Editorial overview: The science of actionable knowledge

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What is the science of actionable knowledge?

Today, perhaps more than ever, voices across science and societies are calling upon science to inform solutions that will enhance environmental sustainability. Increasingly, sustainability scientists and practitioners are responding by working more deliberately, and often more collaboratively with each other, to generate knowledge that is actionable [1,2]. While these efforts often appear beneficial, achieving sustainability remains an all too distant goal. As a result, those desiring stronger links between scientific knowledge and action may benefit from improved understanding of what makes knowledge actionable and what actionable knowledge can and cannot do to enhance social and environmental well-being.

At present many questions about actionable knowledge, both fundamental and applied, lack straightforward answers. For example, what is actionable knowledge? How does it come about? Who is responsible for achieving it? How do we evaluate it? While these knowledge gaps are significant, advancing answers to these questions does not require starting from scratch. Scholarship on science, its relationship with society, and its role in decision-making has for decades helped to imagine how science can more meaningfully inform decisions (e.g. Ref. [3]). And new evidence continues to emerge about what actionable knowledge looks like in different contexts and how it comes about (e.g. Refs. [4,5]). More generally, developments in the ‘science of science’ (or meta-research) are showing how applying a scientific lens to the process of science itself can help inform choices about how best to organize scientific activities [6].

Against this backdrop, the ‘science of actionable knowledge’ is emerging: an area of inquiry that aims to understand and catalyze transitions in scientific knowledge making and use. It is entering into a dynamic and already contested domain. On the one hand, alternative ways of doing science, such as knowledge co-production, are already driving more societally engaged sustainability research that improves use in decision-making [7].

On the other hand, critiques of these approaches continue to underscore uncertainties about the efficiency, efficacy, and equity of methods and outcomes [8]. More systematic investigation on the drivers and mechanisms of actionable knowledge has the potential to help strengthen an empirical and ethical evidence base, which in turn can advance our understanding of knowledge systems and how they can contribute to societal challenges.

The science of actionable knowledge is an interdisciplinary and transdisciplinary endeavor. Science and technology studies, political science, environmental social science, psychological and decision science, and the
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humanities all lend distinctive methods and perspectives for understanding different aspects of the science system and its relationship to decision-making and society. Furthermore, modes of research with long track records of use, including community and citizen science and participatory action research, have much to contribute along with more recent attention being paid to the role of knowledge co-production. The insights of people working at the interface of science and practice at local, regional, and international scales are additionally critical.

In this issue, ten teams of scholars working on the science of actionable knowledge provide reviews of research across diverse topics and questions in this space. Taken together, these articles highlight the breadth and depth of work that this line of inquiry can produce, even as they underscore the knowledge gaps. The remainder of this editorial provides a brief summary of the articles included in this issue as well as a concluding note about possible future directions for the science of actionable knowledge.

Summary of special issue articles

Actionable knowledge and the art of engagement
In support of environmental sustainability, scholars and practitioners alike have increasingly pursued co-production: a model of knowledge production involving substantive interactions between researchers and knowledge-users, ideally resulting in knowledge that fits decision contexts. In practice, co-production has involved diverse forms of engaged research. Mach et al. [9] explore the complexity of actionable knowledge and of co-production processes. They consider the ways in which co-production serves as a tool for governance, as well as the creation of actionable knowledge. The critique unfolds lessons for effective collaborations between researchers and societal partners. The article concludes with a framework for evaluating processes of actionable knowledge, attendant to their context specificity and the need for equitable, meaningful interactions.

Usable environmental knowledge from the perspective of decision-making
Environmental knowledge is an essential input for decision-making, although it often appears unusable. To advance the understanding of when and how knowledge becomes actionable for decision-making, Dewulf et al. [10] distinguish different logics of decision-making. The logic of consequentiality is rooted in theories of rational choice, the logic of appropriateness in institutional theories, and the logic of meaningfulness in theories of sensemaking and interpretation. Across these logics, environmental knowledge can be used, albeit in different ways and for different reasons. For example, knowledge may be useful when it fits well with existing rules and routines (appropriateness), or when it supports meaning in complex situations (meaningfulness). The different logics can usefully inform both the theory and the practice of environmental knowledge production.

The politics of co-production
Along with optimism that participatory research approaches will increase the usability of knowledge, there is also ambition that they will bring about broader societal transformation in areas such as equity or sustainability. Yet as Turnhout et al. [11] argue, co-production can fail to live up to these expectations because the politics of uneven power distributions amongst those who participate in co-production are frequently ignored. Furthermore, they argue that ‘[d]e-politicization is a key factor in the reproduction (and justification) of the unequal power relations.’ In this view, more successful co-production that also empowers participants and plants seeds for societal transformation involves scrutinizing arrangements for power imbalances,
avoiding premature closure of conflicts when they arise, and shifting from a ‘power-over’ to a ‘power-with’ mentality.

Sponsoring actionable science
Public funders of science are often perceived to be influential agents in the science system, but little research has considered how science funders can wield their influence to encourage more actionable knowledge. Arnott et al. [12] identify four opportunities for science funding program management to bolster the generation of actionable knowledge. These include (1) crafting solicitations to encourage research approaches that are more interactive with society, (2) reshaping panel review composition and processes to include and value different approaches to research and expertise, (3) lending other forms of capacity to support research teams during implementation, and (4) augmenting and refining evaluation to both encourage and learn more about the impact of collaborative approaches. In pursuing these opportunities, the authors foresee a more interactive, iterative, and evaluation-centered approach to the study and practice of public science funding program management.

Insights for effective decision support tools for environmental sustainability
A growing number of environmental sustainability decision support tools (DSTs) may not be reaching their intended audience, and they vary in content and quality, potentially impairing action. Wong-Parodi et al. [13] argue that evaluation of DSTs during development may enhance the quality of decisions. They identify six characteristics of successful DSTs; in particular, successful DSTs and associated processes (1) clearly identify goals, (2) identify alternatives, (3) obtain relevant information, (4) articulate values, (5) evaluate alternatives, and (6) monitor outcomes. The authors consider the ways in which the Louisiana Coastal Master Plan process and planning tool embody these characteristics. The article concludes with reflections on integrating science into practice and policy and the role of DSTs.

The aspiration, outcome, and possibility of co-production
The already widespread theoretical literature about co-production is increasingly complemented by research reports on the application of co-production by research–practice partnerships. In this paper, Jagannathan et al. [14] review recent examples of co-produced research alongside current theorization on the topic. Focusing on climate change adaptation, they find that co-produced climate change adaptation demonstrates promise for improving knowledge use, among other positive outcomes. Still, they discover that the breadth of ambition conceived through theory exceeds the potential impact appearing in practice. The authors argue that understanding and reconciling the transformative potential of science–practice collaborations within the context of incremental progress achieved through project-scale timeframes will catalyze a more integrated and actionable scholarship on co-production.

Attributes of boundary spanners
Tackling challenges in environment and sustainability increasingly requires individuals who are able to operate across the still largely segregated realms of science and policy. Goodrich et al. [15] review what is known about the capacities and attributes of these ‘boundary spanning’ individuals. Traits such as emotional intelligence, empathy, and social capital combine to produce a skillset not frequently explicitly acknowledged or supported in typical professional development pathways. The authors themselves include several boundary spanning professionals, along with others who study and support this work in other ways. By articulating their unique attributes and functions, they argue for cultivating and legitimizing the role of boundary spanners as well as building more formal recognition of the profession.

Understanding and countering the motivated roots of climate change denial
More action is needed to meet the challenge of climate change. Wong-Parodi and Feygina [16] argue that psychological science offers insights into the motivated roots of climate change denial, as well as revealing possible strategies for enhancing acceptance and action. They review literature focused on the United States, where climate change denial is exceptionally high and much of the research has been conducted. Specifically, they review system-sanctioned change, identity, social norms, and self-affirmation in terms of both understanding denial and identifying possible counter solutions that encourage people to take action based on climate science.

Making room and moving over
The global environmental change research community, in engaging with Indigenous knowledge holders, often practices engagement in an extractive way, treating knowledge as data to be aggregated and understood abstractly and universally. Indigenous peoples are viewed as stakeholders instead of self-determined nations with rights and responsibilities for their knowledge systems and land. Bringing together scholarship on knowledge co-production with Indigenous knowledge, research, and environmental governance, Latulippe and Klenk [17] underscore that co-production scholars must move away from better ‘integrating’ Indigenous knowledges into western science and make way for Indigenous research leadership. This shift is necessary for respecting Indigenous sovereignty.
Transformation
Across contexts, concepts of transformation are increasingly invoked in the pursuit of environmental sustainability, and this theme cuts across the articles of the special issue. Transformation means fundamental change within a system, and for actionable knowledge, like co-production, can lead to different transformations in both science and society. Pulling different threads of transformation together, Scoones et al. [18] in this issue critique the literature on transformation and propose three distinct, yet complementary approaches: structural changes in the governance and practice of production and consumption; intentional systemic change arising out of interdependent institutions, technologies, and networks of actors; and increased focus on human agency and capacities to collectively manage uncertainty and identify pathways to desired futures. Across such approaches, they assert, effective transformations to sustainability require diverse knowledges, plural pathways, and a recognition of the political nature of transformation.

What is missing and what comes next?
The science of actionable knowledge is a diverse and burgeoning field building from its roots across many disciplines and forms of science–society interactions. The ten articles of the special issue provide insight into key drivers and mechanisms, but the treatment is inevitably incomplete. Additional vantage points should include more practitioners who work on the frontlines of putting knowledge into action, the role of media and other forms of communication, and experiences of other stakeholders who are intended beneficiaries or otherwise affected by actionable knowledge generation. We acknowledge that many of the articles feature climate change even though this is but one of many threats to sustainability in the 21st century and beyond.

Building from the prior research reviewed in these papers, and the new insights that emerge from these syntheses, we hope researchers, practitioners, science policymakers, and funders of science will consider ways in which they can contribute to, and draw upon, the science of actionable knowledge. Fundamental understanding about actionable knowledge will emerge from practical applications; and in turn, practical applications have the opportunity to be enhanced over time through new discoveries about what constitutes and drives actionable knowledge. Sustainability scholars and solution seekers interested in this domain are encouraged to reach out to the corresponding author of this paper for more information about how engage with or utilize resources emerging from this growing community of inquiry.

Conflict of interest statement
Nothing declared.

Acknowledgements
This special issue was developed through, and greatly improved by, discussions within the Science of Actionable Knowledge (SOAK) group. In the development of this special issue, SOAK was convened through support from the National Socio-Environmental Synthesis Center (SESYNC) under funding received from the National Science Foundation (DBI-1639145). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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