

Working with Indigenous science(s) frameworks and methods: Challenging the ontological hegemony of ‘western’ science and the axiological biases of its practitioners

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Kate Harriden 

Abstract

Globally, Indigenous scientific frameworks and methods have been damaged and derided by ‘western’ science, a strategy of the colonial project. Contemporary Australia is no exception, with the transmission of the suite of scientific values and practices formed over millennia in and for this place being actively prevented by legislation, government policies and colonial opprobrium. This paper shows how two crucial Indigenous science(s) frameworks, used alongside two Indigenous research methods, can transform hegemonic scientific research and fieldwork priorities and practices. This transformation occurs because of the focus of each framework. The first, centring country, requires decentring the human to bring forth the needs of the web of relationships that is country. The second framework, relational accountability, is about tending to a broad range of relationships, are often kin-based and including the other-than-human, with yindymarra (or local equivalent). Relational accountability also offers an inbuilt ethic of care superior to institutional ethics protocols. By describing these frameworks and methods and discussing how and when to use them, this paper supports their greater understanding and more widespread use, particularly by Indigenous practitioners, so we may continue to (re)build what colonisation has damaged.

Keywords

Centring country, deep observation, frameworks, Indigenous science(s), methods, relational accountability, walking country

Whose country? Which science?

This paper is premised on the idea that ‘science’ is the use of observation and experiments to identify and understand the sometimes complex patterns and cycles of the natural world and changes in them over time and space (Fischer et al., 2022) (and referred to as the ‘scientific basis’ throughout this paper). Further, the purpose and systemic practice of scientific endeavour is influenced by values and characteristics overlying the scientific basis. In hegemonic science, commonly referred to as ‘western’ (e.g. Broadhead and Howard, 2021; Massey and Kirk, 2015), ‘western modern’ (e.g. Snively and Corsiglia, 2001) and, more recently, ‘Euro-Western’ (May and Viaene, 2022) science, the scientific basis is overlain with values including a human-centred focus, an impersonal and extractive approach that adopts a reductionist and compartmentalised perspective heavily reliant on

elitist evidence (Weir, 2023), ‘universal’ principles (Graham, 2009), and often supported by an over-reliance on engineering while projecting a secular mindset (Watson, 2014).

Conversely, Indigenous science(s) overlay the scientific basis with values including centring the other-than-human,¹ incorporating relationality and reciprocity, relying on long-term, place-based multi-sensory observation to produce complex evidential and expert understandings of the natural world incorporating spiritual entities and explanations and encourage the use of proportionate technology (Martin and

Monash Sustainable Development Institute, Monash University, Clayton, VIC, Australia

Corresponding author:

Kate Harriden, Monash Sustainable Development Institute, Monash University, 8 Scenic Boulevard, Clayton, VIC 3800, Australia.
Email: k.harriden@monash.edu



Mirraboopa, 2003). This paper is silent on the consequences of the cultural features overlaying the scientific basis of each scientific paradigm other than to indicate that western science becomes transactional in its priorities and practices (Watson, 2014), whereas, Indigenous science(s) are relational (Wilson, 2001).

The term ‘western’ science is used in this paper as a semantic device to remind the reader of this scientific paradigms use to justify settler-colonisation broadly and the degradation of Indigenous science(s) as a specific tactic of colonisation (Bishop, 1990; Hartwig et al., 2022; Watson, 2014). The author is cognizant of the complexity and contestability of this term, given this version of the scientific basis is not monolithic, and is essentially a ‘mongrel’ science that has co-opted many of its current preoccupations and practices from a wide range of non-European intellectual traditions, including Indigenous traditions (Watson, 2014). While these colonising roles are critical to the current hegemonic status western science enjoys (Martin and Mirraboopa, 2003), discussion of this colonial strategy is beyond the scope of this paper.

Western science is presented in the singular, despite local variations in practice, because of its own emphasis on its universality. Western science regards itself as a science that can be practised impartially and dispassionately across time and space, with little need to consider the conditions in which it is being practised (Roth and Valentinov, 2020). An indication of the variation within so-called western science is that I momentarily considered using the term ‘settler-state science’ instead because of the specific socio-political motivations informing how western science is wielded in the colonial project, be it Australia or elsewhere. Ironically, the likely existence of a ‘settler-state’ version of western science damages the credibility of claims to both universality and impartiality in the practice of this particular scientific paradigm.

In contrast to western science’s insistence on universality, the place-based specificity in the practice of Indigenous science(s) necessarily results in diversity in the Indigenous science being practised. Beyond the scientific basis, Indigenous science(s) do share universal principles (Watson, 2014) or ‘orientations’ (Whyte, 2020), including centring country and relational accountability discussed in this paper. However, there is no expectation that a specific method or action that works in or applies to one place will suit another. Further, one of these shared orientations, to centre country, essentially precludes the socio-political variability in the role and practice of science, as evident in the application of western science to a plethora of colonial projects. Instead, Indigenous science(s) is conscious that local operations of these shared orientations should be different and that these differences matter as they reflect different local conditions. It is because of this expectation of local variations in practice that Indigenous science is referred to in the plural.

This paper does not describe any specific Indigenous science, instead focussing on those Indigenous science(s)

frameworks and methods employed during my PhD research, specifically the frameworks of centring country and relational accountability and the walking country and deep observation methods. These frameworks and methods represent a small proportion of the Indigenous science(s) repertoire (e.g. Chilisa, 2011; Kovach, 2010), although both frameworks are shared orientations in Indigenous science(s). Despite this paper’s attempt to describe them, there is no codification intention. The paper also provides some comments on when and how to apply each framework and method, supported by examples from my PhD research. The ensuing discussion addresses the influence working with Indigenous science(s) frameworks and methods can have on the practice of science and the scientific practitioner. An influence due to the scientific values, perspectives and priorities of Indigenous science(s) and the marked shift in the same required of the western science-trained researcher to appropriately practice in this paradigm. The discussion also briefly considers ‘mixing’n‘matching’ Indigenous and western sciences frameworks and methods before a general comment on the importance of the resurgence in Indigenous science(s) be Indigenous-led.

The following section addresses some of the (different) issues encountered by non-Indigenous and Indigenous researchers wanting to work within the Indigenous science(s) paradigm, before describing the identified Indigenous science(s) frameworks and methods. Notably, the frameworks and methods presented have applications beyond field-based research and can be validly applied across a myriad of scientific and non-scientific endeavours. Thus, any reader of this paper can (re)consider how they conduct their professional activities to incorporate the presented frameworks and methods.

Working with Indigenous science(s)

There are at least two solid motivations for engaging with Indigenous science(s) frameworks and methods. The gulf between a transactional and relational approach to the scientific basis’s purpose and practice is a central motivation to use Indigenous science(s). Creating knowledge outside the transactional science paradigm increases the scope for identifying country centred solutions that sustain country, human and other-than-human entities. It could be argued that the ideas of connectedness, systems thinking and sustainability integral to (western) climate change and environmental science research represent shallow, early understandings of ‘country’ and the Indigenous practice of relationality. Western science practitioners’ relatively recent forays into systems thinking and ideas of connectedness may explain why the idea of country and the relational basis of Indigenous science(s) resonates with many non-Indigenous people exposed to it.

A second compelling motivation to engage with Indigenous science(s) flows from their place-based nature

(Bawaka Country et al., 2016; Darug Ngurra et al., 2019; Martin and Mirraboopa, 2003). This nature can create a sense of shared place-(re)building with, and for, country. Stemming from this intimate connection to place/space, the knowledge and practices reflect local conditions, affording credence to the appropriateness and effectiveness of Indigenous science(s). Engaging with a place's Indigenous science(s) reduces the imperative to import and adapt (rather than the more common and more fraught, adopt) practices and solutions from distant places bearing little relationship to the natural world in which they are transplanted.

These motivations have contributed to a resurgence of interest in Indigenous science(s) on the part of First Nations peoples and a burgeoning interest on the part of non-Indigenous peoples. The First Nations resurgence of interest can be placed within a nation (re)building context. The interest by non-Indigenous parties runs the gamut from those expecting to be handed data sets that (re)enforce western science's hegemony to those so concerned at offending Indigenous peoples by their interest in Indigenous science(s) as to be paralysed. This range of approaches to engaging with Indigenous science(s) on the part of non-Indigenous peoples creates the imperative for an ongoing conversation about the appropriate application of, and engagement with, the Indigenous science(s) frameworks and methods. Currently, conversations about the appropriate application of, and engagement with, Indigenous science(s) are as necessary and important as those about Indigenous science(s) frameworks and methods and how their use challenges the ontology of western sciences and the axiological biases of its practitioners.

The use of Indigenous science(s) by non-Indigenous practitioners can be problematic. It is important to note that when non-Indigenous practitioners use Indigenous science(s) frameworks and methods, it cannot automatically be claimed that they are practising Indigenous science(s). The boldest claim possible may be that Indigenous science(s) frameworks or methods were incorporated as part of a more extensive research 'toolkit', for example, the classic 'mixed methods' approach. To reduce the likelihood of working with Indigenous science(s) disrespectfully or inappropriately, a good step – an act of *yindyamarra*² – is to acknowledge the framework or method as an Indigenous science practice. Even better is to cite from which country the science came. The best first steps are to (i) critically examine your positionality and (ii) develop genuine relationships with the country and Indigenous peoples with whom you want to collaborate.

Even if Indigenous science(s) frameworks and methods are solely applied in research activity, the non-Indigenous researcher may still not be practising Indigenous science(s). This seemingly contradictory position reflects the complexity of the colonial project, particularly the associated tactic of destroying Indigenous knowledge, language and kinship systems. As a First Nations scientist, I cannot trust that non-Indigenous scientists, who operate in a knowledge system that

over centuries has insisted Indigenous scientific knowledge(s) are at best folklore, now sincerely regard our knowledge(s) as legitimate and vital. It cannot be assumed that this sudden interest in Indigenous knowledge systems will be accompanied by a willingness to incorporate the beliefs and values of Indigenous science(s) applied to the scientific basis (Whyte, 2020) (or, conversely, a willingness to critique or review the beliefs and values of hegemonic science). It is more likely, given the transactional nature of western science, that the interest will pool around the data those knowledge systems generate. Consequently, at present, the best way to ensure appropriate inclusion of Indigenous science(s) ontology and axiology in scientific practice is for the appropriate Indigenous people to lead the scientific activity. The 'appropriate' people are those peoples on whose country the research is conducted, or others they nominate or support. If not Indigenous-led research, Indigenous people must have a genuine co-design role, actively influencing research design, including the frameworks and methods applied for projects seeking to claim Indigenous science(s) status.

It is not inappropriate that non-Indigenous practitioners engage with Indigenous science(s) frameworks and methods. Better science would result more often if Indigenous science(s) frameworks and methods were more widely practised. It is essential that learning to work with Indigenous science(s) is done in respectful and appropriate ways, including exploring the ontology and axiology of Indigenous science(s), particularly those of the Indigenous science specific to the proposed research site(s), and building relationships with First Nations practitioners. To approach Indigenous science(s) and Indigenous peoples with western science's transactional perspective, where the researcher comes, does what they want, as and when they desire and leaves with little for the community to show, clearly demonstrates its extractive and exploitative tendency. Such research practice is 'fly in, fly out' research, and it damages communities (Tuhivai-Smith, 1999). Expecting to work with Indigenous science or scientists without incorporating, or even actively dismissing, the embedded ways of being and valuing is a colonising act immediately negating any suggestion of the practice of Indigenous science(s) by a non-Indigenous party.

Indigenous people are also required to follow protocols when working with Indigenous science(s). These protocols vary between First Nations and whether you belong to the Nation on whose country you work, or the science you are working with. As a *yinaa wiradyuri/wiradyuri* woman conducting PhD research on Ngunawal country, it was appropriate to seek permission from an appropriate Ngunawal authority before starting fieldwork. Importantly it is not my place to speak about Ngunawal science knowledge and practices. I can speak to broad Indigenous science(s) orientations, such as presented in this paper. Even to work on *ngurambang wiradyuri/wiradyuri* country requires me to engage with particular people, including Elders, in the community and receive their support before proceeding.

yindyamarra

I would like to acknowledge the support provided by the Ngunawal community for my PhD research. I hope the work that comes from it directly benefits Ngunawal efforts to (re)assert their sovereign water rights.

Given the place-based nature of Indigenous science(s), it would demonstrate a lack of *yindyamarra* to publish a paper about the use of Indigenous science(s) frameworks and methods without describing the field site where they were used. Having some sense of the place gives the reader a chance to consider how effectively the methods and frameworks may have been applied and how they may be differently applied in their place/space.

Canberra, Australia's capital and known locally as the bush capital, is built on the unceded country of the Ngunawal people. With an altitude of approximately 575 m, on a continent with an average altitude of 330 m, winters are long and cold. Many local streams and creeks, crucial for the ongoing existence of the Traditional Custodians and valued and respected by visiting Indigenous groups, are headwaters or tributaries of Murrumbidgee River. Many of these streams were formerly chains of ponds, having been transformed into urban stormwater systems, in one example of western science being captured by the socio-political imperatives of the colonial project. The Murrumbidgee is part of the Murray-Darling Basin, the largest, most developed basin on the Australian continent where 40% of the gross value of national agricultural production is generated (CSIRO, 2021).

All field sites were in Yarralumla Creek, which runs through a series of established, low-medium density suburbs in south Canberra before discharging into the Molonglo River, downstream of Scrivener Dam that forms Lake Burley Griffin. The majority of the creek is concrete or riprap armoured, converted to a storm water channel. Canberra's rainfall (approximate average of 612mm annually) is roughly evenly distributed across the year, resulting in baseflow being the most common flow regime. Two types of field sites – those for water quality testing and those for experimental treatment trains – were identified. These treatment trains were fashioned with Indigenous frameworks, methods and design approaches.

Frameworks

The two Indigenous science(s) frameworks discussed here, centring country and relational accountability, directly reflect the Indigenous science(s) present in contemporary Australia. However, while the terms particularly reflect First Nations experiences of the Australian colonial-settler project, Indigenous peoples' general sense of the frameworks is broadly shared. As noted in the introduction, these frameworks could be considered universal, or shared orientations, in Indigenous science(s).

Centring country

What is country. 'Country' is the multi-faceted Aboriginal English language word First Nations people in Australia use to describe their territory. As noted, country³ can roughly reflect western ideas of sovereign jurisdiction, with an acknowledged geographical extent, common language and governance system. However, country is more than territorial jurisdiction and socio-cultural cohesion; more than the lands and waters of a place/space. Country is a complex web of relationships encompassing the other-than-human and the human (Martin and Mirraboopa, 2003; Tynan, 2021). That is, how humans, plants, animals and spiritual entities, landforms, soil, water – salt, fresh and brackish – and air, the sun, moon and stars, the dreaming and ancestors and more interrelate over time and space is country (Martin and Mirraboopa, 2003). Critically, country is indivisible (Marshall, 2017), and it is inappropriate to manage any aspect in isolation.

In this paper, 'country' refers to First Nations' territories globally. Cognizant that each First Nations group will have its term articulating similar sentiment embedded in 'country', I have chosen to use one First Nations term to articulate this broadly shared understanding rather than any colonial term. Using another word shifts readers' perspectives by asking them to learn a new concept rather than overlaying a new meaning for a familiar term. 'Country' is a vastly different concept from 'territory' and requires the reader to embrace language to reflect this difference.

Centring country. Centring country is a shared and coherent research framework of Indigenous science(s), in practice, if not terminology. Country is centred because of the shared ontology that without country, nothing exists (Neale and Kelly, 2020). Country's primacy in decision-making, action taking and life-giving contributes to the custodial ethic of all First Nations groups. This custodial ethic strongly contrasts with the ownership ethic embedded in the western scientific tradition.

With country, not humans, the primary consideration in all decision-making (Bawaka Country et al., 2013), it is unsurprising that centring country is a primary research framework. In a research context, centring country requires all research options, actions and decisions to be considered from country's perspective, ruling out any approaches detrimental to country. Such consideration also requires that the human is understood – is placed – as one, sometimes peripheral, part of the web of relationships forming country.

Centring country places the needs, health and cohesiveness of country at the forefront of scientific thought and practice and requires accepting that the other-than-human also have legitimate relationships, rights, responsibilities, memories and desires independent of the human. In my PhD research, centring country led to research options, actions and decisions being considered primarily from the stream's perspective,

including field site locations, materials used and how I approached the sites when visiting. I was required to – wanted to – respect the creek’s rights and responsibilities. I consciously and deliberately sought to become more cognizant of the plethora and variety of the stream’s relationships and desires.

When to centre country. Centring country is an overarching framework that needs to be constantly and persistently applied, not only in specific circumstances. For those trained in a western science tradition, it is unusual that one framework can be applied to all research or scientific activities. While this paper focuses on centring country in a scientific context, it is an approach that can and should be practised across all human endeavours in Indigenous ontology. While centring country is a ‘must have’ framework, as in other scientific paradigms the complementary and simultaneous use of other frameworks is not precluded. Centring country acts as a foundational framework on which other frameworks and methods are readily layered.

Centring country as a research framework touches and alters all aspects of the research (or other) process. Identifying and framing a research topic, refining the research question(s), selecting the methods and the field (or lab) work practices are apparent research aspects that necessarily change when crafted with the complexity of country prioritised. Centring country also encompasses project design, material selection and the line(s) of intellectual enquiry adopted. For my PhD, centring country included asking questions absent of human concerns and perspectives, working with materials from country, identifying field sites that would not greatly upset stream access for the other than human, and interrogating the storm water construct.

How to apply centring country. Despite the many Indigenous communities that adhere to this framework globally, centring country is not a readily standardised practice as its application relies on local understandings and conditions. Conceptually, where this paper is pitched, centring country is about country being foremost in all aspects of scientific practice. For example, centring country requires all research questions, actions, materials and decisions are considered in terms of how country will respond, react or be impacted. If the responses, reactions or impacts are negative for any aspect of country, the initiator needs to be abandoned, changed or repaired. Practically, country’s primacy drives place/space specificity in research practice as the complex web of relationships forming country deeply influences how this framework is applied. The consequent plurality of intellectual and physical practices is a critical factor in the reluctance to codify Indigenous science(s) frameworks.

Two questions will quickly identify if country is being centred.

- (i) is this activity for human gain/purposes only or foremost?

- (ii) has some aspect(s) of country, or one set of relationships, been prioritised over others?

If the answer to either question is ‘yes’, the research project is not centring country. ‘Yes’ to the first question self-evidently means country is not being centred. An affirmative response to the second question indicates that the research project as crafted fails to consider, possibly actively injures, aspects of country outside of the research focus. Strictly discipline-based or single-focus projects readily actively injure relationships of country beyond the project’s focus. For example, a settler-state environment management agency undertook a stream restoration project shortly after the PhD commenced, at the most downstream water quality testing site.⁴ Basically a troika of engineered groins, the agency’s project focussed solely on reducing turbidity (ACT Government, n.d.). Beyond releasing significant volumes of sediment into the channel during construction, the project has resulted in the local extinction of a lounge of eastern water dragons, a change in the dominant water bird species, significantly reduced access to the stream for human and other-than-human parties, and, according to my water quality data, turbidity readings that are unexpectedly high in terms of timing and catchment conditions. Significantly, such ‘restoration’ projects represent scientific activity based on dividing what has already been defined in this paper as indivisible. Country cannot be centred when dividing the indivisible. The complex web of relationships works because the ‘whole’ is given primacy; no one relationship is deemed more vital or significant than any other.

Ultimately centring country is about acknowledging, respecting and working within the web of relationships forming country. To conduct research with relationships at the forefront is the crux of relational accountability, the other Indigenous science(s) framework considered in this paper. Relationships, and the relationality subsequently engendered, directly link the centring country framework to that of relational accountability.

Relational accountability

What is relationality. First Nation scholars identify relationality as critical to Indigenous ways of being (Bawaka Country et al., 2016; Hayman et al., 2017) and scientific practice (Bawaka Country et al., 2015; Tynan, 2020, 2021; Wilson, 2001). This paper has already broadly distinguished Indigenous science(s) and western science, respectively, as relational and transactional. Wilson makes clear that relationality is a critical difference between the practice of Indigenous science(s) and western science. In the western scientific paradigm, knowledge is presented as an ‘individual entity’ (Wilson, 2001: 176) that is pursued, created and owned by the researcher or practitioner. That an individual is regarded as a knowledge producer and owner is characteristic of the transactional nature of western scientific practice.

In contrast, Wilson (2001) argues that knowledge within Indigenous science(s) is relational ‘with all of creation’ (p. 176), where knowledge is created from country and is disseminated to all of country. Tynan (2021) states directly, ‘relationality belongs with and is learnt from Country’ (p. 2). That is, knowledge is created by and shared between the human and other-than-human (Wilson, 2001). This acceptance of knowledge co-creation contributes to the increasing number of academic papers with country as the lead author, such as those referenced in this paper. In the Indigenous science(s) paradigm, knowledge is for country, not competition.

Relationality is often regarded in kinship terms, binding Indigenous science(s), its practice and practitioners to a specific place/space (Tynan, 2021). Totems and totemic relationships are well-known examples of Indigenous kinship principles and practices (Hayman et al., 2021). Totemic relationships bestow on the human party certain rights and obligations (Brockbank and Afoa, 2020), many of which also function as scientific practices and other practices that might be described as environmental conservation in the western science paradigm. For example, an essential obligation is to represent your totem to ensure conditions suitable for their ongoing existence (Hayman et al., 2017).

Relationality extends beyond totemic systems to all relationships. Ultimately this web of human and other-than-human relationships becomes country and provides an indicator of country’s (territory) health (Martin and Mirraoopa, 2003; RiverofLife et al., 2020). Relationality is a bedrock principle for Indigenous peoples and is demonstrated in legal, governance, social and ethical practices (McGregor et al., 2020) and scientific practices.

Relational accountability. Relational accountability is a research framework requiring the researcher be accountable to *all* relationships throughout the entire research process (Bawaka Country et al., 2015), including human relationships with the other-than-human entities and those relationships devoid of a human party. Reflecting the relational basis of knowledge generation and dissemination of Indigenous ontology, this framework thus operationalises a key Indigenous socio-cultural value. That is, in Indigenous science(s), tending to relationships is regarded as a fundamental aspect of research.

Briefly, ‘being accountable’ means conducting relationships with honesty and integrity, accepting responsibility and doing what you agreed. Relationality is being connected and listening, even to challenging communication, ‘in good relation’ (Tynan, 2021: 3). Relational accountability helps develop the trust required for solid, lasting relationships. In a similarly brief synopsis, ‘tending to relationships’ ensures that all parties’ perspectives are considered, for example, imagining the project from a ngarrung/eastern water dragon’s point of view and that those perspectives are taken seriously and accommodated in research design and implementation. Ultimately, relational accountability anticipates that no

relationship will be damaged or deteriorate consequent to any research or project; preferably they will be enhanced.

The web of human-human relationships in which an individual is embedded professional is more complex than initially imagined. This web includes not just the apparent relationships, such as those with fellow field workers, lab staff or data analysts. It is also appropriate to be accountable to relationships with librarians, administrators, publishers and the public. More unusual for those trained in western science practice, is the relationships with, and between, other-than-human entities, such as animals and plants, geomorphological features, water and soil for example. For the Indigenous science(s) practitioner, relationality also requires acknowledging your relationship to the ideas used or rejected in the research.

Ethics role. The nature of relational accountability is such that it simultaneously acts as a practical (and ethical) ethics process (Bawaka Country et al., 2015). Bawaka Country et al. (2015) describe this process as ‘a methodology of attending underpinned by a relational ethic of care’ (p. 270). That is, a consequence of research conducted using the relational accountability framework contains a methodology that is an ethics protocol, to use the academy’s term. The committed and sincere application of relational accountability, where yindyamarra (or local language/cultural equivalent) is demonstrated, matched with centring country promotes a standard of ethical behaviour that institutional ethics protocols, with their emphasis on risk management, are unable to replicate or replace. This ethical standard stems from the researcher recognising and accepting the complex connections in this world includes them; that we are all country. This awareness that the researcher is related to and a part of country creates an imperative to care more attentively about more beings (Bawaka Country et al., 2015).

When to apply relational accountability. Relational accountability is continually applied, though its practice varies with the relationship. This constant and consistent performance of relational accountability, which is automatically enfolded into the scientific culture, reflects how deeply entrenched relationality is in Indigenous cultures. The author readily acknowledges the challenges in being continuously relationally accountable, particularly for those practitioners unfamiliar with Indigenous ways of being and valuing. The author is also aware of the myriad of benefits resulting from operating in an accountably relational manner for all parties in any relationship. These benefits are not limited to more inclusive scientific practices and outcomes.

Critical points in the research process where heightened attention to relational accountability is required include when setting research questions, selecting methods or during decision-making. In those moments when the web of relationships is being challenged and tested it is crucial to tend particularly carefully to relationality, for these are the moments where relationality can fray.

How to apply relational accountability. Relational accountability is to attend to relationships with integrity and care. Ideals such as ‘integrity’ and ‘care’ carry different meanings and expressions culturally, making listing a series of specific activities or actions to be ticked off as ‘equalling’ applying relational accountability in research paradoxical. Researchers need to learn what relational accountability looks like on the country where they work. General guidance to applying this framework is suggested in the wiradyuri ethos of yindyamarra (defined at footnote 3, p. 5). Brief examples of yindyamarra, which arose during my PhD research, include:

- respect for country and senior knowledge holders;
- gentle refers to the treatment of the field sites, including when installing and maintaining the small-scale in-channel infrastructure;
- being polite to an irate creek lover can convert them to a project advocate;
- honouring the other-than-human, their knowledges and ways of being can prompt unanticipated project foci and decisions; and
- to move through research phases slowly allows time to build a better knowledge base of the relationship web, forming the part of country that is your field site.

Methods

To be effective, frameworks require methods as they ultimately enliven them. The relationship between methods and frameworks lends significance to the method choices made, the consequences of which can enhance or diminish research practice effectiveness and outcomes.

There are numerous Indigenous science(s) research methods, including yarning, an Aboriginal English word that describes a particular form of conversation (Drawson et al., 2017), deep listening (Hayman et al., 2017; Ungunmerr-Baumann et al., 2022), storytelling (Datta, 2018) and local language naming (Munkara-Murray, 2022). As in any scientific paradigm, a degree of discrimination is required at project scale to ensure the most efficacious combination of framework(s) and method(s) in research.

The two methods outlined here, walking country and deep observation, described separately in the classic western compartmentalised style, are, in reality, deeply entangled. Symbiotically, effective walking country presupposes the practice of deep observation, which heightens the outcomes of walking country practices. This section concludes with a brief discussion of the complementarity of these methods.

Walking country

Walking country is a crucial Indigenous science(s) method that, reflecting the centring country framework, decentres the human, including their scientific priorities, preferences and importance attached to scientific observations.

Decentring the human affords greater precedence and importance to an increased range of natural world features, giving a more detailed understanding of, for example, the field site(s) and the influence any experimental activities may have beyond the nominal investigation site(s). Country’s complexity becomes the centre of scientific observation, not the human or their priorities.

Walking country decentres the human in scientific observation and importance through regular, considered and deliberate walking of field sites and beyond. There are similarities between walking country and field reconnaissance practised in western science, both about observing widely and critically. Both are essential initial field work activities, where the researcher(s) note all they can about the natural world, including relationships, rather than focusing primarily on the project parameters. However, walking country is a more sustained practice than reconnaissance, which typically ends once field sites (or other field activities) are established. Although sensible within the scientific premise, western science does not oblige further broad-based observation following the reconnaissance phase, preferring focused observation on specific research parameters. Walking country does oblige sustained practice throughout the research activity, with benefits including more complex, sophisticated understandings of country (Karulkiyalu Country et al., 2020), including interactions between biophysical, climatic and socio-cultural features. Understanding such interactions is invaluable in a range of intellectual inquiries.

When to practice walking country. Walking country is not done once or twice at the beginning and end of a research project. When regularly practised, ideally consistently, throughout a project, walking country is a method that offers researchers valuable insights into their field sites. It is also prudent to frequently walk the country associated with the field sites, but are not the actual field sites, throughout the project. Other times to consider walking country is during change of seasons or during/following weather events, such as walking beside storm water channel during or following an intense rain event. Tending to country in this way contributes to identifying the complexity of field conditions and country.

As the project progresses and becomes more focussed on specific parts of the field, the geographical aspect of walking country can be temporally and spatially (re)scaled. This method’s application can be varied to reflect each research stage. As field work progresses, it is reasonable that more time is spent walking that part of country most overtly connected to the field sites. This concentrated focus can enhance researcher understandings of how country influences, or is influenced by, the research project. However, it is prudent to regularly walk the more distant country connected to the field site as the field work progresses. It is respectful to walk the entire country associated with the research at the end of the project. As well as demonstrating yindyamarra to the

other-than-human entities supporting your work, this relational act can help identify and understand unanticipated research impacts or implications.

How to practice walking country. The repeated and regular conscious and attentive walking of this method is generally conducted silently and at a considered pace, within and beyond research sites. Habitual, attentive walking echoes the walking country of Aboriginal groups along traditional boundaries and the creeks and streams within those boundaries. For my stream/storm water channel-based field work this meant walking in the length of the channel and along the riparian zone and flood plains, at different flow stages, many times before and after field sites selection. Walking country also took me to the urban streets hosting the storm water infrastructure funnelling flow to the stream.

Walking country only once during a research project is useless, given the absence of 'baseline' information to support observations or any analysis of the country's condition or changes to the country from the project. Notably, the one-off or highly irregular use of walking country as a research method reflects an absence of yindyamarra (i.e. is disrespectful) for country and demonstrates a clear failure to centre country. If the project cannot sincerely and diligently incorporate the walking country method, it is more appropriate that it not be incorporated.

Crucially, walking country allows practitioners to identify and observe changes in and across field sites over time. In this way, walking country operates as a data gathering method, providing wide-ranging data sets obviously, and not so obviously, related to the research project. In my PhD project, the data gathered from walking country significantly aided water quality testing and intervention site selection and sourcing materials. The data was critical to each iteration of the design and location of the in-channel interventions. The knowledge and data gathered from walking country can support forming hypotheses or finding 'solutions' to project hiccups, or crafting research aims and questions.

Deep observation

Deep observation is more than the usual field observation practices of western science. Deep observation is the search for complexity and interconnections in the surroundings, requiring the researcher to acknowledge and note all they see, hear and feel around them (Karulkiyalu Country et al., 2020). Deep observation is a deliberative multi-sensory consideration of all that surrounds the observer, although the emphasis is on sight. This method has obvious uses beyond field work, including lab work, desk-based research and any artistic practice.

Water quality testing exemplifies the difference between western science observational practices and the deep observation of Indigenous science(s). In the western science tradition, the observational emphasis is often placed on the

numeric value of project parameters such as nitrogen, phosphate and turbidity. The emphasis on water quality parameters further allows, for example, the expeditious practice of the grab sampling technique, where samplers stay at the test site only as long as it takes to collect a sample, with the testing conducted in a lab or other site remote from the testing site. Grab sampling using the deep observation method encourages sample testing to be conducted on-site when possible. Field site-based testing allows the researcher to watch what happens around the site, including observations of environmental processes, the presence (or absence) and behaviour of the other-than-human and to compare current site conditions with those previously observed. Western science-trained field scientists or science practitioners possess the basic skills required to develop deep observation proficiency. Deep observation is intimately connected to the experiential and expert aspects of the Indigenous science(s) praxis and is one of the skills Indigenous rangers hold that are invaluable to western conservation programs.

A more comprehensive and nuanced observation approach than generally practised in western science, deep observation requires more time to observe more 'things'. With all the senses fully engaged and little talking, the Indigenous science(s) deep observation practice invites observing connections beyond those usually identified or accepted by hegemonic scientific research methods. Seasonal calendars provide a robust example of these observational differences. Western seasonal calendars have four seasons based as much on calendar dates as on climatological factors such as precipitation, temperature and relative humidity. Conversely, Indigenous seasonal calendars reference climatological and environmental factors, including fauna and flora behaviours (Bureau of Meteorology, 2016) or even the biocosmic rhythms of the relationship between the sun and mountains (Quilaqueo and Torres, 2013). By combining aspects of the natural world beyond the strictly meteorological or astronomical (Quilaqueo and Torres, 2013; Reading, n.d.), Indigenous seasons starts when the appropriate combination of factors occurs, not on specific yet arbitrary calendar date distantly connected to what is happening in the natural world.

When to practice deep observation. As with walking country, deep observation is practised at all stages of field work. Consistent practice of deep observation causes it to become automatic, further enhancing its value to the research process. Anyone in any situation can do deep observation, for although its use in a research context is this paper's focus, it is not a method exclusive to scientific practice.

Deep observation contributes to developing detailed, nuanced understandings of the interconnections at individual field sites, collecting data, forming hypotheses, and crafting 'solutions' in the field. It requires intently watching, for example, other-than-human behaviours, stream flow or sun shadow patterns, over time and space.

How to practice deep observation. Deep observation, based in yindyamarra, requires considered attentiveness to the connections that make country indivisible, not just to those parameters directly related to the research practice or question. This method is best practised in silence. Silence supports the related, but not discussed in this paper, practice of deep listening.

Deep observation operates across scales. For example, deep observation of a broad field area will lead to a different range of data from the deep observation of a specific tree in that hypothetical field area. Combining data sets nested across scale represent both an extended and deepened range of knowledge about, and understanding, of the research parameters and, importantly, the conditions influencing them.

Time is another crucial aspect of deep observation. For thousands of years, the Tlingit people of Yukon Territory in northwest Canada have known what western science practitioners established toward the end of the 18th century – that glaciers move (Hayman et al., 2018). Diachronic data sets, long-term data of a specific place, are one of the attractions of Indigenous science(s) to western science. Taking the time, regularly, to pay attention to some aspect of the field sites, lab procedure, or project data that you would not normally use to start to building deep observation into daily research activities.

Complementary methods

Walking country and deep observation complement each other in numerous ways, making it easy, almost unavoidable, to use them together. When these methods are simultaneously performed, a deliberative multi-sensory consideration of all that surrounds the researcher results, as they are forced to attend to the myriad of relationships forming country. Both methods reflect yindyamarra as they require the practitioner to go slow – in their movements, observations and judgements – and to honour and respect the natural world, or country, of which they too are part. Critically, walking country and deep observation combined allow the development of a deeply intimate knowing of field sites.

Together these two methods expose the immense value field work brings to research and scientific practice. Individually and combined, walking country and deep observation allow more complex insights into field sites, lab results and other scientific endeavours than offered through the current observation practice of many western science methods. The value of these methods combined is exemplified when contrasted with the increasing reliance on GIS engineering. GIS technology offers the illusion of deep knowledge but is reliant on the skill *and* expertise of the GIS technician and those using the outputs (Couclelis, 1992). As a western science tool, GIS can blind researchers to the complexity of a field site (Couclelis, 1992). Field research experiences convince me that walking country and deep

observation give the field scientist or practitioner details at a scale unmatched by GIS. For example, GIS imagery is not necessarily effective in identifying testing sites. During a previous research project, I was derided by a western trained scientist for not having identified individual field sites in Thailand using GIS (specifically google earth) prior to leaving Australia. I had identified a broad area but google earth could not get to the scale necessary to make a final decision for probe sites measured in square centimetres, meters apart. I knew from previous visits to the area the minutia of data required, such as the range and timing of the tides cyclically submerged the channel banks on which to be located. Again, this type of data not readily available via GIS. Yet it is the small-scale details that often give the necessary context to finalise a range of research-relevant decisions and observations, including site identification, a sense of how a system responds under different conditions, and selecting research methods or materials.

Indigenous science(s) in action

Despite the aspects of Indigenous science(s) frameworks and methods available for discussion, this section reflects on how the identified frameworks and methods influence scientific practice and the practitioner. A brief discussion about combining Indigenous and western science frameworks and methods and one general comment complete this section.

Influence on the practice of the scientific basis

For those trained in western science, working respectfully with Indigenous science(s) frameworks and methods introduces different ways of being and valuing, requiring a marked shift in values, perspectives and priorities. These differences include an emphasis on relationality, the local and spirituality and a de-emphasis on the human, exploitation and competition. These differences subsequently influence how the scientific basis is practiced, for example, the nature of questions asked, research pace and materials, ways of practice or results interpretation are affected. Ultimately, some researchers are transformed by their experiences with Indigenous science(s) ways of being and valuing such that their research becomes driven by different motivations and conducted with altered expectations.

Having one framework that must be applied, that is centring country, simplifies aspects of the research process. In the western science tradition, selecting an appropriate framework for a research activity is a critical consideration, one consuming many words in academic articles, PhD dissertations, research proposals and funding applications. The consideration of, and contestation regarding, ‘appropriate’ frameworks implies more than that certain types of results will be produced by specific frameworks. Also implied is that the ‘wrong’ framework can, at worst, render research results irrelevant. The requirement to centre country removes

some of this angst. While being dictated a research framework may simplify the choice, practising it remains challenging.

Research focus, outcomes and performance expectations necessarily shift in response to the requirements of centring country and relational accountability. For example, the requirements of Indigenous science(s) frameworks presented in this paper to consider issues from a range of perspectives, including the other-than-human, rather than one in isolation, and to tend to all relationships, force a complex sophistication in scientific questioning and practice that is sometimes absent from current western science practice. One consequence of this complexity is that new research questions must be asked, as others are rendered moot. For example, my PhD research identified a widespread Indigenous (science(s)) ontology of water having life, a life often in a kinship relationship with people (Hayman et al., 2017; Poelina et al., 2019). Those related to water or a water body regarded as living are unlikely to propose projects to convert streams to storm water channels, dam rivers or filling in wetlands.

Working with Indigenous science(s) allows what is considered data and its collection, uses and reporting to be expanded, as the following list of examples demonstrates:

- during PhD field work, my fingers were a more reliable measure to obtain accumulated sediment depth on the channel bed than either of the measures in the field kit.
- Indigenous developed participant-employed photography practice that (re)balanced research power dynamics (Castleden et al., 2008).
- reporting protocols change with the relational practice of the scientific basis. No longer can non-Indigenous peoples assume all results will go directly, and unfiltered, to them (Potts, 2022).

When working with the frameworks and methods described, particularly relational accountability, it is important to be aware that more time is required than available in western science-framed research projects. More time is particularly required at the early stages of a project, as the relationships and knowledge of the research place/space are developed. Slowing the pace at the beginning may seem ‘wrong’ to the western-trained practitioner. Going slow, however, has numerous advantages, including allowing time to properly walk country and practice deep observation, review or refine the project or ensure that any research rights holders, stakeholders or participants fully understand the research. Importantly, spending time developing relational accountability at the beginning of the project means it is often easier to reframe or pivot a project that is failing than may be possible in the transactional milieu of western science. It is due to the different nature of the relationships developed, including the ‘ethic of care’ arising through the relational accountability framework, that enhances the capacity to pivot.

The extra time required when applying Indigenous science(s) frameworks and methods can have significant implications for funding and grant applications. Longer project time frames are required for projects steeped in Indigenous science(s), for example, time needs to be allowed to

- gain Elder’s and Traditional Custodian’s support and for community members to comment on the project and its progress;
- developed the appropriate relationships and research project, which can take a significant portion of some funding periods; or
- observe cultural obligations that may arise.

Already researchers in the western science paradigm lament insufficient research time. Indigenous science(s) respects the need for time. Time contributes to increased research and learnings quality while allowing accountable relationships to be built. In turn, it becomes easier to centre country.

A final comment on the influence of Indigenous science(s) frameworks on the practice of the scientific basic relates to the ‘ethic of care’ built-in relational accountability. It would behave non-Indigenous researchers and colonial institutions seeking to engage with Indigenous researchers and Indigenous science(s) to spend more time understanding and displaying local practices of relational accountability than being pedantic about institutional risk assessments and ethics protocols. Regardless of the state of the paperwork, if there is no meaningful relationship between the parties Indigenous practitioners are unlikely to participate.

Influence on the scientific practitioner

As intimated, more than the influence on the practice of the scientific basis, Indigenous science(s) frameworks and methods can also deeply influence the values, perspectives and priorities of the practitioner. This influence can be particularly profound for those unfamiliar with the ontology associated with Indigenous science(s). The combination of frameworks and methods articulated in this paper creates an intimate knowing of the site, rendering its status as country undeniable. As the researcher walks through place/space, attending to all aspects of country, the awareness of that place/space as country – not a waterscape, landscape or ‘the environment’ – grows. Across my PhD intervention field area, for example, specific trees, a local brown snake’s burrow and the drinking habits of the galang muraany/sulphur crested cockatoos flock were known to me. Also known was the condition of the storm water channel – which reaches were cracked and broken, which were gaining, with water being forced through the concrete armour, and which reaches likely to have higher rates of algae. This data, generated by walking country and deep observation, shaped a profound familiarity with the creek’s character, its physical and

hydrological functions, and directly informed water quality testing and intervention site selection. This is a much deeper understanding of ‘the field’ than required of or demanded by western science, or its practitioners.

As field work progressed a virtuous cycle formed, where this deeper understanding of country increasingly encouraged me to trust deep observation skills over desk-based learning. As argued in my dissertation, as this trust grew in this blossoming skill (and the related skills of the walking country method), it became easier to work in a relationally accountable way and the science I practised felt more robust and fulfilling. Consequently, my confidence to continue practising Indigenous science(s) while discarding many of the transactional aspects of western science has grown. Importantly, practising a relational approach to the scientific basis allows many Indigenous peoples to be Indigenous peoples in their professional life.

Undoubtedly understanding and embracing Indigenous science(s) ways of being and valuing is challenging. Accepting the challenge can lead to more vital field work skills and scientific understandings, as well as transform personal approaches to and understandings of scientific practice and priorities.

Mix’n’match frameworks and methods

Indigenous science(s) frameworks and methods were co-created, making them a ‘matching pair’ across the philosophical aspects of axiology (ways of valuing), epistemology (ways of knowing), methodology (ways of doing) and ontology (ways of being). Western science frameworks and methods are similarly paired by shared philosophical perspectives. The intellectual interest in mixing up the pairs is also understandable. There is a robust examination of ways to combine Indigenous and western sciences underway (e.g. Broadhead and Howard, 2021; McRae, 2018; Snively and Corsiglia, 2001). The interest of this discussion is the role of *Indigenous* ontology particularly but also axiology in the application of frameworks and methods from each scientific paradigm presented in this paper.

When mixing and matching frameworks and methods across scientific paradigms, it is necessary to acknowledge the influence of the philosophical differences underpinning each paradigm. Being aware of the philosophical differences is particularly relevant when using Indigenous science(s) methods. While some Indigenous science(s) methods can be used with western science frameworks, the ontological underpinnings of the methods must be addressed and accepted. To strip the ways of being and valuing from Indigenous science(s) methods is to (re)create the real risk of colonising Indigenous science(s). The difference between using Indigenous science(s) methods in western science frameworks or within Indigenous science(s) frameworks is captured in fire practices. Cultural burns use Indigenous science(s) frameworks to run the fire and are led by

Indigenous people. Cool burns use some Indigenous science(s) methods (e.g. fire temperature or ignition practices) within a western science framework to time and run the fire (e.g. using quantitative meteorological data and modelling outputs). Cool burns are generally coordinated by fire/land management agencies or non-Indigenous landholders.

Combining Indigenous science(s) frameworks with western science methods can enhance those methods usefulness – to Indigenous peoples, the academy and research practice and outcomes. This potential stems from the challenge presented to the practice of hegemonic western science methods by the necessarily exacting demands of the Indigenous ontological and axiological insistence on centring country and relational accountability. My preference is to practice Indigenous science(s) frameworks with a mix of Indigenous science(s) and western science methods, rather than using Indigenous science(s) methods in western science frameworks. This is, in Wilson’s (2001) terms, conducting about research ‘from an Indigenous paradigm’ (p. 175) rather than including ‘Indigenous perspectives in research’ (p. 175). This preference is because the ontology of Indigenous science(s), particularly decentring the human and relationality, is required to ensure the widespread application of scientific frameworks with potential to redress the damage done by the human-centred transactional approach of hegemonic western science. Damage done consequent to regarding the natural world as a resource source, rather than a connected complex web of relationships in which the human is inextricably woven.

General comment

The current requirement to have Indigenous peoples involved in the practice of Indigenous science(s) is restrictive, given that there are few qualified people. Numbers are more limited, if relying on colonial institutions standards of expertise to identify Indigenous expertise and collaborators (Weir, 2023). Despite the increasing desire and interest in working with Indigenous peoples and their science(s), it is crucial that non-Indigenous people demonstrate yindyamarra. There are many reasons to be patient and honourable regarding opportunities to collaborate with Indigenous science(s) and Indigenous scientists. The most important reason is to ensure that Indigenous people are the first to be (re)trained in Indigenous science(s) frameworks and methods.

Indigenous peoples must also lead the (re)building of Indigenous science(s) frameworks and methods and retain the right to decide what is an Indigenous science(s) framework or method. Non-Indigenous people, no matter how experienced in Indigenous science(s), must realise that it was never appropriate to make decisions about the nature of Indigenous science(s). To do so in contemporary times is an act of wilful ignorance.

When there is a robust, self-perpetuating stream of indigenous Indigenous science(s) practitioners, then discussions

of systemic training of non-Indigenous peoples in Indigenous science(s) may become appropriate. However, Indigenous people must control who is trained, and how, to ensure the integrity of the beliefs, values and practices of Indigenous science(s). It is imperative that those seeking to practice Indigenous science(s) are clear on the ontological and axiological underpinnings and embrace them. This emphasis on Indigenous-led training will create appropriately skilled non-Indigenous practitioners able to work respectfully and effectively with Indigenous practitioners, reducing the chances of Indigenous science(s) being further colonised and exploited. For example, non-Indigenous practitioners would learn – intellectually and viscerally – that practising Indigenous science(s) without centring country, that is to breach a core orientation, is to colonise Indigenous science(s). Or that taking data generated from the practice of an Indigenous science without an act of reciprocity is to exploit Indigenous science(s). That non-Indigenous researchers and practitioners can already be trained, by Indigenous experts, to skilfully incorporate the values and beliefs of Indigenous knowledge systems, including science, in their work and lives is demonstrated by academics such as Deborah Bird Rose or Sarah Wright, Sandie Suchet-Pearson and Kate Lloyd who work and write collaboratively with numerous Yolngu practitioners, under the lead authorship with Bawaka country (and which this paper liberally references).

Conclusion

This paper made neither claim nor effort to identify or discuss every Indigenous science(s) framework and method, focusing instead on those used during my PhD research. This is an appropriate approach to Indigenous science(s) – that it be based in a specific place/space and practical application. Similarly, this paper has not sought to codify the practices discussed. Codifying any Indigenous science(s) framework or method has strong potential to obscure local/place-based use, defying a critical aspect of Indigenous science(s) – their place-based specificity informing how each is used. An act of arrogance and at odds with my understanding of yindyamarra, codifying can be regarded as a western science practice; an act of colonisation I have no desire to perform.

This paper described two integral Indigenous science(s) research frameworks (centring country and relational accountability) and two Indigenous science(s) research methods (walking country and deep observation). These descriptions were supported by ideas of when and how to apply them and specific examples of their application in my PhD research along Yarralumla Creek, Ngunawal country, Canberra, Australia.

The discussion noted non-Indigenous researchers' concern about the difficulty finding Indigenous research collaborators, requesting yindyamarra to allow Indigenous peoples the time and space – sovereignty – to (re)build the Indigenous science(s) systems still being actively damaged by the

colonial project. With this sentiment in mind, there was also a brief discussion identifying the importance of being mindful of the mix of scientific frameworks and methods. Indigenous science(s) frameworks are best favoured, as this is crucial to maintaining the ontology critical to the integrity of Indigenous science(s) in scientific practice.

The power of a relational rather than transactional approach to the scientific basis is the most significant point of this paper. By centring country and practising relational accountability, Indigenous science(s) prompts crucially different expressions of the scientific basis to those prompted by a transactional, extractive intent, including the focus and priorities of research questions, field lab and other research practices and data collection and analysis. Embracing the relational approach also transforms the researcher and their research priorities and practices. Decentering the human and accepting the breadth of extant relationships beyond human control is initially destabilising for the colonised mind but ultimately liberating. Widely adopted, scientific frameworks such as centring country and relational accountability could deeply disrupt 'western' science's hegemony, transforming researchers and research values and outcomes.

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ORCID iD

Kate Harriden  <https://orcid.org/0000-0001-5318-3769>

Notes

1. other-than-human in this paper refers to all aspects of the natural world other than humans, including animals, plants, streams, mountains, the stars, moon and sun and spiritual entities.
2. yindyamarra is a wiradyuri word defined in English as respect, be gentle, polite, honour, do slowly (Grant and Rudder, 2010). yindyamarra has a deeper meaning, encapsulating our way of being and relating that this paper also evokes. As with country, this term stands in place of all the other Indigenous language words that encompass this meaning/philosophy.
3. Using a lowercase 'c' for country allows the word to, albeit inelegantly, encompass the linguistic and cultural diversity of all Indigenous science(s)'.
4. When the PhD commenced, I had been conducting monthly water quality at this site on Yarralumla Creek as a citizen scientist for over 10 years.

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Author biography

Kate Harriden, Research Fellow – Indigenous water at Monash University, Kate's PhD research investigated the application of certain Indigenous science(s) frameworks and methods to storm water management. Using the umbrella frameworks of centring country and relational accountability, this transdisciplinary research applied methods as diverse as walking country, deep observation, water quality testing and physical measurements, collaboration and photography in the quest to design, install and monitor site-specific small-scale infrastructure in a storm water channel. Kate was the 2020 Student of the Year for the ACT branch of the Australian Water Association (AWA). She is the Global Water Forum's Indigenous water knowledge topic editor, and holds honorary positions at the Australian National University. Her research philosophy is that research is for practical outcomes and knowledge is for sharing.