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Sharing science through shared values, goals, and stories: an evidence-based approach to making science matter

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Abstract: Scientists in and beyond academia face considerable challenges to effectively sharing science, including lack of time and training, systemic disincentives, and the complexity of the modern media/attention landscape. Considering these constraints, 3 achievable shifts in mindset and practice can substantively enhance science communication efforts. Here, we provide evidence-based and experientially informed advice on how to center shared values, articulate science communication goals, and leverage the power of stories to advance our communication goals in connection with the values we share with our stakeholders. In addition to a discussion of relevant, foundational principles in science communication, we provide actionable recommendations and tools scientists can immediately use to articulate their values, identify shared values between stakeholders, set science communication goals, and use storytelling as a means of building and reinforcing relationships around shared values, thereby working productively to achieve those goals.

Key words: backwards design, evidence-based decision making, goal setting, public engagement, public impact of science, science communication, storytelling, values

While scientists, stakeholders, and society at large often call for evidence-based decision-making, we still tend to expect that someone other than the academic scientist will interpret and apply the science we conduct (Besley et al. 2018, Merkle et al. 2019). This expectation persists despite evidence that engaging in so-called advocacy does not automatically undermine a scientist's credibility (Kotcher et al. 2017). Further, the language of science and the language of sharing science are distinct, deriving from separate objectives and values (Baram-Tsabari and Lewenstein 2013). Importantly, overlooking the role values play in most decision-making can become a liability when sharing science, regardless of our professional role or location within science.

For example, we have a faculty colleague who was invited to present the results of an extensive modelling and mapping effort to inform landscape connectivity for a migratory mammal in the U.S. Mountain West. By invitation of a state management agency, he gave his presentation to a government-appointed task force. After his presentation of stark results about the negative impacts of certain kinds of human developments on the ability of this species to migrate, he listened to public comment in response. Several years afterward, he still regularly tells the story of being shocked (and disheartened) that all the citizens who spoke up were skeptical of the credibility of the research. He recounts that someone stood up and said, "I don't trust models. I trust people. And we know that these animals are just fine."

In this instance, the researcher's goal was to share science that would hopefully be used in a public decision-making process. But his core value—that science is reliable for informed policy making—was totally mismatched with the values of the stakeholders who distrusted research that contradicted their perceptions and personal experience. In such cases, it is counterproductive or even dysfunctional for scientists to rely on scientific norms and jargon (Baram-Tsabari and Lewenstein 2013, Fiske 2018).

Here, we outline an approach to move beyond this chasm of values and toward more productive and meaningful efforts to share science. We emphasize the essential interplay between values, goals, and stories, which are shared between and among stakeholders (Figure 1). We delve into attributes of each of these factors, which scientists can actively work on to build a sense of confidence in achieving shared outcomes with stakeholders. We also provide examples from our experience (primarily in the United States), along with explicit suggestions (Figure 2) and resources (Table 1; Supplement 1) for how to implement the recommendations we share. Though we acknowledge the significant time burden and systemic disincentives that complicate and impede scientists' and practitioners' efforts to share science, we argue that the 3 shifts in mindset and practice we present here can improve the reach and utility of research.

Often, values, goals, and stories interact with one another, rather than being completed in a specific stepwise fashion. Science communication efforts can therefore benefit from these 3 practices:

(1) Understanding both our values and those of our target stakeholders and identifying which values we, as the communicator, share with our stakeholders.

(2) Regularly articulating and reflecting on our goals, as they are informed by these shared values.

(3) Leveraging the power of stories to advance our communication goals in connection with the values we share with our stakeholders.

Indeed, stories can be a tool for uncovering the values of our stakeholders. Further, the stories we decide to share are often based on what our goals are, and these stories can also demonstrate how we share values.

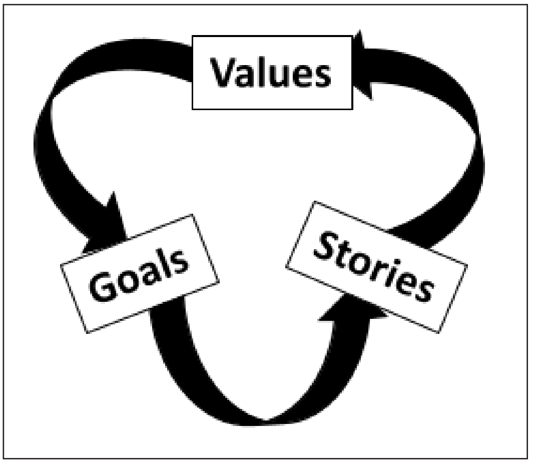

Figure 1. Concept diagram of values, goals, stories interacting together to enhance science communication by scientists.

Key terms in scicomm

As illustrated by our colleague's case above, and recognized widely by international plain language initiatives, jargon (e.g., technical terminology that can be described in more accessible ways) can impede knowledge exchange and convergence on shared values (Plain Language Action and Information Network 2011, Greene 2013, Smith and Merkle 2021). So, before we proceed with our discussion of how to enhance your approach to sharing science, we offer the following working definitions. First, we note that our use of "scientist" throughout this manuscript is inclusive of academic researchers, scientists active in other professional sectors, and science-allied practitioners—essentially, anyone who plays a role in production of and subsequent efforts to disseminate or apply science.

Scientific communication vs. science communication

Within the science communication research and practitioner community, scientific communication (with academic and other field-specific colleagues) and science communication are not considered synonymous (Brownell et al. 2013). The latter is frequently referred to as broader impacts, public engagement or outreach, and the like. We use science communication (scicomm) as an umbrella term for all of these latter efforts, as our focus here is on scicomm aimed at broadly integrating science into stakeholder

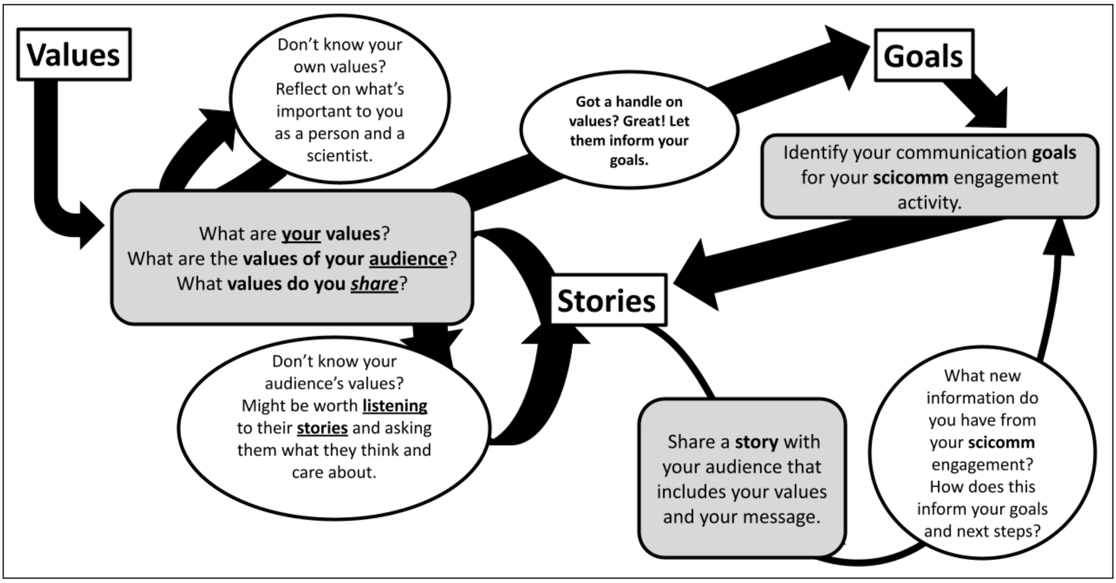

Figure 2. A conceptual flow chart of how to start the process of reflecting on values that inform your goals and how both interact with stories to share science.

environments. These may include arenas such as policy and management, K-12 education, community members, science enthusiasts, etc.

Stakeholders vs. audiences

Similarly, we distinguish between audiences (passive, being talked at) and stakeholders, who are ideally actively engaged with multiple stages of a research and scicomm process. The stakeholder-oriented approach accounts for 2 key considerations: there is no "general public" and the "deficit model" does not work.

Each scientific topic or research endeavor has numerous stakeholder groups with varying needs, interests, and degrees of familiarity with given technical aspects of science. Catching and holding any group of stakeholders' attention, and then effectively sharing our science with them, is a complex challenge. For example, in the United States, there used to be limited media outlets. These were required by federal law to provide factual, balanced coverage of news that was in the public interest. Most of those restrictions have since been overturned or eliminated. Now, we get information from countless sources tailored to increasingly narrow perspectives (Resnik 2011, Scheufele 2014, Iyengar and Massey 2019). Thus, our scicomm efforts must be calibrated to each stakeholder group, rather than an amorphous "public."

We're also faced with "alternative facts," disinformation campaigns, short attention spans, and information overload (Weinreich et al. 2008, Hilbert and López 2011). A growing body of data supports our colleague's experience at that migration task force meeting: people are not persuaded by numbers or facts (Nyhan and Reifler 2010, Lakoff 2014, Kaplan et al. 2016). We are quantifiably more influenced by prior beliefs, social pressures, and convenience (Lidskog 1996, Scheufele 2014). Thus, scicomm efforts must account for the social environments and sociopolitical values of our stakeholders.

Deficit vs. dialogue and co-production approaches to scicomm

What this really means is that traditional, default ways of doing scicomm must be overhauled. The idea that people will change their minds or their behavior if they get enough information is known as the "deficit model" (Simis et al. 2016). As you can imagine, telling people they are wrong or uninformed is not very persuasive (Sambrook et al. 2021). In fact, our brains actively resist information that challenges our sense of identity and understanding of the way we fit in the world (Kahneman 2012). Even the most rigorously trained scientists are driven by these fundamental aspects of human nature.

Instead of hoping that people will make evidence-based decisions if we give them more in-

Table 1. Tools for a more-integrated approach to science communication (scicomm; listed in recommended order of use).

Tool	Source	Citations and links	Aspect of scicomm values-goals-stories triangle
Articulating and acting on values	*Dare to Lead* read-along workbook (pages 30–32) and values worksheet	Brown (2018)	Values
Big-picture goal setting	Angelia Trinidad, Passion Planner	https://passionplanner.com/collections/free-downloads	Goals
Aligning goals with sense of self as a scientist sharing science	Impact identities paper	Risien and Storksdieck (2018)	Values + goals
Determining what kinds of scicomm feel most aligned with your goals and values	Finding your place on the science–advocacy continuum paper	Donner (2014)	Values + goals
Articulating big-picture scicomm goals	This manuscript	See the manuscript section entitled “Articulating and using goals to plan scicomm”	Goals
Choosing and understanding stakeholders	This manuscript	Supplement 1, this manuscript	Values + goals
The Message Box (a straightforward, adaptable worksheet for identifying key aspects of scicomm goals and messages)	COMPASS	https://www.compassscicomm.org/tools-resources/	Goals + stories
And, but, therefore (a simple, powerful story structure)	National Socio-Environmental Synthesis Center	https://www.sesync.org/for-you/communications/toolkit/and-but-therefore-statement	Stories
Tips on telling how to write a personal story about science	The Story Collider	https://www.storycollider.org/writing-your-story	Stories

formation (deficit model), effective approaches involve dialogue (talking with) and co-production (working together) when doing and sharing science (Sloan 2009).

Good scicomm

This brings us to a final definition. We understand good scicomm to be evidence-based, rooted in principles of full inclusion and access to science at all stages, grounded in equity and intersectionality (Canfield and Menezes 2020, Canfield et al. 2020), fundamentally effective in the sense that science has been integrated into the beliefs, values, attitudes, and behaviors of those doing, sharing, and using science, and impacts and outcomes are tracked and assessed. With these definitions in mind, we transition to our delineation and application of the values-goals-stories framework (Figure 1).

Integrating scientific and scicomm identities

Scientists are too often conditioned to keep their personal identities and interests separate from their science (Kosso 1989). Such a paradigm impedes scicomm beyond the academy, since the most efficacious ways of engaging stakeholders require a humanistic approach to other ways of knowing, along with clarity regarding our own motivations for sharing science. Further, such separation ignores the long legacy of science lacking diversity among those who get the privilege to do science at all (Jimenez et al. 2019). It is also unrealistic to strive for full objectivity, as science and scicomm are human endeavors that are informed by the interests and needs of the people participating in them. Indeed, this separation perpetuates the myth of scientific neutrality to the detriment of individual scientists' self-efficacy (Hiles and Hinnant 2014).

A direct and actionable remedy to these persistent, unproductive attitudes about separating science and scicomm is to reframe our scientific identity. By choice, we can actively identify with the impacts of our research beyond our peers as well as within our field. Risien and Storksdieck (2018) provide a robust framework for reconceptualizing our scientific identity to include broader research impacts, which often involve scicomm. Their "impact identity" is "a concept that integrates scholarship in a scientific discipline with societal needs, personal preferences, capacities and skills, and one's institutional context. Approaching broader impacts from a place of integrated identity can support cascading impacts that develop over the course of a career" (Risien and Storksdieck 2018).

Co-author Merkle teaches the "impact identity" in scicomm courses and trainings, and participating students and scientists consistently report that the "impact identity" framework gives them permission to perceive themselves as actively engaged in the production and use of science. We recommend the "impact identity" as an applied framework for instructors, mentors of science trainees, and scientists looking to connect stakeholders to research. It is a valuable tool for science-allied individuals reconsidering their relationship to science and society.

Acknowledging our values as scientists

Once we have given ourselves permission to integrate our scientific efforts with our hopes that our work has some impact in the world, we can acknowledge our own values. Our values as scientists already inform the questions we ask, the type of research we do, and the way we choose to present and describe results (Elliott and Resnik 2014). After all, we are scientists who are also members of society with our own interests, impulses, constraints, and backgrounds.

Using frameworks such as Donner's (2014) science-advocacy continuum and Brown's (2018) leadership values exercises, we can articulate our values. This provides a necessary starting point for determining the types of scicomm we undertake (and why and how). Importantly, as we consider our values, we need not feel alone in doing scicomm—willingness by scientists to share their science beyond academia is increasingly widespread (Besley et al. 2018).

Understanding the values of our stakeholders

Clarifying our values also helps us recognize that others around us may hold different yet complementary values. Self-awareness and transparency about our science-related values can also instill more trust in our stakeholders (Elliott et al. 2017). Considering all this, we can work to account for the many factors at play in others' engagement with science. These include ideology, social identity, and trust, which can each have a strong impact on stakeholders' judgement of science (Choung et al. 2020). Such factors play out in a cascade of values, beliefs, attitudes, and behaviors, with beliefs most closely tied to an individual's identity and thus least changeable (Vaske and Donnelly 1999, Strickland et al. 2021). Understanding how these factors function is crucial to effective scicomm efforts, and Strickland et al. (2021) provide a brief, straightforward discussion oriented to applied science. It is recommended reading.

It is crucial that you design your scicomm efforts around your intended stakeholders. Consider, for example, that what you present at a scientific conference will be grounded in a contribution you are making to the discipline. Meanwhile, what you communicate to a congressional representative will need to be relevant to ongoing policy decisions and likely be framed to resonate with the representative's career and policy needs (American Geophysical Union 2021). Similarly, what you share with a stakeholder group would necessarily apply to their lives and their community. Unquestionably, if you conduct the kind of regional, grassroots efforts that are increasingly common and aim to account for stakeholder values and policy constraints, you will need to move beyond sharing your knowledge to engagement that could include round table discussions, consensus processes, or even conflict mediation efforts (e.g., management of free-roaming equids or migratory native ungulates). These are forums where knowledge, values, and opinions are shared from multiple viewpoints, and stakeholders are critical to policy and decision-making (Rust et al. 2021).

During many scicomm efforts, values intersect with another crucial factor: trust. In the social sciences, the credibility of a communicator is well known to be a function of competence, goodwill, and trustworthiness (McCroskey and Teven 1999). The upshot is that trust in science is generally still high in much of the world but varies by setting (e.g., rural, urban), political and religious affiliation, and specific issues such as vaccines, genetically modified organisms, or climate change (McCright et al. 2013, Krause et al. 2019, Kreps and Kriner 2020). Given this context of widespread but conditional trust that is rooted in individuals' values, scientists must recognize there are also limits to how science can inform decision-making (Sarewitz 2004, Levin et al. 2020). Because working at the boundaries of people's values or comfort levels requires energy and time beyond a conference presentation or a casual conversation with neighbors, good scicomm efforts necessarily require trust-building and an active effort to identify shared values (Weingart and Guenther 2016).

In particular, people have their own knowledge of the place they live, which is critical to any discussion or conversation about ecology. As a result, locally known scientists (e.g., Extension agents, local biologists, or researchers) can be important science information messengers or boundary spanners (Sandmann et al. 2014), if they are trusted in their communities (Knapp et al. 2013). Indeed, trust-based relationships have more influence on stakeholders than does trust in the underlying science (Frerichs et al. 2017).

Who gets to be a stakeholder

And yet, science has an egregious record of overlooking local knowledge and needs. The appropriative, domineering, and even colonial historical context underlying research often goes unaddressed when approaching stakeholders or individuals with a vested interest in the science being done (e.g., Skloot 2010, Zárate-Toledoa et al. 2019). Privilege plays a considerable role in the context people have coming into conversations about wildlife management and natural resource conservation overall. For example, people who grew up camping may be more familiar with and invested in the features of an ecosystem you are researching. However, those whose families could not afford vacations or the appropriate gear, or those who identify with minoritized demographics historically at risk in wild places or at risk recreating out of doors at all (Hill et al. 2021), had less access to the outdoors. For many reasons, stakeholders we hope to reach may be less knowledgeable of the natural landscape we are working within (Bonnell et al. 2019), feel threatened by the landscape itself, or have values and concerns that take precedence (McKemey et al. 2021).

Further, our perception of potential stakeholders may not align with their own. For example, while their relationships to their landscapes are nearly opposite of those socioeconomically excluded from nature, many Indigenous communities are not considered stakeholders, or may actively refuse to identify as stakeholders. Too often, Indigenous communities are approached in ways that either extract their already limited resources, tokenize them for funding purposes, or "discover" things that these cultures already know to be true (Gadgil et al. 1993). Indigenous people globally have lived on and stewarded lands taken from them since time immemorial. Accounting for this history and then working toward shared values demands building research programs in full partnership with and in service to Indigenous people.

This approach is not only the baseline for good scicomm with minoritized communities (Polfus et al. 2017, Canfield and Menezes 2020), but can also be a productive model in fully westernized contexts (Groesbeck et al. 2014). Certainly, it is not remedial to invest in a co-production approach with Indigenous or otherwise minoritized and colonially oppressed communities. Importantly, productive relationships in these communities are not developed or sustained on the same time scale as policy, funding, research, and review and promotion cycles. Thus, we must commit to long-term relationship building, and not rely on ephemeral trainees to do so. Nor should we see historically fraught landscapes as transitory research opportunities that do not integrate the local community (also known as "parachute science"; Stefanoudis et al. 2021).

Good scicomm grounded in inclusive principles accounts for past and present inequities through equal partnerships, and it attends to how marginalized communities are and have been represented and supported in science (Canfield and Menezes 2020). Considering these contexts, we argue that co-production as we describe and cite here is the ultimate version of good scicomm. Ideally, our stakeholders' needs and values are fully integrated into the science we are doing and sharing (Trisos et al. 2021).

Putting values to work

While many scientists may be aware of, agree with, or even be working toward the recommendations detailed above, actually applying a values-driven approach to scicomm can be challenging. We recommend a stepwise process to identify your values, those of your stakeholders, and how to relate the two.

1. Using the worksheets suggested (Table 1), you can first consider what your core values are. Optionally, you can repeat the exercise while specifically considering your goals for science, sharing science, and a specific scicomm situation.

2. Then you can complete a second set of worksheets (Table 1 and Supplement 1) to identify who your specific target stakeholders are and what they value. Doing so is not possible in a vacuum; listening and other essential techniques are discussed in stakeholder worksheets (Supplement 1), which co-author Merkle has used when teaching scicomm. We include them here to provide detailed, step-by-step guidance for scientists and science trainees at any career level working to understand a target stakeholder group.

3. As you use the stakeholder worksheets, you will be prompted to consider your specific scicomm goals. Thus, we discuss goals next.

Goals-informed scicomm

In scicomm generally, and undoubtedly in instances where we work with or want to share science with communities historically excluded from science, we must articulate our scicomm goals. Then, we can plan "backwards" to determine what approach will actually achieve those goals (Baram-Tsabari and Lewenstein 2013, Jensen and Gerber 2020).

Ideally, these goals will not be determined in the vacuum of academia, a management agency, or a conservation nonprofit, but will be determined in close coordination with target stakeholders. Otherwise, the scicomm effort itself may perpetuate the colonial and marginalizing harms discussed earlier. Thus, we recommend that goals are determined at the outset of a research project or funding proposal, so the research and scicomm adequately complement one another and appropriately account for stakeholder contexts (Strickland et al. 2021). Granted, you may not always be in a position at the outset to establish scicomm goals or to do so in partnership with stakeholders. In such cases, it is essential to at least articulate the outcomes you hope will come from publishing your work.

Backwards design for setting goals and planning scicomm

Starting your planning with these final components of the overall project is known as "backwards design" because it emphasizes starting at the end, with one's goals. For example, in a so-called traditional classroom, an instructor identifies the content that needs to be covered, then designs the lesson plan, followed by an assessment to determine how much was learned. Evidence indicates that this approach is counterproductive and leads to a focus on covering the content rather than encouraging critical thinking and transferable understanding (Whitehouse 2014). In contrast, a "backwards design" instructor identifies their goals for what students should ultimately know, designs an assessment around those learning goals, and then develops instructional activities accordingly (Wiggins and McTighe 2004). Ultimately, this process prioritizes key concepts that lead to long-term understanding versus short-term memorization or rote performance. Similarly, articulating our scicomm goals before we undertake research, or minimally, before we embark on a scicomm effort, helps us as scientists to keep our focus on the approaches to sharing science most likely to achieve our goals with and for our stakeholders.

Backward design is also evident in an ongoing movement across scientific studies that use statistical analyses to understand trends in experimental data. A common tenet among empirical scientists is to plan statistical analyses alongside the design of experiments to avoid running analyses that erroneously generate significant results, an outcome known as "*P*-hacking" (Head et al. 2015). Just as scientists rigorously plot out their investigations and analyses, those interested in sharing science should be equally methodical in their approach to public engagement, both to avoid hype (Sumner et al. 2014) and to provide a meaningful benchmark against which to assess scicomm efforts. Doing so encourages accountability and close attention to efficacy at planning, implementation, and assessment stages of our scicomm work (Reed et al. 2018, Brown et al. 2019).

Further, seasoned scicomm practitioners actively employ backwards design. Our stakeholders, and our desired results from interacting with them, often drive the means and content of communication (Aurbach et al. 2019). For example, co-author Shukla backward designed components of her dissertation that involve collaboration with local oyster aquaculture companies (Sea Grant California 2020). While she does intend to publish her research, her goal has been to keep oyster growers apprised of her findings throughout the project to support any ongoing decision-making. Additionally, each phase of the experiment has only progressed after input from the growers. By intentionally involving the aquaculturists at every stage of this research, she hopes her findings will not only be ecologically interesting, but of greater relevance to the oyster aquaculture industry. These engagement components of her research illustrate the factors that lead to more effective co-produced, applied research projects (Jones et al. 2021).

Articulating and using goals to plan scicomm

As with identifying our values, we suggest a concrete set of steps to setting goals that stem from your values and then inform your work.

1. Read the "impact identity" paper (Risien and Storksdieck 2018), then use a goal setting worksheet to articulate your life and career goals. Note that this step is integrated with the values process discussed earlier. Consider what you do in your daily life and work that intersects with those goals.

2. Make note of who your research would matter to, relative to your goals, and circle back to the stakeholder worksheets from the values section (Supplement 1) to refine why you think your science could matter to your target stakeholder group.

3. Develop SMART goals (specific, measurable, achievable, relevant, and time-limited; Doran 1981), perhaps informed by a "types of public engagement" checklist (Brown et al. 2019), to articulate a timeline of tangible goals you can plan for.

4. Importantly, you may also find it necessary to embark on similar goals articulation processes with your research partners and your stakeholders. Several authors we cite provide solid grounding for how to do so: Knapp et al. (2013), Varga et al. (2016), Bodin (2017), Kotcher et al. (2017), Polfus et al. (2017), Brown et al. (2019), Merkle et al. (2019), Zárate-Toledoa et al. (2019), Canfield et al. (2020), Noy and Jabbour (2020), and Strickland et al. (2021).

Story-carried scicomm

We now return to our example of co-author Shukla's experiences with co-production research and scicomm. Given the major role that aquaculture plays in growing California's (USA) iconic oysters, and more recently, in restoring threatened marine species, it is critical that Shukla's research efforts are not siloed from growers. Further, climate change is shifting seawater temperature and chemistry, driving researchers and aquaculturists alike to invest in community outreach and demonstrate the need for mitigation. Developing functional, working partnerships in communities around divisive problems like climate change requires a deliberate, shared narrative that targets emotions over evidence; it requires a good story.

Stories as mechanisms for finding shared values and goals

Stories like those we have shared throughout this paper are crucial to effectively sharing science because our brains are hardwired to receive information through stories (Pickering and Garrod 2004, Stephens et al. 2010). Here, we are defining a story as a narrative—a series of events happening over a period of time (Green 2008, Neeley et al. 2020). Perhaps the oldest story known is that of the eruption of Budj Bim around 37,000 years ago, told as a legend about giants by the aboriginal Gunditjmara people in Australia (Lovett 2016, Matchan et al. 2020). This is, of course, a story about the landscape that demonstrates how the local environment is woven into the language, culture, knowledge, and traditions of people through story. Stories originate from a combination of information and personal experiences (Dahlstrom 2014), and when we convey both through storytelling, our listeners connect what they hear to their own lived experiences (Downs 2014). Because of this intuitive merging of one's story with our own, stories improve our understanding of material and are more engaging, relatable, interesting, and generally very persuasive (Dahlstrom and Ho 2012, Dicks 2018).

Thus, we can build trust and community in scientific ideas through the exchange of stories (Bayer and Hettinger 2019). In educational science, technology, engineering, and math (STEM) settings, listening to personal stories from diverse scientists correlates with marginalized students having higher course grades, an increased interest in science, and a sense of belonging within STEM (Schinske et al. 2016). Many scientists can likely relate to these outcomes because many of our reasons for becoming scientists include empathizing with, relating to, or being inspired by fictional and nonfictional characters whose stories we know (Dessart and Pitardi 2019, Neeley et al. 2020). For example, co-author Valdez-Ward's work co-founding ReclaimingSTEM has created a welcoming space within science through scicomm. ReclaimingSTEM is a scicomm and policy workshop for marginalized scientists, created by and hosted by marginalized scientists. Valdez-Ward and her colleagues have found that science communicators from marginalized backgrounds can encourage fellow marginalized scientists to communicate and share their own science. Many of the scientists attending these trainings do so with the aim of co-creating science within their communities; this includes increasing representation and advocating for policies directly impacting their communities among other actions. Scicomm in this way not only impacts who conducts or communicates science, but also aids in selecting which topics are funded and researched. This is critically important when tackling scientific problems affecting marginalized communities.

Further, when stakeholders feel heard by scientists, they feel valued not only for their knowledge and lived experiences, but for their emotional or personal stake in their community (Varga et al. 2016). Actively listening to stories means respecting the teller's perspective and values, which greatly increases the chance of building strong, long-term relationships (Weger et al. 2014). This does not mean giving up your perspective as a scientist. Rather, respecting a stakeholder's position demonstrates your ability to acknowledge them (and by extension their community) as equal partners (Martinez-Conde and Macknik 2017). This mutual respect is essential for trusting and collaborative partnerships in which knowledge exchange and use or even co-produced research can occur.

For example, co-author Bayer was involved with a nearshore, scallop fishery closure in Maine, USA. While a fishing closure is typically a fractious situation, the experience was mutually productive thanks to a deliberate use of storytelling. Managers shared the success story of an offshore closure and the desire to have a similar success story in nearshore Maine. Fishermen shared their stories of where they formerly caught scallops. Managers used that information to design a small-scale closure that the fishermen and scientists could study collaboratively. Ultimately, the data from this project were important, but not as important as the relationships. Per one of the fishermen, "[when] you gain that relationship [with scientists], that's invaluable…that's the type of relationships that can talk shop, they comprehend what you're saying and vice versa" (Bayer and Hettinger 2019). Relationship building through story is backed up by studies reporting the success of long-term, collaborative ecological and environmental research projects (Bodin 2017) and the efficacy of shared personal experiences, rather than facts, to bridge value and political divides (Kubin et al. 2021).

Stories can influence policy

For example, when advocating to congressional representatives for increased science funding, co-author Valdez-Ward also emphasized that increased federal funding led to increased diversity in the sciences. To do so, Valdez-Ward and several other graduate students in a scicomm training (www.aibs.org/news/2021/210112-communication-bootcamp.html) shared stories of ways that science funding helped them become scientists by lowering barriers of access to scholarships, research opportunities, and fellowships. In their stories, these students were able to humanize science with their own personal reflections on their pathways to science. These stories helped show politicians that federal dollars fund science and the scientists being supported. The team also shared stories of undocumented and international colleagues whose graduate degrees could not be funded by federal science grants, further exacerbating issues of historic marginalization in STEM. The congressional representatives were touched by the stories being told. This helped convince some to push for increased federal funding for sciences in 2019, when the U.S. National Science Foundation, U.S. National Institutes of Health, and the U.S. Department of Agriculture were facing potential budget cuts.

Even scientific papers tell stories

Effective stories usually have common characteristics: (1) a clear reason why the story is being told (what are the stakes to the teller); (2) the teller's personal or emotional connection to the story; (3) detailed characters and imagery; (4) a climax with relatable conflict, vulnerability, or achievement; and (5) a clear beginning, middle, and end (Downs 2014, Green et al. 2018).

Often, when scientists target coveted journals like *Science* or *Nature*, our papers must be framed with a lot of the characteristics of classic stories. In particular, such manuscripts focus on why the research is important (the stakes), what the study's results are (climax), and the implications (the ending). Regardless of your publication venue, scientific writing must have characters, events, and plotlines to be clear and understandable (McGill 2014, Heard 2019). You will want the reader to know why your characters (i.e., variables, subjects, experiments) are important and that there are events (observations, experiments, analysis) that these "characters" will experience or even cause. Further, the specificity we are conditioned for in science has an analogue in the writing of stories; that is, specifics, not generalities, are what enable others to relate to our stories (Merkle 2019). Including ourselves in our stories of conducting science is even more powerful (Gross et al. 2018, Neeley et al. 2020) because we bring in something that people can often relate to best—another human being.

Finding your own science stories

Drawing on expertise from organizations like The Story Collider, COMPASS, and others (Table 1) and building upon the previous 2 sections on values and goals, we propose a series of steps to help you build a story that will aid you in your scicomm goals.

1. Begin with your goals. What do you hope to accomplish by sharing your story? Staying with the theme of connecting with people, you might share a personal story that's important to you (stakes).

2. Identify the important characters (especially you as the teller, and other main characters of your story).

3. Describe the main conflict/climax of the story.

4. Then, describe the consequences of the conflict/climax of the story. The results of a story have consequences that tie back to your stakes.

5. Following that, rough out a draft, on paper or aloud with someone else. Bring your audience along with you by candidly describing your emotions, internal thoughts, imagery, or details that share the setting, etc.

6. Test this story framework on others. See what they think or if it's hard to understand. Repeat a lot of times, testing out the tools we recommend (Table 1). Ask yourself, who can relate to this story? Is there too much jargon in it? Would your stakeholders relate to at least some of it?

Table 2. Systemic disincentives impeding effective science communication (scicomm) and the stakeholders directly impacted by each. "STEM [science, technology, engineering, and math] professionals" encompass science-trained professionals and trainees in any sector other than government (e.g., K-12 education, higher education, consulting, nongovernmental organizations, etc.).

Systemic disincentives	Major stakeholder groups				Essential context
	STEM professionals	Individuals (outside STEM)	Community level (excluding policy)	Policy at all levels	
Academic peer pressure (real and perceived) to not do scicomm	X				Ecklund et al. 2012, AbiGhannam 2016
Deficit-model assumptions (more info = logical decisions, behaviors)	X	X	X	X	Simis et al. 2016
Discrepancies in global access to science information and training	X	X	X	X	Márquez and Porras 2020, Trisos et al. 2021
Dominance of English as the language of science and scicomm	X	X	X	X	Márquez and Porras 2020
Lack of scicomm training in science curricula	X				Ecklund et al. 2012, Brownell et al. 2013
No "general public" exists	X	X	X	X	Scheufele 2014, Resnik 2011, Iyengar and Massey 2019
Polarization, weaponization of science	X		X	X	Sarewitz 2004, Levin et al. 2020
Public trust in science (or lack; including credibility of science advocates, misinformation, etc.)		X	X	X	Lidskog 1996, Resnik 2011, Weingart and Guenther 2016, Kotcher et al. 2017
Scientists' perceptions and insecurities regarding credibility and public trust	X				Donner 2014, Kotcher et al. 2017
Papers and grants "worth more" in academia, though social impacts touted by institutions and called for by funders	X				Shanley and López 2009, Ecklund et al. 2012
Social justice issues intersect with devaluation of scicomm as academic service and suppression of cross-training in scicomm	X				Greene et al. 2008, Filetti 2009, Hirshfield and Joseph 2012, Kuhen and Corrigan 2013, Trejo 2020, Watermeyer and Rowe 2021

Note that you may need multiple stories, either different versions of an event or distinct anecdotes, to meaningfully connect with different stakeholders. If sharing your story does improve engagement with your stakeholders, evaluate your next stage and how stories can further support your goals. Perhaps your next approach is finding ways to listen to your stakeholders' stories more, to better understand what they care about so you can relate back to them in a richer way (Noy and Jabbour 2020).

Discussion and Conclusion

Good practices in scicomm provide us with strategies for putting rigorous science into action within communities that can benefit from scientific information. It is ideal to coordinate your science with stakeholder needs at the outset of a project. To do so, thinking deeply about your role as a scientist and communicator in service to society can be productive. Here we have discussed some foundational concepts that inform evidence-based, contemporary scicomm efforts, while also suggesting a framework for doing effective scicomm: connecting scicomm goals with shared values through effective storytelling.

Despite the positive outcomes that scicomm offers, it is important to consider the micro- and macro-scale "consequences" for engaging in this work. Thus, we must acknowledge that scientists face 2 major challenges to sharing science effectively: (1) time constraints plus multifaceted job responsibilities, along with (2) systemic disincentives that can complicate sharing science and even demotivate us from doing so (Table 2). Sometimes, scicomm is ineffective no matter how hard we try (e.g., sometimes we're not the right messenger; Knapp et al. 2013). We also recognize that good, evidence-based practices for sharing science are not an embedded, systemic part of research training, despite long-standing calls for their inclusion (Brownell et al. 2013, Simis et al. 2016). Nor are researchers outside the field of psychology often taught the nuances of how communication is received by audiences (Fiske 2018). Indeed, in some disciplines and professional settings, cross-training and inter/transdisciplinary work are disincentivized or discouraged (Naiman 1999).

For example, 3 co-authors (Bayer, Shukla, and Valdez-Ward) were not required to take science communication courses at any degree level. Co-author Valdez-Ward also faced a particularly egregious combination of these hurdles when she was told by a colleague that engaging in scicomm would mean she would "not be treated seriously as a scientist." In this era of broad scientific misinformation, the false dichotomy or competition between producing novel science and integrating it into civic discourse is a disservice to the (often taxpayer-funded) science we produce, the decision-makers that we hope use our science, and the other stakeholders who can benefit from it. While we note many disincentives, we do not mean to discourage you. Rather, our goal is to equip you with both essential context and actionable advice you can leverage to enhance your scicomm practices.

Regardless of our ultimate career ambitions or paths, engaging with and listening to people inside and beyond our field is critical to professional and civic success. We hope that the materials we shared can help you reach the level of self-confidence that co-author Merkle often observes in students and scientists she trains in scicomm after they experience the values-goals-stories sequence that we have suggested here. For example, a student wrote, "I think it will be extremely important to integrate my personal beliefs and interests in my scicomm project, as described in the "impact identities" paper (Risien and Storksdieck 2018). Not only will this improve the content and delivery of my final project, but I will gain a personal fulfilment from it as well." Ultimately, this is what we invite you to embrace: the deep personal and professional satisfaction that we have experienced ourselves as we find ways to share science and support others to do so more effectively.

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Supplemental material

Supplemental material can be viewed at https://digitalcommons.usu.edu/hwi/vol15/iss3/27.

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