Citizen Science and Scientific Authority: Have You Checked the Boundary Work?

E. CAROLINA MAYES ⓘ

ABSTRACT

This article uses the sociological concept of boundary work to evaluate how epistemic authority is performed in citizen science initiatives. Drawing on two case studies of boundary work in practice, first in the ecosystem of science journalism before and during the pandemic, and second through the Virginia Tech team's analysis of their experience in Flint, Michigan, I demonstrate how the legitimacy of citizen science is powerfully shaped by the perspectives of professional or credentialed experts. I argue that demarcations of credibility are an omnipresent but often unacknowledged force in citizen science, and that the meaning of credibility is often dictated by the norms and standards of dominant or mainstream scientific cultures. Recognizing performances of boundary work can reveal how epistemic exclusion is enacted in citizen science, as well as how contradictions or crises of credibility become exacerbated when the social relations of expert authority shift. In conjunction with other recent proposals to expand the terminology and institutional recognition of citizen science, I suggest that scholars and practitioners of citizen science could benefit from reflexive analysis of epistemic exclusion.

CORRESPONDING AUTHOR:

E. Carolina Mayes

University of California San Diego, US

emayes@ucsd.edu

INTRODUCTION

As a concept, citizen science is a bit of a paradox. In one sense, citizen science is a movement advancing the argument that science is not exclusively the domain of credentialed experts. Simultaneously, however, the distinction of "citizen" science suggests that work performed by uncredentialed actors is separate from or even unequal to "science" proper (Eitzel et al 2017; Trejo et al 2020). Like Shapin and Schaffer's (1985) classic demonstration that the public witnessing of experimental science was in fact extremely exclusive, citizen science occupies a strained space of epistemic egalitarianism and restriction. Citizen science promises to deconstruct the boundaries between experts and the public, but the structure and validity of citizen science projects are powerfully shaped by the expectations and standards of expert institutions. Citizen science is, in fact, a product and performance of scientific boundary work.

The framework of scientific boundary work has been used to understand how scientists create distinctions between legitimate and illegitimate scientific knowledge and practice, within disciplines and between "scientific" and "pseudoscientific" ideas (Gieryn 1983; 1999). As others have shown, the very premise of citizen science is dependent on the boundaries of scientific professionalization, from which the distinction between credentialed experts and an unexpert public became meaningful (Mahr and Dickel 2019; Strasser et al 2019). Contemporary analyses recognize the constructed distinction between experts and imagined lay publics, and the questions motivating citizen science inquiry today are less concerned with whether un-credentialed actors can contribute to scientific research. The more complicated boundary negotiations taking place at present contend with when, how, under what conditions, and with what recognition such contributions can take shape. These questions are recurrently unsettled in part because boundary work is dynamic; the boundaries of science are never rigid or final, but context-dependent and subject to continuous renegotiation. But these questions are also powerful performances of epistemic inclusion and exclusion, because they demand decision-making about expertise: what it is, who has it, how it can be recognized, and crucially, who or what determines its substance, presence, or absence.

In this essay, I argue for a greater awareness of the presence and role of scientific boundary work in citizen science, specifically in the ways that epistemic authority is performed and perceived in language and action. I focus on the function of boundary work as a performance of authority, such that claims of expertise and authority can also be claims of the right and responsibility to gatekeep scientific credibility and legitimacy. My purpose here is not to argue against determinations of credibility and legitimacy, but to bring attention to how authority and expertise are not neutral or inherent qualities, but social relationships imbued with power (Epstein 1995). I contend that understanding how the authority of credentialed and institutional actors shapes the epistemic inclusivity of science might enable more generous, and at minimum more transparent, collaboration and communication between mainstream and citizen sciences. I present a discussion of boundary work in two contexts, representations of citizen science in science journalism and the reflections of professional collaborators in the Flint water crisis response, to illustrate how mobilizations of authority concomitantly make claims about whose perspective, experience, or expertise is scientifically valid.

EPISTEMIC IN/EXCLUSION

Determinations of expertise are exceedingly consequential issues in our present social and political moment. However, we cannot dismiss all critiques of expertise as fundamentally motivated by an attempt to establish alternative facts or to destabilize trust in knowledge. The more complicated but necessary conversation to be had is to discern how the interactions between institutional power, expert authority, and citizen or non-professional science generate epistemic exclusion. The issue posed by boundary work is also a function of its inherent purpose: to advocate for certain ideas, practices, and methods as legitimately scientific, and to suggest, if not outright argue, that others are not. This demands that we pay particular attention to how credibility is established and who or what adjudicates credibility within the larger ecosystem of scientific knowledge.

Sociologist Gil Eyal has argued that expertise is more accurately understood as a property of a collaborative network rather than a possession of credentialed experts (Eyal 2013). This approach offers a much more inclusive perspective on the roles of non-professional actors in contributing to and maintaining the authority of expertise, but it understates the extent to which institutional and academic actors set the norms of scientific legitimacy. As an example, Steve Epstein's work on AIDS activism (1995; 1998) demonstrates that non-credentialed actors can establish themselves as experts in their own right. However, Epstein's analysis also makes it clear that the activists' lay expertise did not level the epistemic hierarchy between biomedical and other forms of knowledge. Getting in the door of biomedical institutions, and keeping a seat at the table, necessitated that activists learn and adopt

the language and debates of biomedicine (Epstein 1998). More significantly, the larger landscape of patient and health advocacy movements present today demonstrates that patient groups have been able to keep the door open by continuing to negotiate their credibility. Activism that works within the epistemic playing field of science and medicine, rather than against it, may more easily establish the credibility of their perspectives (Rabeharisoa, Moreira, and Akrich 2014).

This observation is especially consequential in the context of citizen science because contests of credibility do not take place on a neutral playing field, but one that is "affected by existing, already constructed features of the social world" (Kinchy and Kleinman 2003, pg. 881). Citizen science is emerging in an epistemic landscape highly shaped by the infrastructure and "authorized discourse" (Buchanan 2017, pg. 529) of professional fields and institutions. The norms and standards of scientific institutions can play a "boundary-policing role" (Ottinger 2010, pg. 246) in citizen science projects, and inadvertently reduce social justice movements into projects of generating credible evidence (Kimura and Kinchy 2016). Credibility itself is not simply judged by standards of evidence, but is refracted through the social position and power of who is presenting the evidence, where racial and gender identity remain highly salient (Pereira 2019).

My point here, again, is not to suggest that scientific norms and standards of evidence are flaws that need to be eliminated. I emphasize the imbalance of power in professional and non-professional performances of scientific credibility to underscore the meaning and limitations of epistemic inclusion. In their paper introducing the concept of "tracking science," Liebenberg and co-authors (2021) explain the term as a means of recognizing and including the extensive knowledge of indigenous communities. The metaphor of "tracking," they argue, helps extend validity to the epistemic structures of indigenous knowledge and sets aside the exclusionary, nation-based connotations of "citizen" science. My proposal is that our interrogations of citizen science and scientific authority need to go deeper, and contend with how epistemic exclusion takes place and what forms of knowledge it limits.

In what follows, I discuss two examples of the contexts and consequences of boundary work in biomedical and human health citizen science projects. My aim in these discussions is to describe how boundary work takes place within citizen science projects and the larger social environment surrounding them, and to demonstrate what I argue to be underappreciated points of epistemic tension. These examples of unresolved and ongoing boundary negotiation reflect divergent ideas about how non-experts can, should, and do participate in the production and

revision of expertise. But these examples also indicate the more expansive role of boundary work as a performance of expert authority, even when consensus is absent, by demonstrating how scientific knowledge is afforded credibility in reference and deference to credentialed and institutional perspectives. In my first case, I discuss performances of boundary work in representations of citizen science in science journalism. I contrast findings from a pre-pandemic analysis (Mayes, forthcoming) with Sonja Erikainen and Ellen Stewart's (2020) analysis of journalism in the early months of the COVID-19 pandemic to illuminate how non-expert participation in health research and public health responses is contradictorily portrayed as beneficial and dangerous. These contradictions, I suggest, reflect professional and mediated doubt about the legitimacy of certain actions and knowledge claims, and unarticulated tensions between the expected or acceptable roles of non-experts in scientific processes. My second case reviews analyses of the Flint, Michigan collaboration by two members of the Virginia Tech water testing team, Siddhartha Roy (Roy 2017) and Marc Edwards (Roy and Edwards 2019). I reconstruct their arguments concerning the loss of trust among Flint residents as an example of institutional betrayal and informed refusal. I draw upon Gwen Ottinger and Phil Brown's studies of social movement science to consider how disconnect between residents' embodied experiences and federal water safety standards may have foreclosed an opportunity for epistemic inclusion. I conclude with an invitation to emphasize, not disguise, the boundary contests of citizen science.

MISSING EXPERTS OR MISTAKEN PRACTICES? CREDIBILITY AND CONTRADICTION

Science communication is a central environment of boundary work (Bucchi 1996; Gieryn 1999). Journalism and other forms of public-facing media are shared spaces between media actors and scientists; scientists may "turn to the public" via media to argue for or against a particular idea or issue (Bucchi 1996), and media sources regularly approach selected experts for input on subjects. However, journalism does not simply disseminate information from experts outward; media actors are central mediators of topics, perspectives, and framings (Briggs and Hallin 2007; Hallin et al 2013; Hallin and Briggs 2015). Moreover, audiences are not simply passive recipients of information. In the context of health communication specifically, information is intwined with expectations concerning its utility and expectations concerning individual behavior (Briggs and Hallin 2007). Rhetorical characterizations of

engaged or informed patients position individuals as active and capable agents in medical encounters (Timmermans 2020).

The synergistic nature of science journalism is therefore especially useful for situating how non-expert credibility is discursively constructed in conjunction with messaging about individual empowerment and responsibility, and for identifying who is positioned as a voice of epistemic authority. My discussion here makes use of two sources: a discourse analysis of 51 articles discussing citizen science in general-audience news publications (2010–2019) (Mayes, forthcoming), and another discourse analysis of 290 news articles addressing do-it-yourself COVID-19 responses (February 2020–March 2020) (Erikainen and Stewart 2020). Both analyses highlight contradictory valuations of non-expert credibility: discussions are caught between competing positions of praise and skepticism, sometimes celebrating and sometimes condemning actions and ideas taking place outside of mainstream or traditional science. This is true even when the actors discussed are recognized experts or credentialed professionals themselves engaged in non-traditional research processes, indicating both the normative and performative nature of credibility. However, critiques of credibility can themselves exist in contradiction to the larger social context of expert credibility, performing or attempting to perform boundary work when the authority of scientific institutions themselves is in question.

A first example is the framing of patients and citizen science participants as personal health experts. In my analysis of citizen science in popular news media (Mayes, forthcoming), I describe three ways in which the knowledge or activities of citizen scientists was framed in relation to institutional networks of expertise: a subservient frame, a corrective frame, and a normative frame. While in the subservient frame, citizen science was subsumed within institutional and academic structures of epistemic authority, the corrective frame described citizen science as a needed revolution for scientific and biomedical research. In the corrective framing, patients and non-professionals were specifically and repeatedly described as experts in their own right, and identified as "missing" contributors whose insight was needed to advance biomedical knowledge (Carlson 2016). The corrective framing, in other words, represented citizen science as an epistemic expansion, bringing absent or underutilized knowledge from affected individuals into the larger network of expertise.

Importantly, however, in all three framings and throughout the entire dataset, perspectives of professional and institutionally affiliated experts dominated the discussions of citizen science; quotations from scientific experts outnumbered those of adult citizen scientists nearly 5:1 (Mayes, forthcoming). Perspectives from non-

professionals never appeared as the only quoted voices in an article, while the reverse was true in 15 of the 51 publications. The greater influence of professional perspectives was not just quantitative, however; the normative frame made clear that corrective citizen science was constrained by professional perspectives of credibility. Although lay individuals were characterized as "experts" in their personal health, their expertise was implicitly and explicitly framed as valued and legitimate when it conformed to or was made tractable within the norms and standards of institutional or academic science. Normative framings portrayed "epistemic deviations" (Mahr and Dickel 2019) in citizen science as questionable or straightforwardly dangerous ventures. Do-it-yourself (DIY) biology movements in particular were critiqued as opportunities for non-professionals to exercise too much epistemic freedom, featuring hypothetical examples of individuals going "too far" with self-experimentation (Jorgensen 2016) or even bioterrorism (King 2012). In cases where citizen science lacked proximate professional oversight, most notably participatory microbiome testing, audiences were repeatedly cautioned to exercise patience and not pursue individual interventions. Researchers spoke of the need to "manage expectations" about their findings even when they acknowledged making personal health changes themselves (Pollan 2013).

Erikainen and Stewart's analysis brings the normative role of scientific boundary work into even sharper relief against the higher stakes of an ongoing public health crisis. Their article traces how media outlets became central mediators of the credibility of DIY coronavirus interventions, by raising questions concerning the validity or efficacy of different practices and by bringing forward perspectives from professional and credentialed experts. In the panicked early months of the pandemic, individual and community efforts to DIY scarce protective materials like sanitizer and face masks or to experiment with potential treatments received considerable media attention and criticism. Although knowledge about the novel coronavirus and appropriate preventive mechanisms was both limited and uncertain, media outlets routinely mobilized credentialed experts and specialists to comment on the credibility of DIY activities, often through speculation about their safety and efficacy. As they describe, DIY efforts were alternately praised for their ingenuity and criticized for "dangerous kinds of self-initiative" (Erikainen and Stewart 2020, pg. 6). DIY biology and biohackers again received specific attention for developing tools and technologies that couldn't be verified according to professional standards of safety and evidence.

Where in my analysis the underlying tension primarily concerned the juxtaposition between "missing" lay or patient experts and professional standards of expertise,

here the contradiction lies in the contrast between the motivating factor behind DIY responses and the reaction to the responses themselves. As they describe, the DIY initiatives addressed in this media coverage emerged in reaction to "perceived insufficiencies in state pandemic responses" (Erikainen and Stewart 2020, pg. 10). While the larger DIY biology movement is tightly linked to ideologies of independence, anti-elitism, and self-reliance (McGowan et al 2017; Giordano 2018; Erikainen 2022), in the pandemic, DIY also became a way to make up for apparent institutional failures. The stakes of the contradiction are therefore far more pronounced, as mediations of non-expert credibility take place in an environment where expert credibility is also in doubt.

When state agencies or institutions are perceived as ineffective or failing in their roles, particularly in matters of public health, a "credibility gap" (Epstein 1995, pg. 411) may form. Credibility gaps bear witness to the instability of scientific authority: Like expertise itself, authority is not an intrinsic quality of experts, but a relationship mediated by expectations, utility, dependency, and power. The pandemic's present epistemic landscape is not devoid of expert authority – the advocacy networks of those affected by "long COVID" are a clear example of how patients have fought for biomedical recognition and inclusion in expertise (Callard and Perego 2021; Roth and Gadebusch-Bondio 2022). However, studies also suggest that perceptions of the safety and efficacy of COVID-19 vaccines are strongly informed by an individual's confidence in the activities of public health institutions (Lueck and Callaghan 2022). Erikainen and Stewart's analysis demonstrates both how boundary work serves to reinforce expert authority, and how that authority is incredibly contingent on the social relationships that establish credibility. Media solicitations for expert input are as much a part of scientific boundary work as the substance of the input itself; boundary work and credibility are not expert-controlled processes. Nonetheless, the unremarked contradictions apparent in public-facing discourse are missed opportunities for recognizing the nuanced and dynamic pathways by which credibility is asserted and undermined. In the larger ecosystem of science communication, acknowledging the strain between professional norms and non-professional activities or practices could help bridge the credibility gap by making apparent the real stakes, needs, and limitations involved.

EPISTEMIC CONTRADICTIONS AND INFORMED REFUSAL

As Aya Kimura and Abby Kinchy (2016) have previously described, contradictory values can be at work within citizen science initiatives themselves, particularly when initiatives attempt to challenge the narrative or standards of regulatory institutions. Challenges to scientific regulation can encompass boundary work in both directions: Agencies and affiliated actors work to uphold the authority and impartiality of their methods (Kinchy and Kleinman 2003), and social movements work to deconstruct the methods and the value of impartiality itself (Ottinger 2017). Regulatory agencies hold both epistemic authority and state power, however, enabling considerable if not complete control over the rules of engagement for such challenges and influencing the epistemic dynamics within a movement. Community health justice initiatives can foster empowerment and disempowerment, for example, by working to produce counter-evidence of an ecological harm while simultaneously acceding to regulatory standards of documentable evidence. Social movement-based citizen science (Ottinger 2017) may be particularly at risk of internal contradiction because such movements are often motivated by perceptions of scientific absence, insufficiency, or failure. Acceding to the evidentiary standards of a neglectful or discriminatory system may delegitimize the standards and the actors who utilize them, fracturing credibility within the movement if members disagree about how to best make their claims.[1]

In this section, I use the framework of epistemic contradiction to re-situate the "general state of science anarchy" in Flint, Michigan during the water crisis (Roy and Edwards 2019, pg. 1). I make two suggestions: first, that the splintering of scientific credibility among different actors in Flint demonstrates the relational nature of credibility and its particular relationship to state power in the regulatory context. I agree with the perspective taken by Virginia Tech scientists Siddhartha Roy and Marc Edwards that state attempts to ignore the lead problem radically destabilized the credibility of regulatory institutions in Flint, but I also reposition their own reliance on regulatory standards as a mediating factor in subsequent conflicts. Second, I suggest that the atmosphere of mistrust in Flint can be understood more fully by acknowledging the epistemic grounds of Flint residents' responses, which included forms of experiential knowledge that regulatory standards could not assimilate. Rather than "science anarchy," I consider Flint as a case study in contrasting epistemic traditions (Ottinger 2017), where the asynchronous needs of social justice and federal water safety standards could not be reconciled.

Flint residents' collaboration with the Virginia Tech water testing team initially resembled a "popular epidemiology" movement (Brown 1992). Flint residents had reported health issues that they linked to their tap water for months before an initial lead test was conducted. According to Roy and Edwards, resident LeeAnne Walters became the

"Ground Zero" of the lead crisis as she worked to follow up an initial high lead contamination result with further testing and documentation by outside experts (Roy and Edwards 2019, pg. 2). Unlike the ideal typical stages of popular epidemiology, however, the testing evidence seems to have been deliberately squashed rather than disproven by regulatory standards, upending the credibility of state and federal agencies once the crisis came to light. Community water testing performed in collaboration with the Virginia Tech team generated critical new data and successfully drew widespread public attention to the issue, eventually spurring the State of Michigan to switch the water supply and then-President Obama to declare a Federal Emergency. Following the declaration, relief and recovery efforts were formally implemented, civil servants were prosecuted, and citizen scientists monitored the quality of Flint's water through repeat testing. By the summer of 2017, Roy and Edwards report, "Flint's water met all existing federal standards" (Roy and Edwards 2019, pg. 3).

Despite this apparently successful citizen science initiative, Flint residents continued to report health problems they attributed to the water and some residents stated that they considered the water to be permanently unsafe. Regulatory malfeasance in Flint is a paradigmatic example of the socially-embedded nature of credibility, and how it "hinges on the ways that scientists interact with the rest of the social world" (Kinchy and Kleinman 2003, pg. 871). But the fragmentation of credibility in Flint is also emblematic of the power of regulatory agencies and the ways in which scientific standards may constrain citizen science movements. In their recounting of the Virginia Tech team's conflict with the Water Defense testing group, Roy and Edwards write that they felt "ethically obligated to publicly undermine [Water Defense's] credibility" due to the misleading quality of their data (Roy and Edwards 2019, pg. 6). However, Virginia Tech's own efforts to demonstrate to Flint residents that their water met federal safety standards may have played an unseen role in the destabilization of their credibility. Standards can foreclose other ways of seeing the world, or constrain "legitimate" ways of knowing within their own structure (Bowker and Star 1999). Safety standards and statistical measures of risk can further impose outside determinations of significance that may not align with the experiences or concerns of those affected (Brown 1992). Roy and Edwards write, for example, that after the leader of Water Defense publicly admitted to and apologized for misconstruing testing results, certain Flint residents perceived Water Defense as having sold out, literally, to the power and influence of state actors (Roy and Edwards 2019, pg. 16). The credibility of EPA-approved methods and standards was seemingly so

undermined that for some residents, any acquiescence to their legitimacy was an act of betrayal.

That some Flint residents refused, emphatically and repeatedly, to accept the results of any test or to use Flint's tap water again for any purpose is therefore also not fully explained by the respective credibility of federal safety standards, the Virginia Tech team, and Water Defense. Evaluations of risk that are informed by experiences of disaster and multiple marginalization, Thomas Beamish (2001) argues, are not irrational perceptions of vulnerability. Rather, they emerge from the compounded effects of institutional disregard and fear of future harms. Measures of risk produced by outside institutions can be inflected through community-based experiences of deception, neglect, and willful denial, subverting institutional credibility against the situated rationality of community members. This alternative epistemology can in turn take the form of "informed refusal," (Benjamin 2016) or a rejection of the structure of one epistemic tradition through the counter-knowledge of another. Roy and Edwards describe the landscape of epistemic contradictions in Flint as "a populist anti-elitist, 'all opinions are equally valid' anarchist movement that aims to undermine expertise, scientific rigor, and organized knowledge" (2019, pg. 15). Their frustration is palpable and understandable, but also misguided by the expectation that fixing the lead levels would resolve the crisis. Residents' conviction that the water would never and could never be safe is a refusal of the very idea of abstract risk metrics and disinterested expertise.

My analysis is not intended to replace or "prove wrong" Roy and Edwards' explanations of what occurred in Flint. Misinformation and epistemic contradiction can, and unfortunately do, coexist. I advocate for recognizing the contexts in which epistemic contradiction emerges, and to ask what it might look like if overlapping and contrasting forms of knowledge were taken as a given rather than treated as a problem to be solved. Gwen Ottinger has recently argued that citizen science can offer solutions to "hermeneutic ignorance" in regulatory science, but it is incumbent on dominant networks of expertise to accept and make use of missing insights (2022). This demands actual, not just discursive, integration of "missing experts" into the generation of expertise.

CONCLUSION

In the preceding discussions I have explained how boundary work is omnipresent in citizen science, because citizen science itself is a form of boundary work. And because citizen science is an explicit reintegration of

science and society, social and historical knowledge are inherent features of citizen science initiatives – whether or not they are afforded epistemic legitimacy. Citizen science boundary work often signals an awareness of epistemic contradiction, in other words, but professional and institutionally affiliated actors tend to retreat to the authority of the mainstream, academic epistemic tradition.

There have been some calls to reevaluate and expand the epistemic structures of science to actively incorporate non-institutional research practices. In response to the self-experimental work of the Rapid Deployment Vaccine Collaborative (RaDVaC), for example, Christi Guerrini and co-authors advocate for the FDA to establish a dedicated pathway for supporting citizen science research (2020). Lisa Rasmussen and co-authors (2020) similarly advance the need for a "trust architecture" to recognize the validity of DIY science, by acknowledging the codes of ethics DIY communities have self-generated and by working with those communities to establish regulatory standards. And as this essay addresses previously, collaborative citizen science groups like the CyberTracker Conservation network (Liebenberg et al 2021) have proposed a redefinition of citizen science to actively recognize the epistemic contributions of indigenous peoples.

Without detracting from the value of any of these efforts, I nonetheless contend that there is more to be done. I do not think that we can pursue true epistemic inclusivity without addressing boundary work, and without working through how citizen science projects can reinforce epistemic exclusion. This is a tension that warrants our recognition even if, as Bruno Strasser and colleagues argue, there is no unified "thing" that is citizen science (Strasser et al 2019). As my examples demonstrate, there is also no unified thing that constitutes scientific authority, and intentionally recognizing the ways in which we work to delineate credibility or to question it, how this occurs and what is removed in the process, may help academic, citizen scientist, and institutional communities alike work through science skepticism.

I do not think that this would force us into "science anarchy" or require that standards be destroyed. I do think that epistemic inclusion demands that we open the black box of epistemic authority, and ask, as Phil Brown (1992, pg. 275) has, "for whose standards, and by what version of proof is a 'standard of proof' determined and employed?" In short, I suggest that we as academics, experts, and public figures proactively acknowledge how we perform epistemic exclusion, and work to identify the unequal dynamics of state power and expert authority that are concurrently invoked. Boundary work will in all likelihood remain an integral part of science, and no radical change to how we recognize knowledge will

happen quickly or easily. However, paying attention to the boundary work that takes place here and now is a chance for reflexivity, to ask different questions, and to learn what is missing.

DATA ACCESSIBILITY STATEMENTS

The article dataset for Mayes (forthcoming) is available by request of the author.

NOTE

1 Steve Epstein described a very similar phenomena occurring among ACTUP activists over the nature of clinical trial evidence; activists who became more closely aligned with the standards of biomedical professionals were characterized by others as "seduced by the aura of science" (Epstein 1995, pg. 424).

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AUTHOR AFFILIATION

E. Carolina Mayes [ID] orcid.org/0000-0001-8093-3596
University of California San Diego, US

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