



Reflecting on the co-production ideal through practice

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Abstract

Co-production, or integrating a range of perspectives from researchers and non-researchers into the knowledge development process, is considered valuable for increasing the potential that scientific results will be applied by practitioners. While the literature around co-production often touts the benefits of such work, there is less focus on the potential costs of co-production, and discussions often lack nuance about the specific meaning of co-production in a particular context. In this perspective essay, we use an example co-production process focused on the development of a science agenda for a federal research program to consider the ideal of co-production. Specifically, we reflect on the appropriate level of non-researcher involvement throughout the full cycle of research, and position our process within the diverse range of existing co-production approaches. We suggest that the ideal of co-production is not necessarily one that integrates the maximum amount of non-research involvement throughout the full cycle of research at all costs, but one that focuses on mitigating the research-management gap while limiting the risks to those involved.

Keywords Q-methodology · Science planning · Partner engagement · Wilderness research

1 Introduction

Relevant research often can be overlooked in decision-making processes. This disconnect is variously referred to as the “theory–practice gap,” “research–management gap,” or the “knowledge–action” gap, to name a few; Cooke et al. (2021, p. 245) identified 24 different terms used to describe the “challenge of mobilizing knowledge for specific outcomes.” In response to the challenge of applying scientific knowledge in practice, there is an increasing focus on co-production, which rejects the notion that scientists alone perform research that is then delivered to society to use. Instead, people within and outside research institutions work collaboratively to develop knowledge that can address complex problems (Ostrom 1996). “High-quality” co-production

implies interaction among researchers and partners throughout the full cycle of research, from topic definition to results dissemination (Norström et al. 2020, p. 186).

Literature on co-production is plentiful and increasing exponentially (Bandola-Gill et al. 2023), and sometimes indistinguishable from a broad literature (e.g., transdisciplinary, participatory action research) trend that embraces the basic premise that complex social-ecological problems need to be addressed with participatory approaches. There is a growing implication that the popularity of co-production has become a detriment (Durose et al. 2022), with concerns that conceptual ambiguity may lead to the embrace of co-production as a panacea (Chambers et al. 2021, p. 984) and, consequently, it may crowd out other “good” approaches to addressing complex problems (Harcourt and Crepaz-Keay 2023). While plentiful, the co-production literature is not particularly diverse. As Turnhout et al. (2020, p.15) note, much of the focus is on the merits and importance of co-production (e.g., bridging the theory–practice gap Nel et al. 2016; Hinderer et al. 2021; Glenn et al. 2022)) and its methodology and associated principles (e.g., Beier et al. 2017). The focus on the merits and methodology of co-production are understandable, as Lemos et al. (2018, p. 722) noted that there is compelling evidence that co-production is successfully addressing the research-management gap.

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The focus on the potential merits of co-production may obscure potential limitations and concerns, though recent discussions are increasingly addressing the latter. For instance, there is increasing discussion of the potential for co-production to further entrench and perpetuate existing power dynamics (Turnhout et al. 2020; Musch and von Streit 2020). And attention to the potential risks and costs of co-production highlight significant implications including researcher burnout and potential reputational damage, increased administrative burden and unforeseen sunk costs, risk to the careers of non-researchers, and investment in relationships without commensurate outcomes (Garlatti et al. 2019; Oliver et al. 2019). In summary, the potential “dark side” of co-production is becoming clearer, with an associated questioning of the general assumption that co-production, in and of itself, is a virtue (Steen et al. 2018, p. 290).

Within the methodological domain, there is increasing focus on moving beyond general principles and guidelines to more nuanced descriptions of co-production. For example, Chambers et al. (2021) proposed six different modes of co-production based on an empirical analysis, with corresponding differences in why actors co-produce, how human agency is conceptualized, how power relations are changed, and how impacts from the work are catalyzed. Bandola-Gill et al. (2023) contributed a review that highlighted five different approaches to, or meanings of, co-production, as defined by key challenges being addressed, theoretical underpinnings, and disciplinary roots. Musch and von Streit (2020) developed a typology of four participatory approaches (i.e., emancipatory, deliberative, competitive, and functional), each of which view process design, participants, decision-making, and knowledge generation differently. Further, it has been recognized that co-production as a broad concept can be distinguished across research traditions, though with common themes (Miller and Wyborn 2020). For instance, sustainability science and public administration conceive of co-production as “intentional practices,” whereas science and technology studies view co-production as a theoretical lens to interpret and understand complex phenomena (Wyborn et al. 2019, p. 327).

The upshot is a collective call for nuance within co-production discussions; whether that be nuance related to the benefits and costs of the work itself, or nuance related to what is meant by “co-production” in each context. In essence, there is a need to explicitly distinguish the ideal from practice. Or perhaps the need is to more clearly define the ideal itself, which may vary in different applied contexts. Maas et al. (2022, p. 8–9) suggest that the dominant view of co-production increasingly emphasizes interaction between researchers and practitioners to participate in the linear process of developing science to address policy. And they further suggest that this emphasis is potentially impeding an imagined alternative where fully sharing the workload

is not necessarily the goal, but instead it is equal levels of commitment with “differentiated responsibilities and tasks” and a symmetrical focus on both the science and policy side of the gap (Maas et al. 2022, p. 8–9).

Here, we reflect on the ideal of co-production as an intentional practice, and whether there is a singular ideal or a plurality of ideals. We question whether an ideal co-production process would include a high level of researcher and non-researcher involvement throughout the full cycle of scientific inquiry, irrespective of costs, benefits, goals, and outcomes. While a focus on the level of non-researcher involvement likely only represents one of several facets constituting an ideal co-production process, we do so for two reasons. First, despite differences throughout co-production discussions, a shared suggestion is the need for some level of interaction between researchers and non-researchers; therefore, we are confident that the level of interaction between researchers and non-researchers is one, and potentially the primary, facet to consider when pursuing an ideal co-production process. Second, by reflecting on the level of non-researcher involvement in a co-production process, other facets of the co-production ideal are illuminated. We begin by briefly reviewing the co-production setting and associated goals, process, and results. We then discuss the extent of non-researcher involvement at each stage of the project (with an associated conceptual model), and the opportunities and challenges that emerged when pursuing an ideal of co-production in practice.

2 The co-production setting

Our perspective essay is grounded within the development of a ten-year science agenda for the Aldo Leopold Wilderness Research Institute (ALWRI), a federal wilderness research program in the USA. There are relatively few examples of co-producing a science agenda, though there are examples in the fields of psychology and health care (Abma and Broerse 2010; Rivkin et al. 2013; Dillard et al. 2018; Fancourt et al. 2021; Fellenor et al. 2021), as well as environmental research (Steelman 2000; Edgeley et al. 2020; Holterman et al. 2023). At ALWRI, we wanted to co-produce our science agenda with the hope to increase the relevance and potential application of individual research projects, while strengthening relationships with partners by fostering ownership in the overall science agenda.

Stewardship of the National Wilderness Preservation System (111.7 million acres of federal land in the USA managed by four land management agencies in the US –the USDA Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, and National Park Service) is a complex social-ecological issue. Federal land stewards of wilderness, in cooperation with a variety of partners, are perpetually

grappling with meeting the multi-faceted and sometimes conflicting mandates of the Wilderness Act of 1964, evolving societal needs and perspectives around public lands, and the uncertainty of ecological change and broad scale drivers like a changing climate. ALWRI is an interagency program with a primary focus on providing research and science in support of stewarding the National Wilderness Preservation System (NWPS). In addition, ALWRI works with stewardship professionals at all levels of land stewardship in all four agencies within the NWPS, as well as external partners such as tribal governments, universities, and NGOs with diverse research needs. Carrying out ALWRI's science agenda requires multiple disciplines (e.g., philosophy, psychology, economics, geography, ecology, biology), and the need to meet multiple stewardship needs (e.g., recreation allocation decisions, climate change adaptation, navigating policy intersections between the Wilderness Act of 1964 and the Endangered Species Act of 1973).

To plan the next decade of science, we engaged the broad wilderness community to co-develop a set of research priorities to be formalized in ALWRI's science agenda. While the wilderness research foci of ALWRI may be somewhat specific to the US context, the process of co-producing a science agenda is relevant to all research institutions. Generally, research institutions plan research priorities years in advance, and decisions regarding funding and staff specialization based on these plans may leave less room for high-quality co-production at the individual project level, if the overall plan is not co-produced to prioritize research topics which are valued by partners.

3 The co-production process and results

Co-production is generally defined as “a loosely linked and evolving cluster of participatory and transdisciplinary research approaches” (Norström et al. 2020, p. 182), but recent contributions add nuance to co-production approaches. Using the six modes of co-production outlined by Chambers et al. (2021, p. 989), our approach incorporated elements of “researching solutions” and “navigating differences.” Our approach aligned with the researching solutions mode of co-production largely based on the goal to create knowledge that influences policies and interventions (in our case, ALWRI had a goal to create a science agenda that met the needs of diverse partners). However, the navigating differences mode of co-production was also relevant to our case, because our capacity was limited in pursuing all perceived research needs; there was a need to prioritize science directions, and better understand how meeting various needs could help diverse partners within the wilderness community. As such, we aimed to create a process of “relating together,” whereby hierarchies were minimized and all forms

of expertise among our partners were embraced (Chambers et al. 2021, p. 989). Akin to a “boundary management” mode of co-production, our process was “more oriented towards the practice of bridging different communities” of wilderness partners to directly create usable knowledge to inform our science agenda and, consequently, increase the applicability of future science (Bandola-Gill et al. 2023, p. 289).

Irrespective of the mode of co-production, all such processes, to some extent, strive to involve non-researchers throughout the knowledge generation cycle (i.e., problem definition through results dissemination and application). Applied research processes likely exist on a spectrum from no transdisciplinary or participatory elements (i.e., not a co-production process) to highly transdisciplinary or participatory. We conceived the co-production process as a wheel representing the full cycle of research, segmented by phase of the knowledge generation process (Fig. 1). While we reduced the knowledge production process to component parts, largely to facilitate our discussion herein, it is worth stressing that creating actionable knowledge is more of a holistic social process in practice (Stern et al. 2021). In a fully integrated/co-produced cycle of science, there would be participation at every segment of the process.

We aimed to design a participatory process that included non-researchers throughout the entire knowledge generation process. However, in practice, the level of participation of non-researchers varied by phase and therefore, we provide a level of involvement that the broader wilderness community had beyond the researchers and staff at ALWRI. This ranged from zero (no involvement), to high a level of involvement. To illustrate this more fully, we provide an overview of each phase of co-production process used to develop a science agenda for ALWRI, explore the level of partner engagement at each segment, and provide specific examples of the results from our engagement process.

3.1 Problem definition and context setting

Co-produced, transdisciplinary, or participatory knowledge generation is context-dependent (Norström et al. 2020), which implies a priority for knowledge application, as opposed to knowledge for the sake of knowledge. In other words, non-researchers are generally incorporated into the research process, from start to finish, to increase the likelihood that the knowledge generated is more applicable to addressing the problem or applied need. Within the context of ALWRI's science planning, there was an initial and well-defined (policy-mandated) need to update ALWRI's science agenda for the next ten years. While this part of the context was not particularly flexible, in terms of it being influenced by non-researchers (**zero** involvement) thinking about how science can influence management of wilderness, as a broader issue, was an important part of context

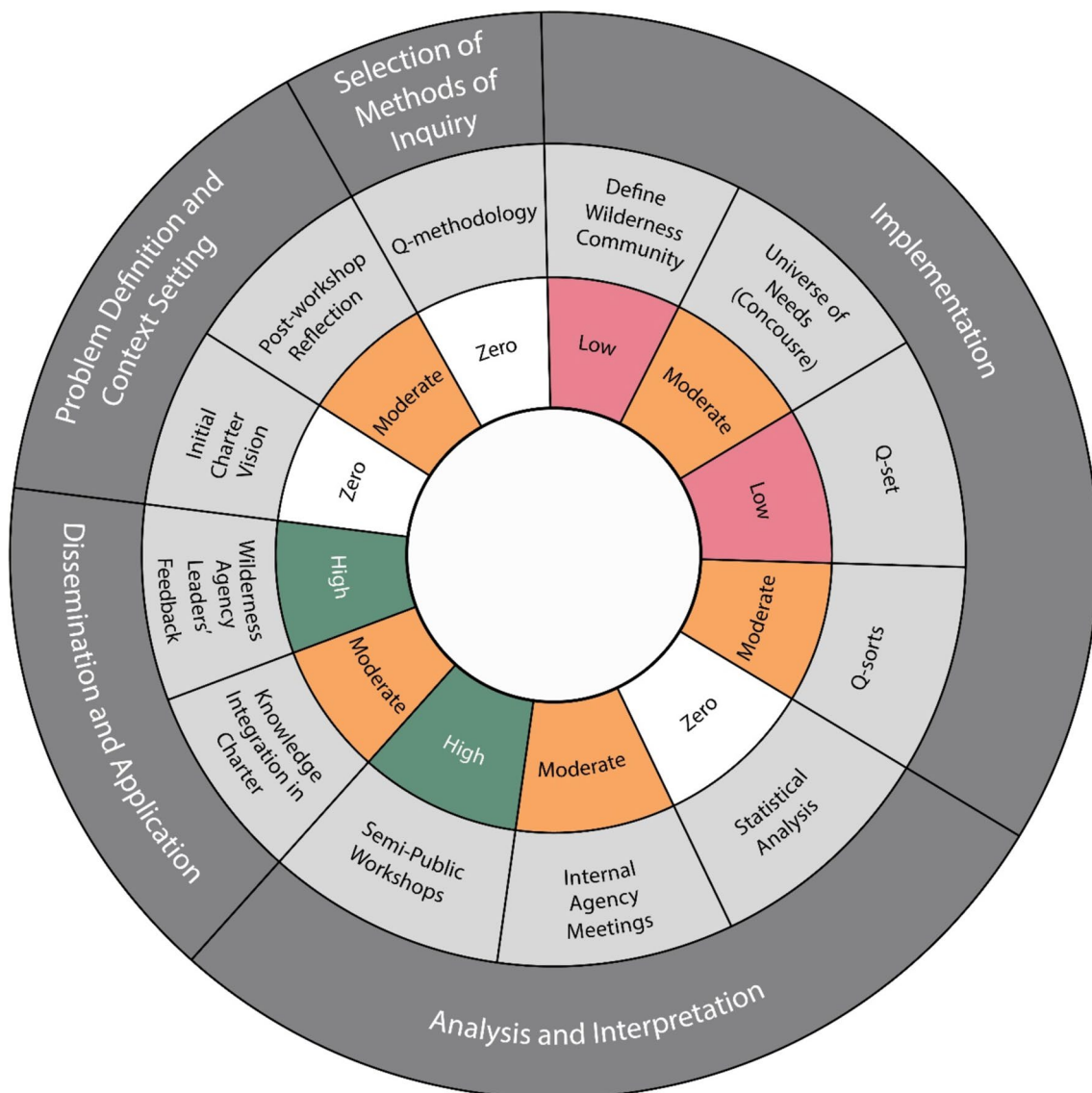


Fig. 1 An overview of the co-production process with degree of non-researcher participation during each phase

setting. Through the wilderness community workshops and post-workshop reflection (discussed below in Sect. 3.4), non-researchers did have some influence (**moderate** involvement) on the definition of the problem and the context for the application of knowledge around understanding science priorities.

3.2 Methods selection

Our process was anchored by a structured social science approach, known as Q-methodology (Brown 1980; Watts and Stenner 2012), which aims to understand the diverse range of perspectives around a topic of interest. Q-methodology aims to gather diverging opinions

through a targeted and purposeful sampling approach, as opposed to a random sampling approach; consequently, the results provide a range of divergent perspectives, as opposed to an understanding of how such perspectives are distributed across a population (see Taylor et al. (2023) for specifics on Q-methodology in the context of ALWRI's science agenda). This methods selection phase was non-participatory (**zero** involvement); however, as discussed below, once we moved into implementation of the structured approach with the wilderness community, there were ample opportunities for non-researchers to engage in the knowledge generation process beyond the precise structure of Q-methodology.

3.3 Implementation

The implementation phase of our participatory process aimed to capture the opinions of the wilderness community related to science priorities that could be pursued by ALWRI. In alignment with Q-methodology, this phase of our co-production process consisted of four efforts, discussed briefly below.

3.3.1 Identifying and convening the wilderness community

The dividing line between the non-researchers in the wilderness community who participated in the knowledge generation *process* and those who, more typical to social science studies, participated as respondents is blurry and overlapping. To ensure that the knowledge produced met the needs of ALWRI, there was an underlying goal to engage a diverse range of wilderness partners. To develop a foundation of diverse partners, researchers and leadership at ALWRI developed a preliminary email list of partners, which would be used to solicit participation in three primary elements of the knowledge production process (i.e., concourse development (Sect. 3.3.2), research topic prioritization (Sect. 3.3.4), and non-researcher interpretation and analysis workshops (Sect. 3.4). While the initial list of the partners was created by ALWRI, the non-researcher community had a **moderate** amount of involvement in identifying and defining the wilderness community in two primary ways. First, we shared and expanded our partner list with wilderness managers and leadership from all agencies tasked with managing wilderness. Second, when we invited our partners to provide input on different phases of identifying science priorities, they were asked to forward the invitation to provide input to any person that they felt might be interested. We might think of this as a slight adaptation to the commonly used chain referral method; instead of asking participants who else we, the researchers, should contact, we removed the researcher filter (which can generally mediate the chain referral method by deciding if a suggestion for another participant is worthwhile).

3.3.2 Exploring and identifying the universe of wilderness research needs

In the parlance of Q-methodology, the first step is developing the “concourse.” The concourse is the broad range of statements that might, in our case, qualify as research needs. There are no bounds to this discussion, as it is mostly a brainstorming exercise where issues of overlap, redundancy, or even perceived relevance are ignored, for the moment. Creating the concourse is often done through a combination of approaches, including literature review, interviews, focus groups, or surveys (Zabala et al. 2018). Although the initial

brain storming effort was non-participatory, there was **moderate** involvement of partners during this phase of implementation as we engaged key partner groups and the broader wilderness community to create a more extensive universe of potential research needs through an online brainstorming tool. A link to the tool was circulated via email and was intended to foster a collaborative spirit through its language, namely referring to recipients as “Friends” and “Partners.”

3.3.3 Narrowing the universe of science needs into a representative subset

Once the “universe” of science needs is developed, there is a need to create a more manageable list of statements (Q-set) to be sorted by partners. The Q-set should be representative of the broader concourse, to ensure that the entirety of the “conversation” is captured in the sorting exercise (Watts and Stenner 2012). Narrowing the concourse to the Q-set was done primarily by ALWRI researchers, with **low** involvement of the broader wilderness community. However, the Q-set was piloted with the Wilderness Advisory Group, a working group of wilderness managers within the USDA Forest Service, to ensure that we captured the primary science needs, as perceived by managers (see Taylor et al. (2023) for the final list of integrated research topics).

3.3.4 Collecting individual prioritizations (Q-sorts)

The final step of the implementation phase is collecting the individual prioritization exercises (Q-sorts), which consists of a diverse range of people prioritizing statements along a quasi-normal distribution. The Q-sort can be done (virtually or in person) to understand individual perspectives without the influence of a group (Zabala et al. 2018), or as a group to facilitate discussion (Edgeley et al. 2020), depending on the desired outcomes. For our application, the wilderness community had **moderate** involvement in the collection of the Q-sorts, because there were non-researchers involved in the completion, and even circulation of the Q-sorts; however, researchers at ALWRI made the decision to have Q-sorts completed individually and online, and primarily led the implementation of the Q-sort phase. Our final count of completed Q-sorts was 175.

3.4 Analysis and interpretation

Processing the input received from our wilderness partners consisted of two primary steps; the first had **zero** involvement from partners, and the second that had **high** involvement.

With **zero** involvement from the non-researcher community, ALWRI scientists performed summary analysis on the Q-sorts to understand how the integrated research

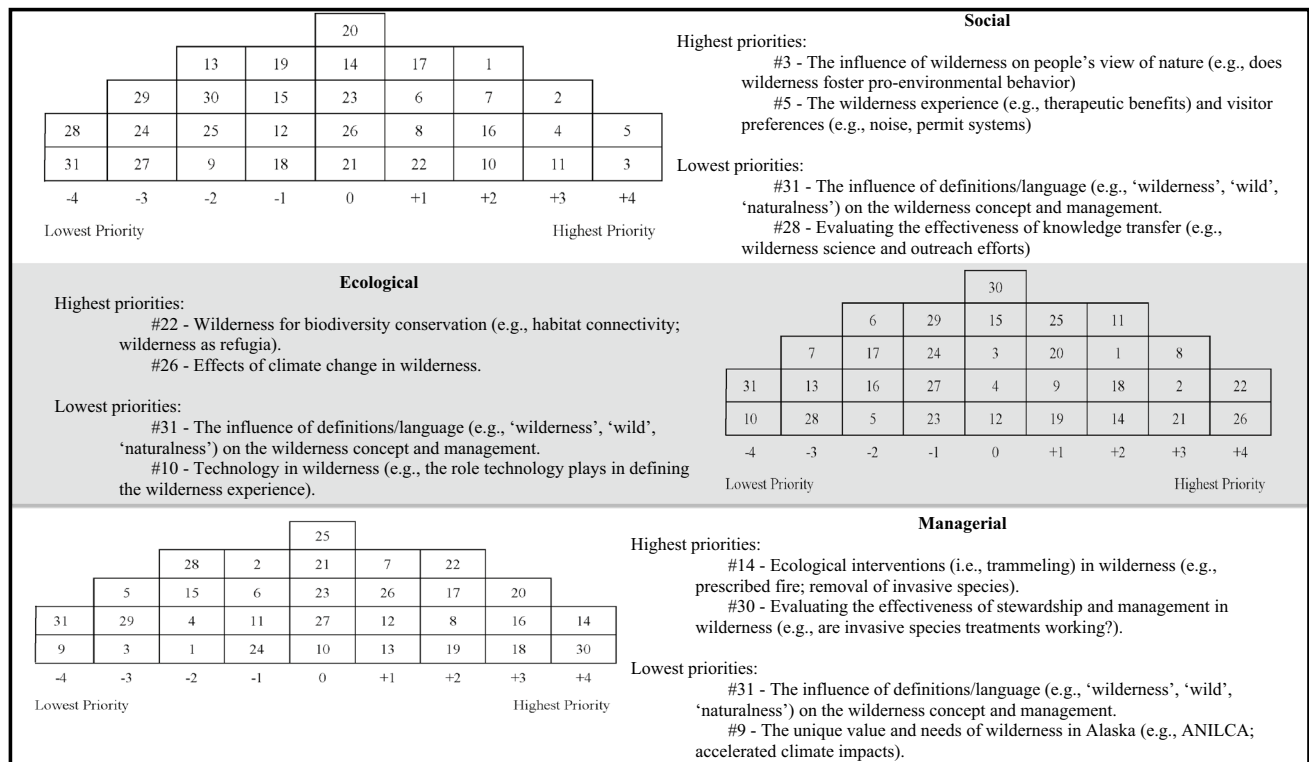


Fig. 2 Archetypal perspectives of integrated research topic priorities. *Note* Each number represents an integrated research topic, but we only define the two highest and lowest priorities for each perspective as an example

topics were sorted, overall. Additionally, principal components analysis (PCA) was performed to yield a limited number of divergent perspectives that were shared by multiple partners (Armatus et al. 2019). The statistical analysis of the 175 Q-sorts completed by ALWRI's partners yielded an overarching understanding of three archetypal perspectives about priorities for wilderness research, as well as how the different perspectives are different and similar (Fig. 2). Figure 2 illustrates "factor arrays," with each number representing an integrated research topic; however, we only define with a corresponding number the two highest and lowest priorities for each perspective as an example.

While statistical analysis provides an understanding of different opinions related to priority research needs, we added nuance to the factor arrays by having partners describe the reasoning around their Q-sort to aid in interpretation of the results. While it is common in a Q-methodology study to add nuance to individual Q-sorts through conversations with participants, it is less common to work together to interpret the resulting factor arrays. Active and **high** involvement in the interpretive process can give participants a sense of ownership and can "identify paths for cooperation or collaboration" (Edgeley et al. 2020, p. 574); further, an iterative process with room for participant review is critical for rigorous co-production practice and informing the interpretation of

results (Mazur and Asah 2013; Onwuegbuzie and Corrigan 2014). Combining the workshops and the original statistical analysis resulted in nuanced archetypal perspectives.

With a focus on co-production, ALWRI scientists arranged five workshops in August 2021, where partners in the wilderness community were invited to reflect on the factor arrays (Fig. 2), add nuance to them, and aid interpretation in a variety of ways. This included naming the perspectives and suggesting how the various wilderness science needs, if met, can support wilderness management decisions. A critical element of our co-production process was to better understand how the potential future research completed by ALWRI could influence decision-making and wilderness stewardship. An invitation to participate in the workshops was sent at the same time that partners were invited to prioritize their research needs (i.e., complete the Q-sort); however, as word of our effort to engage the wilderness community spread, some people who did not complete a Q-sort attended the workshops. The workshops were small (6–7 participants), and they lasted about one hour. The workshops consisted of a short presentation of the statistical results, and then a free flowing conversation around the following questions: (1) do any of the perspectives (i.e., factor arrays) resonate with you, and if so, which one(s); (2) why do the perspectives resonate with you, and/or what is your

reasoning for prioritizing the research topics as you did; and, (3) what might you name the three perspectives? Workshops were transcribed, and the transcripts were analyzed using NVivo, a qualitative analysis software, to summarize comments and determine themes. Thirty-three partners, across a broad range of organizations (e.g., universities, NPS, BLM, non-profit organization), participated in one of the five co-production workshops.

The workshops yielded names for each of the perspectives: Social, Ecological, and Managerial. “Social” in this case refers to society at large, including the diverse cultures which participate in wilderness. “Ecological” describes a focus on scientific conceptions of ecosystems and biology in wilderness. “Managerial” focuses on measures of effective wilderness management. Partners relayed how the research prioritized in each perspective would be useful in everyday fieldwork, which validated our desire and need to conduct research with strong implications for wilderness management. To facilitate our reflection on the ideal and practice of co-production, we highlight three examples (one from each archetype) of knowledge that, without non-researcher involvement, would likely not have been gained.

3.4.1 Example 1: research for management (today) and for public education

While discussing the social archetype, we heard reflections from partners that such research would help practitioners meet their short-term needs, which was parsed between on-the-ground management and public education. Partner 13 (BLM manager) summarized: “[the social perspective] has the potential to produce more information that will be readily applicable to management of wilderness and to the public’s understanding of the benefits of wilderness.” This insight can help researchers working on topics prioritized by the social perspective to more effectively communicate and understand the value of their work in applied contexts.

3.4.2 Example 2: questioning whether all conservation science is applied

Interpretation of the ecological archetype yielded insights from non-researchers about the value of what is often thought of as “basic science.” As a researcher, articulating the day-to-day application of the findings from broad research questions like the influence of climate change on wilderness can be challenging. Indeed, partners who aligned with this perspective recognized how many research priorities from the ecological perspective are often contextualized in longer timescales. However, the long-term view did not necessarily impede the relevance of research from this perspective to day-to-day field work. Partner 9 (NPS manager) stated: “what’s really important about [the ecological

perspective is] all of the climate change and ecosystem issues are maybe not, at the moment, the things that are being litigated....but...as a manager, for me, I really want to be able to focus a lot of time and energy on being as proactive as we realistically can be at this point.” This comment highlights, through a legal lens, the dual need of practitioners for science that addresses both pressing issues today, and those that are going to become increasingly relevant as a changing climate continues to influence wilderness areas.

3.4.3 Example 3: distinguishing end-users with more nuance

In the conservation sciences, references to the end-users of research outputs is commonly an amalgamation of general and undefined terms like planners, managers, policy-makers, and/or decision-makers. This amalgamation is understandable, because as a researcher, parsing how research outputs can specifically be incorporated into applied contexts can be challenging. Insights from non-researchers who aligned with the managerial archetype provided support for distinguishing how research findings support different types of end-users. For instance, Partner 7 (BLM manager) noted that pursuing the research priorities in the managerial perspective would “help us, as agency managers, tell the story of what we need to meet Congress’ expectations and to meet the public’s expectations. And quite frankly, to me, the ecology’s expectations, if we were to anthropomorphize it.” Partner 3 (USFS manager) called this perspective “an agency steward’s lens on what is actionable.” Enhancing our ability to connect potential research results with more specific end-users is important for mitigating the research-management gap, and making those connections is facilitated by non-researcher involvement.

While we (as researchers) were encouraged by the insights gained from the co-production process, there is a need to highlight the co-production process and results in the context of the dissemination and application phase.

3.5 Dissemination and application

To disseminate and apply the co-produced results, we incorporated a **moderate** amount of partner engagement to narrow the priority research topics. First, we identified the highest-priority research topics by carrying forward the highest-ranking research topics from each perspective (Fig. 2), along with the five highest-ranking research topics from each of the NWPS management agencies and Tribal respondents. Then, based on the expertise and interest of ALWRI scientists, we identified which research topics should be considered in the new strategic plan. Collectively our research priority areas captured the different perspective needs (i.e., Fig. 2 archetypes), as well as the overall needs

(based on source data mean rankings). The research priority areas became the foundation for our 10-year research plan and emerged from intersecting partner perspective priorities, different demographic and institutional backgrounds, and scientific expertise. We then presented these research priority areas to key partners for input and modified our research priority areas to incorporate suggestions and knowledge from these partners, resulting in **high** level of involvement from partners. In the example presented herein, co-production did assuage the research-management gap. In large part, ALWRI's leadership and decision-makers (i.e., the end-users) used the ideas embedded in Fig. 2 to inform the actions taken to complete the required science agenda. Specifically, ALWRI's leadership decided to frame the science agenda by considering partner responses to our co-production efforts. Results and in-depth methodology of this effort can be found in Taylor et al. 2023.

In addition to supporting ALWRI's science agenda, the interactive nature of the process, and the substantive discussion between researchers and non-researchers, provided a foundation for relationships to be built. There was excitement expressed as the group worked toward a common goal: "I really appreciate being able to connect directly with all of you, it is nice to be invited into the conversation and connect management with science, together. Thank you!" (Partner 17, USFS manager). And one Partner highlighted an enjoyment with gaining new insights: "What I've enjoyed is seeing different perspectives that show up on the same [integrated research topic]. That's fun to broaden my own thinking" (Partner 27, NPS scientist). The value of the co-production process for bringing people together as a team, for the long-term, was perhaps best reflected by Partner 20 (NPS manager) who noted: "this sure seems like a great way to support the [science agenda]. I mean, both to inform it on the front end, but on the back end to say, hey, this is what we heard from a large group of people and this is what we're after. And it will help me internally to show relevance and responsiveness...when it comes right down to stuff like funding or whatever else...this shows a pretty strong effort." There appears to be a recognition that the co-production process is appreciated, with the implication that future research, as well as funding for future research, will benefit.

4 There is no singular co-production ideal

We have highlighted the details of our co-production process, with examples of the insights gained from a high level of partner involvement, and the ways that the co-production process informed action and supported relationship building. As we reflect on the process, we consider how our approach fits within the broader contexts and conversations surrounding co-production, with a focus on whether the investments,

realized and potential benefits, and progress toward our goals constitute a co-production ideal.

While we argue that there is no singular co-production ideal, in terms of the level of collaboration and diversity among researcher and non-researcher participants, we also argue that the converse (i.e., a unique ideal for every situation) is likely not the case. We suggest that the mode(s) of co-production, as well as the co-production context, can provide guidelines about the appropriate and perhaps ideal level of investment in a co-production process. In the example presented herein, we positioned our approach largely within the "researching solutions" and "navigating differences" modes of the six co-production modes outlined by Chambers et al. (2021, p. 989). These two modes are in contrast to "brokering power" (controlling participation to facilitate safe spaces for dialog in highly contentious situations), "empowering voices" (elevating marginalized voices), "reframing power" (shifting power away from powerful actors to marginalized actors), and "reframing agency" (identifying collective forms of agency capable of addressing systemic governance issues) (Chambers et al. 2021, p. 989–991). Even though all six modes of co-production share the common goal of interaction between researchers and non-researchers, as well as the inclusion of a plurality of voices, it is perhaps reasonable to suggest that "researching solutions" and, to a lesser extent, "navigating differences" are modes of co-production that are not as reliant on repairing or developing trust, with an associated need for co-designing and developing a shared understanding of every minor detail of the co-production process.

It is important to stress that different modes of co-production, regardless of the framework used (e.g., Chambers et al. 2021; Bandola-Gill et al. 2023; Musch and von Streit 2020), are not mutually exclusive, and will often incorporate different elements from different co-production modes. However, the issue being addressed will both dictate the co-production mode(s) used, and perhaps the corresponding amount of researcher and non-researcher involvement. For instance, the level of collaboration and interaction among those involved in a co-production process focused on indigenous revitalization through family-based land management (Reed and Diver 2023), given the historical trauma and potential for participant harm if the process goes wrong, is likely higher than in the case of wilderness science planning. Further, the co-production mode(s) used and the context may shift the evaluation of an ideal co-production process from the level of involvement of non-researchers, to additional and different facets. Maas et al. (2022) suggested at least two additional facets of an ideal co-production process, with less emphasis on the level of interaction and a full sharing of the workload: (1) equal and full commitment from all involved and; (2) clearly delineated roles and responsibilities of those involved with a focus on addressing some

element of the research-management gap. In reflecting on our co-production process and the level of non-researcher involvement through the full cycle of research, various roles and responsibilities became evident, even if they were not explicitly articulated at the outset.

Informing ALWRI's science agenda via a co-production process was of interest based on several potential benefits or goals. First and foremost, to increase the chance of producing relevant science through the Institute's finalized science agenda, we planned the agenda's areas of focus around the directly reported needs of our community. As such, as the Institute pursues its science agenda, regardless of whether future individual studies are co-produced or not, it is perhaps more likely that the resulting knowledge will be perceived as relevant. Another benefit is enhanced relationships between researchers and practitioners (in both the near and long-term), with the hope that future partnering with practitioners may become easier based upon the shared understanding that the overall research priorities were jointly created. Co-developed decisions at the institutional level may increase the level of ownership partners perceive, potentially creating a virtuous cycle of co-production that leads to better relationships over time (Ikhile et al. 2023).

Finally, a co-produced science agenda can help sustain research programs. The societal structures in which research programs are embedded require researchers to demonstrate value to justify their existence. Siloed, esoteric research that leaves end-users dissatisfied and distrustful is unlikely to prove viable in the long term; research that is transparent and useful to a variety of end-users demonstrates accountability, leading to sustained support. This basic assertion is supported, in part, by a shift in the traditional funding model whereby the end-users of research are more influential in how funders (or sponsors) make decisions about how to allocate research dollars (Arnott et al. 2020). For ALWRI, as a federal research program that relies on agency partners within the government to advocate for funding support, there is a need to put effort toward create knowledge that can be applied, for the sustainability of the program itself. The co-production of a science agenda, as discussed in Sect. 3.5, appears to have contributed to the perception that ALWRI is working hard to be relevant and supportive of the broader wilderness management community.

With these goals and potential benefits in mind, we question whether increased non-researcher participation at various stages would have been worthwhile. For instance, increased participation in the methods selection (and methods analysis) is challenging because often methodologies are highly specialized and analysis is time-consuming. While increased incorporation of non-researchers into the methods selection and analysis phases could have occurred, the potential costs are more apparent than the potential benefits. Non-researchers do not generally have the requisite training

to meaningfully engage in the topics of data analysis and methods selection; therefore, those researchers involved in the process would be required to provide some level of training or technology transfer. This would require both time and effort on the part of researchers and non-researchers alike. Without clear benefits of increased co-production at these two specific phases of the cycle, there is the risk of: (1) potential burnout (largely to researchers) from the co-production process (Oliver et al. 2019) and (2) what Cross et al. (2016) call "collaboration overload," whereby meetings and interactive sessions become excessive, substantive contributions come from a limited number of people, and those who contribute more time and effort experience increased requests for other collaborative projects. Ultimately, we decided that increasing the level of co-production in the methods selection and data analysis phases was not worth the effort, but it is an open question as to whether aiming for a higher level of co-production would have yielded increased benefits.

Returning to another open question, we wonder whether the ideal co-production process is one where every phase (as shown in Fig. 1) has a "high" level of involvement from non-researchers, regardless of the costs and effort associated with the process. Or is it a process whereby a group of non-researchers and researchers work together throughout the research cycle to the point that maximizes the potential for achieving whatever outcomes are of interest, while also minimizing the costs to those involved? Our view is that the costs of co-production should be considered within the context of the added benefits. This view highlights some alignment with Maas et al. (2022), with perhaps a larger focus on levels of commitment and clearly delineated roles of those involved. However, we would also suggest that as interaction between researchers and non-researchers increases, potential and impactful roles and responsibilities may organically emerge, which is to say explicitly identifying roles and responsibilities at the outset might be challenging.

Lastly, and particularly within the context of the researching solutions mode of co-production where mitigating the research-management gap is a primary objective, we see a challenge in distinguishing our process from a typical social science study. Largely because there is a blurry boundary between those non-researchers involved as co-producing partners and those involved as more typical research subjects. In other words, one could argue that the research process presented herein is not distinct from a typical social science project aiming to learn something (research priorities) from some group of people (ALWRI's partners). Of course, we would reject such an argument, because our intention, the tone of our approach with partners, and the interpretation workshops were all characteristic of a co-produced research process. However, we nonetheless acknowledge the potential challenge of distinguishing co-produced knowledge from

a more typical research process, particularly in the social sciences, and call upon other co-production enthusiasts to continue the discussion moving forward.

5 Conclusions

Co-production is a widely embraced approach for developing actionable knowledge, but the concept is perhaps threatened by its own success, as it has become a catch-all for participatory approaches addressing complex social-ecological issues. There is an increasing focus on adding nuance to what is meant by co-production, as well as both the potential benefits and costs of co-production processes. In this perspective essay, we reflected on the ideal of co-production within the context of a process aimed at informing the science agenda of federal research program in the USA. While co-production may provide various benefits, including a mitigation of the research-management gap, the process requires significant resources. We suggest that the ideal of co-production is not necessarily one that integrates the maximum amount of non-research involvement throughout the full cycle of research at all costs, but one that focuses on mitigating the research-management gap while limiting the risks to those involved. As such, there are a plurality of ideal co-production processes, each of which is likely multi-faceted.

Author contributions C. Armatas co-developed the process for partner engagement, including the collection of input, co-led analysis, and co-led manuscript conceptualization and writing. T. Hollingsworth co-developed the process for partner engagement, including the collection of input, co-led analysis, and co-led manuscript conceptualization and writing. C. Black led qualitative analysis, and co-developed and co-wrote the manuscript. J. Taylor co-developed the process for partner engagement, and supported conceptualization and writing of the manuscript.

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Data availability The data that support the findings of this study are available in the United States Forest Service Research data archive: <https://doi.org/10.2737/RDS-2024-0081>.

Declarations

Conflict of interest The authors declare no competing interests or funding.

Consent for publication The findings and conclusions in this publication are those of the authors and should not be construed to represent any official US Department of Agriculture or US Government determination or policy.

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