Philosophy of Science (2024), **91**, 1221–1231
doi:10.1017/psa.2023.127

PSA PHILOSOPHY OF SCIENCE ASSOCIATION
PHILOSOPHY OF SCIENCE

SYMPOSIA PAPER

Transdisciplinary Philosophy of Science: Meeting the Challenge of Indigenous Expertise

David Ludwig[1], Charbel N. El-Hani[2,3], Fabio Gatti[1], Catherine Kendig[4], Matthias Kramm[1,5], Lucia Neco[6], Abigail Nieves Delgado[7], Luana Poliseli[1,3], Vitor Renck[1,3], Adriana Ressiore C.[1], Luis Reyes Galindo[1], Thomas Lloyd Rickard[8], Gabriela De La Rosa[1,3], Julia J. Turska[1], Francisco Vergara-Silva[5] and Robert A. Wilson[6]

[1]Knowledge, Technology and Innovation Group, Wageningen University and Research, Wageningen, The Netherlands, [2]Instituto de Biologia, Universidade Federal da Bahia, Salvador, Brazil, [3]Instituto Nacional de Ciência e Tecnologia em Estudos Interdisciplinares e Transdisciplinares em Ecologia e Evolução, Universidade Federal da Bahia, Salvador, Brazil, [4]Department of Philosophy, Michigan State University, Lansing, USA, [5]Instituto de Biología, Universidad Nacional Autónoma de México, Ciudad de México, Mexico, [6]School of Humanities, University of Western Australia, Perth, Australia, [7]Freudenthal Instituut, Universiteit Utrecht, Utrecht, The Netherlands and [8]Programa de Pós-graduação em Análise e Modelagem de Sistemas Ambientais, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil
Corresponding author: David Ludwig; Email: david.ludwig@wur.nl

(Received 18 April 2023; revised 08 September 2023; accepted 21 September 2023; first published online 04 October 2023)

Abstract

Transdisciplinary research knits together knowledge from diverse epistemic communities in addressing social-environmental challenges, such as biodiversity loss, climate crises, food insecurity, and public health. This article reflects on the roles of philosophy of science in transdisciplinary research while focusing on Indigenous and other subjugated forms of knowledge. We offer a critical assessment of demarcationist approaches in philosophy of science and outline a constructive alternative of transdisciplinary philosophy of science. While a focus on demarcation obscures the complex relations between epistemic communities, transdisciplinary philosophy of science provides resources for meeting epistemic and political challenges of collaborative knowledge production.

Introduction

Transdisciplinarity is widely embraced as a methodological framework for addressing social-environmental challenges, such as climate change mitigation, food production, biodiversity loss, public health, social inequality, soil erosion, and sustainable energy production (OECD 2020). None of these challenges can be addressed through isolated disciplinary approaches but demand the collaboration of diverse academic and nonacademic actors (Chambers et al. 2021; Tengö et al. 2014).

For example, biodiversity conservation requires diverse academic knowledge ranging from ecology and pedology to legal and policy studies. Thoroughly interdisciplinary collaborations between academic researchers go some way to ensure that interventions account for the complexity of social-environmental dynamics of biodiversity loss. Beyond this, transdisciplinary approaches highlight the critical importance of nonacademic actors in successful conservation projects. For example, many actors beyond those in institutionalized academic settings, such as Indigenous communities, farmers, or fishers, have substantial insights into local ecosystem dynamics and the interplay between biodiversity and livelihood practices. Conserving biodiversity often also requires the mediating expertise of additional actors, such as conservation managers, engineers, policy makers, science communicators, or teachers, who are capable of connecting academic knowledge with diverse domains of intervention. Far from being a problem within one discipline, biodiversity conservation represents a paradigmatic transdisciplinary problem that requires diverse forms of knowledge and expertise from both within as well as outside academia.

This article reflects on the experiences of a collaborative research group that places philosophers in transdisciplinary projects to engage not only with natural and social scientists but also with local communities and their expertise regarding social-environmental challenges (El-Hani et al. 2022; Ludwig and El-Hani 2020; Renck et al. 2023). Philosophy can contribute to the epistemological and political reflexivity necessary for transdisciplinary research. For example, philosophical accounts of epistemic diversity and expertise (Rolin 2019; Whyte and Crese 2010) can help to specify the benefits and challenges of transdisciplinary approaches when intervening in complex systems. Philosophical debates about social diversity and values in science (Harding 2015; Elliott 2017) can inform transdisciplinary reflection about heterogeneous material needs and interests in scientific practice.

While philosophy of science can contribute to reflexivity in transdisciplinary research, philosophical, and transdisciplinary research communities often remain disconnected in practice. The following sections address the roles of philosophy of science in transdisciplinary research in three steps. First, we introduce the case of Indigenous expertise, as it emphasizes both the epistemic and political stakes of transdisciplinary approaches to social-environmental challenges. Second, we argue that recent demarcationist approaches in philosophy of science obscure Indigenous expertise as well as the epistemic and political concerns that drive transdisciplinary research. Third, we outline a constructive perspective on transdisciplinary philosophy of science that supports critical reflexivity in scientific practices to meet the social-environmental challenges.

Indigenous expertise and philosophy of science

Debates about Indigenous expertise highlight both the epistemic and political stakes of transdisciplinary research. On the epistemic side, Indigenous expertise challenges a simple divide between the expertise of academic researchers and the allegedly superficial "folk knowledge" of everyone else. Indigenous people have developed complex epistemic traditions that are far from superficial, articulating fine-grained expertise about issues such as biodiversity and ecosystem dynamics (Chilisa 2019). As the epistemic practices of Indigenous communities have coevolved with ecosystems

over many generations, they are constantly refined through daily livelihood practices such as farming, fishing, forest management, and hunting (Albuquerque et al. 2021; Kendig 2020).

The notion of expertise remains contested and has been operationalized in various ways by philosophers (Goldman 2018), psychologists (Hoffman 1998), and sociologists of science (Collins and Evans 2019). Recognizing Indigenous peoples as experts on issues such as ecosystem dynamics and conservation management, however, does not require prior endorsement of one particular account of expertise. While competing accounts of expertise emphasize different aspects from problem solving to propositional knowledge to reliable testimony, all of them are clearly reflected in Indigenous relations to local environments. We therefore consider Indigenous expertise to be relatively straightforward and empirically verifiable even when the characterization of Indigenous expertise as science remains contested due to competing operationalizations of "science."

Recognition of Indigenous expertise highlights not only the epistemic but also the political dimensions of transdisciplinary research. Even if issues such as food security or biodiversity loss "affect everyone," they clearly do not affect everyone equally. Not everyone's access to safe and nutritious food is threatened to the same degree, and the effects of biodiversity loss are not disruptive to everyone's lives in equal ways. The expertise of Indigenous people regarding sustainable food production or conserving biodiversity contrasts with Indigenous livelihoods being undermined through dominant unsustainable approaches in agriculture and conservation (Hernandez 2022). In the case of food production, agricultural sciences often focus on increasing outputs through industrialization that replaces Indigenous agricultural systems with export-oriented monocultures. The results for many Indigenous communities are devastating: Indigenous land becomes dispossessed for the creation of large farms; Indigenous labor becomes expendable through mechanization; Indigenous livelihoods become dependent on the ability to produce profitable agrifood commodities; and local crop diversity disappears and with it the capacity to respond to unforeseen events such as droughts, deforestation, and soil erosion that undermine the long-term sustainability of food production (Vijayan et al. 2022).

In the case of biodiversity conservation, dominant approaches commonly redistribute burdens of environmental crises to Indigenous communities. Resource extraction that drives biodiversity loss is largely driven by consumption in urban areas, while biodiversity becomes most cheaply conserved in Indigenous territories. Indigenous and other subjugated rural communities therefore often become forcibly relocated for the creation of wildlife parks, their traditional practices of hunting and farming become criminalized, and their murder becomes celebrated on social media through their dehumanization as "poachers" (Lunstrum 2017). The violence of modern conservation is marked by a deep disconnect between those who drive biodiversity loss and those whose livelihoods are disrupted for biodiversity conservation (Ramutsindela et al. 2022).

Questions about Indigenous expertise crystallize both the epistemic and political stakes of transdisciplinary research that is oriented toward urgent social-environmental challenges. Meeting these challenges requires transdisciplinary research with sufficient methodological depth to address epistemic diversity and its entanglement with competing material interests, values, and worldviews.

Embedding philosophers in transdisciplinary research can contribute to this methodological depth and thereby connect philosophical reflexivity with scientific and social practice.

Philosophy of science as boundary policing

While philosophers have much to contribute to reflexivity about epistemic and social diversity, philosophy of science plays only a peripheral role in current debates about Indigenous expertise and transdisciplinarity. Questions of Indigenous expertise have been most forcefully pushed by Indigenous scholars (Chilisa 2019; Smith 2021) and have been picked up by academics in the social and environmental sciences (Peddi et al. 2022; Turnhout et al. 2019). With some notable exceptions in feminist and decolonial scholarship (Harding 2015; Wylie 2015), the philosophy of science community has been at best reactive and has only recently started to engage more robustly with Indigenous epistemic traditions (e.g., Kendig 2020; Koskinen and Rolin 2022; Ludwig 2016; Ludwig and Poliseli 2018).

The situation is equally dire in wider debates about transdisciplinarity that have been flourishing since the 1970s. These debates have largely remained off the radar of philosophers of science, even when transdisciplinarity is celebrated as a "paradigm shift in research practice," as a recent report by *The Organization for Economic Cooperation and Development* puts it (OECD 2020, 9). Again, philosophy of science enters the conversation at a late stage with recent attempts to theorize transdisciplinarity as a major development in the science system (Koskinen and Mäki 2016; Kiyashchenko 2017; Ludwig and Boogaard 2021; O'Rourke et al. 2019; Poliseli and Leite 2021).

The delayed reception and peripheral role of philosophy of science in debates about Indigenous knowledge and transdisciplinarity reflects structural limitations of its intellectual heritage. Indeed, many tools of twentieth-century philosophy of science are not only insufficient for understanding the dynamics of collaborative knowledge production but also often misrepresent the role of Indigenous expertise through a focus on demarcation instead of transdisciplinary collaboration.

Public controversies about the role of Indigenous knowledge in academia illustrate this risk of misrepresentation. For example, consider the debate between philosopher Massimo Pigliucci (2021a, 2021b) and ecologist Root Gorelick (2021a, 2021b) at a roundtable on *Indigenizing the University* in Canada that was held in 2016 and published in a collected volume recently (Widdowson 2021). The debate is framed in terms of the "demarcation problem" of distinguishing science from nonscience while focusing on the question of whether Indigenous knowledge qualifies as "science." Gorelick proposes an account of science as "anything that is Bayesian" (2021a, 177), arguing that "[W]estern and indigenous sciences conduct generalized Bayesian updating of their auxiliary hypotheses" (2021a, 180). Pigliucci objects that Gorelick's account of science is "too general and vague" (2021b, 224) as his appeal to the updating of prior probabilities through observations is not unique to science but applies to all kinds of human thinking. Instead, Pigliucci proposes a demarcation "between local knowledge and universal statements about how the world works. Science uses the former in order to get to the latter, while the sort of Indigenous knowledge that is scientifically sound is always local" (ibid.). In illustrating this presumed divide, Pigliucci argues: "Inuit knowledge does not qualify as 'science' by any standard understanding of the

word: science isn't just local knowledge. My local knowledge of the New York subway system ... doesn't mean that I am doing subway science" (2021a, 204).

While the debate between Gorelick and Pigliucci is focused on the Canadian context, similar controversies have emerged in other contexts, such as the status of Mātauranga—Māori knowledge in Aotearoa, New Zealand. In July 2021, biologist Kendall Clements and six of his colleagues at the University of Auckland published a letter "In Defence of Science," which challenged a government proposal to anchor Mātauranga in the secondary school curriculum (Clements et al. 2021). Akin to Pigliucci's critique, the letter relies on claims about the universal aims of science and, in particular, the insistence on a sharp demarcation between "science" and Māori knowledge, which is described as falling "far short of what we can define as science itself" (ibid., para. 4). While the letter has been criticized as obscuring much-needed discussion over Māori knowledge by both scientists and philosophers (Parke and Hikuroa 2021), it also gained substantial support from public figures, including Richard Dawkins, who associates the debate about Māori knowledge with "self-righteous virtue-signalling, bending a knee to that modish version of Original Sin which is white guilt" while he reduces Indigenous expertise to "valuable tips" on issues like edible fungi (Dawkins 2023, para. 3).

Both cases illustrate how demarcationist framings from twentieth-century philosophy of science create tensions with the complex reality of transdisciplinary research. Philosophy of science developed various accounts of the "structure of science" (Nagel 1961) or the "logic of research" (Popper 1935), which have grounded competing demarcation criteria for separating science from pseudoscience. Applying these demarcation criteria to transdisciplinary research appears (a) pragmatically, (b) epistemologically, and (c) politically misleading.

(a) To reveal the extent to which the demarcationist framing misleads pragmatically, consider Gorelick and Pigliucci's debate about the boundaries of science against the backdrop of transdisciplinary projects that aim for collaborative responses to social-environmental challenges. Such projects tend to involve a large variety of actors, such as agronomists, anthropologists, community elders, conservation managers, ecologists, engineers, farmers, fishers, government technicians, hunters, medical practitioners, policy makers, policy scholars, science communicators, social activists, social workers, teachers, and students. As many of these actors have no interest in being labeled "scientists," the demarcationist question whether their knowledge is "scientific" simply misses the point of their inclusion in transdisciplinary processes. For example, Gorelick and Pigliucci's debate about the role of Indigenous perspectives in universities should address issues such as: Where is Indigenous expertise important for answering questions that are asked in universities? How should Indigenous perspectives contribute to shaping questions that are asked there in the first place? Addressing these issues does not require engagement with the demarcation problem as the substantial issues do not depend on whether we apply the label "science" to Indigenous expertise or not. Pragmatically speaking, demarcationism misses the rationale for transdisciplinary inclusion of different forms of expertise by focusing on the extension of the label "science."

(b) Demarcation exercises are often not only off-topic but also actively mislead epistemological analyses of transdisciplinary research. Consider Pigliucci's demarcation line "between local knowledge and universal statements about how the world works."

Pigliucci lumps together Inuit knowledge and New York subway riders as belonging to the former category and therefore not qualifying as science. This simple divide fails to recognize the expertise of the Inuit who have built complex epistemic traditions over many generations that coevolved with Arctic environments. While researchers in Arctic regions commonly recognize this expertise (e.g., Gilchrist et al. 2005; Huntington 2000), Pigliucci's binary divide lacks resources for a substantial epistemological analysis of its relevance for research. While it is true that Inuit knowledge is often local in the sense that it is specifically about Arctic environments, most academic researchers who specialize in Arctic ecosystems also have genuinely local goals rather than treating the Arctic as a mere case study for the formulation of universal laws in ecology. Transdisciplinary research commonly aims at understanding particular systems rather than making universal statements about how the world works. The claim that science is always fundamentally oriented toward universal statements is disconnected from the reality of transdisciplinary research that addresses social-environmental systems with distinctly local materializations and thereby misrepresents the empirically well-documented diversity of science (Galison and Stump 1996). Methodologies for transdisciplinary research require recognition of diverse forms of expertise and their relations, rather than a simple demarcation between science and nonscience or universal and local knowledge.

(c) Demarcation exercises foster political misuse beyond merely pragmatic or epistemological misunderstandings. Philosophical debates about the demarcation problem often remain ambiguous as to whether they aim to distinguish "science" from "nonscience" (which may include legitimate nonscientific knowledge) or from "pseudoscience" (which excludes claims of epistemic legitimacy). For example, Pigliucci suggests that Indigenous knowledge is legitimate for local purposes, but he also defines the demarcation problem as "the question of how to meaningfully and reliably separate science from pseudoscience" (Pigliucci 2023). As a result, demarcation exercises obscure Indigenous expertise by lumping it together with pseudoscience on the other side of the demarcation line. Framing Indigenous expertise as pseudoscience is not only epistemically misleading but also reinforces its political marginalization through unwarranted association with epistemically corrupt practices. Rather than developing constructive accounts of epistemic diversity in transdisciplinarity, demarcationism risks a blanket delegitimization of knowledge outside of academia, no matter whether it is epistemically corrupt or not. The debate between Gorelick and Pigliucci illustrates this move toward delegitimization when turning from the nature of science to the political positioning of Indigenous knowledge in academia. Pigliucci argues that "Indigenous science ... is pseudoscience, and as such has no place in the university" (2021b, 228). Reflecting on the Canadian debates about "Indigenizing the university," Pigliucci claims that "the future [of] the entire nation is at stake" (2021a, 211) through the alleged threat of framing Indigenous knowledge as science. Instead of facilitating collaborative research on complex social-environmental systems, transdisciplinary research therefore becomes dragged into culture war polemics, as we saw in Dawkins's (2023) rhetoric of "knee-bending to white guilt."

To summarize, philosophical engagement with Indigenous knowledge and transdisciplinarity lags behind debates in many empirical disciplines and science studies. This section has shown how traditional tools from twentieth-century

philosophy of science can mislead debates about Indigenous knowledge. Without generating new methods for transdisciplinary mediation between different forms of expertise and evidence, philosophy of science risks contributing to pragmatic, epistemological, and political confusion. Philosophical debates about the "structure of science" and the "demarcation problem" raise the question of whether Indigenous knowledge truly qualifies as science. Negative answers both obscure Indigenous expertise and politically delegitimize it through its classification as epistemically corrupt "pseudoscience."

The delegitimization of Indigenous expertise through demarcation exercises reflects a concerning disconnect between the state of empirical research and philosophical commentary. Transdisciplinary methods have become firmly established in a wide range of academic fields including agricultural sciences, conservation biology, disaster studies, ecology, educational sciences, ethnobiology, health sciences, management sciences, policy studies, soil sciences, sustainability sciences, and taxonomy (e.g., Bohensky and Maru 2011; Reyes-García and Benyei 2019). One might expect philosophers of science to provide helpful commentary and maybe even guidance on how to navigate tensions in these types of transdisciplinary practice. This section has argued that philosophy of science runs the risk of disappointing this expectation if it continues to rely on demarcationist exercises that focus on policing the boundaries of "science" rather than developing a positive account of transdisciplinary research.

Transdisciplinary philosophy of science

Obstructive polemics about "pseudoscience" (Pigliucci 2021b) or "self-righteous virtue-signalling" (Dawkins 2023) to one side, philosophy of science provides constructive entry points for engaging with epistemic and social diversity in science. Many philosophers of science have abandoned the search for one unified demarcation criterion and instead focus on plurality as a pervasive feature of epistemically productive research environments (Kellert et al. 2006). While scientific pluralism has largely focused on the internal heterogeneity of academic research (see Ludwig and Ruphy 2021), many of its insights can inform a substantial philosophy of transdisciplinarity that aims to understand and relate different forms of expertise beyond academia.

For example, one of the core themes of scientific pluralism is the diversity of scientific classifications and ontologies (Dupré 1993; Kendig 2016). Rather than assuming that science converges toward one absolute description of the world, pluralist philosophers have shown that different epistemic and nonepistemic interests drive different classificatory practices in science. Research in our group demonstrates that these pluralist arguments extend beyond academia—from the classification of fish (Renck et al. 2022) to nomenclatures of lichens (Kendig 2020). These case studies point toward a complex interplay between interests and evidence in classificatory practices. Transdisciplinary research often involves actors who not only have access to different bodies of evidence but also are driven by different epistemic and nonepistemic interests that shape their classificatory practices. For example, a farmer may classify agricultural pests or crop varieties along morphological or ecological or even economic features that allow for empirically

robust farming practices, even if they do not converge on academic classifications of plants based on phylogenetic relations (Robles-Piñeros et al. 2020).

Scientific pluralism can help to make sense of the lack of unification and of the productive tensions between heterogeneous concepts and methods that are characteristic of transdisciplinary research. Feminist philosophy of science provides another helpful entry point that adds a distinctly political element to scientific pluralism. Especially through standpoint epistemology (Harding 2015), feminist philosophy of science questions the relations between different actors and their epistemic practices. Challenging an overly harmonious picture of epistemic diversity by examining biases and hierarchies, standpoint epistemology shows that it is not sufficient to highlight the expertise of different actors. Rather, it is necessary to engage critically with the political dynamics of their positionings and relations in transdisciplinary research.

In the research of our group, these issues emerge most clearly when moving beyond documenting diverse forms of expertise toward addressing their relevance for intervention and policy. Consider our work in the Brazilian fishing communities of Siribinha and Poças whose subjugated political position is intertwined with the marginalization of their fishing expertise that draws on Indigenous, African, and European elements. For example, we found that fishers in Siribinha and Poças are experts about a variety of issues from fish morphology to ecosystem dynamics to reproductive periods of fish (El-Hani et al. 2022; Renck et al. 2022). However, this expertise remains largely unacknowledged and unincorporated in policy decisions, leading to decisions that negatively affect community livelihoods. For example, we learned from these fishers that Brazilian law protects many fish at the wrong time by prohibiting fishing outside their actual reproductive period in the Itapicuru River estuary, where Siribinha and Poças are located (Renck et al. 2023). Such policy failures reflect the systemic exclusion of local expertise in environmental policy. Gesturing toward epistemic diversity is not enough: Philosophers of science need to engage with the political dynamics of inclusion and exclusion of different standpoints at the interface of science and society.

Scientific pluralism and feminist philosophy of science illustrate the availability of philosophical resources for addressing transdisciplinary dynamics. While philosophers can theorize about these issues from the outside through a philosophy *of* transdisciplinarity, novel perspectives emerge when positioning philosophy *within* these transdisciplinary dynamics. Positioning philosophers as collaborators in transdisciplinary projects comes with substantial challenges. For example, it requires that normative authority is recognized as distributed across collaborators rather than exclusively assigned to philosophers who judge the epistemologies, ontologies, and values of everyone else.

Treating philosophers as collaborators instead of external judges, however, also creates new opportunities. Philosophers of science can contribute to transdisciplinary practice with knowledge of a wide range of both descriptive and normative frameworks for analyzing and navigating diverse epistemologies, ontologies, and values, as well as the skills to integrate heterogeneous epistemic resources employing distinct standards (Poliseli, forthcoming). For example, our research has related ecological explanations of academic researchers and fishers in the Itapicuru River estuary in such a manner that it can foster or advance collaborations on issues such as

conservation, education, and fisheries policy (El-Hani et al. 2022). Philosophers can also help to situate values and politics in transdisciplinary research without collapsing knowledge into power. For example, our research considers how political hierarchies between epistemic communities can be addressed in transdisciplinary research that aims for more equitable forms of collaboration (Ludwig and Boogard 2021).

By treating philosophers as collaborators in transdisciplinary practice, transdisciplinary philosophy aligns with "philosophy of science in practice" (Ankeny et al. 2011; Boumans and Leonelli 2013; Poliseli 2018), challenging philosophers to become part of scientific communities rather than merely commenting on them from the outside. Situating philosophers in transdisciplinary research, however, also confronts philosophers with entanglements of scientific and social practices. Transdisciplinarity is located not only at the epistemic but also the social interface of science and society, requiring engagement with inequity and social stratification in knowledge production, as reflected in academic relations to Indigenous knowledge. Transdisciplinarity therefore constitutes an opportunity for expanding philosophy of science by embracing the practical relevance of philosophical reflexivity in addressing contested real-world challenges from climate change to public health.

References

Albuquerque, Ulysses Paulino, David Ludwig, et al. 2021. "Integrating Traditional Ecological Knowledge into Academic Research at Local and Global Scales." *Regional Environmental Change* 21:1–11. https://doi.org/10.1007/s10113-021-01774-2

Ankeny, Rachel, Hasok Chang, Marcel Boumans, and Mieke Boon. 2011. "Introduction: Philosophy of Science in Practice." *European Journal for Philosophy of Science* 1:303–7. https://doi.org/10.1007/s13194-011-0036-4

Bohensky, Erin L., and Yiheyis Maru. 2011. "Indigenous Knowledge, Science, and Resilience" *Ecology and Society* 16 (4), 1–19. https://doi.org/10.5751/ES-04342-160406

Boumans, Marcel, and Sabina Leonelli. 2013. "Introduction: On the Philosophy of Science in Practice." *Journal for General Philosophy of Science* 44:259–61. https://doi.org/10.1007/s10838-013-9232-6

Clements, Kendall, et al. 2021. "In Defense of Science." *New Zealand* Listener, July 23 2021, 4.

Chambers, Josephine M., Carina Wyborn, Melanie E. Ryan, Robin S. Reid, Maraja Riechers, Anca Serban, and Nathan J. Bennett. 2021. "Six Modes of Co-production for Sustainability." *Nature Sustainability* 4 (11):983–96. https://doi.org/10.1038/s41893-021-00755-x

Chilisa, Bagele. 2019. *Indigenous Research Methodologies*. Chicago: Sage.

Collins, Harry, and Robert Evans. 2019. *Rethinking Expertise*. Chicago: University of Chicago Press.

Dawkins, Richard. 2023. "Why I'm Sticking Up for Science." *The Spectator* https://www.spectator.co.uk/article/why-im-sticking-up-for-science/

Dupré, John. 1993. *The Disorder of Things*. Cambridge, MA: Harvard University Press.

El-Hani, Charbel, Luana Poliseli, and David Ludwig. 2022. "Beyond the Divide between Indigenous and Academic Knowledge." *Studies in History and Philosophy of Science* 91:296–306. https://doi.org/10.1016/j.shpsa.2021.11.001

Elliott, Kevin. 2017. *A Tapestry of Values*. Oxford: Oxford University Press.

Galison, Peter, and David Stump. 1996. *The Disunity of Science*. Stanford: Stanford University Press.

Gilchrist, Grant, Mark Mallory, and Flemming Merkel. 2005. "Can Local Ecological Knowledge Contribute to Wildlife Management?" *Ecology and Society* 10(1). https://www.ecologyandsociety.org/vol10/iss1/art20/

Goldman, Alvin I. 2018. "Expertise." *Topoi* 37 (1):3–10. https://doi.org/10.1007/s11245-016-9410-3

Gorelick, Root. 2021a. "Indigenous Sciences Are Not Pseudoscience." In *Indigenizing the University*, edited by F. Widdowson, Winnipeg: Frontier Center for Public Policy, 175–98.

Gorelick, Root. 2021b. "A Case for Indigenous Sciences." In *Indigenizing the University*, edited by F. Widdowson, Winnipeg: Frontier Center for Public Policy, 215–21.
Harding, Sandra. 2015. *Objectivity and Diversity*. Chicago: University of Chicago Press.
Hernandez, Jessica. 2022. *Fresh Banana Leaves*. Huichin: North Atlantic Books.
Hoffman, Robert. 1998. "How Can Expertise Be Defined?" In *Exploring Expertise*, edited by R. Williams, W. Faulkner, and J. Fleck, 81–100. London: Palgrave Macmillan.
Huntington, Henry. 2000. "Using Traditional Ecological Knowledge in Science: Methods and Applications." *Ecological Applications* 10:1270–74. https://doi.org/10.1890/1051-0761(2000)010[1270:UTEKIS]2.0.CO;2
Kellert, Stephen, Helen Longino, and Kenneth Waters. 2006. *Scientific Pluralism*. Minneapolis: University of Minnesota Press.
Kendig, Catherine. 2020. "Ontology and Values Anchor Indigenous and Grey Nomenclatures: A Case Study in Lichen Naming Practices among the Samí, Sherpa, Scots, and Okanagan." *Studies in History and Philosophy of Biological and Biomedical Sciences* 84 (101340):1–11. https://doi.org/10.1016/j.shpsc.2020.101340
Kendig, Catherine (ed.). 2016. *Natural Kinds and Classification in Scientific Practice*. London: Routledge.
Kiyashchenko, Larisa. 2017. "Philosophy of Transdisciplinarity: Approaches to the Definition." *Transdisciplinary Journal of Engineering & Science* 8:20–35. https://doi.org/10.22545/2017/00084
Koskinen, Inkeri, and Uskali Mäki. 2016. "Extra-academic Transdisciplinarity and Scientific Pluralism: What Might They Learn from One Another?" *European Journal for Philosophy of Science* 6:419–444. https://doi.org/10.1007/s13194-016-0141-5
Koskinen, Inkeri, and Kristina Rolin. 2022. "Scientific/Intellectual Movements Remedying Epistemic Injustice." *Philosophy of Science* 86 (5):1052–63. https://doi.org/10.1086/705522
Ludwig, David. 2016. "Indigenous and Scientific Kinds." *British Journal for the Philosophy of Science* 68:187–212. https://doi.org/10.1093/bjps/axv031
Ludwig, David, and Birgit Boogaard. 2021. "Making Transdisciplinarity Work." In *The Politics of Knowledge in Inclusive Development and Innovation*, edited by D. Ludwig, B. Boogaard, P. Macnaghten, and C. Leeuwis, 19–33. New York: Routledge.
Ludwig, David, and Charbel N. El-Hani. 2020. "Philosophy of Ethnobiology: Understanding Knowledge Integration and Its Limitations." *Journal of Ethnobiology* 40:3–20. https://doi.org/10.2993/0278-0771-40.1.3
Ludwig, David, and Luana Poliseli. 2018. "Relating Traditional and Academic Ecological Knowledge: Mechanistic and Holistic Epistemologies across Cultures." *Biology & Philosophy* 33:1–19. https://doi.org/10.1007/s10539-018-9655-x
Ludwig, David, and Stéphanie Ruphy. 2021. Scientific Pluralism. *Stanford Encyclopaedia of Philosophy*. (Winter 2021 Edition), edited by Edward N. Zalta. https://plato.stanford.edu/entries/scientific-pluralism/
Lunstrum, Elizabeth. 2017. "Feed Them to the Lions: Conservation Violence Goes Online." *Geoforum* 79:134–43. https://doi.org/10.1016/j.geoforum.2016.04.009
Nagel, Ernest. 1961. *The Structure of Science*. New York: Harcourt Brace & World.
OECD. 2020. *Addressing Societal Challenges Using Transdisciplinary Research*. https://doi.org/10.1787/0ca0ca45-en
O'Rourke, Michael, Stephen Crowley, Bethany Laursen, Brian Robinson, and Stephanie E. Vasko. 2019. "Disciplinary Diversity in Teams." In *Strategies for Team Science Success*, edited by Kara L. Hall, Amanda L. Vogel, Robert T. Croyle, 21–46. Cham: Springer.
Parke, Emily, and Dan Hikuroa. 2021. "Let's Choose Our Words More Carefully When Discussing Mātauranga Māori and Science." *The Conversation*. https://theconversation.com/lets-choose-our-words-more-carefully-when-discussing-matauranga-maori-and-science-165465
Peddi, Branwen, David Ludwig, and Joost Dessein. 2022. "Relating Inclusive Innovations to Indigenous and Local Knowledge: A Conceptual Framework." *Agriculture and Human Values* 40:395–408. https://doi.org/10.1007/s10460-022-10344-z
Pigliucci, Massimo. 2021a. "Is Indigenous Science Pseudoscience? A Response to Gorelick." In *Indigenizing the University*, edited by F. Widdowson, Winnipeg: Frontier Center for Public Policy, 199–214.
Pigliucci, Massimo. 2021b. "Is Indigenous Science Pseudoscience? A Further Response to Gorelick." In *Indigenizing the University*, edited by F. Widdowson, Winnipeg: Frontier Center for Public Policy, 223–29.

Pigliucci, Massimo. 2023. "Pseudoscience and the Demarcation Problem." *Internet Encyclopedia of Philosophy*. ISSN 2161-0002, https://iep.utm.edu/pseudoscience-demarcation/

Poliseli, Luana. 2018. "When Ecology and Philosophy Meet: Constructing Explanations and Assessing Understanding in Scientific Practice." Salvador: PhD Diss.

Poliseli, Luana. Forthcoming. "Causality and Interdisciplinarity in the Philosophy of Science in Practice." In *The Routledge Handbook of Causality and Causal Methods*, edited by P. Illari and F. Russo. New York: Routledge.

Poliseli, Luana, and Clarissa Leite. 2021. "Developing Transdisciplinary Practices." *In Global Epistemologies and Philosophies of Science*, 77–90. New York: Routledge.

Popper, Karl. 1935. *Logik der Forschung. Zur Erkenntnistheorie der modernen Naturwissenschaft*. Springer: Berlin.

Ramutsindela, Maano, Frank Matose, and Tafadzwa Mushonga. 2022. *The Violence of Conservation in Africa*. Cheltenham, UK: Edward Elgar Publishing.

Renck, Vitor, David Ludwig, Paride Bollettin, and Charbel N. El-Hani. 2022. "Exploring Partial Overlaps between Knowledge Systems in a Brazilian Fishing Community." *Human Ecology* 50:633–49. https://doi.org/10.1007/s10745-022-00335-3

Renck, Vitor, David Ludwig, Paride Bollettin, José Amorim Reis-Filho, Luana Poliseli, and Charbel N. El-Hani. 2023. "Taking Fishers' Knowledge and Its Implications to Fisheries Policy Seriously." *Ecology and Society* 28. https://doi.org/10.5751/ES-14104-280207

Reyes-García, Victoria, and Petra Benyei. 2019. "Indigenous Knowledge for Conservation." *Nature Sustainability* 2 (8):657–58. https://doi.org/10.1038/s41893-019-0341-z

Robles-Piñeros, Jairo, David Ludwig, Geilsa Costa Santos Baptista, and Adela Molina-Andrade. 2020. "Intercultural Science Education as a Trading Zone between Traditional and Academic Knowledge." *Studies in History and Philosophy of Biological and Biomedical Sciences* 84, 1–10. https://doi.org/10.1016/j.shpsc.2020.101337

Rolin, Kristina. 2019. "The Epistemic Significance of Diversity." In *The Routledge Handbook of Social Epistemology*, edited by Miranda Fricker et al., 158–166. New York: Routledge.

Scott, James. 1998. *Seeing Like a State*. New Haven, CT: Yale University Press.

Smith, Linda Tuhiwai. 2021. *Decolonizing Methodologies*. London: Zed Books.

Tengö, Maria, Eduardo Brondizio, Thomas Elmqvist, Pernilla Malmer, and Marja Spierenburg. 2014. "Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Base Approach." *Ambio* 43:579–91. https://doi.org/10.1007/s13280-014-0501-3

Turnhout, Esther, Willemijn Tuinstra, and Willem Halffman. 2019. *Environmental Expertise*. Cambridge: Cambridge University Press.

Vijayan, Dhanya, et al. 2022. "Indigenous Knowledge in Food System Transformations." *Communications Earth & Environment* 3(1), 1–3. https://doi.org/10.1038/s43247-022-00543-1

Whyte, Kyle Powys, and Robert Crease. 2010. "Trust, Expertise, and the Philosophy of Science." *Synthese* 177:411–25. https://doi.org/10.1007/s11229-010-9786-3

Widdowson, Frances. 2021. *Indigenizing the University*. Winnipeg: Frontier Centre for Public Policy.

Wylie, Alison. 2015. "A Plurality of Pluralisms: Collaborative Practice in Archaeology." *In Objectivity in Science*, edited by Flavia Padovani, Alan Richardson, Jonathan Y. Tsou, 189–210. Dordrecht: Springer.

Cite this article: Ludwig, David, Charbel N. El-Hani, Fabio Gatti, Catherine Kendig, Matthias Kramm, Lucia Neco, Abigail Nieves Delgado, Luana Poliseli, Vitor Renck, Adriana Ressiore C., Luis Reyes Galindo, Thomas Lloyd Rickard, Gabriela De La Rosa, Julia J. Turska, Francisco Vergara-Silva, and Robert A. Wilson. 2024. "Transdisciplinary Philosophy of Science: Meeting the Challenge of Indigenous Expertise." *Philosophy of Science* 91 (5):1221–1231. https://doi.org/10.1017/psa.2023.127