CCS at ANR.

¹ See ANR Public Value Statements: http://ucanr.edu/sites/anrstaff/2016-2020_Strategic_Plan/Goal_5__Prioritize_programs_and_services/Public_values_statement/

Approach and Methods

Insights and recommendations presented in this report are the result of interviews (n = 16) and informal interactions with a broad range of ANR personnel. Interviewees were selected to represent a mix of focal areas and roles across ANR, including Strategic Initiative leads (n = 4), other administrative roles (n=6), extension specialists (n=3), and advisors (n=9).² The semi-structured interviews were designed to draw out a range of examples of CCS, and explore the institutional context and other factors that shaped those examples by presenting both challenges and opportunities. Some interviewees had direct experience working on one or more CCS projects, and we tried to engage with a wide range of project types; we also sought broad perspectives on how CCS fits into the ANR context, and so direct project experience was not a requirement for our interviewee selection.

Informal interactions included a broader range of communication – for example, a request for an interview might be turned down due to scheduling conflicts but yield a link to a website or mention of a project that we further explored when searching for the range of examples of projects. In addition, one of the authors is an ANR Extension Advisor, and her embedded experience in the organization, combined with the expertise in the field of CCS on the part of the UC Davis authors, yielded insights through extensive conversations. In addition, simply searching through ANR websites and reports informed our sense of the role of community science in needs assessment and program development.

At the 2018 ANR Statewide Conference, we convened a panel discussion on CCS. We used that opportunity to gather a broader range of opinions and input than could be gathered from interviews by developing a survey to capture input and ideas from those in attendance. In order to maximize participation during a busy time, the survey was kept very short, and was designed to gather additional qualitative information to supplement the interviews. We decided that a more in-depth survey supporting a quantitative analysis of perceptions across the whole of ANR was not likely to receive a high enough response rate to justify the effort. We ultimately received 74 responses to the survey, which can be used to understand perspectives across ANR, but cannot be broken down across roles, disciplinary backgrounds, or other demographic factors. A more systematic and detailed survey, targeting questions of specific interest to ANR leadership, could be a useful next step if more depth is desired. Throughout the rest of this document, survey results are integrated with insights from interviews. The survey results are also presented as a standalone in Appendix B.

We begin by revisiting the definition of CCS, in light of specific themes and considerations that emerged from our results. We then turn to a discussion of the status of CCS at ANR, broken down into specific topics of practical importance. We discuss what motivates people at ANR to undertake CCS, the roles that ANR is playing in fostering and advancing such projects, and the types of participants that are becoming involved in a variety of contexts and roles. After a discussion of challenges and barriers to CCS at ANR, we put forward recommendations and a vision of what CCS could look like in the coming years and beyond.

² Numbers exceed our total interviewees because many people serve multiple roles. Administrative roles ranged from high-level administration such as Associate Vice Provost or Vice Provost to locally-based or program-specific administration such as REC or county or program director.

Defining CCS at ANR: Gray areas and institutional considerations

We discussed definitions from the literature and larger field above, but it is worth returning to the topic in light of observations and results from our project. Definitions can be important, especially when it comes to shifts in resources or other kinds of incentives that might guide the future of CCS at ANR, or to the perceptions and priorities of the people or communities participating in CCS (see Eitzel et al. 2017). It is not our aim in this report to settle on a definitive or restrictive definition of CCS for ANR; indeed, we began this project with a wide definition of CCS, drawn from the diverse traditions and practices reflected in the field at large. But we raise the question of how ANR might define CCS for its own purposes, a task which must balance goals, practical considerations, and the unique context of ANR itself.

Examining Different Forms of Public Participation at ANR

Because of the extensive and diverse forms of engagement underway at ANR, we suggest that it is useful to consider some gray areas that consistently arose in the course of this project, and offer ideas for developing guidelines (see Figure 1). Our interviews all began with a discussion of what is meant by community and citizen science, and this often surfaced specific examples that raised questions about how we draw the line between CCS, and other activities involving the public that are very common at ANR.

Distinguishing between standard social science research/evaluation and CCS

For example, it is often helpful to ask, “are the participants in this study social science ‘research subjects’ in a traditional sense, or are they also helping to *conduct* the research in one or more ways?” (see Figure 1d). Typically the former, including activities like filling out a survey, would not be seen as CCS.

Distinguishing between traditional outreach and CCS

Similarly, science education, outreach, and science communication activities are generally not within the definition of CCS, unless they involve some meaningful participation in the scientific research or monitoring process, such as contributing to a national biophysical science data set, beyond receiving information resulting from a scientific process (Figure 1a).

Distinguishing between traditional self-assessment and CCS

ANR programs regularly develop tools that help clientele improve their practices and get better outcomes. In some cases, these tools also involve the collection of data by growers, ranchers, or other clientele groups (Figure 1b), which they use in their efforts to improve practices. In cases where those data are also used by researchers to extend advance scientific knowledge, this resembles CCS, but this is a gray area.

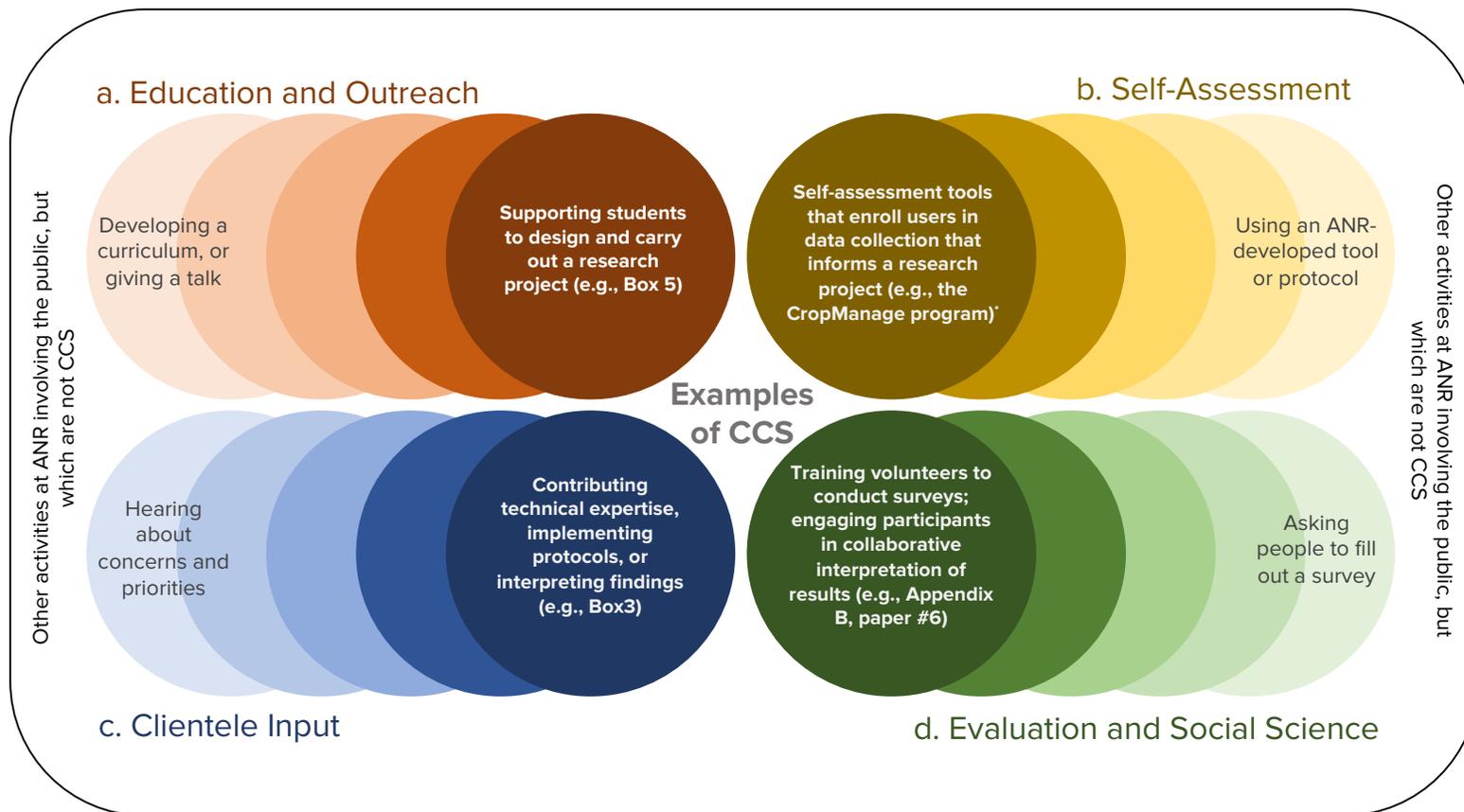


Figure 1. Illustration of several broad categories of activity (a. Education and Outreach; b. Self-Assessment; c. Clientele Input; and d. Evaluation and Social Science) where one may find activities that are well within common definitions of community and citizen science, and activities that are both important and common at ANR, but not usually seen as CCS. In each category there may be a spectrum of public involvement, and some projects may evolve in ways that move along the spectrum in one direction or another.

*Learn more about CropManage at <https://v3.cropmanage.ucanr.edu/>

Distinguishing between traditional clientele interactions and CCS

Another definitional gray area that seems particularly prominent at ANR is at the early stages of the research process (Figure 1c). Regular contact with clientele communities helps advisors and extension specialists understand and prioritize research needs. This kind of communication might seem outside the bounds of meaningful CCS, but in some cases it might evolve into close consultation that involves in-depth technical input into not only research questions but also research design. These cases do seem to fit more appropriately into our initial broad definition, even if participant activities do not include data collection.

What kinds of public input constitute CCS?

There is also a question about whether anecdotal observations contributed by the public constitute data and would be considered CCS. One of our interviewees observed:

When I think of citizen science, it's mostly observational, and they're not testing a hypothesis. They're using data to form hypotheses. And that's really similar to what's going on when lots of people are calling in about a problem, which leads us to do experiments or analyses – form a research agenda.

The interviewee hits on an interesting point about the ranges of public input that occur across ANR, and the ways in which that input might play a role in shaping research agendas. If a person reports sighting a dangerous pest via a phone call, this would not typically be considered CCS. But if the report, with the same basic information, came in via a smartphone-based app, perhaps it would. Should both of these mechanisms be considered CCS, or both of them not? Our discussions of participant roles and project types below elaborate on some of these issues.

Deciding on Terminology

In addition to defining CCS, the authors and, in some cases, interviewees spent a fair amount of time on the definition of citizen/community member. While a discussion of how our work is or is not influenced by clientele immigration status may be of value and is an important conversation in the larger CCS field (Eitzel et al), that is not what we mean here. The extension education cycle, involving working with clientele to assess needs, conducting research, extending research results through publications and trainings, evaluating adoption of and effectiveness of new practices based on research and educational activities, and using that evaluation to guide the next stage of research, has always incorporated a close relationship with clientele that may have included involving them in research. Therefore, the question becomes: are professional clientele (such as farmers), rather than a broader public, “citizens” in our formulation? We take a broad approach that includes this history of working with clientele, and therefore believe Extension has been engaging in CCS for the past century. What may be new is the emphasis on engaging all Californians in this pursuit, and the wider range of models for encouraging participation of both clientele and other communities.

Recommendations:

R1. Develop a definition of CCS that fits the ANR context. Because no definition of CCS is perfect, we recommend that ANR develop a broad definition that matches its goals for recognizing, supporting, and growing this kind of work in California, accompanied by a clear rationale. The definition should be flexible and allow for specific programs to advance particular approaches that fit within the ANR umbrella. We intend for this report to help in the development of this definition.

R2. The definition of CCS at ANR should avoid conceptual overreach. At the same time, we recommend against a definition that includes all forms of engagement with clientele, stakeholders, and the public, because this ultimately confuses and dilutes both the CCS work, and the other kinds of important engagement work, ANR does. The definition should probably not include normal advisor-client interactions as part of the traditional extension cycle. Some additional distinctions that might be appropriate in this regard:

- Advice/ input/ consultation vs. collaboration.
- Anecdotal/ ad hoc/ one-off reporting vs. systematized, repeated data collection.
- Science education/ outreach vs. authentic scientific knowledge generation within an educational context.

Status of Community and Citizen Science at ANR

As mentioned in our introduction, ANR is already home to a rich and diverse array of projects and programs that fit within a broad definition of CCS. ANR personnel are undertaking these projects with a wide variety of motivations, and in so doing, engaging with many different kinds of audiences. They are drawing on some important resources that exist within the ANR system, but at the same time are helping to sustain and develop those resources (see Figure 2). In this section we discuss the many different ways that community and citizen science are manifesting, and some of the factors that have led to this picture. We also examine some of the apparent gaps, and other findings that point to opportunities and important considerations for ongoing support of CCS across the ANR system.

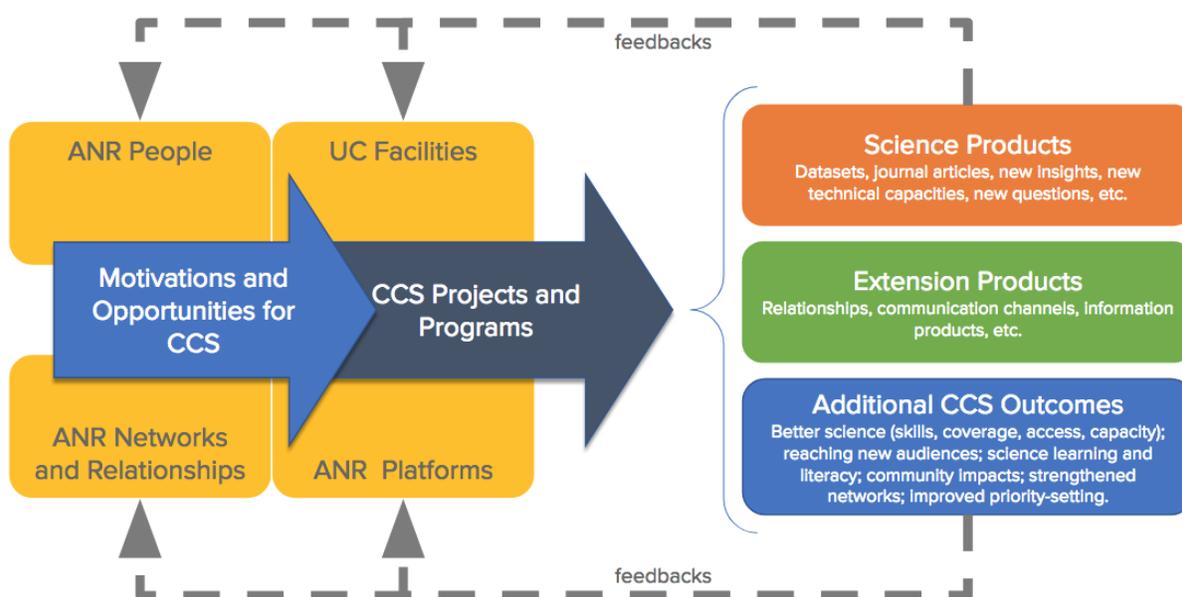


Figure 2. Overview of the key inputs and contextual factors (gold boxes) that are shaping both the motivations and opportunities the ANR personnel perceive (light blue arrow), and the resulting CCS projects and programs (dark blue arrow). The products and outcomes of CCS projects create feedbacks to the ANR context itself.

Why do people undertake CCS at ANR?

In some conceptions of citizen science, the primary motivator is access to “the crowd” – the possibility of large-scale, low-cost data collection or data processing. But in reality, there are many different reasons to engage the public in a research process, and the same is true at ANR. The table below presents a list of goals and motivations that were expressed during our interviews, which range from practical to philosophical, and from self-interested to service-oriented. In many cases, a person might express more than one motivation for doing CCS, and the goals and motivations could change over the course of a project. For example, a person

might start with a very practical focus on getting data cost-effectively, or from inaccessible private property. But later, he or she might discover ancillary benefits from the resulting collaborations, or that this kind of work is rewarded during merit review.

Table 1. Goals and reasons for undertaking CCS projects at ANR emerging from our interviews and survey.

- Expanding observation capacity and scale.
- Access to private property and other inaccessible sites.
- Outlet for stakeholder energy – people wanting to be involved.
- Tap into skillsets researchers don't have.
- Deepening relationships with communities (and clientele) close to the problem being studied.
- Bridge the divide between research and extension.
- Bridge the divide between county CE offices and statewide programs.
- Increase ANR visibility.
- Institutional incentives within ANR.
- Enjoyment, personal satisfaction of working with different communities.
- Policy impact – sometimes research is a good venue for dialog and progress on difficult issues.
- Increase credibility of research among distrustful audiences.
- Enhance science literacy and other learning goals.
- Support communities in tackling locally important issues.

Many of the motivations listed in Table 1 are directly linked to the improving the quality of research itself, rather than to other goals such as outreach and education. A variety of interviewees pointed to examples in which they simply needed knowledge that was possessed by non-scientists in order to move ahead on an important project or gain insights about a difficult issue. Sometimes this can be done through consultation and interviewing, but in other cases, skill sets and knowledge are needed within and as a part of the research process. As one interviewee in the area of rangeland management put it, “There’s nothing better than looking at the ground together.” Local knowledge, specialized skill sets, and access to important places are all reasons to bring people into a research process, thus directly improving the science itself (see Box 1). And of course, expanding capacity and scale is another important motivator related to research outcomes.

We also heard a variety of perspectives on how CCS can help achieve other goals, including science learning, broadening awareness and visibility of ANR, empowering communities, and improving relationships between researchers and stakeholders or communities.

The number one thing is that the more people we involve, it expands their ability to talk about your research beyond you talking about it. When people take what they're doing to their friends and family, that helps ANR avoid being invisible. It's more meaningful than having just read an article. I'm not sure how you measure that, but you definitely can't buy that kind of outreach. It's not just a job. They're volunteers, and they care about it.

CCS can also be a source of professional fulfillment, providing an enjoyable way to conduct research, and to bridge the perceived divide between research and extension. It may also work to bridge statewide programs and county offices by encouraging closer collaboration between county advisors and sources of volunteers such as the Master Gardener, 4H, and California Naturalist programs. The diversity of motivations reflected in our research speaks to the diversity of outcomes that can result from successful CCS work. It also points to the many different ways that researchers might be encouraged to begin building these kinds of approaches into their work.

Box 1. Accessing knowledge and skills.

An understanding of fish communities in the Los Angeles River would provide a valuable piece of the broader puzzle of river health and help inform revitalization efforts. LA County Cooperative Extension began investigating this question using standard fish biology techniques, but immediately ran into challenges. The combination of rocky substrate and high levels of trash made the traditional methods practically unworkable. On the other hand, fishermen seemed to be catching plenty of fish through a variety of methods. The researchers began holding volunteer fish events and collecting data at fishing derbies. They then hit on the idea of expanding this work through a project on the online platform iNaturalist, which has received ongoing participation from diverse communities. The result has been improved data about species diversity, and the size and condition of fish in the river, which can directly inform the revitalization process, and has also been published in a peer-reviewed journal. On top of these results, the project has seen increased public engagement with ANR from a very diverse set of participants, and awareness of some of the environmental issues associated with the river.

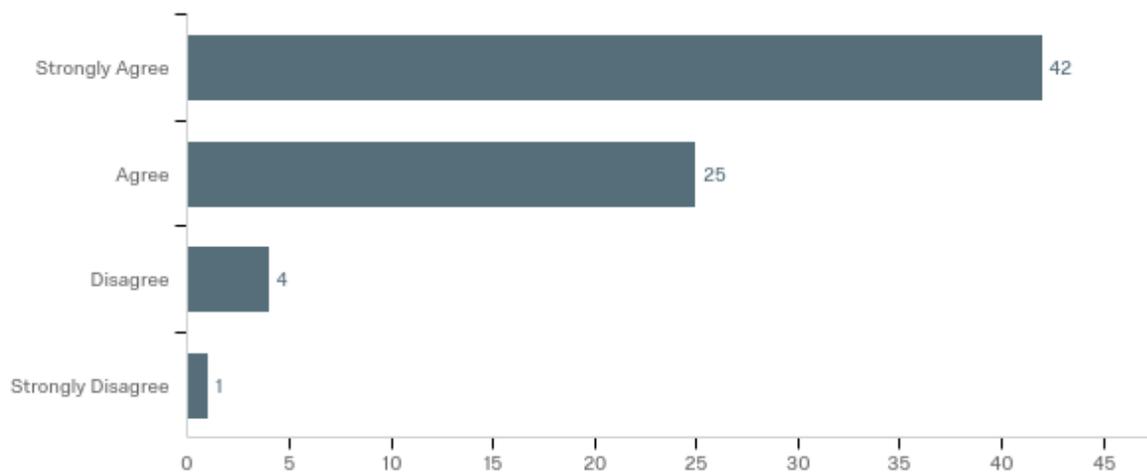


Figure 3. Survey responses indicating the level of agreement with the following statement: “involving volunteers (e.g., the public, ANR clientele, other groups) as active participants in the research process (beyond being research subjects, advisors, or recipients of research results) is a good idea.”

Opportunities and Challenges

The diversity of motivations reflected in our findings presents an opportunity for ANR. This is especially true in light of survey results relating to perceptions of CCS in general. Although there may be some bias in the survey due to self-selection of respondents, it is clear that a large segment of the ANR community shares a positive attitude toward the idea of public participation in research (see Figure 3). For ANR leadership, the challenge is not to convince the ANR community that CCS is a good idea. We believe the challenge should be viewed as one of supporting and harnessing the energy of a diverse group of practitioners who are excited about the opportunities presented by CCS.

Recommendations

R3. Foster existing enthusiasm, experience, and capacity for CCS. ANR's approach to citizen science should focus on fostering and supporting the considerable enthusiasm, energy, and talent that already exists across the system for involving the public in research and monitoring in creative and meaningful ways. This involves building awareness of the many options and approaches to CCS available as tools.

R4. Articulate the wide range of goals and potential benefits of CCS. ANR could clearly state the many varied benefits and reasons for engaging in CCS activities, including from their own colleagues, to help people find their way into this kind of work.

How ANR Fosters CCS Activities

In addition to understanding why individuals at ANR undertake CCS projects, we can also consider the ways in which we see the institution itself playing a role in making CCS happen.

Developing novel projects

There are some researchers who have developed projects entirely within ANR in terms of technology, design, participant communities, and other factors. These projects can be very simple – for example, a researcher might tap into a network of stakeholders via email to ask for some very simple data gathering to inform a limited study. But they can also involve novel software and technology development and extensive communications and recruitment efforts (e.g., Coyote Cacher; see Box 2), or substantial investments in training and management of volunteer networks (e.g., Sudden Oak Death Mapping³). In some cases, such as an emerging project focused on rural broadband (see Box 6, below), ANR might play a lead role in developing a new project but bring in a wide variety of partners who share an interest in the issue.

ANR as a hub for larger projects

The California Naturalist Program has also participated in Nature's Notebook, linked with the National Phenology Network, to record observations which then go into a national database. This example points to the fact that ANR may be positioned to serve as a major contributor to such efforts for California, in service of national or global efforts. ANR's extensive networks of volunteers, its presence throughout the state, and its connection to UC researchers are all assets that position ANR to effectively implement California-focused elements of national or even global citizen science projects, if priorities are well-aligned and resources are well-coordinated. Such

³ For more information, visit https://nature.berkeley.edu/garbelottowp/?page_id=148

efforts can also potentially set examples for Cooperative Extension in other areas, and for other land grant universities.

ANR building capacity for, and incentivizing CCS

There are also ways in which ANR has built programmatic infrastructure that fosters CCS activities without direct involvement by ANR researchers. ANR's California Naturalist program has a curriculum that calls for instructors to lead a citizen science project of their choosing, and graduates of the program can choose to devote their service hours to citizen science. However, there is not necessarily direct involvement by ANR researchers, either in the formulation of projects, or the use of results. In this way, an ANR program has built capacity for, and interest in, CCS throughout the state without needing to play a direct role in its implementation.

Another example of this facilitator role arises with the 4H program, where a variety of investigators have facilitated youth-focused community and citizen science projects. In these cases, ANR staff may develop curriculum around a particular topic, such as school nutrition or biosecurity, but youth become the leaders of the specific projects. The youth formulate questions, design and carry out studies, analyze and disseminate results. ANR researchers and other adult volunteers may play a supporting/facilitating role, but the youth are the leaders in most aspects of the research and may take that forward in various ways in their communities beyond the bounds of the program.

Recommendations

R5. ANR should inventory and develop a guide to existing resources, including off-the-shelf tools and in-house capacity for developing new tools and resources. There are many resources already available for researchers seeking to begin CCS projects, and this inventory, accompanied by other supports, could lower the bar for those individuals.

Box 2. Coyote Cacher: Developing a citizen science app from scratch.

Human-Wildlife Interactions Advisor Niamh Quinn worked with the ANR Informatics and GIS Statewide Program (IGIS) to develop an online citizen science project known as Coyote Cacher. The project allows anyone to report information about sightings of, and interactions with, coyotes in urban areas. Since its creation there have been 600 coyote sightings reported by 1300 unique users, information that can be used by both scientists and managers to understand trends in human-coyote interactions, and what kinds of management responses might be needed. City and county officials are using the tool across southern California. The online app also provides real-time information to the public about where sightings and interactions are being reported. It engages clientele and fosters increased awareness of agricultural, health, natural resource, and technology issues.

Why develop a citizen science app from scratch?

The Coyote Cacher app was developed in-house by the IGIS team, using a Microsoft SQL Server, spatial technologies created by Environmental Systems Research Institute (ESRI), and custom web programming. One advantage of this approach is that the researcher did not have to adapt to the capabilities offered by existing applications: IGIS was able to tailor the app to meet specific requirements. Through developing the Coyote Cacher App, IGIS also gained valuable experience in a range of technological applications, which can now be applied to create similar apps for others in ANR. Moreover, when IGIS builds an app in-house, they commit to maintaining the app and data over the long-term. Apps built by an outside contractor or volunteers often run into problems if something breaks or a key person moves on. IGIS conducts regular testing of all their live web and mobile apps.

R6. ANR should track, report, and reward contributions to CCS. Tracking should examine the projects developed and run by ANR personnel, and the ways in which ANR activities support a wide variety of local to global efforts by garnering participation and building capacity. This would add a new dimension to our understanding of how ANR is creating impact through research.

Who is participating in ANR CCS projects and what are they doing?

In this section we discuss the wide range of individuals and groups that are becoming involved in ANR research, and different kinds of roles they are playing in that process.

Participant Audiences

There are a few prominent ways in which ANR researchers are bringing volunteers into their research. Each of these has implications for the kinds of people who participate, what can be accomplished in terms of research, and other impacts of the work (see Table 2). There are plenty of examples of CCS projects at ANR that are open to anyone (e.g., surveys of fish biodiversity in the LA River; Coyote Cacher; Sudden Oak Death Mapping). However, these projects seem to be less common than CCS projects designed for specific groups. Figure 4, which shows the groups that respondents to our survey indicated collaborating with in research, suggests that collaborating with clientele, stakeholders, and members of existing ANR networks is more common than collaborating with the general public. Our survey is not definitive, but these results do fit with expectations and the kinds of examples that emerged during interviews.

Clientele and other community stakeholders

Projects such as Coyote Cacher are open to the general public, but there are many examples of projects at ANR targeting specific groups for specific reasons. Many CCS projects that involve clientele and other community stakeholders skew toward the traditional model of extension. As mentioned above, these projects don't necessarily begin with, or even involve data collection. At one end of the spectrum there may be an advisory role that falls outside the definition of CCS, but there are many other kinds of projects in which these groups play a critical, technical role in research.

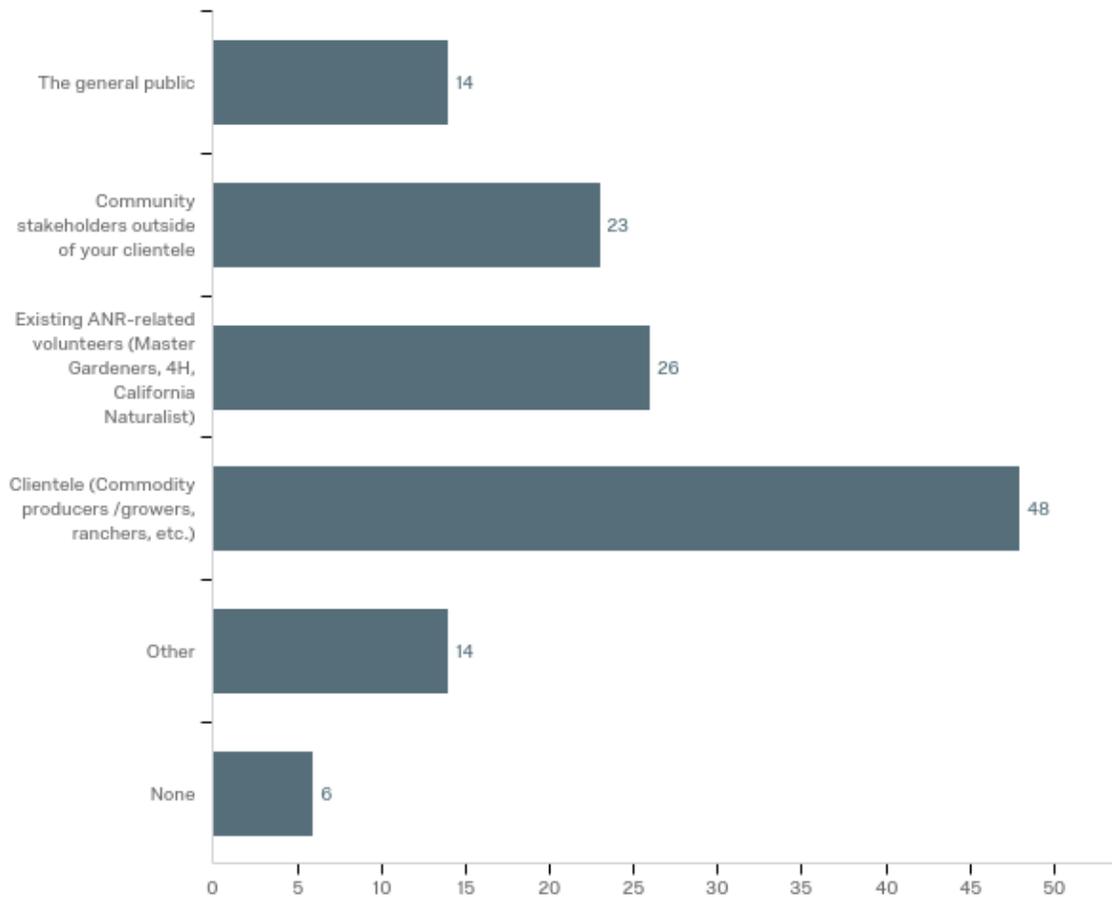


Figure 4. Survey respondents (n = 74) were asked to indicate which groups they collaborate with on research (i.e., as more than research subjects, advisors, or recipients of results).

Table 2. Common approaches to defining volunteer pools for CCS at ANR	
Volunteer source	Explanation
General Public	Anyone can sign up and participate. Examples include crowdsourcing projects such as Coyote Cacher, Sudden Oak Death Mapper, LA River Fish Survey, or event-based citizen science projects such as bioblitzes.
Targeted Groups	Researchers work with specific groups for specific reasons. For example, researchers may include clientele and other stakeholders to guide research, and develop shared understandings of fraught, divisive issues. Or researchers might work with school groups on nutrition projects in order to gain new insights and empower communities as part of the process.
Existing ANR Networks	Researchers tap into capacity that has been built through ANR programs such as Master Gardeners, 4H, California Naturalist, and the On-Farm Demonstration Network.

Involving clientele and community stakeholders may be motivated by a variety of needs in addition to the scientific results themselves. Especially when the topic of study is at risk of being highly politicized and has important policy implications, collaborative science can provide a space for communication and finding common ground. As one researcher advised, “Don’t underestimate the value of field-based work for building relationships and mutual understanding.” As exemplified in Box 3, these targeted groups can be crucial to a scientific process, even while their involvement satisfies other goals such as building mutual understanding of challenging problems at the nexus of areas such as environment, agriculture, public health, and community development.

ANR Networks

ANR networks were very prominent across many of our interviews. Master Gardeners and 4H in particular came up time and time again. These programs, and the networks they support, provide a wide variety of opportunities for ANR researchers to tap into the energy, knowledge, and ongoing commitment of volunteers that participate in them. Master Gardeners have been involved in CCS projects focused on pest management, water quality, urban forestry, and food safety (see Box 7 below), among other topics. Master Gardeners can be ideal collaborators on a project, as they already have relevant background knowledge, have demonstrated a prior commitment to these issues, and have a direct connection to ANR.

The California Naturalist program includes citizen science as a formal part of the curriculum that instructors follow, and upon completion of the program, participants may also choose to dedicate their service hours to additional citizen science activities. As discussed above, this is an example of ANR as facilitator and capacity builder – in many cases, these CCS projects are not run by ANR researchers. But there are also cases in which ANR and UC researchers enter into collaborations with CalNat participants, either during or after the course, to engage them in CCS projects (see Box 4).

Box 3. Engaging Stakeholders to Advance Research and Build Shared Understanding

A recent collaborative project, led by UC Rangelands, tapped into the unique expertise of ranchers and managers to design an experiment testing different approaches to adaptive management. In this example, the stakeholders served as both research subjects and as collaborators in experimental design. They contributed their views about different approaches to rangeland management in order to structure experimental treatments across 8 pastures. Although the participating stakeholders did not carry out the experiments themselves, their deep experience and technical knowledge played a direct role in shaping the study and guiding it throughout the process. Professional researchers were able to learn from the stakeholders in multiple ways: through surveys and interviews, and through the results of experiments that they co-designed. The project also provided a forum in which diverse stakeholders who are sometimes in conflict with one another could share knowledge and develop relationships.

Box 4. ANR networks as a source of capacity for UC research: Citizen Monitoring of Live Fuel Moisture in Santa Barbara County

A common indicator of both drought stress and fire danger is the water content in living plant tissue. This metric is typically assessed 1-2 times per month by fire agencies, but the results are not generally communicated to the public. Furthermore, most of the sampling is done relatively far from the wildland-urban interface (WUI) where people tend to live. Cooperative Extension Specialist Max Moritz is working with the Santa Barbara Botanical Garden and dedicated volunteers to fill an important gap in data that helps to understand wildfire risk at the Wildland-Urban Interface (WUI). Volunteers collect samples of particular species at particular locations on a regular basis and return them to the Moritz Lab for analysis and submission to a public database.

The Moritz Lab's efforts to address this issue grew out of an engagement with the California Naturalist (CalNat) course run at the Santa Barbara Botanical Garden. After delivering a lecture and getting to know the course participants, Moritz was able to build a partnership with an organization that shared an interest in both science and education related to wildfires and tap into a pool of knowledgeable and motivated volunteers. Not all citizen and community science activities at CalNat involve direct collaboration with ANR or UC researchers, but this example shows the potential of such partnerships.

There are also many CCS projects involving 4H. These projects may or may not contribute data to a larger scientific effort on the part of ANR researchers or other scientists. In one example, youth contributed to Cornell's eBird project, which gathers data on bird migratory patterns throughout the world. However, other examples more closely fit with the community science model, in which youth participants make use of data for their own purposes, within their own communities. Examples include youth-led studies of nutrition and public health in communities and schools, and of biosecurity risks and interventions in homes and at county fairs (see Box 5). Such projects follow a scientific process – developing research questions with unknown answers; designing experiments; collecting and analyzing data; and developing and disseminating results to outside audiences. They may or may not lead to scientific publications, but they can produce situations where science is used to inform policy or practice that has impacts on local communities.

Box 5. Reducing Disease Risks in 4-H Animal Science Projects through Community Science

This community-based science intervention engaged youth aged 9-15 enrolled in 4-H Animal Science projects in 11 counties in California. The project supported youth in improving their knowledge and skills related to bio-security, and applying what they learned to risk mitigation projects in authentic settings. The majority of youth worked on projects on their home premises, including making changes to animal housing and care to reduce disease transmission risks. Youth from two county 4-H programs (Yuba/Sutter and Santa Cruz) worked on community-based projects with local county fairs, including performing a biosecurity risk assessment and presenting their findings to fair administrators. These youth also made science-based recommendations for changes in fair policies and practices as they pertained to protecting animal and human health. As a result of the youths' involvement, numerous improvements were made at both fair locations. This project successfully strengthened partnerships between county 4-H programs and fair management. It also leveraged the 4-H network to work on an important issue across a large part of the state, and advanced both extension and education goals through scientific work.

Programs that build networks of potential volunteers throughout the state are obviously a huge asset for ANR, UC, and CCS in California, generally. These networks can help researchers surmount early hurdles in establishing a CCS project related to recruiting, training, and motivating volunteers, which is particularly valuable when there is a need to respond quickly to disasters or other events (see Box 7). However, there may be uneven, and in some cases very little, awareness of this opportunity across ANR, and the University of California more broadly. Processes through which scientists engage with California Naturalists and Master Gardeners are somewhat ad hoc. Developing guidelines and processes for linking ANR researchers with networks of potential volunteers could help bring clarity and could result in more effective leveraging of this built capacity. Such guidelines could also address issues such as scale, and present opportunities to align curriculum and training with researcher needs.

Box 6. Statewide Networks with Statewide Potential: Rural Broadband

Internet access is key to enhancing the vibrancy of rural economies and unlocking the potential of agricultural technology. In rural areas, mobile broadband coverage can be spotty and of poor quality. Moreover, we lack reliable data about coverage in rural areas. ANR is now leading an effort to improve understanding of mobile broadband access across the state, partnering with the California Public Utilities Commission (CPUC), and the USDA, among others. Key to this challenge will be a citizen science approach that leverages ANR networks already in existence in every county, and a user-friendly mobile app developed by CPUC. Although this initiative is in its early stages, it's a perfect example of how ANR's programs such as 4H can expand what's possible for citizen science in California. Not only does ANR have relationships and networks throughout rural California, it also has the programmatic expertise to mobilize these relationships in service of rigorous scientific results and beneficial learning and community outcomes.

However, this recommendation comes with a caution. When encouraging greater engagement between ANR researchers and volunteer networks, care must also be taken to protect and value the time and commitment of those volunteers, and the staff who carefully build and maintain these networks. It would be easy to overwhelm volunteers and volunteer coordinators with requests and unrealistic expectations. What is needed is greater definition of what it means to work with these volunteer networks, and what commitments researchers must make and resources they need to bring to the table in order to be successful and potentially reap significant professional benefits. As one interviewee put it: "I hope we're not thinking [CCS] is a way to shortcut the process. It's not a way to make things easier. It's harder, but the answers you get are better."

Recommendations

R7. Strengthen connections between UC researchers and ANR networks. ANR should take steps to increase awareness of, and collaboration between, researchers and ANR volunteer networks. A first step in building collaboration between networks and researchers would be to convene a working group involving network coordinators, volunteers, researchers that have worked with them, and other interested parties to devise plans for encouraging further collaboration.

R8. Leverage existing ANR networks, county-based offices and volunteer programs to expand the geographic scope of research at the University of California. Statewide networks of volunteers are a significant and arguably unique asset for ANR, for individual researchers, and for the state. These should be a centerpiece of an ANR CCS strategy, which could focus on how to better create and sustain large-scale projects (i.e., greater than one or two counties).

Box 7. Leveraging ANR networks for event response

The fires that spread through Northern California in October 2017 burned over 160,000 acres of wildland, suburban, urban and industrial areas, creating dangerous air quality conditions for the region that lasted long beyond the fires themselves. Immediately after the onset of the wildfires in Sonoma County in October 2017, the UCCE Sonoma office began receiving phone calls with questions on the safety of eating Sonoma County grown produce in the wake of the wildfires. The wildfire smoke likely included high concentrations of toxic air contaminants, and there are well-known human health impacts from the inhalation of these contaminants. Additionally, plants have the potential to absorb air pollutants directly through their leaves, but little research has been done on the risk to human health from ingesting contaminants from smoke and ash on produce grown near a burn site.

In the weeks following the Sonoma County fires, UCCE Sonoma stepped up to develop and facilitate a research project to understand these health risks and help educate the community on this important topic. UCCE Sonoma needed to energize concerned community members to initiate some fast produce sampling from local gardens and farms. Of particular value was that the UC Master Gardener (MG) Program of Sonoma County Program Manager was able to leverage the Sonoma County MG volunteer base for sampling. In the weeks after the fire, the team collaborated to take samples from over 25 sites across the region using a sampling protocol created under advisement by UC Environmental Health and Food Safety Specialists. Samples included washed and unwashed produce, each in triplicate, to determine if contaminants are present and whether contaminants can be easily washed off produce. Volunteers focused on leafy greens with large surface area directly exposed to air pollution: kale, collards, chard, and lettuce. In total, over 200 samples were taken and frozen for subsequent laboratory analysis. The value of UCANR as a facilitator of community engagement was key, as well as access to the invaluable resource of Master Gardener volunteers as a source of readily and quickly activated citizen scientists. In the initial phases of the project, the financial support from the UCANR Opportunity Grant program was also critical for advancing the project as the team sought other grant funding.

Is ANR providing equitable opportunities for CCS participation?

Equity and inclusion are vital components of ANR programs that focus directly on reaching underserved or at-risk populations. The topic is also a central concern for the broader field of CCS, where questions about who participates are seen as directly related to questions about who shares in the many potential benefits of public participation in science, and the potential of CCS to address historic inequities (Soleri et al. 2016). Research suggests that participation in community and citizen science, if implemented appropriately, can help to strengthen science identity and promote agency among participants, particularly those in traditionally underrepresented populations (Calabrese Barton and Tan 2012; Ballard, Dixon, and Harris 2017). On the other hand, without explicit attention to these issues, CCS may only be available to participants with the money and time to engage, thereby entrenching or exacerbating the inequities that already pervade the science system and society at large.

It was beyond the scope of this study to comprehensively assess CCS participation at ANR along these lines. We can point to programs, for example within 4H and the Nutrition Policy Institute, that explicitly serve disadvantaged communities through CCS. California Naturalist also has made concerted efforts to expand its reach through conservation corps and other partners, and by providing scholarships.

Recommendations

R9. Evaluate and develop a strategy for addressing equity and inclusion through CCS.

Undertake an evaluation of CCS participation in ANR research in terms of socio-economic and other factors that relate to equity and opportunity that these programs provide. Results can help to determine whether CCS at ANR is playing a positive role in advancing more inclusive programs, inform a strategy for improving equity, and foster exchange across programs that are working toward this goal.

Participant Roles

In our survey, when asked about the roles participants are playing in CCS projects at ANR, the most commonly selected options were: suggesting research needs/ideas; shaping research questions; and data collection (see Figure 5). Although our survey cannot be taken as robustly representative of ANR in general, these findings do line up with our expectations. The first two are very much in line with ANR's history of engaging with and listening to clientele communities, and using those interactions to develop studies that may or may not have further involvement from those communities. As discussed above, this may or may not fall within an appropriate definition of CCS. The rate of response for "experimental design," which is more squarely within a set of scientific practices, is much lower. This also makes sense, as such processes are far more complex as they leverage various forms of technical expertise and local knowledge.

Table 3. Roles of participants in three idealized modes of community and citizen science.*

	Contributory projects generally designed by scientists, for which members of the public primarily contribute data.	Collaborative projects, generally designed by scientists, for which members of the public contribute data but also help to refine project design, analyze data, and/or disseminate findings.	Co-Created designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all aspects of the research process.
Define a question/issue			X
Gather information			X
Develop explanations		X	X
Design data collection methods		X	X
Collect samples	X	X	X
Analyze samples	X	X	X
Analyze data		X	X
Interpret data/conclude			X
Disseminate conclusions			X
Discuss results/inquire further			X

*Adapted from Bonney et al. (2009) and Shirk et al. (2012).

The other common response, data collection, is reflective of the broad trend in CCS, where data collection is often the starting point for the design and implementation of projects, and roles may expand out from that core activity. There are examples of contributory, collaborative, and co-created projects, and in all of those, participants are involved in data collection, and sometimes other activities (see Table 3).

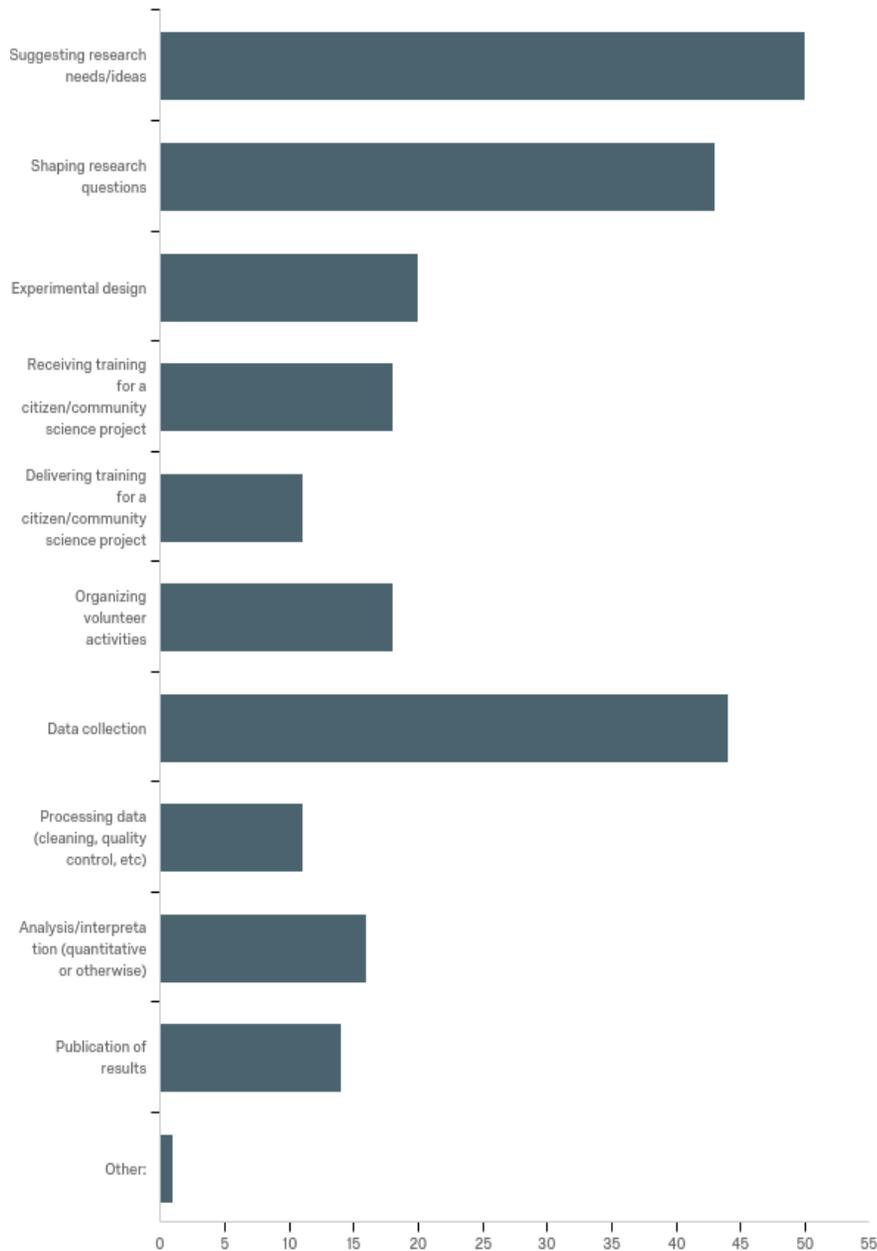


Figure 5. Respondent indications of the kinds of activities that participants have been involved in, when collaborating on research.

In considering the design of projects and the role of participants, it may not make sense to take it for granted that data collection represents the starting point or minimum standard for a CCS project in the ANR context. We encountered a variety of examples that started with participants in an advisory role (as opposed to data collection), and grew into something more elaborate and technical, in terms of participation. Activities in the On-Farm Demonstration Network⁴ often follow this alternative path, with initial discussions among growers, industry groups, advisors and other researchers growing gradually into projects that may involve extensive technical activity on the

⁴ For more information visit <http://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=24596>

part of non-scientists. In another example, stakeholders in rangeland management with diverse perspectives and goals were deeply involved in conceptualizing and designing an experiment to test various land management practices at a field station. Input from these participants included technical knowledge, feedback on experimental design, and consultation throughout the experiment, but the practical implementation of the experiment was carried out by professional researchers (see Box 3 above).

When thinking about the ways in which CCS is encouraged and supported in the ANR system, these insights about participant roles and about the ways in which roles evolve along with projects should be explicit considerations. For example, one line of thinking would be to focus on the types of projects that seem to be most common and think about ways to encourage and support those. Another approach is to look at the kinds of participant roles that are less common and consider ways of supporting more researchers to build toward those roles. For example, how and when does it make sense for clientele communities to play a more substantial, technical role in a project, rather than an advisory role? What opportunities are there to develop “train the trainer” programs that can expand capacity and scale of existing projects? It is also important to note that individual roles can evolve over the life of a project, as volunteers gain experience and skill, and researchers build trust with those involved. If researchers enter into a collaboration with those trajectories in mind, this can help with long-term sustainability of a project as things grow and as needs change.

Recommendations

R10. Train and support UC researchers to work with volunteers. ANR should provide professional development opportunities focused on working with volunteers and designing projects with volunteers in mind. Such professional development should consider the broad range of ways that clientele and the public can participate in research.

The Role of Technology in ANR Projects

Not all projects are online, or app-based

Not all CCS projects must take place online or make use of tailored software. There are examples of successful CCS projects at ANR that use very basic communications and information management approaches, and primarily revolve around direct in-person relationships between researchers and volunteers often working together on the ground to carry out research. For example, Master Gardeners have conducted water quality research, California Naturalists have collected live fuel moisture samples, 4-H youth have studied biosecurity risks at county fairs (see Box 5 above) and nutrition at school. Each of these projects may have involved basic scientific equipment, but the activities did not center around a specialized data collection app.

Some use third-party apps, and others develop apps in-house

CCS projects at ANR vary widely in their approaches to developing and using information technology. A variety of projects use smartphone apps or web-forms, some of them developed by a third party (see Box 1 above), and others developed by ANR (see Box 2 above). Whether developed in-house or by a third party, these apps are typically designed to allow recording of data with a very low bar to entry for the general public. The apps may involve some degree of background information, guidance, and specific training to help users generate high quality data from observations they make in the world.⁵

The iNaturalist platform is the basis for a variety of CCS projects, including invasive species and pest monitoring, surveys of fish diversity (see Box 1 above), and a range of projects undertaken through the California Naturalist program. In these cases, specific projects can inform individual interests and research purposes, but the recorded observations also go into a global database that can be used by any scientist.⁶ ANR's emerging initiative focused on rural broadband will use an app developed by the California Public Utilities Commission (see Box 6 above). Coyote Cacher and Sudden Oak Death Mapping projects each use mobile-friendly software developed by ANR's IGIS program.

We did not observe any projects facilitating online crowdsourced data processing

Another common use of technology that we did *not* observe in this study of ANR is online crowdsourcing of data processing.⁷ In such projects, users help scientists to make sense of large volumes of data that have been collected, but which need to be interpreted in some way by humans in order to be useful. The best-known platform for this type of project is Zooniverse, where participants can engage in activities ranging from disaster response via satellite photos, to characterizing camera trap photos, to transcribing ancient texts. The fact that such projects can be undertaken in the comfort of one's own home or office comes with some obvious advantages: a project can tap into potentially very large audiences with minimal investments of time and

⁵ More in-depth engagement may occur when clients use online self-assessment tools such as CropManage, and in the course of doing so, also generate data that ANR researchers can use in their work.

⁶ It is worth noting that although iNaturalist currently serves as a third party application usable by any researcher, it began as a UC-based project, and its early development was closely intertwined with the ANR California Naturalist program. iNaturalist subsequently found a new institutional home at the California Academy of Sciences, and has become one of the most globally prominent citizen science platforms for environmental observations, having recently recorded its 12 millionth observation (more at <https://www.inaturalist.org/>).

⁷ The term crowdsourcing can be applied to a wide range of activities that enlist large numbers of people to chip in their time, talents, or other resources. Here we are specifically discussing the idea of *online* crowdsourcing for help in processing large datasets.

resources in each volunteer participant. There can also be opportunities to “gamify” the experience by adding a competitive element to participant activities, such as a scoring system, or other reward for performance on the project. The flip side of these advantages is the low level of direct engagement between researcher and participant. However, there are examples of field-based projects that also incorporate an online data-processing component.⁸

Recommendations

R11. Support low-tech CCS. Not all CCS is online or app-based. An institutional framework for supporting CCS at ANR should explicitly include low-tech and in-person approaches to CCS.

R12. Promote online crowd-sourced processing for large datasets that need human engagement. Online crowdsourcing and gamification appear to be underutilized approaches in ANR; professional development and other kinds of support could help researchers dealing with large datasets that need human engagement.

⁸ See, for example, a case study involving youth in tracking sage grouse in the field, and classifying camera trap photos online: <https://education.ucdavis.edu/yccs-tracking-sage-grouse-field-and-online>

Challenges and Barriers for Community and Citizen Science at ANR

Most of our interviewees and survey respondents agreed that CCS is a good idea for ANR, but this resounding enthusiasm is not without caveats and reservations. It is important to bring up the topic of challenges to CCS for a few reasons. First of all, an increased focus on this kind of work should be accompanied by realistic expectations about when it is or is not appropriate. Just as we have emphasized that there is no single model of CCS, we should also be wary of the idea that all researchers can and should be engaged in CCS as part of their work. There are ways to be effective with clientele communities and the public at large without those groups playing a substantive role in the conduct of research.

Secondly, it is important to be realistic about challenges associated with doing CCS well, whatever model a researcher might be pursuing. Poor execution of a CCS project can have negative consequences for all involved and can damage the reputation of the organization. In this section we discuss some of the challenges, barriers, and cautionary notes that emerged in our interviews. Finally, an understanding of the challenges researchers are facing can inform efforts to better support this work going forward.

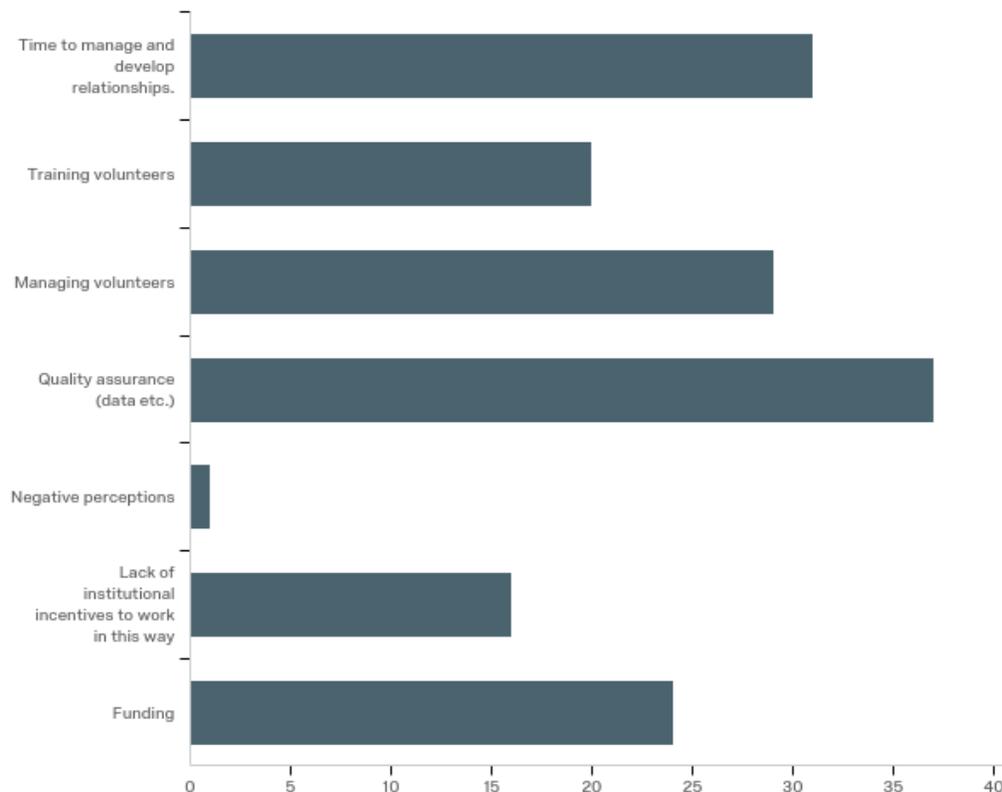


Figure 6. Selections by survey respondents indicating their perceptions of the biggest obstacles to involving volunteers in research. Respondents were invited to select up to 3 options.

Resources: CCS takes time, money, skills.

A very common theme in discussions of challenges and barriers was time, money, and skills needed to do community and citizen science. Perhaps the observations about time and money are not so different from research challenges in general, but it is worth focusing in on some of the particular resource constraints that came up in the course of interviews and the survey. Although most researchers probably feel pressed for time, as one noted, collaboration “takes more time so there needs to be an understanding that it might look less productive in the end.” In other words, it’s not just the time needed to build a successful project, but also that evaluations of people and projects might not capture some of the value that comes from that investment of time. One way to effectively lower this barrier would be to make sure that extension personnel have the capacity to measure the impacts of CCS not only in terms of research, but also extension, as referenced in Recommendation 6. Though this would not reduce the amount of inputs required for successful CCS, it could tip the scales so that the benefits to personnel balance it out.

Beyond financial resources, some pointed to the variety of skills needed for successful CCS, and the difficulty of acquiring those skills. There are many skills related to volunteer management and community engagement, which are not typically taught in science degree programs. However, as one interviewee pointed out: “if you’re going to be a successful extension advisor, you have to have *some* extension skills, so maybe that’s less of a barrier than for other parts of academia.” This general limitation also points to an inherent advantage that ANR can use, not only internally, but as a resource for the University of California and society writ large: by nature of its mission ANR is already fostering some of the important skills needed to support CCS.

Return on Investment: Don’t force it.

Sometimes, in taking stock of the project goals, available resources, and the potentially viable approaches, CCS is simply not the best option. One researcher pointed out that she felt quality control is not necessarily a greater problem with volunteers than with a hired crew, but with a hired crew there’s more accountability – there are consequences if the hired staff don’t show up. With a small-scale, methodologically intensive project, a volunteer approach may not be advisable. Another researcher described a process of considering a CCS approach to drought research, but opting for a different set of tools in the end:

There was a time when we were trying to fill monitoring gaps for precipitation, and we considered a CoCoRHaS effort.⁹ But we ended up going a different direction because it would be such a big lift, and we were able to use modeling and remote sensing.

Similar goal-setting and prioritization, capacity assessment, and resource assessments are recommended for anyone considering initiating a CCS project. While the overall cost-efficiency associated with data generation need not be the overriding consideration, balancing this explicitly with other potential outcomes (e.g., partnerships, education, expanded reach) can help to determine the best course of action.

Sustaining and Scaling

With volunteer programs, it is possible to be the victim of your own success. What works well at one scale – in terms of the administrative support and engagement with participants – might not

⁹ The Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) is a network of volunteers working together to measure and map precipitation. See <https://www.cocorahs.org/>

in another. One researcher described a water quality monitoring effort involving Master Gardeners that got significant participation, leading to a variety of positive outcomes. When the organizers started getting interest from other counties, they found that they couldn't implement the project in the same way, because it simply required too much face-to-face time between volunteers and the research staff. What had worked at the local scale was not workable at a larger scale because of time and travel costs.

On the flip side, many volunteer CCS projects experience significant attrition over time. For researchers, what seems like a worthwhile investment in the early days of a project that has successfully recruited a large volunteer pool can begin to seem less and less worth it if that pool begins to dwindle. This raises tough questions about time and resource management related to continually foster volunteer engagement, and the need to work toward the research goals that may have motivated a project to begin with.

Perception and Awareness

The perceptions of CCS we encountered in this project were largely, but not exclusively positive. For example, one interviewee felt unsure that the motivations behind CCS at ANR are really related to science:

I have wondered about quality of the science. Is it being supported at ANR as a way to support the image, budget, or for actual science? ... From the ANR perspective, I think a lot of it is seen as an educational tool, rather than a science tool. Am I doing it because I want my merit package, or my educational/outreach package? Those things aren't isolated, but people probably lean more toward the outreach as a motivation.

And some reported experiencing negative perceptions from others in the course of their work. This could be specifically focused on data quality, or a more general rejection of the idea of non-scientists doing science:

Years ago, we were very interested in engaging colleagues across ANR to say "how can young people contribute to your work on, for example, plant pathology, e. Coli, etc etc." It was like talking a foreign language. They could NOT fathom how a young person could make a contribution. It's a narrow idea of what science is and who can do it.

And some pointed toward a perceived tension between supporting the agriculture industry and California communities writ large:

If programs feel like money will be shifted from one thing to another, people get territorial and provincial. "We're developing commodities that generate millions of dollars, and you just want to work with the layperson."

These perspectives illustrate some the challenges and ongoing questions that individuals and whole programs are facing at ANR. They also parallel, to some extent, ongoing national and global debates about the legitimacy of community and citizen science (e.g., Burgess et al. 2016; Parrish et al. 2018; Wiggins et al. 2011). However, it should also be noted that "negative perceptions" was by far the least common selection among survey respondents who addressed this question (Figure 6). Both interviews and survey results suggest an institutional culture that is already oriented very positively toward CCS in its many different forms.

Recommendations

R13. Explicitly address practical and professional obstacles to initiating, sustaining, and growing successful CCS projects. This does not mean that all CCS projects deserve permanent core support. But ANR can take actions to explicitly recognize cases where CCS projects are making great strides to advance its mission and deliver public value, and create structures (e.g., appropriate staffing, professional development, technological support) that help those efforts flourish.

R14. Leverage the example of CCS at ANR to foster CCS in California and beyond. ANR can be a leader in academia, among land grant universities, and for cooperative extension by not only continuing to foster CCS, as has been happening for more than a century, but by continuing to look closely at what that means and how it can improve.

Looking Ahead

Throughout this report we have offered recommendations related to each topic addressed by our assessment (summarized in Box 8 below). Beyond those specific recommendations, a broader, more forward-thinking rationale is needed. In other words, CCS must not be an end in and of itself. We must address the how and why of CCS at ANR for both present-day and long-term considerations, as ANR pursues its vision of a thriving California where healthy people and communities, healthy food systems, and healthy environments are strengthened by a close partnership between the University of California and its research and extension programs and the people of the state.

An important high-level observation is that CCS is already playing an important role in advancing multiple ANR strategic objectives.¹⁰ We see examples of ways that CCS is expanding the audience of people who understand the value of ANR, and ways that research and extension are directly improved through CCS approaches. The motivations and goals of people doing CCS at ANR also speak to the other strategic objectives; for example, some of our interviewees reported finding this kind of work challenging and fulfilling. In the rest of this final section, we offer vision statements for CCS at ANR, and some concluding recommendations that build off the specific recommendations that appear throughout this report.

¹⁰See <http://ucanr.edu/sites/anrstaff/files/254338.pdf>

Box 8. Recommendations drawn from throughout this document.

Defining Citizen and Community Science at ANR

- R1: Develop a definition of CCS that fits the ANR context.
- R2: Avoid conceptual overreach.

Understanding why people at ANR pursue Citizen and Community Science in their work

- R3: Foster existing enthusiasm, experience, and capacity for CCS.
- R4: Articulate the wide range of motivations and potential benefits of CCS.

Understanding how ANR as an institution supports Citizen and Community Science

- R5: Inventory and develop a guide to existing resources, including off-the-shelf tools, and in-house capacity for developing new tools and resources.
- R6: Track, report, and reward ANR contributions to broader (i.e., national, global) CCS efforts.

Leveraging diverse forms of participation in ANR research

- R7: Strengthen connections between UC researchers and ANR networks.
- R8: Leverage existing ANR networks, county-based offices and volunteer programs to expand the geographic scope of research at the University of California.
- R9: Evaluate and develop a strategy for addressing equity and inclusion through CCS.
- R10: Train and support UC researchers to work with UC experts in volunteer management and volunteers.

The role of technology

- R11: Support low-tech citizen and community science; don't solely focus on apps and online platforms.
- R12: Promote online crowd-sourced processing for large datasets that need human engagement.

Challenges and Barriers

- R13. Explicitly address practical and professional obstacles to initiating, sustaining, and growing successful CCS projects.
- R14. Leverage the example of CCS at ANR for change and development of meaningful CCS in California and beyond.

Vision Statements for CCS at ANR

We present below four vision statements for consideration as ANR explores ways of supporting and expanding CCS across its programs. The vision statements speak to the range of benefits that could be associated with a strategy for CCS at ANR, and they offer a rationale for tracking and evaluating CCS periodically, as a part of such a strategy.

V1. Opportunities to participate in ANR research are more pervasively available, equitable, and impactful throughout California.

V2. UC Researchers who want to engage communities in their work can gain skills and access support structures for doing this effectively.

V3. CCS Networks at ANR are providing a unique statewide resource to researchers, state and federal agencies, and others striving to understand and address large scale environmental challenges.

V4. CCS is expanding awareness of, and appreciation for, the role of ANR in California's environment, economy, and communities.

The final vision statement (V4), deals specifically with the notion of expanding reach. We provide additional insights and recommendations about this particular ANR Goal in Box 9. Overall, we hope that these vision statements can form the basis of discussions about the future of CCS at ANR.

Box 9. CCS as a tool for expanding reach: Key insights and recommendations.

Because it was a significant motivator for undertaking this assessment, we offer specific insights about how CCS can advance Goal 2 of the ANR 2016-2020 Strategic Plan, Expanding Reach. As mentioned above, this is just one of the goals and objectives that CCS can support, but our interviews and surveys did turn up many creative ways in which ANR is drawing people into science and monitoring.

1. **Diversifying modes of engagement can also diversify those who are engaged.** Adding CCS to a portfolio of engagement strategies may increase the appeal of a program to a larger and perhaps more diverse audience.
2. **CCS can be an avenue to community impact.** Collaborative approaches to research can empower communities, giving them ownership and agency over a process when it comes to tackling a difficult issue such as nutrition in communities and schools.
3. **CCS builds capacity for science communication.** A variety of interviewees reported on the value and significance of experienced volunteers talking about science in their communities, based on their first-hand knowledge from CCS experiences.

There are additional promising ways that CCS may be valuable to ANR as an approach to expanding reach. While this assessment did not empirically demonstrate these dynamics, they could be the focus of subsequent evaluations and explicit considerations in the design of future programs.

4. **CCS can act as an entry point.** Participating in citizen and community science may be an individual's first introduction to ANR but later lead them to participate in other programs.
5. **CCS can increase science literacy and trust in science.** Those who have participated in CCS at ANR may go on to seek out and more effectively utilize other science-based extension materials. Research in other areas (outside of ANR) has pointed to similar dynamics.

Concluding Recommendations

How can ANR work toward the vision expressed above? The recommendations offered throughout this document (assembled in Box 8 above) point to actions that would foster and improve the impact of CCS at ANR. In addition to those recommendations, we offer the following broad concluding recommendations:

- 1. Develop a shared understanding of CCS.** This can take place through a gradual process, using approaches such as advisory groups, conference workshops, and evaluation or other assessment activities. (R1, R2)
- 2. Embrace the diversity of CCS happening at ANR.** Some examples show the promise of scaled up research that can address big challenges facing the state; others show how science in communities can open doors to a variety of positive outcomes in a local place. Some involve new technology, and some involve little technology at all. These models are not mutually exclusive, but they can look very different, and lead to different kinds of benefits. ANR can welcome, support, and foster the full breadth of CCS. (R4, R5, R6)
- 3. Better equip and prepare researchers with skills, technology, and administrative support needed for CCS.** ANR may be ahead of many other research institutions when it comes to the skills needed for CCS, but more can be done to support the community in taking on this work. (R3, R8, R10)
- 4. Continue to foster inclusive volunteer networks, expand volunteer opportunities, and think big about how they can yield data and insights that would be otherwise impossible.** While Master Gardeners, California Naturalists, and 4H might be powerhouses of CCS in California, they are for the most part locally focused. How can this resource work for CCS at larger scales? (R7, R9, R11, R12)
- 5. Strategically invest in capacity that helps sustain and scale valuable projects.** Evaluation and reporting can help to identify promising opportunities to “level-up” ongoing CCS at ANR. Training programs, technology platforms, and expert staff are needed to capitalize on those opportunities. (R10, R13)
- 6. Seek and support creative partnerships that expand participation, and ensure meaningful learning through that participation.** CCS is built on partnerships, often at multiple scales. Innovative CCS partnerships with government, industry, and non-profit groups throughout the state can advance CCS that specifically improves ANR’s performance with respect to its mission and vision. (R14)

The Center for Community and Citizen Science is well-equipped and enthusiastically willing to partner in advancing all of these recommendations. It should also be noted that the larger field of CCS is galloping forward, and there are many ways in which insights from this broader community can inform ANR’s next steps. At the same time, we believe that ANR is already well-positioned to be an innovative leader in this field, setting an example for what a university system, cooperative extension, and an entire state can do when we work together on research that matters to our own lives, landscapes, and communities.

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Appendix A. Articles for a Special Issue of California Agriculture

A special issue of California Agriculture focused on Citizen and Community Science is planned for October, 2019, co-edited by Ryan Meyer, Sabrina Drill, and Heidi Ballard. The following is a list of article titles and abstracts that were accepted into the special issue after review by the co-editors. Given that the articles are currently in preparation, and will be subject to peer review, the information below is tentative.

1. How participation in scientific research as part of a stewardship development program (UC California Naturalist) influences science identity, understanding, and future participation in community science.

Abstract:

Hands-on involvement in environmental research plays a profound role in improving people's capacity for inquiry, connection to nature, and fostering of ecosystem stewardship. While the numbers of people participating in citizen science projects is on the rise, it's not clear how the public understands what constitutes citizen science and how adults engage with the existing opportunities. The UC California Naturalist Program uses participation in research to integrate and reinforce essential elements of what it means to be a naturalist. Data were collected on types of participation in citizen science during the course which included a group citizen science project, individual contributions to iNaturalist projects, and a subset of participatory research-focused individual capstone projects. Also, activity by the naturalists following the course that included contributing data, or coordinating and training others to participate in research, reveals the potential benefits of deeper engagement. Several information sources are analyzed, including post-course surveys, logged volunteer hours, and information about class and capstone projects. These data, collected from thousands of California Naturalists, offer a unique opportunity to examine the impact of adult participation in these activities on knowledge gain, skills development, and environmental self-efficacy. We examine whether participation in a class community science project and selection of capstone topics influenced their trajectories as volunteers after the course to examine what participation in science means for personal development, their communities, and the ecosystems they are a part of.

2. Project 4-H2O: Engaging teens in conducting research and advocacy for better drinking water access and appeal at school.

Abstract:

In Contra Costa County, 62% of teens reported drinking 2 or more sodas daily. Drinking sugar sweetened beverages (SSBs) is a key factor in the increased incidence of childhood obesity and encouraging teens to drink zero calorie water could help reduce this trend. We collaborated with teens at a local high school to ascertain what students are drinking while in school. Utilizing an online system, 320 students took the survey (57% return rate). We found that 90% of the student's first choice is water; 67% have a reusable water bottle; 62% do not drink the water provided at school and instead bring it from home; and reported a low daily water intake of 4.92 cups. The teens used this data to advocate for water refilling stations with positive outcomes from the local school board.

3. Mitigating Zoonotic and Animal Disease Risks in 4-H Animal Science Projects through Coordinated Education and Research project.

Abstract:

This community-based science intervention engaged youth aged 9-15 enrolled in 4-H Animal Science projects in 11 counties in California. The focus of the project was to improve knowledge and skills related to biosecurity, and apply what they learned to risk mitigation projects in authentic settings. The majority of youth worked on projects on their home premises including making changes to animal housing and care to reduce disease transmission risks. Youth from two county 4-H programs (Yuba/Sutter and Santa Cruz) worked on community-based projects with local county fairs, including performing a biosecurity risk assessment and presenting their findings to fair administrators. These youth also made science-based recommendations for changes in fair policies and practices as they pertained to protecting animal and human health. As a result of the youths' involvement, numerous improvements were made at both fair locations. This project successfully strengthened partnerships between county 4-H programs and fair management.

4. The California environmental DNA "CALeDNA" program

Abstract:

California has the highest biodiversity of the mainland United States, and has extraordinary levels of endemism across many different biomes and unique ecotones. In 2017, the University of California Conservation Genomics Consortium launched the California Environmental DNA program (CALeDNA) that engages community scientists to obtain samples for eDNA acquisition, metabarcode sequencing, data exploration and analysis. The open platform allows the public and researchers alike to critique eDNA as a community ecology tool and as a biodiversity baseline enabling easy monitoring of environmental change. Now with a network of a dozen academic institutions and museums, with over 700 volunteer participants, the CALeDNA program serves as a novel education tool connecting public-academic partnerships. Here, we assess the structure of CALeDNA that allowed it to be successful and a potential model for future biodiversity research initiatives.

5. The Process and Benefits of Engaging Stakeholders in Program Evaluation and Camp Research

Abstract:

Engaging stakeholders in evaluation data is an important yet often difficult task. For the last three years, a team of 4-H volunteers, staff and academics have explored the impact of California's 4-H camping program on youth and teen leaders. Volunteers and non-academic staff in the field informed the study design, collected data, and engaged in data analysis through "data parties." Their participation led to their deeper understanding and buy-in to the data, and provided insight to those on the research team concerning findings. Since 2016, participation in the study has grown from 7 to 18 sites. This paper describes the benefits of stakeholder involvement in studies and how to engage them in the research process. It presents new tools for sharing data and creating conversation with lay audiences (data parties), and also presents findings from the last two years of the statewide 4-H Camp Evaluation.

6. The California Ecosystem Management Database: enhancing data access and synthesis by integrating data from managers and researchers.

Abstract:

Working landscapes are expected to deliver multiple ecosystem services, but we have limited understanding of how to manage for multiple services, especially at the site-specific level. Designed with diverse stakeholders, the California Ecosystem Management Database is a depository for management and research trials in California's grasslands and oak woodlands. Management plans can be informed by searching for similar projects based on location, goals, management, and/or site conditions, and assessing the successes and failures of these projects.

Scientific syntheses will drive a decision support tool that (1) prescribes site-specific management for suites of goals, and (2) maps how sites vary in their potential to deliver multiple services. This project has provided insights into how site conditions and management practices influence the effects of drought on vegetation production and composition. It also has shown how site conditions and spring rainfall influence the potential to control for the noxious weeds goatgrass and medusahead.

7. Engaging Community Scientists in the Management of an Invasive Marine Pest

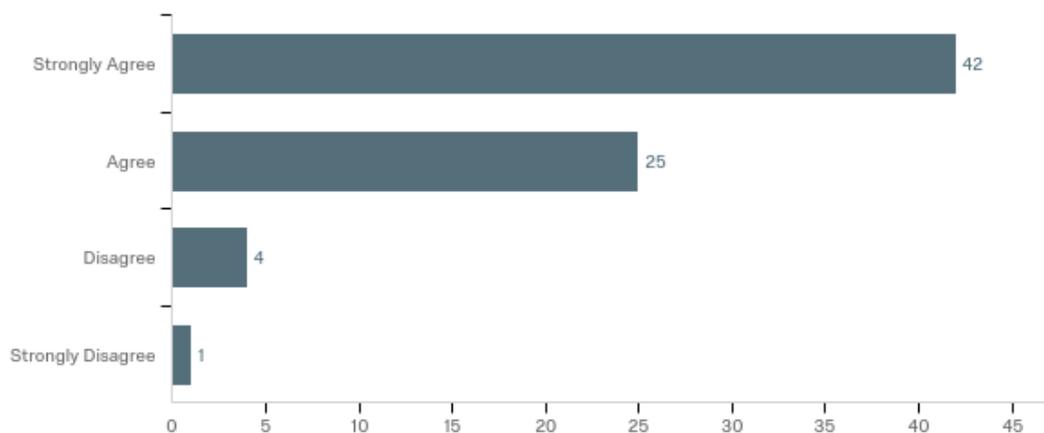
Abstract:

Biological invasions are widespread in the coastal waters of the United States resulting in significant negative impacts on both aquatic ecosystems and human economies. Attempts to manage invasions once established are often costly with few examples of successful eradication. In many cases, high profile invasions can be controlled or contained within specific geographic boundaries using relatively simple methods. However, the ability to maintain long-term projects that require this level of management often require considerable human effort even if the other costs are modest. The ability to engage local community members as volunteer participants in this management process can add substantial to the capacity of these efforts making them sustainable over much longer time periods. Here we describe a case study involving the participation and now the management of a volunteer community scientist project that has controlled the invasive European green crab in Sadrift and Bolinas Lagoons in western Marin County, California, USA. Initially this project was federally funded and staffed by academic scientists, but throughout the project has involved substantial participation by community members. These community scientists were involved in primary data collection and other removal activities, but also other aspects including providing working space, disposal (composting) of post-removal crabs, etc. The project had strong learning component aimed at educating community members about the problems caused by invasive species, what to do about them and how to avoid contributing to their spread. The community volunteers also added considerably to this effort by multiplying the education capacity of the project. The result was that over a nearly ten year period, many dozens of local community members participated in this project, which resulting in a 70-80% reduction in the invasive green crab population in this lagoon. This reduction in the predator population resulted in significant improvement in ecosystem function including the return of several native species. One community member, who works for a local resource agency, has now taken over the management of the project on a volunteer basis. This community project manager is committed to continuing to engage local community members in project activities and to maintain the project and its goals for the foreseeable future.

Appendix B. Survey Results

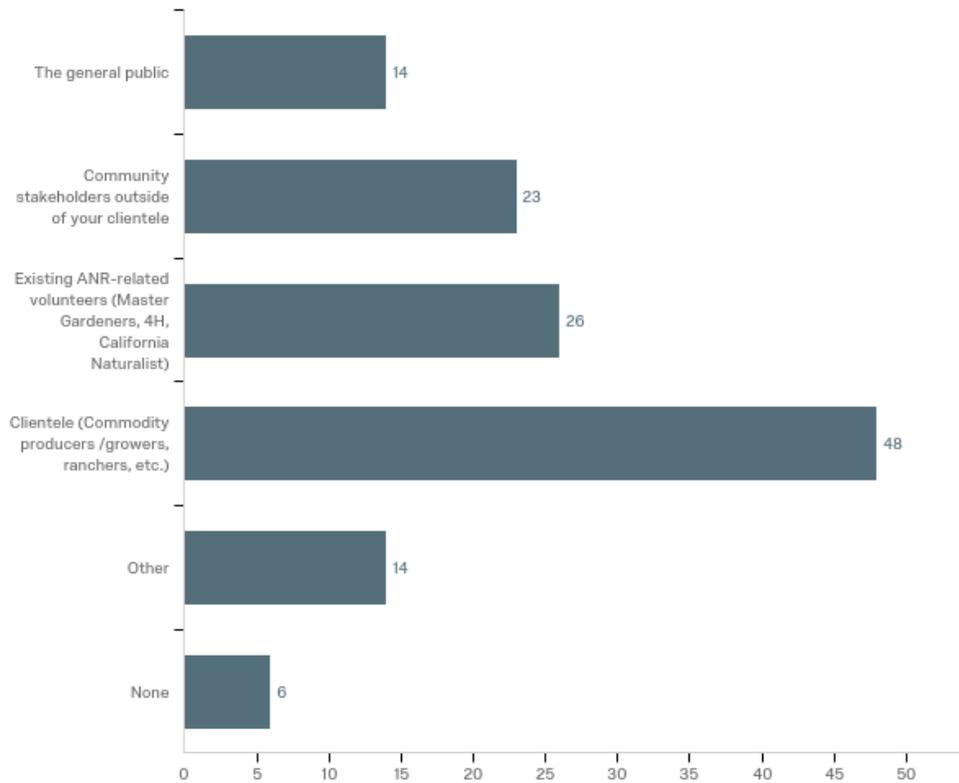
To gather a broader range of opinions and input than could be gathered from interviews, we developed a survey to capture input and ideas during the ANR Statewide Conference that took place in April, 2018. In order to maximize participation during a busy time, the survey was kept very short, and was designed to gather additional qualitative information to supplement the interviews. The survey was advertised via Twitter, emails to the ANR community of specialists, advisors, and other personnel, flyers posted at the Statewide meeting, and word of mouth. We ultimately received 74 responses, which can be used to understand perspectives across ANR, but cannot be broken down across roles, disciplinary backgrounds, or other demographic factors. A more systematic and detailed survey, targeting questions of specific interest to ANR leadership, could be a useful next step if more depth is desired.

Q1 - Do you agree or disagree with this statement? “I think involving volunteers (e.g., the public, ANR clientele, other groups) as active participants in the research process (beyond being research subjects, advisors, or recipients of research results) is a good idea.”



#	Answer	%	Count
1	Strongly Agree	58%	42
2	Agree	35%	25
3	Disagree	6%	4
4	Strongly Disagree	1%	1
	Total	100%	72

Q2 - Which groups do you collaborate with on research (i.e., as more than research subjects, advisors, or recipients of research results)?



#	Answer	%	Count
1	The general public	11%	14
2	Community stakeholders outside of your clientele	18%	23
3	Existing ANR-related volunteers (Master Gardeners, 4H, California Naturalist)	20%	26
4	Clientele (Commodity producers /growers, ranchers, etc.)	37%	48
5	Other	11%	14
6	None	5%	6
	Total	100%	131

Other

Other - Text

Mostly other Extension colleagues internal and external to ANR.

students outside the sciences

UCCE and affiliates, farmers, commodity board, there is basically a built in system for me

Schools, students, teachers

CRFG

Local rose society club members

Faculty at uc or other institutions

state agencies and nonprofit organizations

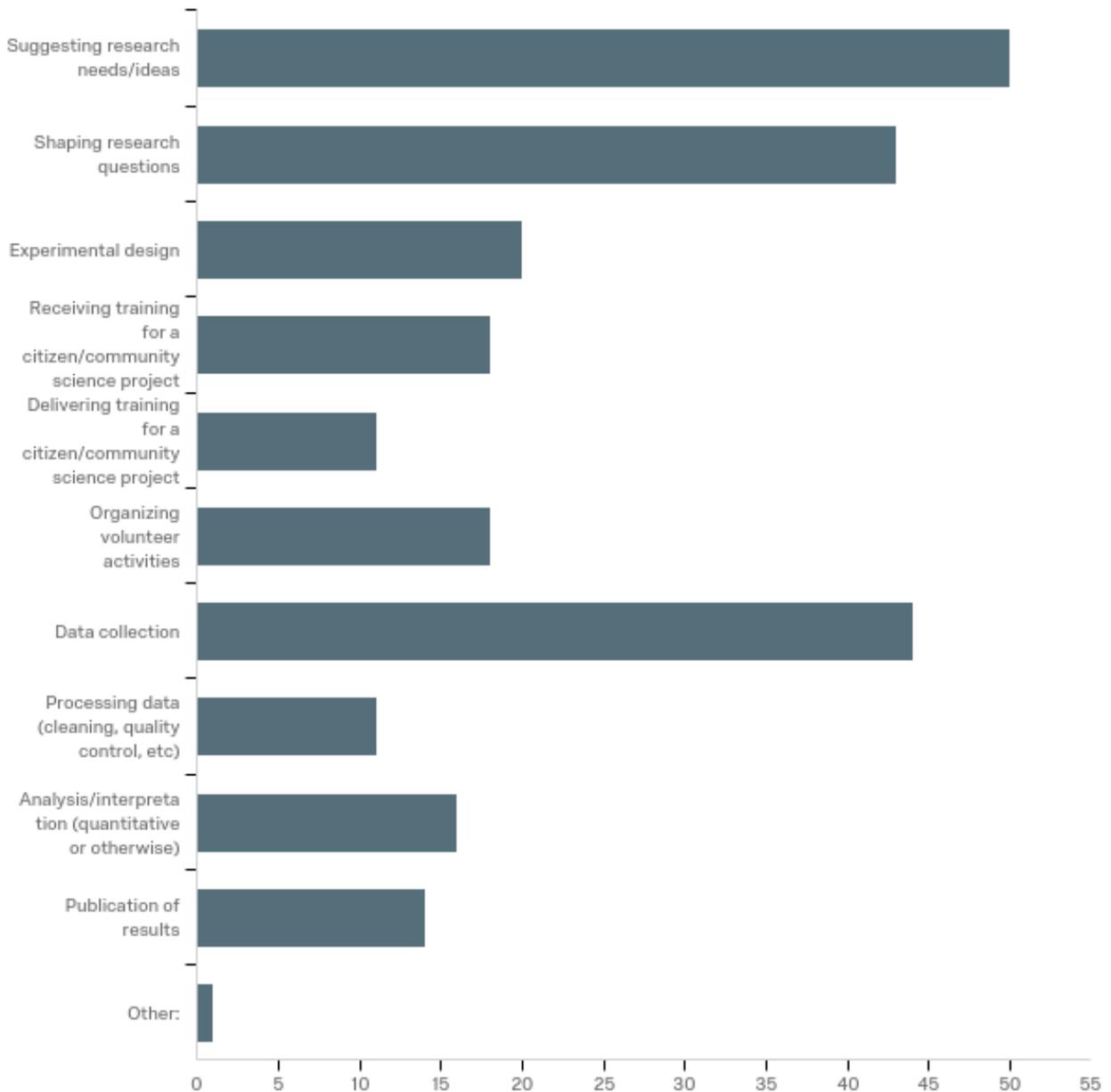
UC Extension office

REgulatory agency personnel

University partners from other states

it all depends on the project or issue

Q3 - In those collaborations, what activities have participants have been involved with? Check all that apply.



#	Answer	%	Count
1	Suggesting research needs/ideas	20%	50
2	Shaping research questions	17%	43
3	Experimental design	8%	20
4	Receiving training for a citizen/community science project	7%	18

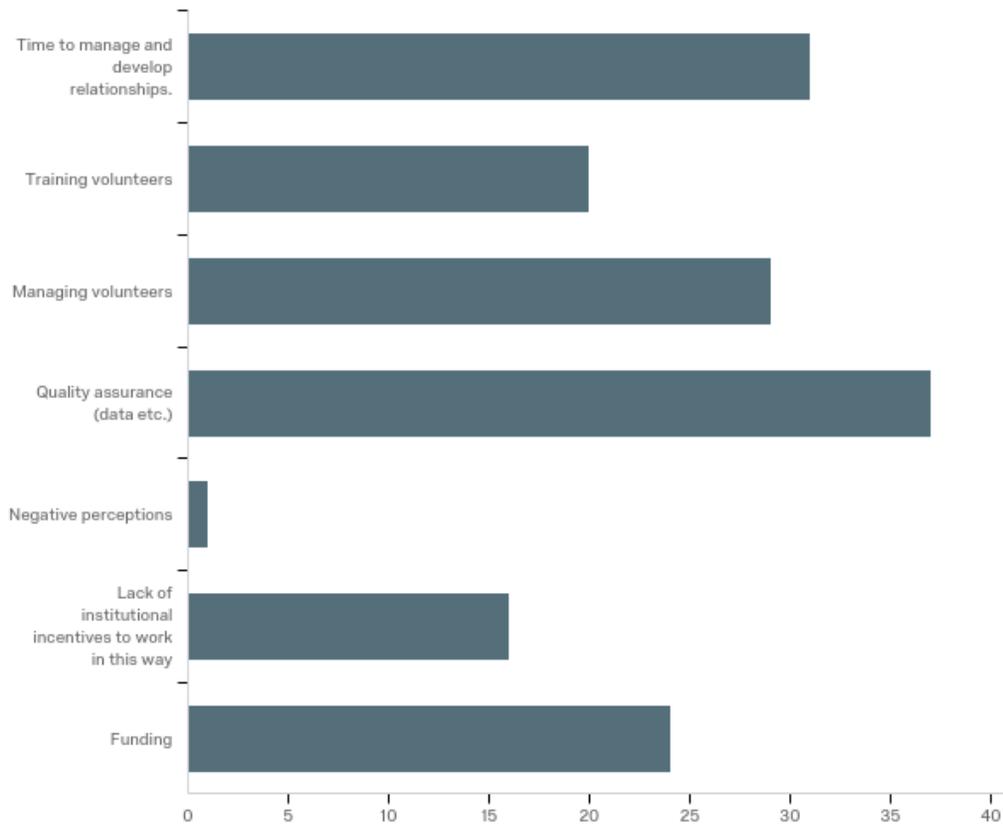
5	Delivering training for a citizen/community science project	4%	11
6	Organizing volunteer activities	7%	18
7	Data collection	18%	44
8	Processing data (cleaning, quality control, etc)	4%	11
9	Analysis/interpretation (quantitative or otherwise)	7%	16
10	Publication of results	6%	14
11	Other:	0%	1
	Total	100%	246

Other:

Other: - Text

Farmers often help direct my research program and they often help establish plots - for example, they plant the cover crop, they manage the field, they do not collect the data, analyze the results or publish

Q4 - What do you think are the biggest obstacles to involving volunteers in ANR research? (Check up to 3 options).



#	Answer	%	Count
1	Time to manage and develop relationships.	20%	31
2	Training volunteers	13%	20
3	Managing volunteers	18%	29
4	Quality assurance (data etc.)	23%	37
5	Negative perceptions	1%	1
6	Lack of institutional incentives to work in this way	10%	16
7	Funding	15%	24
	Total	100%	158

Q4a - Any other obstacles to mention?

Any other obstacles to mention?

Funding institutions expect objectives to be met. Can't change those objectives to comply with a volunteer. However could use as basis for next grant

Time is the major obstacle.

Poor data collection if it is done incorrectly. For example, some of the citizen-science studies I've seen are biased because the citizens that volunteer or respond have a predeveloped idea of what the results should be

Projects may require technical skills that volunteers are unlikely to possess

Didn't know these volunteers were available?

Lack knowledge, skills, education, training

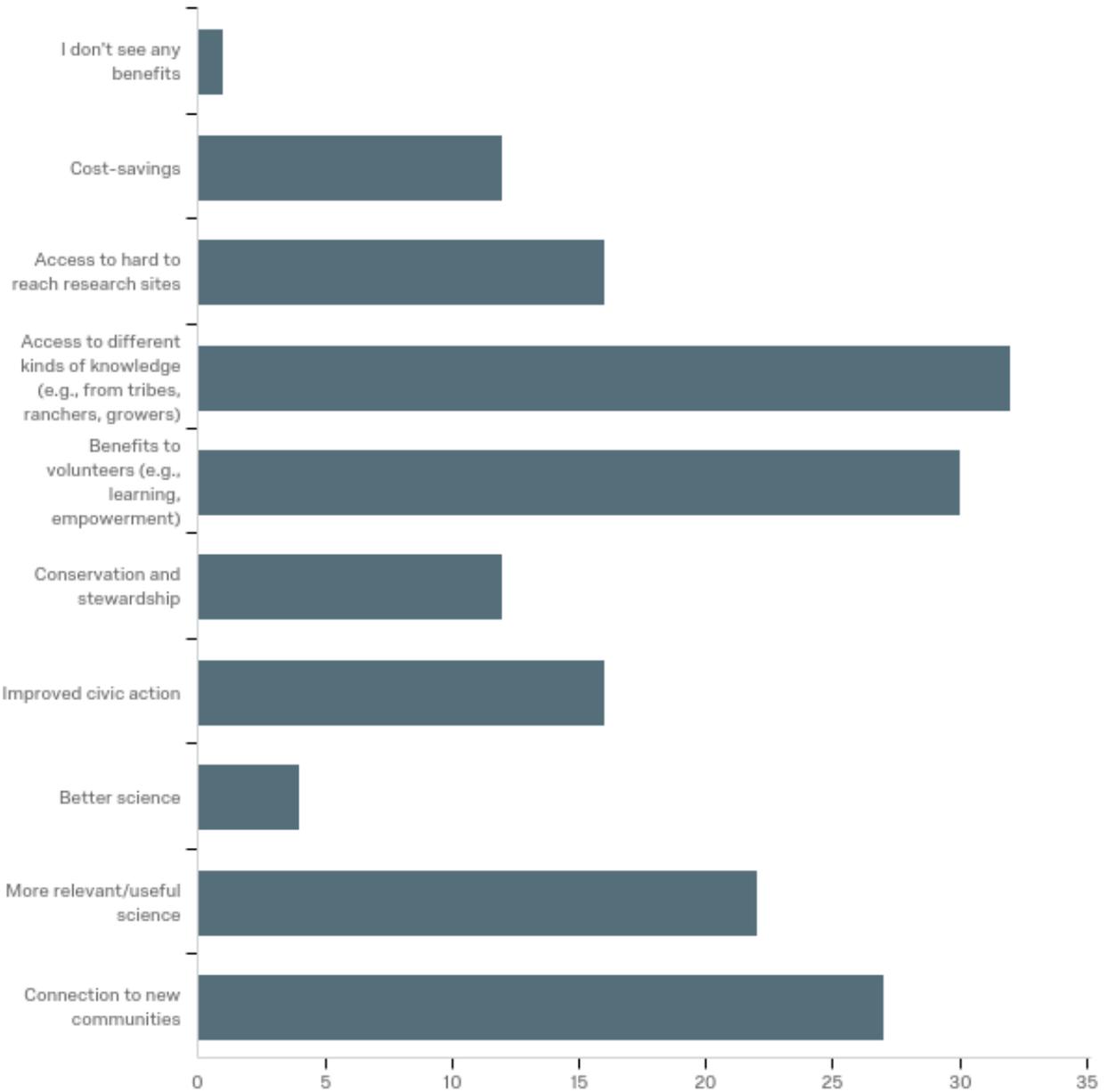
Large commercial and well established growers are not interested in this type of activities. Newer communities sharing a common problem are more willing to collaborate in the fashion.

Current volunteers are maxed out. Prospective volunteers would need training

All are issues, but not if proper training and instruction is provided

reliability of volunteers- its hit and miss

Q5 - What do you see as the most important benefits, if any, associated with citizen and community science? (Check up to 3 options)



#	Answer	%	Count
10	I don't see any benefits	1%	1
1	Cost-savings	7%	12
2	Access to hard to reach research sites	9%	16
3	Access to different kinds of knowledge (e.g., from tribes, ranchers, growers)	19%	32

4	Benefits to volunteers (e.g., learning, empowerment)	17%	30
5	Conservation and stewardship	7%	12
6	Improved civic action	9%	16
7	Better science	2%	4
8	More relevant/useful science	13%	22
9	Connection to new communities	16%	27
	Total	100%	172

Q5a - Any other thoughts about benefits (or lack thereof)?

Any other thoughts about benefits (or lack thereof)?

All depends on the volunteers.

better informed public, increase in science literacy

Buy-in for program improvement (in relation to program evaluation research)

Opportunity to educate citizen about science literacy

More appreciation for ucce research efforts

increased public awareness (citizen science as quasi-outreach on behalf of the organization / science awareness)

Appreciation by clientele of reserch conducted locally

Working with the local famers and community scientists will have bigger impact than working alone or with folks who arent local. Someone from Kansas may not know specifics of area (soils, temps, pests, local reg's, etc) or have trust from locals.

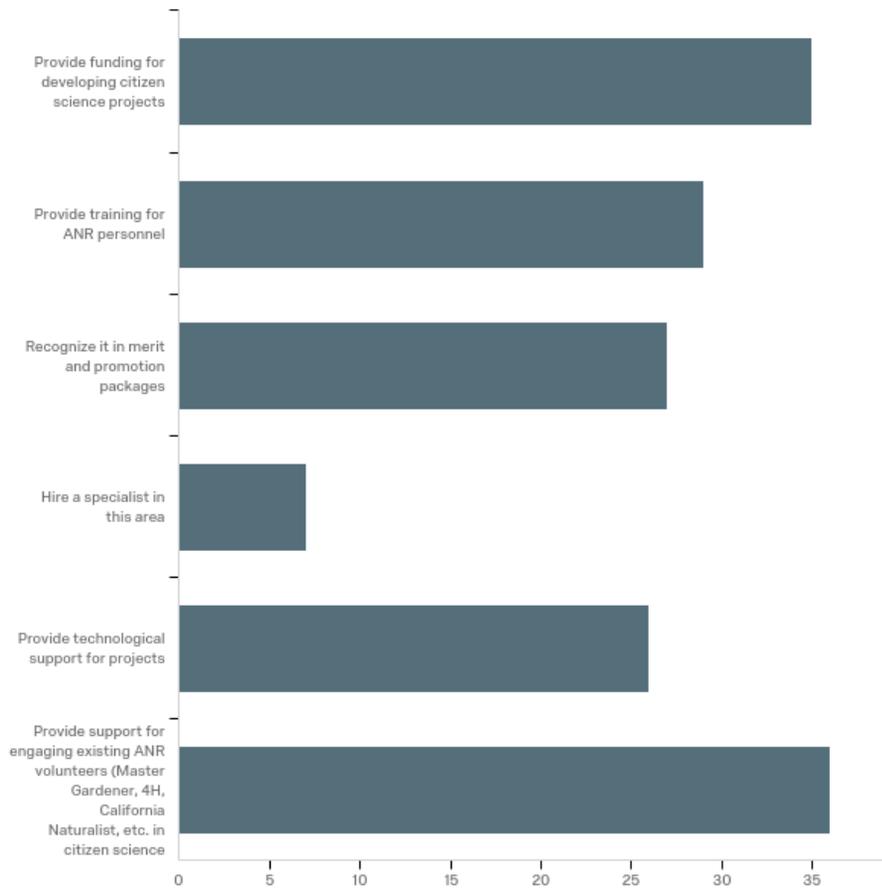
Magnifying the reach of research (many more people, many more sites, bigger view)

Muliplier effect of getting the word out

Larger data set

Developing relationships. The data is often not usable.

Q6 - What can ANR do to more effectively support citizen and community science in alignment with its mission (Check up to 3 that you think would be most effective).



#	Answer	%	Count
1	Provide funding for developing citizen science projects	22%	35
2	Provide training for ANR personnel	18%	29
3	Recognize it in merit and promotion packages	17%	27
4	Hire a specialist in this area	4%	7
5	Provide technological support for projects	16%	26
6	Provide support for engaging existing ANR volunteers (Master Gardener, 4H, California Naturalist, etc. in citizen science)	23%	36
	Total	100%	160

Q7 - Any additional comments? Any initiatives you want to make sure we know about? What communities should be participating in community and citizen science at ANR? Email us at rmmeyer@ucdavis.edu or submit your response below.

Any additional comments? Any initiatives you want to make sure we know about? What communities should be participating in community and citizen and community science at ANR? Email us at rmmeyer@ucdavis.edu or submit your response below.

There is a proposal in Temecula Valley to train high school students that are autistic to look for a pests in the vineyards.

Is this the new terminology for community action research and participatory action research where objectives are driven by

I can see this being useful for community mapping projects (health/unhealthy environments)

I've heard of the push to hire a citizen science specialist but I don't like this idea because it is a tool rather than a discipline of study. So that Specialist would always follow another's research path rather than develop the questions.

How can our volunteers (specifically CalNat) be "catalysts" or "facilitators" to better connect and more systematically and meaningfully engage the public in Citizen Science

We have initiated the California Master Beekeeper program as well. I have just started a new project with a small subset.

Already recognized in ANR merit and promotion process if candidate effectively communicates activity, outcomes and impacts.

Farmworker communities are important recipients of these types of programs. I worry that efforts would be focused primarily in urban areas because of ease of access

no

I work with pest and diseases and the best approach is an area-wide management. The involvement of the community is crucial to achieve success in managing some pests and diseases.

There a lot of existing well-developed citizen science projects that might be already useful to ANR academics if they knew about them rather than coming up with new efforts.

It works well when citizen scientist projects are intimated at the state level and volunteers, youth and the community is invited to participate.

invasive species detection - very helpful to have eyes out there

We basically need to recognize the value of members of our community and tap into their interests in science

This survey is written with a bias to support community science