KEYWORDS: ***Traditional ecological knowledge – Rock art – Archaeology – Biocultural heritage***

ROCK ART AS A MECHANISM FOR SAFEGUARDING TRADITIONAL ECOLOGICAL KNOWLEDGE

Marcela Ortega-Rincon

Abstract. Traditional ecological knowledge (TEK) refers to culturally transmitted systems of knowledge, practice and belief accumulated over generations through coadaptation processes between humans and nature. In many cases, TEK is a matter of survival as ancient and contemporary communities require TEK to navigate and thrive in their worlds successfully. More recently, TEK has become a valuable concept for worldwide ecological conservation. Devastating colonial processes across the globe have critically threatened elements of Indigenous biocultural heritage, causing the loss of TEK. Rock art and its associated ecological knowledge have been one of the tangible and intangible biocultural heritages most critically impacted by colonial incursion. The association between both has been rarely recorded in most parts of the world, requiring imperative efforts to maximise its conservation. While the role of Elders and oral histories as cultural mechanisms helping to retain TEK has previously been discussed, rock art, as deep-time evidence for human-environment interactions, has not been explored as a mechanism for safeguarding TEK. This paper outlines the critical role of rock art as a mechanism for safeguarding, maintaining and acting as a reservoir of TEK. As neither theoretical nor methodological approaches linking rock art and TEK exist, this research develops these analytical frameworks for the first time by explaining how TEK is encoded in rock art. I highlight the importance of this approach for enhancing conservation strategies for intangible and tangible biocultural heritage related to rock art and for cultural and ecological conservation.

Introduction

Rock art researchers have overlooked the inclusion of the traditional ecological knowledge (TEK) perspective in archaeological rock art research. TEK involves all our perceptions of the world from physical to spiritual dimensions and then defines our actions (after Berkes 1993, 1999; Berkes and Folke 1998; Berkes et al. 2003; Nicholas and Markey 2015), constituting the basis of our worldviews, which we express symbolically through art (among other things), to support our cognition, our understanding of the world. Therefore, art is a cognitive expression of our worldview.

Rock art acts as cognitive maps representing mindscapes built on the base of culture-specific TEK. Even though it has been broadly unrecognised, aspects of rock art are associated with TEK. For instance, environmental context, resource availability, resource use (e.g. animal species, food, water), territoriality, landscape management, land ownership and other aspects of TEK may be represented in rock art, including at both physical and spiritual levels. On the other hand, rock art contains several levels of meaning ranging from outside to inside information (after Morphy 1991; e.g. Taylor 1989, 2016). However, the effects of colonisation on Indigenous people around the world forced many rock art practices to stop, and various forms of associated knowledge, such as TEK, have also been lost.

Rock art explains and maps the landscape of Indigenous peoples; if the code, map, the text disappears, or the knowledge to read it, that world of meaning is lost. Therefore, both tangible and intangible heritage must be protected, and in Australia, there is an opportunity that is no longer possible in other parts of the world. Building upon Faulstich (2003), the research I outline herein describes a new alternative theoretical and methodological approach developed as a starting point to advance a framework for integrating the study of TEK into rock art research. It is a new and alternative framework in rock art research, which focuses on explaining how we can identify TEK in rock art and offers insights to researchers and future applied studies.

What is traditional ecological knowledge?

Traditional ecological knowledge (TEK) refers to 'a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about

the relationship of living beings (including humans) with one another and with their environment' (Berkes 1999: 8). Hence TEK encompasses the 'integrated principles, practices, and beliefs that reveal and perpetuate the interconnectedness of people, animals, plants, natural objects, supernatural entities, and environments' (Nicholas and Markey 2015: 291). TEK's first recognition was in intergovernmental spheres, not in academia (see Johannes 1989). The use of the term 'traditional ecological knowledge' was established in the 1980s due to the work of the International Union for Conservation of Nature and Natural Resources' (IUCN) research group in the field of TEK (IUCN 1986; Johannes 1989). Thereafter, multiple intergovernmental meetings and reports have emphasised TEK's importance (for a review, see e.g. Ortega-Rincon 2022).

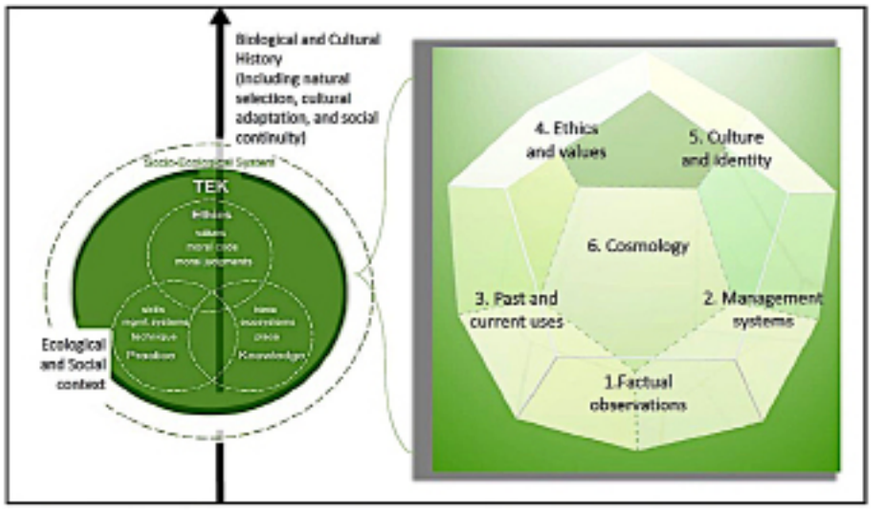

Figure 1. *The six facets of TEK in the 'biocultural synthesis'. Compiled using: Ellen 2006; Houde 2007; Reo and Whyte 2012.*

The progressive intergovernmental recognition of TEK's value has resulted in the rapid growth of academic research on TEK, mainly due to the contributions of interdisciplinary research. Since then, the study of TEK has been present in multiple fields, including conservation, natural resource management, sustainability, climate change, agriculture, pharmacology and botany. However, research into TEK in archaeological disciplines is still incipient.

TEK can be understood in diverse facets (after Houde 2007; Fig. 1), including factual observations, management systems, factual knowledge regarding past and current uses of the environment, ethics and values, TEK as a vector for cultural identity and survival, and as a part of cosmology. TEK facets are linked to the cosmology that gives meaning to a knowledge system and which, taken together, form the TEK of a culture.

The information contained in rock art

The terms outside and inside knowledge and meaning of rock art refer to those hierarchical principles within knowledge systems (after Morphy 1991). The concepts refer to levels of knowledge on a continuum of more restricted to less restricted knowledge in a system that controls access to it by established boundaries about what should and should not be known by defined categories of individuals (Morphy 1991). Since ancient times through to the recent past, the content of rock art has portrayed information that ranks from the outside to the inside knowledge and meaning (after Morphy 1991) in a type of 'cognitive map' representing the grammar of the mind or mindscapes (see e.g. Joy 2016). A mindscape that contains perceptions of the scalar dimensions of the world and closely influences activities related to maintaining the Cosmic Order between different levels of a person's understanding of their universe.

Essentially, inside things are ancestrally powerful and sacred, whereas outside things are mundane. Inside things are restricted, whereas outside things are unrestricted. The contrast between inside and outside can be applied to all types of natural and cultural phenomena, for instance: the bones of the body are inside relative to the skin; the centre of a tree is inside relative to the bark; below the ground is inside relative to the surface; and the ceremonial ground is inside relative to the main camp. Inside forms are always linked in a continuous flow to outside forms, just as the ancestral world extends into the present everyday world. Outside forms are, in a sense, generated by inside forms and are not separate from them (Morphy 1991).

Grounded Theory approach

The Grounded Theory approach, which follows inductive reasoning for analysing and conceptualising qualitative data for theory construction, is used here. 'Inductive reasoning seeks to discover a binding principle and construct generalisations, relationships and even theories by analysing the data collected for this purpose' (Gray 2009, referenced in Khan 2014: 224). The inductive process may still have some pre-existing theories or ideas when approaching a problem, and it does not intend to approve or negate existing theories but endeavours to create outlines and stabilities and explore significance by collecting data (Gray 2009, referenced in Khan 2014).

Grounded Theory aims at conceptual thinking and theory-building. It is based upon an interpretive approach, as the researcher wants to see the social world from the participant's perspective and consider the participant's perception of the world (Edwards and Skinners 2009). Therefore, the Grounded The-

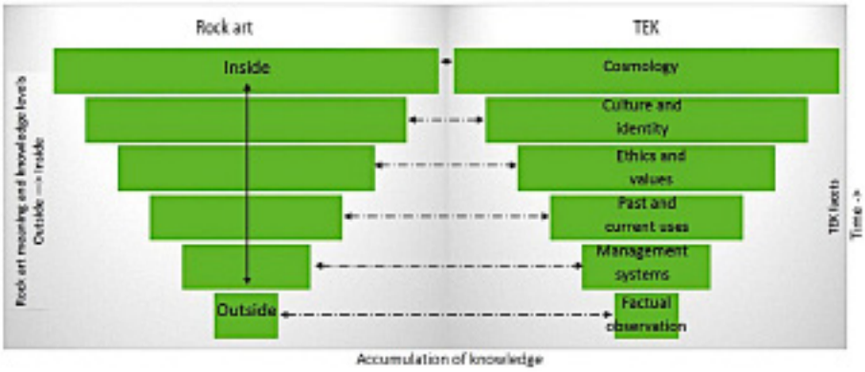

Figure 2. *TEK and rock art knowledge-accumulation equivalences.*

ory approach is appropriate for studying human behaviour on controversial topics, even in a different cultural context (Wolcott 1980). The Grounded Theory process includes creating categories, specifying their properties, defining relationships between categories and identifying gaps. Data sampling is aimed toward theory construction, not representativeness, and a literature review is conducted after developing an independent analysis.

TEK in rock art

General analytical dimensions (categories)

The starting point for attempting to integrate TEK into rock art research is to comprehend the general facets of TEK (after Houde 2007) and the rock art knowledge-accumulation system (after Morphy 1991). Understanding these characteristics will allow the researcher to see the equivalences between TEK and rock art and understand that the significance and information contained within rock art are actually part of TEK. Therefore, the first part of this article focuses on explaining these general characteristics and the identified equivalences between TEK and rock art to underpin the creation of a new alternative framework for future applied research. The second part of the article discusses each of the proposed dimensions in more detail. These dimensions constitute essential initial analytical levels for integrating the TEK framework in rock art research.

In recognition of the holistic nature of Indigenous knowledge systems, the following proposed analytical dimensions represent dimensional interconnections as layers of relationship and interdependencies rather than Western dualistic separations. None of the analytical dimensions are exclusive of the others. Considering the previously outlined facets of TEK (see Houde 2007) and the information contained in rock art that researchers have identified (see Morphy 1991), it is possible to discern that much of the information in rock art is indeed part of TEK and, reciprocally, much TEK has a physical expression in rock art. In such a way, TEK makes up part of the intangible heritage of rock art. Moreover, TEK and rock art represent analogous knowledge systems (Fig. 2) or actually constitute the same system of knowledge, TEK in the intangible dimension and rock art in the tangible dimension.

Figure 2 illustrates how the knowledge accumulation systems of TEK and rock art work in similar ways: from basic to more complex levels, from the basic factual observations level in TEK equivalent to the outside knowledge in rock art, to the cosmological level in TEK equivalent to the inside knowledge in rock art. In the middle, an interface between inside and outside knowledge in rock art resembles a landscape/ecosystem level in TEK.

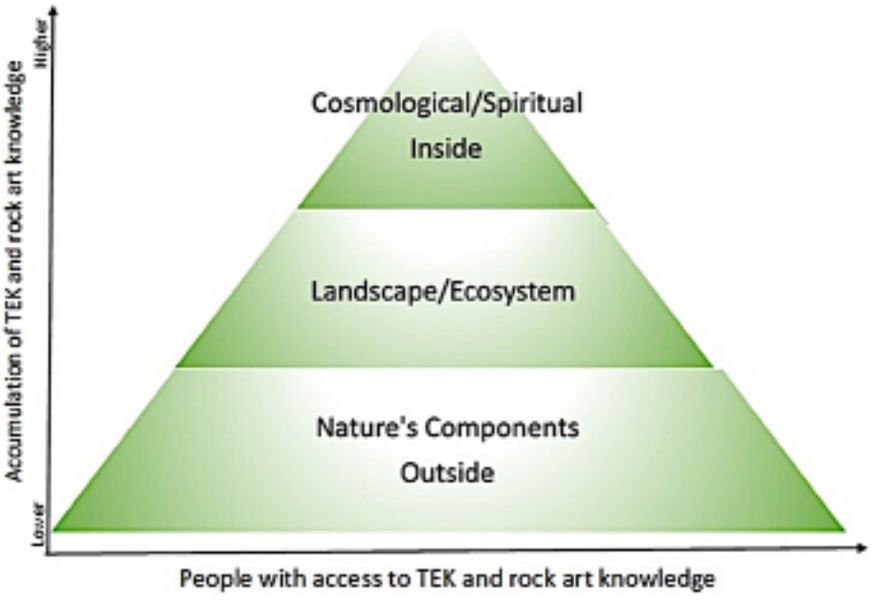

Figure 3. *Accumulation of knowledge of TEK and rock art vs people with access to that knowledge.*

Equivalences between TEK and rock art knowledge systems have been discerned within this research (Fig. 3), and as a result, the proposed analytical dimensions correspond to:

1. The nature's components dimension – outside knowledge;
2. The landscape/ecosystem dimension – outside and inside knowledge; and
3. The cosmological/spiritual dimension – inside knowledge.

Additionally, TEK and rock art are culturally structured knowledge systems (e.g. Mor-

phy 1991; Berkes 1993; Berkes and Folke 1998). This means that cultural strategies have been created to control access to knowledge. An inverse relationship exists between the accumulation of TEK and rock art knowledge and the number of people with access to that knowledge (Fig. 3). As such, the primary nature's components of ecological knowledge and outside knowledge are accessible to most people. In contrast, cosmologically advanced ecological and inside knowledge are restricted to a few senior knowledge holders.

Integrally, TEK and rock art are cultural systems, reflections of each other, and as such, are closely interdependent. Rock art has been one of the material cultural mechanisms—a tangible way—to assist in safeguarding, maintaining and transmitting TEK, which is, in principle, intangible (although it has multiple material expressions) (for basics about intangible heritage, see e.g. Smith and Akagawa 2008). Essentially, what has been usually studied in separate boxes in the Western sciences is one in the real world. Therefore, the Western world needs to advance in understanding these intangible dimensions and the interdependences between cultural expressions.

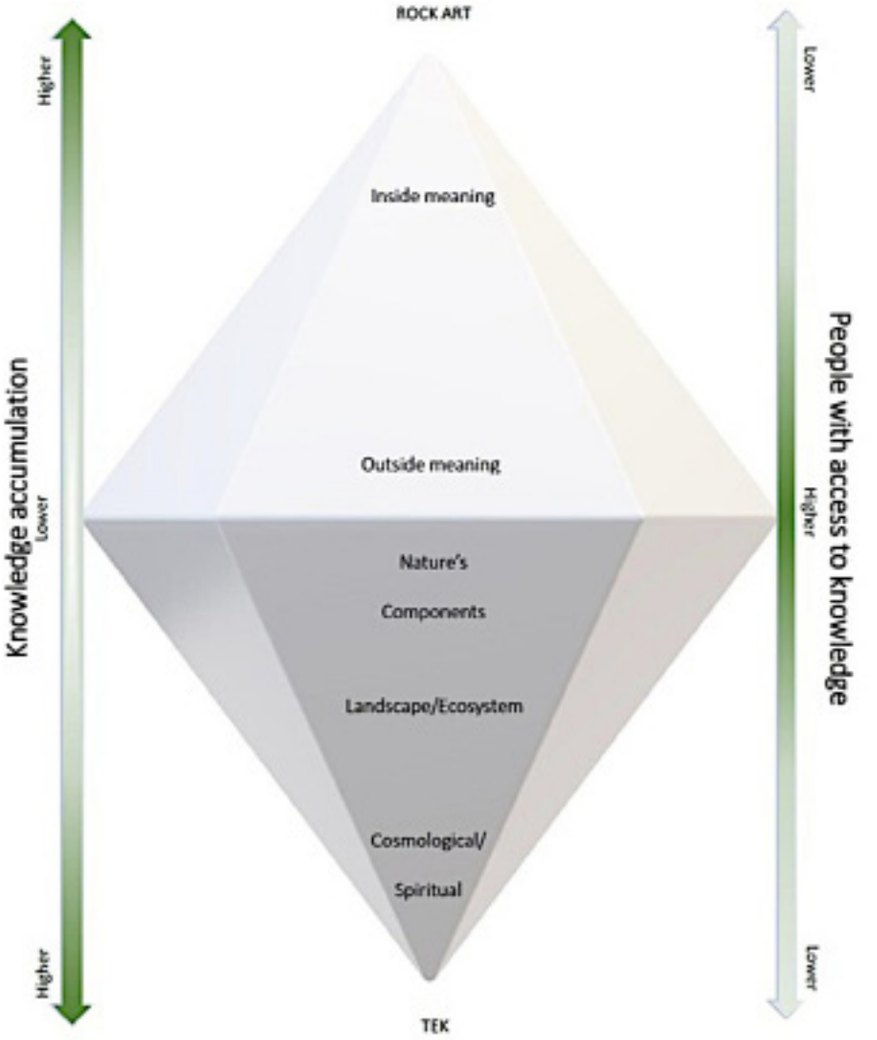

Figure 4. *TEK and rock art knowledge.*

Figure 4 depicts the 'reflection' of both knowledge systems in an integrated view. In other words, TEK is implied in rock art. The horizontal line in the middle of the figure plays the role of a mirror. So, when researchers 'see' outside rock art meaning and knowledge, the nature's components dimension of TEK is what underpins it. Likewise, the progressive accumulation of knowledge will bring us to the inside rock art meaning and knowledge underpinned by the landscape/ecosystem level and, finally, TEK's cosmological/spiritual level.

In Figure 4, distance from the mirror line is correlated with the broader accumulation of knowledge, as indicated by the vertical double arrow at the left. Whereas as more distant from the mirror line, the people with access to broader knowledge are fewer, in an inverse relationship. As they become more distant from the mirror line, the complexity of the knowledge systems gradually increases, as well as their integration.

I stress that researchers must not forget that the knowledge was, is and will be from the people who made the rock art and from their ancestors. Therefore, an emic approach must be exercised to study TEK in rock art. Here I have shown how TEK and rock art equivalences can be perceived as a starting point.

Characteristics of analytical dimensions

1. The nature's components dimension – outside knowledge

The identification and knowledge about components of nature constitute the primary TEK facet, and any further TEK is built upon this base. Nature's components might include animal and plant species—note that the Linnaean classificatory system is a Western construction and differs from Indigenous systems of nature's components identification (see e.g. Ellen 2006), but also soils, rocks, water sources, rain, clouds, wind, and so on. Thus, this analytical dimension refers to the TEK of specific human groups about components of nature that can be perceived in rock art. To explain this dimension in this document, I use

Figure 5. *Extinct animal species depicted in the rock art: a, b, thylacine, source: (a) Darrel Lewis (http://www.naturalworlds.org/thylacine/art/rockart/image_25.htm); (b) George Chaloupka (www.pinterest.com.au); (c) extinct animal species depicted in the rock art, source: Morwood 2002.*

the animals and aspects like their presence/absence, extant/extinct, native/introduced species and the relationships between animals and humans, including possible changes through time and the coadaptation process, as the more perceptible exemplar to illustrate this dimension. This analytical dimension refers to the outside information contained in rock art. It makes part of what Houde (2007) has classified as the first facet of TEK or *'factual observations'* consisting of the recognition, naming and classification of discrete components of the environment, e.g. animals. It also refers to synthesising empirical observations and information (e.g. facts about anatomy, behaviour, habitat and abundance of animals, classifications, naming of places, and descriptions of ecosystem components). Likewise, it is about understanding the interrelationships that occur among species, the connections within the biophysical environment, and the historical trends in spatial distributions and population patterns. This knowledge allows for monitoring ecosystem dynamics and ecological changes; thus, it implies an understanding of the dynamics of ecosystems and their elements. The empirical knowledge consists of a set of generalised observations conducted over a long period, reinforced by information from other TEK holders.

Regarding fauna and flora, most empirical rock art data relates to animal species, but the same applies to plant species. The study of animals depicted in rock art is a source of evidence for the fauna present in a region, including extant, extinct, native and introduced species. Representations of animals in rock art have been abundant at geographical and temporal scales worldwide (for a review, see Davidson 2017) despite cultural and ecosystem differences. However, the abundance of animals in rock art is not adequately explained by subsistence hypotheses alone (Davidson 2017), and the underlying ecological imperative of the images is indiscernible, although the symbolic profundity of animals might indicate an expression of a human biological imperative (Faulstich 2003; Watson 2009).

In some regions, animal depictions relate to myths of shared ancestry with the message that we are two or more things at once: human and other (e.g. Molyneaux 1989; Ciani 2014). In other cases, petroglyphs and rock paintings may have explicated creatures observed in distant lands, providing information about the geographical ranges of human movements and possible cultural contacts (e.g. Wesley 2013). It can be speculated that some early animal depictions addressed the desire to avoid being prey to other animals. There are documented examples of rock engravings and rock paintings functioning as part of the hunter's art (see Schaafsma 1989; Lenssen-Erz 1997; Lewis-Williams and Dowson 1999). Also, other forms of sympathetic magic may have been employed in rock art, for example, transferring some qualities of the depicted animal to the artist (see Davidson 2017).

In Australia, research on possible depictions of now-extinct species has been the focus of several authors who have attempted to anchor relative rock art chronologies. Important depictions exist that may be of species of macropods that became extinct (Taçon and Webb 2017) and of the more famous case of the thylacine (Tasmanian tiger), extinct on the Australian mainland around 3000 years ago (Fig. 5) (Akerman 2009; Bednarik 2013; Lewis 1977, 2017; Murray and Chaloupka 1984; Ouzman et al. 2002; Taçon and Webb 2017).

Depictions of these animals exist in what are argued to be the oldest Australian sequences of the rock art of Arnhem Land, Kakadu, the Pilbara and

the Kimberley, with possible depictions in southeast Cape York Peninsula and the Sydney region (Taçon et al. 2010; Knights and Langley 2021). Other cases of extinct megafauna such as *Thylacoleo* (marsupial lion), *Diprotodon*, the bird *Genyornis* (Gunn et al. 2011; Barker et al. 2017; Chalmin et al. 2017; Gunn et al. 2017), and *Palorchestes* may be depicted in the rock art of South Australia, southeast Cape York Peninsula and western Arnhem Land (Lewis 2017; Taçon and Webb 2017). Researchers have stressed that accurate identification of megafauna, birds and fish in rock art depends upon understanding the local artistic conventions (style), species-specific traits and the integration of palaeontology, rock art and archaeological studies (Lewis 2017).

As with extinct species, rock art is a source of evidence for the introduction of animal species into a territory. For instance, the case of the dingo introduced more than 3200 years ago (Mulvaney 1975; Balme and O'Connor 2016; Balme et al. 2018; Koungoulos and Fillios 2020a, 2020b); species introduced more recently, such as horses, buffalos and pigs (Morwood 2002); and established populations of native fauna that once inhabited this land and then became extinct, for example, the well-established populations of dugongs in Moreton Bay 4000 years ago (Ross 2019), now locally extinct due to overexploitation.

Other cases similar to Australia exist all around the world. For instance, Drouin (1989) explored the 'archaeology of knowledge' across time and cultural boundaries in the art and myth of North Africa. Drouin demonstrated how knowledge about the now regionally extinct elephant was maintained in the oral tradition of the Tuareg—even though it was unknown physically—thanks to the rock art of this species made by pre-Historic populations. She argued for the transmission of a theme over time, whose continuity may have been ensured by the permanence of motifs in regional rock art (Drouin 1989).

While at the base of the 'pyramid' (Fig. 3) and the most basic knowledge one person could attain, the TEK associated with nature's components dimension (animals and/or plants, among others) is as necessary as the ecosystem and spiritual dimension. It is essential to highlight that when we attempt to study a rock art depiction of an animal or plant, we must be mindful that the person who made that depiction must have had at least rudimentary knowledge about that species. This knowledge may include at least morphological and anatomical features, behaviour, movement patterns (including migration), ecological cycles and even locations where it was present. Moreover, any TEK about that species is interlinked and influences cultural activities. Including, among others, monitoring and hunting techniques, long-term observations, determining the location of hunting camps and uncertainty reduction in future hunts (Berkes 1999). Therefore, losing an animal or a plant can threaten a culture in much the same way as losing a language. With the disappearance of species, linked cultural activities also disappear. For instance, the knowledge, activities and beliefs linked to the *Thylacinus*, like knowledge about its hunting or avoidance, knowledge about areas with its presence, and practices for transmitting stories and ceremonies related to *Thylacinus*, have disappeared. The history of animals and plants is inextricably tied up with the people's history (see Bennett 2003; e.g. Kimmerer 2013).

Likewise, the disappearance of the space, in some cases with the disappearance of species, implied by the movement of communities from their territory, would have removed people from the local ecological contexts in which they learned hunting, gathering and farming TEK. Ethnographic cases of TEK loss cite movement outside of local contexts as a significant factor in disrupting the transmission and maintenance of that knowledge (Blewitt 2016).

As we transition to the next analytical dimension of TEK encoded in rock art, we can posit the TEK about seasonality as an exemplar (among others), which has also been developed through years of trial and error, experiential knowledge, observations and connections to the environment. Seasonality implies an understanding of the dynamics of ecosystems and their components. It combines the empirical knowledge gained through generalised observations conducted over a long period, reinforced by information from other TEK holders. Seasonal migration patterns are one component of the TEK developed, among others, through observations of seasonal changes and food source availability in a space. Limited access to a space can lead to the loss of crucial cultural knowledge associated with it, including resource management strategies and cumulative environmental knowledge adapted to generational environmental change. Passing down this type of experiential knowledge faces difficulties without curating deep relationships with specific locations (Dolinar 2019), of which rock art is a mechanism.

An example of the seasonal ecological knowledge embedded in rock art is the panel of the ceiling of Altamira's Great Hall, where twenty bison are painted with details of female and male individuals. This panel denotes a herd of bison during their brief late-summer rut season, which is the only time of year when adult male and female bison associate closely (Diamond 1993: 26 in Faulstich 2003).

In Australia, perceptible examples are the depictions of whales in the rock art of the Sydney region. The sandstones of the Sydney region preserve wonderful petroglyphs of whales, some almost life-size (Stanbury et al. 1990). Whales are seasonal migratory species not fully observable from land—except when stranded on the coast. With the presence of the whale images, we can at least discern, regarding TEK, that the makers of these petroglyphs might have had some important seasonal ecological knowledge about this marine life. For instance, their ecological cycles of mi-

gration, the seasons when their migrations took place, or the environmental indicators for the change of seasons heralding whale migrations might have been observed. The artists probably invested a reasonable amount of time observing the whales—or listening to the ones that observed them—to get to know this information; either way, they had some form of close contact with the whales to know their complete body anatomy.

2. The landscape/ecosystem dimension – outside and inside knowledge

The relationship between TEK and rock art at the landscape/ecosystem dimension can be perceived in several ways, including at temporal and spatial scales. For instance, information and practices related to landscape management cultural practices, and the rock art's broad spatial scale characteristics concerning the availability of natural resources.

The landscape/ecosystem analytical dimension refers to the interface of inside and outside knowledge in rock art and the grouping of three facets described for TEK. I have included the second, third and fourth facets of TEK in this analytical dimension owing to its characteristics strongly anchored to the knowledge accumulated through previous generations and at broad spatial scales (see Houde 2007), including: *'management systems'* as complex webs of practice and strategies ensuring the sustainable use of local resources (e.g. harvesting rotations, controlled fires); '*factual knowledge regarding past and current environment use'* which asserts a historical connection of people to the land (e.g. historical patterns of land use and settlement, harvest levels of plants and animals, location of medicinal plants and cultural and historical sites), and; '*ethics and values'* facet, which connects the belief system and the organisation of facts and actions, that keeps exploitive potential in check (e.g. values of respect toward non-human animals, the environment in general, and between humans).

As rock art is imagined, executed and contemplated in relation to places, it joins the human psyche with the landscape. Because the perceived landscape continually reflects and informs the psyche, rock art traditions help define people in relation to their environment. When the land is populated, and a relationship with the place is further cultivated, people are grounded in it. Fundamentally, rock art helps to construct, define and communicate the cultural history of a place; as such, it is a reminder of the relational existence of the rock art makers and their cultures with the place, of their internal and subjective and external and objective identities (Faulstich 2003):

> For Aboriginal peoples, the observable objects of the world are the phenomenal manifestations of Dreamtime noumena. Patterns of information are being communicated through the ecosystems in which people participate, and Aboriginal arts have metaphorical frameworks that embrace essential features of the territory (Faulstich 2003: 4).

Rock art is a way of human place-making and material culture evidence that gives insights into how physical landscapes are embedded in cultural knowledge (Faulstich 2003). The network of meaningful places across space is created from the dynamic relationships between humans and nature, constituting cultural landscapes (Anschuetz et al. 2001). The landscapes embed material culture, inherited properties, performance characteristics and life histories (Zedeño 2000: 98) and serve as reminder devices to recall memories and social interactions that occurred in places while also legitimising present relationships. Humans embed symbolic meaning and memory via the spatial, historical and social dimensions of human-nature relationships while building cultural landscapes, but those dimensions cannot be deciphered by purely materialistic approaches (Dolinar 2019). However, materialistic approaches may be the only way to decipher cultural landscapes in some extreme cases where traditional knowledge has disappeared (e.g. Binford 1982). Therefore, it is essential to understand 'not only the physical environment *onto* which people live out their lives but also the meaningful location *in* which these lives are lived' (David and Thomas 2008: 38).

Traditional landscape management

The importance and close relationship between rock art and landscape have been frequently mentioned in Australia. Local Aboriginal people interpret rock art as 'a whole in respect to its association with creation events and subsequent human land ownership and use' (Taylor 2016: 314). Thus, rock art contains information about the landscape uses that cultural groups might develop.

Indigenous groups generally establish social rules to control the exploitation of natural resources in terms of, for example, delimitations of hunting activities concerning restricted and accessible areas, times, amount and types of individuals allowed to hunt, all of which constitute part of the *knowledge regarding past and current environment use* and of *ethics and values* facets of TEK. Specific rock art depictions embed this type of information; however, to the best of my knowledge, no study has yet been attempted on rock art and this type of traditional landscape management practice and its rules.

The practice of hunting implies a considerable amount of knowledge derived from the interrelationship a culture has with animals. A human hunter in action is implementing the knowledge and experience of past generations, handed down as an accumulating tradition (see Ingold 1987). Therefore, changes in the interrelationship between the culture and the animals can be perceived by changes in the hunting practice, which in turn can also be perceived in rock art. For instance, Molyneaux (1989) referred to the systems of knowledge found in Micmac rock art in eastern Canada, evidence of the change in the cultural human-animal relationships from the past to after the

coming of Europeans, when the participation of the Micmac and other Algonkians in the fur trade led to the local extinction of the moose (Molyneaux 1989). This human-animal relationship ranged between ideology and subsistence relative to the individual's place in a social group. In Algonkian culture, non-human animals and humans are metaphorical equals; however, animals are also a primary food source. That is why among many groups, killing an animal requires some form of compensation through specific rules of conduct for the hunting process and the processing, distribution, consumption or disposal of the animal remains, which may include rituals according to mythology.

Molyneaux (1989) found that changes in rock art evidenced the changes in the conception of the animals by the Micmac, from a time of integration with depictions mainly with the shaman practices, to the depictions of the 19th century with artefacts of European origin that reflect a time when animals were no longer culturally significant outside their use as food, tools or commodities. The continuity with the aboriginal past was broken, as evidenced by Micmac's work at the hunting lodges and in the fur trade that led to the extinction of the moose in the early 20th century, which would have been at odds with their past cosmovision (Molyneaux 1989). 'The fixed position of rock art within fluid cultural landscape makes it potentially sensitive to changes in the patterns of group occupation or adaptation within a region' and it can reflect the culture's broader socio-economic and ideological changes (Molyneaux 1989: 196). Molyneaux (1989) states that any attempt to interpret and understand concepts of humans and animals in a specific society must consider how humans and animals enter each other's worlds in specific cultural contexts.

Knowledge about the interaction with natural resources essential to survivorship, like water, is evidenced through rock art. Sustained human interaction with water resources implies climatic knowledge at broad spatial and temporal scales and influences cultural strategies like human migration patterns (see e.g. Bird et al. 2016). Evidence for the functional relationship of rock art for resource use is also found in representations associated with song cycles of waterholes, which are an integral part of the passable tracks in arid regions, helping people memorise locations with water and had survival value (Spencer and Gillen 1904; Prins 1990; McDonald and Veth 2012, 2013). Jackson (2005) researched Indigenous values and water resource management in the Northern Territory. The information she compiled mentions several rock art sites directly associated with springs, waterholes, billabongs, creeks or rivers. In central Queensland, Morwood (1979) found a relationship between a Rainbow Serpent storyline and the location of depictions of paired tortoises in rock art, interestingly restricted in distribution to only four sites that form a line that crosses the Great Dividing Range from the upper Warrego to the upper Nogoa River catchment (Fig. 6). He argued that '[t]he path taken by the snake … runs parallel to that delineated by rock art sites with tortoise motifs, while both paths also link sites at which water was available' (1979: 362).

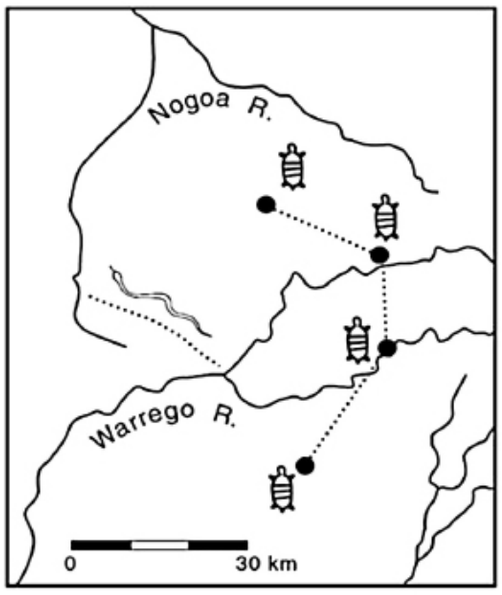

Figure 6. *Depictions of the tortoise and the Rainbow Serpent in central Queensland (source: Morwood 1979: 360).*

Likewise, Myers (1986: 27) stated that 'the Western Desert population was a vast and interlocking network of persons who were themselves localised around several loosely defined areas. The unreliability of rainfall necessitated continual interdependence among people in a wide area for water and resources. Social isolation, in other words, was ecologically impossible'.

Rock art's broad spatial scale characteristics in relation to natural resource availability

The influence of the availability of natural resources on rock art's broad spatial scale characteristics can be discerned both over space and through time. In order to explain this relationship at the Landscape/Ecosystem dimension, ecological theory is applied to humans as one more element of an ecosystem, to understand their ecological adaptation strategies and resulting cultural expressions, specifically rock art.

Specifically in Australia, past archaeological rock art research focused on the motifs of rock art depictions, looking into rock art images to build chronologies and gain insights about ecological characteristics in parallel. For instance, in western Arnhem land, the depictions of animals in rock art were used to propose chronologies. Brandl (1972) proposed a chronology partially based on the presence of paintings of extinct fauna—principally thylacine—and dingoes. Chaloupka (1993) attributed faunal types in the rock art to specific environmental conditions to propose broad

periods. In deeper analysis at the broad spatial scale, regional differences in rock art through the localisation or spread of styles have been related as probably depending on the nature of resources, population levels and social organisation. For instance, the choice of specific subjects in rock art depictions and styles might reflect control of access to information (see e.g. Lourandos 1983; Lourandos and Ross 1994; Morwood 2002; David 2004; McDonald 2005, 2017).

The same trend marks the general Australian rock art sequence through time. The earliest rock art across much of Australia is characterised by petroglyphs of a specific range of non-figurative forms, and its homogeneity through space is interpreted as reflecting widespread information exchange networks (see e.g. Maynard 1979; McDonald 2005, 2017). In contrast, during the late Holocene, rock art assemblages are dominated by highly regionalised forms/bodies of rock art which may reflect a highly regionalised (spatially discontinuous) social landscape (Lourandos 1983; David and Lourandos 1998; Morwood 2002; David 2004; McDonald 2005, 2017, 2020; Wesley et al. 2017; Veth et al. 2018), representing the rise of regional social alliances and extensive, geographically complex exchange patterns (Lourandos and Ross 1994; Morwood 2002; David 2004).

From an ecological perspective, the human-in ecosystem approach of resilience theory (see Gunderson and Holling 2002) and optimal foraging strategy thesis proposes that 'in locations where resources are unpredictable (referred to as 'resilient system') a generalist strategy is pursued, whereas in areas with predictable resources (referred to as 'stable system') a specialist strategy emerges' (Davidson-Hunt and Berkes 2000: 61), which explains the why of this human behaviour as ecological adaptation strategies. Thus, the shift in rock art assemblages through time is related to changes in natural resource availability from more scarce to more abundant with the wetter conditions and reflects the human adaptation strategies from a more *generalist* rock art (i.e. a *generalist* adaptation strategy in the face of scarce natural resources availability) to a more *specialist* rock art (i.e. a *specialist* adaptation strategy in the face of abundant natural resources availability).

Likewise, by analysing rock art's broad spatial scale characteristics in the *same time lapse*—for example, comparing tropical vs temperate regions, desert vs rainforest, and inland vs coast areas—we can detect a more homogeneous rock art style throughout central Australia, where the ecological conditions have been very harsh for humans, and the population was lower. In contrast, in more predictable, productive environments with higher population densities, such as Arnhem Land, boundaries between art areas have tended to be abrupt with diverse regional rock art styles (see Maynard 1979; Lourandos 1983; David and Lourandos 1998; Morwood 2002; David 2004; McDonald 2005, 2017, 2020; Wesley et al. 2017; Veth et al. 2018).

Finally, the relationship between rock art and the landscape is in the landscape *per se*, not the images. However, it is possible to obtain information about the relationship between rock art and the landscape through the contextual location and analysis of rock art in the context of past and present ecological and cultural features. For example, the location of rock art in reference to physiographic features of the landscape, including rivers, hills, water sources, mountains, dunes, forest patches, and natural resources available (in general or presence of specific plant/animal populations and their movement routes). Likewise, in context to cultural features of the landscape (which are often intangible features for Western people), such as the magnet of the earth, the presence of cultural spirits from humans and/or nature, and the location of cultural events—mythological or historical—that happened in the past. Considering past and present ecological and cultural features on the landscape for understanding rock art moves us forward to the most intangible levels of TEK and rock art knowledge and significance: the cosmological/spiritual dimension.

3. The cosmological/spiritual dimension – inside knowledge

This dimension explores the inside rock art knowledge in correspondence to TEK's cosmological/spiritual level; much of this information is described in a culture's myths and oral history. In this dimension, I have grouped the fifth and sixth facets of TEK described by Houde (2007), corresponding to '*TEK, as a vector for cultural identity-survival'* which emphasises the role of language, land and images of the past, in identity and giving life to culture, and '*cosmology'* which refers to the culturally-based worldview that is the foundation of the other facets of which it is inseparable. It gives the principles that regulate human-animal/landscape relations and the role of humans in the world by explaining how things are connected (e.g. beliefs and spiritual relationships with the environment).

Among material culture expressions, '[r]ock art may be one of the most obvious examples of symbolism that offers promise in understanding the more idealistic aspects of the past' (Ciani 2014: 19). Lévi-Strauss (1978: 42) postulated mythology as a strategy for conservation of knowledge: 'for societies without writing and without archives the aim of mythology is to ensure that as closely as possible … the future will remain faithful to the present and to the past'. Australian Aboriginal designs used in rock art—as well as in other art, ceremonies, songs, and dances—took their meaning from the creation myths associated with particular tracts of the Country (McCarthy 1958; Taçon 1989, 2011; Gunn 1992; Morwood 2002; Flood 2004). Knowledge of mythology (i.e. the Dreaming in Australia) is an essential element in the attachment of Australia's Aboriginal peoples to the landscape and provides the dominant reference points for human identity, understanding and action concerning the land (Napaljarri and Cataldi 1994). Rock art images

often explain and map the Country, including information on the culture and nature/land relationships over long periods and of Ancestral Beings' connection to local landscape features. People ensure the landscape's regeneration, the land's fertility, the rules of conduct humans must follow and the source of conception spirits by keeping the presence of the Ancestral Beings alive (Flood 2004; Brady et al. 2017; Gunn et al. 2017). As such, rock art preserves the Law, ritual and mythology related to hunting, fishing, survival of humans and nature, and even to the climate (e.g. rain); hence, rock art and TEK linkages are vital for the existence of cultures.

The most intangible levels of TEK and rock art knowledge and significance depend on the cosmology/spirituality of the rock artists. Thus, it is essential to be aware that the connectivity between Indigenous peoples, past and present, and their natural environment, with the deep environmental knowledge systems that have formed cultural landscapes, needs to be contextualised within the cultures and traditions in which they were created. Such cultural landscapes constitute a fundamental component of the identity of rock art makers. Then, the value of a landscape could not be adequately assessed by anyone outside the particular Indigenous community that values it because a lack of tangible physical remains on the landscape may not equate to a lack of value for Indigenous descendant communities (see Teeman 2008). The lack of rock art in a place does not imply such a place's lack of importance, nor does the abundance of rock art in a place imply the paramount importance of such a place, *per se*. For instance, the reason for some rock art depictions is the importance of mountains located some distance from the actual rock art. However, the importance of that rock art relies upon those mountains, even though the rock art is not materially *in* the mountain (pers. obs.). Likewise, several rock art depictions are related to water sources (see e.g. Jackson 2005), but the rock art is usually located on land, not inside the water source.

Most Australian Aboriginal peoples established systems that allowed people to cluster or disperse depending on food availability, which required—among other things—sophisticated monitoring of resources and possession of esoteric knowledge about creation events and the associated meaning of rock art. In southeast Queensland, with the change of natural resources available, the archaeological evidence involves more sites concerning symbolic activities such as rock art and more intensive economic strategies in the hunting, from individual hunting of single kangaroos and wallabies that were speared, to cooperative hunting involving drives and nets for catching large numbers of animals (Morwood 1987; Satterthwait 1987).

Most studies focus on the exploitation of resources rather than their conservation (e.g. Sundstrom 1989), which could be crucial to biocultural heritage conservation in several parts of the world, particularly the study of the relationship between rock art and sacred origin areas. For instance, important and restricted rock art depictions in the Colombian Amazon are often located in sacred origin areas (pers. obs.). These are areas where it is forbidden to hunt, considered origin areas of the Indigenous groups, origin of their spiritual ancestors or origin of the animals and their spirits. They are areas protected for the recovery and maintenance of natural resources and spiritual realms, with the maintenance of viable populations of species of fauna and flora, representing critical areas for ecological and cultural conservation and perpetuation.

The need for people to have localised symbolic knowledge to be able to use resources—for example, in hunting—was a way of reducing territorial access. Since rock art served as a marker of land custodianship, rights to use rock art were closely guarded. To retain custodianship and use of their estates, clans had to maintain the sacred Law, perform the required ceremonies and pass on the Law to succeeding generations. Therefore, they needed knowledge of the stories, songs and art that encoded the sacred Law (Morphy 1991; Morwood 2002; Flood 2004; Brady et al. 2017; Gunn et al. 2017).

Passing a series of formal initiation ceremonies, individuals acquired knowledge about the symbolic landscape and its associated stories and symbols, including rock art. Differences in the level of initiation also determined an individual's status and authority in a clan and their entitlement to exchange information with other clans. Knowledge of the symbolic landscape was differentially accessed within clan groups based on sex, generation, primogeniture and sub-group affiliation. This hierarchy of ritual authority was the fundamental basis of social and economic power in Aboriginal society (Morwood 2002), which has as its basis the ecological knowledge often strategically encoded in rock art.

Rock art may well be a by-product of ceremonies rather than the end-product of deliberate marking behaviour; for instance, rubbing rock surfaces in the course of ceremonies to maintain and increase natural resources may lead to cupules as marks (e.g. the ritual for the increase of pink cockatoos and their eggs; Flood 2004). This case is evidence of other aspects of the importance of rock art as a reservoir of information linked to traditional knowledge that allows the practice of cultural rituals and is directly related to the ecological management of fauna and flora. Rock art is the only traditional Aboriginal 'art' that leaves a long-term, immovable record in the landscape and is used as a memory aid for learning from generation to generation (Flood 2004), facilitating the transmission of cultural knowledge (including TEK) across space and time.

In southwestern Arnhem Land, the Jawoyn substyle of x-ray rock art is dominated by paintings of macropods, which also highlights a substantial difference between the beliefs of the Jawoyn and those of their northern neighbours. This dominance

of macropod paintings is well exemplified by an emphasis on the macropod Dreaming Beings Gupu and Barrk in the south (Gunn 1992; Gunn et al. 2017). Likewise, at Undiara (Inteyerre) waterhole, a large red and white striped painting was identified as the body and spiritual home of the Kangaroo Ancestral Being. It was periodically ritually repainted in the Intichuma ceremony by initiated individuals of appropriate totemic affiliation to maintain the numbers of kangaroos in Arrernte Country (Brady et al. 2017, based on Spencer and Gillen 1899). At the site of Unthurqua (Nthwerrke or Emily Gap), other large red and white striped paintings were associated with the caterpillar Intichiuma, yet, in this instance, the paintings are related to the activities of other Ancestral Beings linked to the Intichiuma site. The paintings were described as 'sacred *Ilkinia*, a drawing on the rocks which it is believed sprang up spontaneously' to mark particular instances of the local mythology (Spencer and Gillen 1899: 425–426 in Brady et al. 2017).

In remote northern Australia, rock art and the knowledge of its meaning by some elderly Aboriginal people is still 'alive', and the retouching of rock paintings is still practised in some areas (Flood 2004). This knowledge and practice also occur in the south of the continent, like in the Sydney Basin, although it is not yet published (pers. comm. Jillian Huntley, 31 May 2022). However, the effects of colonisation on the Aboriginal people caused rock painting to virtually cease all over Australia (Flood 2004; Taçon 2011). Various forms of associated knowledge, such as TEK, were also lost. Australian Aboriginal rock art explains and maps the landscape; then, if the map disappears or the knowledge to read it, that world of meaning is lost. Therefore, both tangible and intangible heritage must be protected, and in Australia, there is an opportunity that is no longer possible in other parts of the world.

Worldview and ritual are strongly tied to ecological conditions (Ciani 2014) as symbolic systems are grounded in daily subsistence activities (Jordan 2008 in Ciani 2014). Daily subsistence activities bring us back to the base of TEK, the nature's components analytical dimension explained above, which sustains all the system and allows the survivorship of humans, the development of adaptation processes and the creation of socio-ecological systems.

To comprehend human-animal interactions in the past, or any human-nature interaction, it is fundamental to integrate TEK. Because the worldview of past and contemporary individuals influences many aspects of a person's behaviour, it affects the archaeological record. Therefore, researchers cannot regard animals just as material for the lives of humans but also need to acknowledge alternative belief systems and consider the cosmological aspects of human-nature interactions and the possible spiritual importance of the remains of animals and other natural resources (Ciani 2014).

Conclusion

Understanding the characteristics of how TEK and rock art knowledge works allow us to discern that, actually, much of the knowledge encoded in rock art is the TEK of the rock art artists. Realising the broader spectrum of TEK and integrating it into rock art research gives broader theoretical fundaments to its analysis beyond physical archaeological remains. Furthermore, extending the integration of TEK in rock art research provides one means of compiling and preserving the intangible and tangible biocultural heritage of ancient and present cultures. It is important to stress that TEK is not only knowledge but practice and belief, which implies lifeways; as such, it also provides one means of protecting and perpetuating the community's traditional lifeways.

Rock art has a crucial role as a reservoir of TEK for maintaining, conserving and safeguarding information about animals, plants, soils, ecology, the functioning of the earth and culture, and for TEK's practice and transmission through generations. Rock art heritage at the global level is the heritage of humanity and, therefore, must concern all of us. This proposed approach is a tool for explicitly integrating TEK frameworks into archaeological rock art research. It is a starting point on which to move forward.

Acknowledgments

I want to acknowledge Dr Jillian Huntley, Dr Michelle Langley and Professor Darryl Jones for their valuable support and feedback during this research process. I also thank the *RAR* peer reviewers for their constructive feedback.

Data availability statement: The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.
Competing interests: The author declares no conflicts of interest.

Dr Marcela Ortega-Rincon
Australian Research Centre for Human Evolution (ARCHE)
School of Environment and Science
Griffith University, Gold Coast Campus
QLD 4215
Australia
marrcchh@gmail.com

REFERENCES

Akerman, K. 2009. Interaction between humans and megafauna depicted in Australian rock art? *Antiquity* 83(322). www.antiquity.ac.uk/projgall/akerman322/

Anschuetz, K. F., R. H. Wilshusen and C. L. Scheick 2001. An archaeology of landscapes perspectives and directions. *Journal of Archaeological Research* 9(2): 157–211.

Balme, J. and S. O'Connor 2016. Dingoes and Aboriginal social organization in Holocene Australia. *Journal of Archaeological Science: Reports* 7: 775–781.

Balme, J., S. O'Connor and S. Fallon 2018. New dates on dingo bones from Madura Cave provide oldest firm evidence for arrival of the species in Australia. *Scientific Reports* 8(1): 9933.

Barker, B., L. Lamb, J.-J. Delannoy, B. David, R. Gunn, E.

Chalmin, G. Castets, K. Aplin, B. Sadier, I. Moffat, J. Mialanes, M. Katherine, J.-M. Geneste and S. Hoerlé 2017. Archaeology of JSARN–124 site 3, central-western Arnhem Land: determining the age of the so-called '*Genyornis*' painting. In B. David, P. S. C. Taçon, J.-J. Delannoy and J.-M. Geneste (eds), *The Archaeology of rock art in western Arnhem Land, Australia*, pp. 423–496. Terra Australis 47, ANU Press, Canberra.

Bednarik, R. G. 2013. Megafauna depictions in Australian rock Art. *Rock Art Research* 30(2): 197–215.

Bennett, D. 2003. Often crude and quaint: some Australian conceptions of nature, ecology, and rock-art. *Before Farming* 4(4): 1–11.

Berkes, F. 1993. Traditional ecological knowledge in perspective. In J. T. Inglis (ed.), *Traditional ecological knowledge concepts and cases*, pp. 1–9. International Program on Traditional Ecological Knowledge and International Development Research Centre, Ottawa.

Berkes, F. 1999. *Sacred ecology: traditional ecological knowledge and resource management*. Taylor & Francis, Philadelphia.

Berkes, F., J. Colding and C. Folke 2003. *Navigating social-ecological systems, building resilience for complexity and change*. Cambridge University Press, Cambridge.

Berkes, F. and C. Folke 1998. *Ecological systems: management practices and social mechanisms for building resilience*. Cambridge University Press, Cambridge.

Binford, L. R. 1982. The archaeology of place. *Journal of Anthropological Archaeology* 1: 5–31.

Bird, M. I., D. O'Grady and S. Ulm 2016. Humans, water, and the colonization of Australia. *Proceedings of the National Academy of Sciences* 113(41): 11477–11482.

Blewitt, R. 2016. Loss and discard of traditional ecological knowledge: archaeology of Catawba foodways. Unpubl. MA thesis, The University of North Carolina at Chapel Hill. Available from ProQuest Dissertations Publishing (No. 10120116).

Brady, L. M., R. G. Gunn, C. Smith and B. David 2017. Rock art and ethnography in Australia. In B. David and I. J. McNiven (eds), *The Oxford handbook of the archaeology and anthropology of rock art*. Oxford Handbooks Online, DOI: 10.1093/oxfordhb/9780190607357.013.55.

Brandl, E. J. 1972. Thylacine designs in Arnhem Land rock paintings. *Archaeology and Physical Anthropology in Oceania* 7(1): 24–30.

Chalmin, É., G. Castets, J.-J. Delannoy, B. David, B. Barker, L. Lamb, F. Soufi, S. Pairis, S. Cersoy, P. Martinetto, J.-M. Geneste, S. Hoerlé, T. Richards and R. Gunn 2017. Geochemical analysis of the painted panels at the 'Genyornis' rock art site, Arnhem Land, Australia. *Quaternary International* 430(A): 60–80.

Chaloupka, G. 1993. *Journey in time: the world's longest continuing art tradition*. Reed, Chatswood.

Ciani, M. D. 2014. The bear in the footprint: using ethnography to interpret archaeological evidence of bear hunting and bear veneration in the northern Rockies. Graduate Student Theses, Dissertations, & Professional Papers 4218. www.scholarworks.umt.edu/etd/4218.

David, B. 2004. Rock-art and the experienced landscape: the emergence of late Holocene symbolism in northeast Australia. In C. Chippindale and G. Nash (eds), *The figured landscapes of rock-art. Looking at pictures in place,* pp. 153–181. Cambridge University Press, Cambridge.

David, B. and H. Lourandos 1998. Rock art and socio-demography in northeastern Australian prehistory. *World Archaeology* 30(2): 193–219.

David, B. and J. Thomas (eds) 2008. *Handbook of landscape archaeology*. Left Coast Press, Walnut Creek, California.

David, B., P. S. C. Taçon, J.-J. Delannoy and J.-M. Geneste (eds) 2017. *The archaeology of rock art in western Arnhem Land, Australia*. Terra Australis 47. ANU Press, Canberra.

Davidson, I. 2017. Images of animals in rock art: not just 'good to think'. In B. David and I. J. McNiven (eds), *Oxford handbook of the archaeology and anthropology of rock art,* pp. 435–467. Oxford University Press, Oxford.

Davidson-Hunt, I. and F. Berkes 2000. *Environment and society through the lens of resilience: toward a human-in-ecosystem perspective*. International Association for the Study of Common Property Conference, Indiana University. Canada, Local Knowledge, Institutions and Resilience Panel. A panel associated with the 'Commons and Resilience Group of Panels'. Natural Resources Institute, University of Manitoba.

Diamond, J. 1993. Drowning dogs and the dawn of art. *Natural History* 3(93): 22–29.

Dolinar, L. 2019. Reconnecting indigenous knowledge to the sunlight basin: integrating traditional ecological knowledge and archaeology. Unpubl. MA thesis, University of Montana, Missoula.

Drouin, J. 1989. The bestiary of rupestrian and literary origin in the Sahara and the Sahel: an essay in the investigation of correlations. In H. Morphy (ed.), *Animals into art*, pp. 343–369. Unwin Hyman, London.

Edwards, A. and J. Skinners 2009. Research paradigms in qualitative sport management research. In A. Edwards and J. Skinners (eds), *Qualitative research in sport management,* pp. 15–43. Elsevier Ltd.

Ellen, R. (ed.) 2006. *Ethnobiology and the science of humankind*, Vol. 388. Oxford, Blackwell.

Faulstich, P. 2003. Dreaming the Country and burning the land: rock-art and ecological knowledge. *Before Farming* 3(3): 1–13.

Flood, J. 2004. Linkage between rock-art and landscape in Aboriginal Australia. In C. Chippindale and G. Nash (eds), *The figured landscapes of rock-art, looking at pictures in place,* pp. 182–200. Cambridge University Press, Cambridge.

Gray, D. E. 2009. *Doing research in the real world* (2nd ed.). SAGE Publications.

Gunderson, L. H. and C. S. Holling (eds) 2002. *Panarchy: understanding transformations in human and natural systems*. Island Press, Washington D. C.

Gunn, R. G. 1992. Mikinj: rock art, myth and place – sites of significance to Jacob Nayinggul. Unpubl. report to Australian Institute of Aboriginal and Torres Strait Islander Studies, Canberra.

Gunn, R., B. David, J.-J. Delannoy and M. Katherine 2017. The past 500 years of rock art at Nawarla Gabarnmang, central-western Arnhem Land. In B. David, P. S. C. Taçon, J.-J. Delannoy and J.-M. Geneste (eds), *The Archaeology of rock art in western Arnhem Land, Australia,* pp. 303–328. Terra Australis 47, ANU Press, Canberra.

Gunn, R. G., L. C. Douglas and R. L. Whear 2011. What bird is that? Identifying a probable painting of *Genyornis newtoni* in western Arnhem Land. *Australian Archaeology* 73: 1–12.

Houde, N. 2007. The six faces of traditional ecological knowledge: challenges and opportunities for Canadian co-management arrangements. *Ecology and Society* 12(2): 34.

Ingold, T. 1987. *The appropriation of nature: essays on human ecology and social relations*. University of Iowa Press, Iowa City.

IUCN. 1986. *Tradition, conservation and development*. Occasional Newsletter of the Commission on Ecology's Working Group on Traditional Ecological Knowledge 4. Gland, Switzerland.

Jackson, S. 2005. Indigenous values and water resource management: a case study from the Northern Territory. *Australasian Journal of Environmental Management* 12(3): 136–146.

Johannes, R. E. (ed.) 1989. *Traditional ecological knowledge: a collection of essays*. IUCN, Gland, Switzerland and Cambridge, UK.

Joy, F. 2016. Sámi shamanism past and present and the desecration of the sacred in Finland. In D. Bunikowski (ed.), *Philosophy of law in the Arctic,* pp. 53–60. The University of the Arctic, Rovaniemi.

Khan, S. N. 2014. Qualitative research method: grounded theory. *International Journal of Business and Management* 9(11): 224–233.

Kimmerer, R. W. 2013. *Braiding sweetgrass*. Milkweed Editions, Minneapolis.

Knights, T. and M. C. Langley 2021. Invisible or ignored: investigating the lack of thylacine-based material culture in the Australian archaeological record. *Archaeology in Oceania* 56(2): 100–110.

Koungoulos, L. and M. Fillios 2020a. Hunting dogs down under? On the Aboriginal use of tame dingoes in dietary game acquisition and its relevance to Australian prehistory. *Journal of Anthropological Archaeology* 58: 101146.

Koungoulos, L. and M. Fillios 2020b. Between ethnography and prehistory: the case of the Australian dingo. In B. Bethke and A. Burtt (eds), *Dogs: archaeology beyond domestication*. University of Florida Press, Gainesville.

Lenssen-Erz, T. 1997. Metaphors of intactness of environment in Namibian rock paintings. In P. Faulstich (ed.), *Rock art as visual ecology*, pp. 43–54. IRAC Proceedings I. American Rock Art Research Association, San Miguel.

Lévi-Strauss, C. 1978. *Myth and meaning*. Routledge and Kegan Paul, London.

Lewis, D. 1977. More striped designs in Arnhem Land rock paintings. *Archaeology and Physical Anthropology in Oceania* 12: 98–111.

Lewis, D. 2017. Megafauna identification for dummies: Arnhem Land and Kimberley 'megafauna' paintings. *Rock Art Research* 34(1): 82–99.

Lewis-Williams, J. D. and T. A. Dowson 1999. *Images of power. Understanding southern African rock art*. Struik, Cape Town.

Lourandos, H. 1983. Intensification: a late Pleistocene-Holocene archaeological sequence from south-western Victoria. *Archaeology in Oceania* 18: 81–94.

Lourandos, H. and A. Ross 1994. The great 'intensification debate': its history and place in Australian archaeology. *Australian Archaeology* 39(1): 54–63.

Maynard, L. 1979. The archaeology of Australian Aboriginal art. In S. M. Mead (ed.), *Exploring the visual art of Oceania,* pp. 83–110. University of Hawaii Press, Honolulu.

McCarthy, F. 1958. *Australian Aboriginal rock art*. Sydney, The Australian Museum, Sydney.

McDonald, J. 2005. Archaic faces to headdresses the changing role of rock art across the arid zone. In P. Veth, M. Smith and P. Hiscock (eds), *Desert peoples archaeological perspectives*, pp. 116–141. Blackwell, Oxford.

McDonald, J. 2017. Discontinuities in arid zone rock art: graphic indicators for changing social complexity across space and through time. *Journal of Anthropological Archaeology* 46: 53–67.

McDonald, J. 2020. Serpents Glen (*Karnatukul*): new histories for deep time attachment to Country in Australia's Western Desert. *Bulletin of the History of Archaeology* 30(1): 1–13.

McDonald, J. and P. Veth 2012. The social dynamics of aggregation and dispersal in the Western Desert. In J. McDonald and P. Veth (eds), *Companion to rock art*, pp. 90–102. Wiley-Blackwell, Oxford.

McDonald, J. and P. Veth 2013. Rock art in arid landscapes: Pilbara and Western Desert petroglyphs. *Australian Archaeology* 77: 1–16.

Molyneaux, B. 1989. Concepts of humans and animals in post-contact Micmac rock art. In H. Morphy (ed.), *Animals into art*, pp. 193–213. Unwin Hyman, London.

Morphy, H. 1991. *Ancestral connections: art and an Aboriginal system of knowledge*. The University of Chicago Press, Chicago.

Morwood, M. 1979. Art and stone: towards a prehistory of central western Queensland. Unpubl. PhD thesis, Australian National University, Canberra.

Morwood, M. J. 1987. The archaeology of social complexity in south-east Queensland. *Proceedings of the Prehistoric Society (London)* 53: 337–350.

Morwood, M. J. 2002. *Visions from the past: the archaeology of Australian Aboriginal art*. Allen and Unwin, Crows Nest.

Mulvaney, D. J. 1975. *The prehistory of Australia*. Penguin, Ringwood.

Murray, P. and G. Chaloupka 1984. The Dreamtime animals: extinct megafauna in Arnhem Land rock art. *Archaeology in Oceania 19*(3): 105–116.

Myers, F. 1986. *Pintupi Country, Pintupi self.* Smithsonian Institute Press and Australian Institute of Aboriginal Studies, Washington/Canberra.

Napaljarri, P. R. and L. Cataldi (transl.) 1994. *Warlpiri Dreamings and histories.* HarperCollins, San Francisco, CA.

Nicholas, G. and N. Markey 2015. Traditional knowledge, archaeological evidence, and other ways of knowing. In R. Chapman and A. Wylie (eds), *Material evidence: learning from archaeological practice*, pp. 287–307. Routledge, New York.

Ortega-Rincon, M. 2022. Rock art as a mechanism for safeguarding Traditional Ecological Knowledge. Unpubl. PhD thesis. Griffith University, Gold Coast.

Ouzman, S., P. S. C. Taçon, K. J. Mulvaney and R. Fullagar 2002. Extraordinary engraved bird track from north Australia: extinct fauna, Dreaming Being and/or aesthetic masterpiece? *Cambridge Archaeological Journal* 12(1): 103–112.

Prins, F. E. 1990. Southern-Bushman descendants in the Transkei rock art and rainmaking. *South Africa Journal of Ethnology* 13(3): 110–116.

Reo, N. J. and K. P. Whyte 2012. Hunting and morality as elements of Traditional Ecological Knowledge. *Human Ecology* 40: 15–27.

Ross, A. 2019. *Traditional Ecological Knowledge: indigenous science, archaeology and 'truth'*. U.S. National Park Service.

Satterthwait, L. 1987. Socioeconomic implications of Australian Aboriginal net hunting. *Royal Anthropological Institute of Great Britain and Ireland* 22(4): 613–636.

Schaafsma, P. 1989. Supper or symbol: roadrunner tracks in Southwest art and ritual. In H. Morphy (ed.), *Animals into art,* pp. 253–269. Unwin Hyman, London.

Smith, L. and N. Akagawa (eds) 2008. *Intangible heritage*. Routledge, London and New York.

Spencer, B. and F. J. Gillen 1899. *The native tribes of central*

Australia. MacMillan & Co, London.

Spencer, B. and F. J. Gillen 1904. *The northern tribes of central Australia.* Macmillan & Co, London.

Stanbury, P., J. Clegg and D. Campbell 1990. *A field guide to Aboriginal rock engravings: with special reference to those around Sydney* (2nd edn). Oxford University Press, Melbourne.

Sundstrom, L. 1989. Archaic hunting practices depicted in a Northwestern Plains rock art style. *Plains Anthropologist* 34(124): 149–169.

Taçon, P. S. C. 1989. From Rainbow Snakes to 'x-ray' fish: the nature of the recent rock painting tradition of western Arnhem Land, Australia. Unpubl. PhD thesis, The Australian National University, Canberra.

Taçon, P. S. C. 2011. Special places and images on rock: 50,000 years of Indigenous engagement with Australian landscape. In J. Anderson (ed.), *Australian art*, pp. 11–21. Cambridge University Press, Melbourne.

Taçon, P. S. C., R. Chapple, J. Merson, D. Ramp, W. Brennan, G. King and A. Tasire 2010. Aboriginal rock art depictions of fauna: what can they tell us about the natural history of the Greater Blue Mountains World Heritage Area? In D. Lunney, P. Hutchings and D. Hochuli (eds), *The natural history of Sydney,* pp. 58–73. Royal Zoological Society of NSW, Mosman.

Taçon, P. S. C. and S. Webb 2017. Art and megafauna in the Top End of the Northern Territory, Australia: illusion or reality? In B. David, P. S. C. Taçon, J.-J. Delannoy and J.-M. Geneste (eds), *The archaeology of rock art in western Arnhem Land, Australia,* pp. 145–164. Terra Australis 47, ANU Press, Canberra.

Taylor, L. 1989. Seeing the 'inside': Kunwinjku paintings and the symbol of the divided body. In H. Morphy (ed.), *Animals into art,* pp. 371–388. Unwin Hyman, London.

Taylor, L. 2016. Recent art history in rock Country, bark painters inspired by rock paintings. In L. Brady and P. S. C. Taçon (eds), *Relating to rock art in the contemporary world: navigating symbolism, meaning, and significance*, pp. 307–335. University Press of Colorado, Boulder.

Teeman, D. 2008. Cultural resource management and the protection of valued tribal spaces: a view from the western United States. In B. David and J. Thomas (eds), *Handbook of landscape archaeology*, pp. 626–637. Left Coast Press, Walnut Creek.

Veth, P., J. McDonald and S. De Koning 2018. Archaeology and rock art of the north-west arid zone with a focus on animals. *On the Ecology of Australia's Arid Zone* 283–305.

Watson, B. 2009. Universal visions: neuroscience and recurrent characteristics of world palaeoart. Unpubl. PhD thesis, The University of Melbourne, Melbourne.

Wesley, D. 2013. Firearms in rock art of Arnhem Land, Northern Territory. *Rock Art Research* 30(2): 235–247.

Wesley D., T. Jones and R. Whitau 2017. People and fish: Late Holocene rock art at Wulk Lagoon, Arnhem Land. In B. David, P. S. C. Taçon, J.-J. Delannoy and J.-M. Geneste (eds), *The archaeology of rock art in western Arnhem Land, Australia*, pp. 21–50. Terra Australis 47, ANU Press, Canberra.

Wolcott, H. F. 1980. *Ethnographic research in education.* American Educational Research Association, Washington.

Zedeño, M. N. 2000. On what people make of places: a behavioral cartography. In M. B. Schiffer (ed.), *Explorations in social theory*, pp. 97–111. University of Utah Press, Salt Lake City.

RAR 41-1446