Supporting Indigenous Rangers Manage the Impacts of Climate Change on Cultural Sites

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Abstract

A growing global awareness of climate change threats to cultural heritage sites (cultural sites) has seen the recent emergence of multiple management methodologies. However, none of these are amenable to use by local, non-specialist groups using participatory planning processes, such as Indigenous ranger groups. This research aimed to develop a Cultural Site Adaptation Guide (the Guide), a decision support tool to assist non-specialists undertaking participatory, climate change adaptation planning for cultural sites. A preliminary version of the Guide was created by synthesising elements from generic, bottom-up climate change adaptation planning tools on the one hand, and a risk analysis methodology that combined and built on archaeological approaches pioneered in the United Kingdom and France on the other. The first three steps of the five-step Guide are steps for Scoping, Risk analysis, and Options analysis. The research engaged two Indigenous ranger groups in Australia's Northern Territory with strong perceptions of climate change impacts on cultural sites and a strong view that managing these impacts is a priority need. The preliminary Guide was tested and further refined by the Indigenous rangers, using a Participatory Action Research methodology. The Scoping step allowed rangers to undertake: a detailed problem analysis that identified types and general locations of vulnerable cultural sites and the nature of impacts; planning goals and appropriate methodological approaches; and resource deficiencies and planning barriers. The Risk analysis step allowed rangers to allocate a management priority rating to 126 cultural sites. The Options step found rangers were able to identify, appraise and rank a diverse range of adaptation options, including ones aimed at direct cultural site intervention, building ranger adaptive capacity, and building cultural site resilience. The Option step also allowed rangers to generate their own preliminary cultural site adaptation plan. The research found that practical and rigorous approaches can be taken to climate change adaptation of cultural sites by non-specialists, even where resources are likely to be severely constrained.

Author statement

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Chapter 1

Introduction

Figure 1. Testing the Risk Field Survey at an Ubirr rock shelter.

During field work in 2016, Kakadu National Park Ranger and Traditional Owner Sean Nadji tests and further develops the Risk Field Survey.

Aims of the research

This thesis seeks to contribute new knowledge to the fields of:

(a) cultural heritage site (cultural site) climate change adaptation, and

(b) Indigenous climate change adaptive capacity.

It aims to do so by investigating methodologies for climate change adaptation planning and their application in Indigenous cultural site climate change adaptation. In so doing, it proposes a model planning methodology, a Cultural Site Adaptation Guide (Guide), for independent use by Indigenous ranger groups. The methodology is a synthesis and extension of a number of existing approaches to archaeological climate change risk *analysis*, which is then integrated with modified elements from generic adaptation planning guides that are designed for participatory adaptation decision making, or risk *management*. The methodology resulting from this process consists of five steps or analytical devices (tools): (1) Scoping, (2) Risk analysis, (3) Options analysis, (4) Implementation, and (5) Review. The first three of these steps are collaboratively tested and further developed with two ranger groups from Arnhem Land in Australia's Northern Territory.

By proposing and testing the planning methodology, the thesis aims to investigate Indigenous rangers' cultural site adaptive capacity. It does this, more specifically, by investigating:

1. Indigenous rangers' perceptions of climate change impacts on cultural sites;
2. Indigenous rangers' perceived need for a planning approach to managing climate change impacts on cultural sites;
3. Indigenous rangers' willingness and capacity to engage with an iterative, empirical process of refinement of a proposed planning methodology, via a

collaborative, Participatory Action Research approach, which involves rangers as co-researchers;

4. Indigenous rangers' capacity to reach a consensus on: (a) the climate change threats posed to cultural sites, (b) appropriate goals for a cultural site adaptation planning process, (c) the most appropriate and practical methodological approaches to cultural site risk analysis, (d) a list of barriers and (e) a list of resources available, or otherwise, to Indigenous ranger climate change adaptation, (f) adaptation leadership roles and (g) approaches to maintaining intellectual property rights during a facilitated research project;
5. Indigenous rangers' particular needs in terms of cultural site risk analysis;
6. Indigenous rangers' capacity to generate a management prioritisation of sites based on: (a) risk of loss or damage from climate change and other threats combined with (b) the relative significance of sites;
7. Indigenous rangers' capacity to identify and appraise adaptive actions for cultural heritage sites.

Background

Climate change impacts on cultural heritage sites

Over the last 30 years, there has been a growing awareness that a wide range of climate change impacts pose grave dangers to an equally diverse range of cultural sites, which include archaeological sites, historic monuments and cultural landscapes (e.g., Rowland 1992; Cassar et al. 2006; Harvey and Perry 2015). In particular, increased coastal erosion due to sea level rise threatens to destroy hundreds of thousands of the world's coastal cultural sites (Erlandson 2012). Even without climate change, coastal erosion is a major threat to cultural sites (Rick and Fitzpatrick 2012; Rowland and Ulm 2012; Jones et al. 2008). Rising sea levels, however, will

extend the reach of storm surge (IPCC 2013), resulting in greater beach, cliff and sand barrier retreat, and saltwater inundation of floodplains, which in turn will increase rates of destruction of cultural sites (Murphy, Thackray, and Wilson 2009; FitzGerald et al. 2008). Rowland, one of the first archaeologists to raise the issue, wrote:

> … there seems little doubt that the greenhouse effect will impact on climate and sea-levels … archaeologists and cultural resource managers therefore need to begin addressing the potential impacts of these changes on coastal archaeological sites. (Rowland 1992, p31)

Early studies considering the consequences of climate change for cultural sites were concerned primarily with enumerating possible impacts rather than proposing methods to address them. Such studies focussed on climate change impacts on particular types of archaeology, such as wetland sites (Chapman 2002); national heritage properties (Cassar and Pender 2005); built heritage and cultural landscapes (Sabbioni et al. 2006; Blankholm 2009); natural and cultural world-heritage listed properties (UNESCO 2006); and architectural surfaces and structures (Brimblecombe et al. 2011; Bonazza et al. 2008; McCabe et al. 2011). They also considered broad strategies (Cassar et al. 2006) and called for major programs to identify high-risk cultural sites in order to record them before their demise (Ashmore 2005; Pearson 2008).

Risk analysis, climate change and cultural sites

Only recently, however, have methodologies dedicated to addressing the issue of climate change impacts on cultural sites begun to emerge. These are risk-assessment methodologies, aimed at prioritising the most vulnerable cultural sites in order to better target limited conservation or salvage resources (Bickler, Clough, and Macready 2013; Reeder, Rick, and Erlandson 2012).

The most common approach prioritises sites on the basis of likelihood of impact alone (Table 1), either in regard to the site's proximity to the coast (Reeder-Myers 2015; Moore and Wilson 1998), or to hazard zones mapped on the basis of a climate change projection model (Dupont and Van Eetvelde 2013; Westley et al. 2011; Constantinidis 2009). These approaches are particularly useful for broad regional scale landscape assessment, but can equally be performed at a local scale (Johnson, Marrack, and Dolan 2015).

Other studies have taken a traditional hazard or biophysical risk approach, considering the *likelihood* of damage or loss of sites, *sensitivity* to *exposure* and/or the *magnitude of the consequence*. Bickler *et al* (2013), for example, used a remote GIS-based analysis of likelihood of impact complemented by a standardised formula for the consequence of impact for particular site types. Daire *et al* (2012) and Mazel *et al* (2014) used a field survey to collect data *in situ*. Daire *et al* (2012) measured a site's exposure and sensitivity to threats (see Table 2), requiring surveyors to choose from a range of given options corresponding to a set of fixed variables in order to generate a standardised vulnerability score for each site.

Dawson (2015) and English Heritage (2007) outlined methods using remote GIS analysis and data collected *in situ* to assess likelihood of damage, combining results with an assessment of the relative archaeological significance of a site.

A third stream, represented by a single study (Daly 2014), engages with vulnerability literature, proposing a framework for an *in situ*, qualitative vulnerability approach based on *exposure*, *sensitivity* and *adaptive capacity*. Of all the approaches cited here, Daly's is the only one that approaches a risk *management* or planning process, as opposed to a standalone risk *assessment* process.

Table 1. Review of methodologies for climate change risk analysis of cultural sites

	Reeder-Myers *et al.* (2015) Johnson *et al.* (2015) Westley (2011) Dupont *et al.* (2013)	Bickler *et al.* (2013)	Daly (2014)	Dawson (2015) English Heritage (2009)	Mazel *et al.* (2014)	Daire *et al.* (2012)
amenity to non-professional use					✓	✓
risk based on likelihood of impact	✓	✓	✓	✓	✓	
risk based on consequence of impact		✓				
risk based on significance				✓		
risk based on exposure & sensitivity			✓			✓
considers adaptive capacity			✓			
includes non-climate impacts					✓	✓

Table 2. Summary of vulnerability assessment method devised by Daire *et al* (2012 pp178-9)

Variables		Value options *Score for each Value option* *1*	*0.8*	*0.6*	*0.4*	*0.2*
A – IMPACTS						
A1	**infrastructures**	−10m	−50m	−200 m	−500 m	+500 m
A2	**activities**	−10m	−50m	−200 m	−500 m	+500 m
A3	**traffic/frequency of passage**	−10m	−50m	−200 m	−500 m	+500 m
A4	**distance to the cliff**	−10m	−50m	−200 m	−500 m	+500 m
A5	**biological erosion**	very strong	strong	moderately strong	weak	almost inactive
A6	**weathering**	very strong	strong	moderately strong	weak	almost inactive
	Score for Impacts = A1+A2+A3+A4+A5+A6					
B – RESISTANCE						
B1	**resistance of the remains**	very active	active	moderately strong	weak	almost inactive
B2	**resistance of the local substrate**	very active	active	moderately strong	weak	almost inactive
B3	**physical protection**	−10m	−50m	−200 m	−500 m	+500 m
B4	**legal protection**	−10m	−50m	−200 m	−500 m	+500 m
	Score for Resistance = B1+B2+B3+B4					
Vulnerability score = subtract score for B from score for A						

The following subsections consider these models in terms of critical issues germane to climate change adaptation planning conducted independently at a local scale by non-professionals. Details on the selection of these critical issues are discussed at length in chapter four of this thesis.

Amenity to use in a bottom-up planning process Risk analysis methods partly or entirely using remote mapping techniques and computer applications such as ArcGIS (e.g., Bickler, Clough, and Macready 2013; Reeder-Myers 2015; Dupont and Van Eetvelde 2013; Johnson, Marrack, and Dolan 2015; Westley et al. 2011; Dawson 2015; English Heritage 2007) do not readily avail themselves to use by non-professionals or local stakeholders. Their approach is top-down, that is they are for use by academics and heritage professionals with ultimate control over the planning process, as opposed to a bottom-up process in which non-professionals maintain control of the risk management planning process. Dawson (2015) does, however, attempt to tread what he calls a 'middle path'. After expert planning, risk analysis and prioritisation, a subsequent phase is added in which local community members are recruited to assist in implementation but also to augment data collection and update the values given to sites on the basis of any special meaning particular sites might hold for them. Stakeholder inclusion has been vital to considerable progress in managing climate-change impacts to date. Dawson's (2015) approach, however, does not constitute a stakeholder-led process or bottom-up planning process.

A standardised field-survey approach (Mazel et al. 2014; Daire et al. 2012) is, however, amenable to non-professional use and might conceivably by inserted into a broader, bottom-up planning process. Daire *et al* (2012) require surveyors *in situ* to choose from a range of given

options corresponding to a set of fixed variables in order to generate a standardised score for each site.

While Daly (2014) outlines a planning process, it is dependent on an expert assessor who incorporates interviews with managers and local stakeholders and background research into a qualitative, vulnerability assessment.

Mainstreaming Mainstreaming climate change risk analysis into broader risk analysis makes practical action significantly more likely (Huq and Reid 2004; Smit and Wandel 2006). The field-survey approach (Daire et al. 2012, Mazel et al. 2014) is unique in that it includes exposure and sensitivity to additional non-climate threats, avoiding a scenario in which a site rated as a low climate change priority is lost to another threat not considered.

Uncertainty and adaptation to current extremes Approaches partly or wholly reliant on climate change projections (Westley et al. 2011; Dupont and Van Eetvelde 2013; Daly 2014; Johnson et al. 2015,) are not ideal for local-level adaptation planning. At a local scale, detailed climate trend data and high-confidence, downscaled climate change projections are rarely available, and if so entail a substantial degree of uncertainty. Local stakeholders, however, are likely knowledgeable as to the extent and impacts of past and recent extreme weather events (Reid et al. 2009). Given future climate change will see an increase in the frequency of extremes, practical expediency may necessitate reducing exposure and sensitivity to *present extremes* as a first step towards adaptation to future climate change (Smit and Pilifosova 2003; Hofmeijer et al. 2013; IPCC 2014).

Monitoring Where data is scarce, one of the first options in managing climate change is developing appropriate monitoring systems (Rowland et al. 2014). While all the assessment systems not based on climate change projections avail themselves to a monitoring function, a field survey's *in situ* gathering of a fixed range of data and consideration of non-climate as well as climate exposure (Daire et al. 2012), recommends itself in this capacity also.

Significance The importance of integrating an assessment of a site's archaeological significance with an assessment of the risk of damage or loss is acknowledged by four studies (English Heritage 2007; Bickler et al. 2013; Daly 2014; Dawson 2015). When immovable sites confront an impact such as sea-level rise, their loss may be inevitable (Cassar et al. 2006). The loss is likely to take place over a very short time period rather than by a slow degradation over an extended time (Bickler et al. 2013) or in a non-linear, step process in response to discreet episodes of extreme conditions or changes (Giesen et al. 2013). The loss of one cultural site may be of far greater consequence than that of another. Only Dawson (2013) and English Heritage (2007) incorporate significance assessment into risk assessment. Dawson assesses each site in terms of 'rarity', 'period', 'condition', 'group value' and 'potential' (Dawson 2013 p. 80).

Non-academic assessment of significance is challenging. A field survey for non-professional application, for example, would have difficulties in replicating Dawson's (2013 p80) assessment criteria. There are also other issues to consider.

Absolute notions of scientific significance were abandoned in the post-war period in favour of determining which sites best represent a range of archaeological variation (Briuer and Mathers 1996). Assessing the significance of Australian Indigenous sites, Bowdler considered a site's

'representativeness' and ability to 'answer timely and specific research questions' (1981 p1). In one of the case studies considered by this thesis (see below) research has been prolific, but in the other no comprehensive survey for each site type has been undertaken to date. This is likely to be the case in many Indigenous contexts internationally.

Although the relativistic approach acknowledges that significance is mutable and dynamic, it still sees significance residing in the physical fabric of the place, rather than something given to a place by those who value it (Little, Mathers, and Darvill 2005). However, as Sutton *et al.* (2013 p3) eloquently state:

> Values cannot be objectively identified within places, landscapes or objects; they originate and dwell within the hearts and minds of people.

A solution might be to determine significance according to cultural values rather than scientific ones and then, where possible, invite archaeologists to review the results. This approach has merit in contemporary thinking on archaeological significance, which questions privileging archaeological significance over Indigenous values (Owen and Veale 2015; Byrne, Brayshaw, and Ireland 2003; Little, Mathers, and Darvill 2005).

Unfortunately, however, there is a dearth of literature discussing a rigorous methodology for assessing the cultural value of Australian Indigenous cultural sites (Brown 2008).

Adaptive Capacity Only Daly (2014) outlines a framework for cultural site climate change risk assessment that includes assessment of adaptive capacity. This vulnerability approach aims to address organisational barriers to adaptation and build resilience.

From the consideration of aspects of various risk and vulnerability analysis methodologies above it can be said that they are largely tailored for academic use or heritage professionals. They are, with the exception of Daire *et al* (2012) and Mazel *et al* (2014), not readily amenable to use by non-professionals. Furthermore, all tend, including Daire *et al* (2012) and Mazel *et al* (2014), to overlook important concepts developed by climate change adaptation studies, including the value of a bottom-up, participatory planning process in climate change adaptation.

Implications for Indigenous cultural sites

Rowland (1992, p31) noted that it should be a priority to:

> Discuss with Aboriginal Traditional owners the potential impacts of greenhouse changes on coastal sites.

This research pointedly does so, focusing on northern Australia. The northern rangelands of Australia are home to a rich and diverse cultural heritage (Keen 2004; Hiscock 2008). Cultural sites continue to be valued and maintained by traditional owners (Zander et al. 2013), but also by Indigenous rangers and ranger groups. Northern rangelands are experiencing a transition towards multifunctional occupancies, and Indigenous values are often contesting past production values (Holmes 2010). Ranger groups funded by the Australian government (Department of Environment 2013) bring new approaches to natural-resource management, including bottom-up participatory planning (Altman and Kerins 2012). Ranger groups and the Indigenous estate, however, face an array of significant climate-change impacts that are exacerbated by socio-political disadvantage (Altman and Jordan 2008).

One disadvantage in particular is that professional heritage services and coordination are largely unavailable on the Indigenous estate (Tacon and Marshall 2014). As stated above, new methodologies for managing climate change impacts on cultural sites are not only poorly disposed to non-specialist use, they come without an accompanying, explicit planning process, let alone a bottom-up, stakeholder-led planning process. This is regrettable given stakeholder-led planning is such a central tenet of the land management undertaken by Indigenous ranger groups (WalterTurnbull 2010).

Planning guides to support bottom-up, climate change adaptation planning

Real world climate change planning that overlooks academic adaptation concepts is not uncommon (Preston and Westaway 2010), and for this reason recent years have seen the development of a host of planning guides (procedural frameworks or decision support products) designed to support bottom-up climate change adaptation planning (Webb and Beh 2013). They aim to guide stakeholders through a systematic process that involves an iterative cycle of research and planning. Five such generic climate-change adaptation frameworks were given a favourable rating by Webb and Beh (2013) against a set of principles of 'good climate change adaptation':

1. The UNDP's 'Adaptation policy frameworks for climate change' (Burton, Malone, and Huq 2005) is the highest rated in terms of the principles.
2. The UKCIP's 'Adaptation Wizard' (UKCIP 2013) does well in terms of principles; and is also rated highly in terms of user features.
3. Care International's 'Climate change vulnerability and capacity analysis handbook' (Dazé, Ambrose, and Ehrhart 2009) is a good performer in terms of principles – sustained leadership and stakeholder engagement in particular.

4. The UNEP Provia's 'Guidance on assessing vulnerability, impacts and adaptation to climate change' (Hinkel et al. 2013) is a strong performer in terms of principles; it also rates highly in terms of functionality across the options phase.
5. The UKCIP's 'Climate adaptation: risk, uncertainty and decision-making' (Willows and Connell 2003) is a good performer in terms of principles; and it also rates highly in terms of functionality across phases.

The scope of the above guides is, however, generic rather than sector specific. As Preston and Stafford-Smith point out (2009), in many instances specialised, sector-specific guides become necessary.

Planning guides supporting cultural site adaptation

No specialised, multifaceted adaptation planning guide, or risk 'management' methodology, has been developed for local, non-professionals working independently in the cultural heritage sector. As we saw above, there are risk 'analysis' methodologies, but these 'tools' are specific to the limited task of assessing cultural site risk, and do not outline an overall planning process for non-professionals. A comprehensive risk 'management' planning guide, or methodology, is warranted in Australia considering cultural sites are increasingly managed by Indigenous ranger groups: indeed, it is estimated that almost 80 per cent of projects undertaken by Australian Indigenous ranger groups involve cultural sites (Department of Environment 2013). Aboriginal and Torres Strait Islander peoples are best placed to manage climate change impacts on cultural sites due to the fact that their domains are often remote and poorly resourced by heritage professionals (Tacon and Marshall 2014). Indeed, Aboriginal and Torres Strait Islander peoples' rights and interests in land are formally recognised for around 40 per cent of

Australia's land mass (DPMC 2018), so that Indigenous lands contain a significant proportion of Australia's potentially vulnerable cultural sites.

Indigenous ranger groups

In 2015, 108 Australian Indigenous ranger groups managed 70 Indigenous Protected Areas[1] (IPAs) covering some 63 million hectares of land (Pew Charitable Trusts 2015). A significant number of Indigenous rangers are also employed in Australia's national and state parks. Ranger work involves addressing a host of environmental issues, such as wildfire, weeds and feral animals, but also managing tourism operations, quarantine services and illegal commercial fishing (Djelk Rangers 2014). IPAs and national parks contain an extensive range of cultural sites (Department of Environment 2013) that are increasingly managed by Indigenous rangers in consultation with Traditional Owners[2]. Importantly, these sites are vital to ongoing traditional cultural practice. The participatory planning undertaken by ranger groups aligns well with climate change adaptation theory, which emphasises the importance of local communities taking a central role in adaptation planning (Dessai and Hulme 2004; Wilby and Dessai 2010; Raiser 2014).

Adaptive capacity

Adaptations to climate change, or system changes adopted to deal with challenging climate exposures and sensitivities, are the manifestations of adaptive capacity (Smit and Wandel 2006). Adaptive capacity is closely related to many other standard adaptation concepts, including adaptability, coping ability, management capacity, stability, robustness, flexibility

[1] Indigenous land owners nominate their estates as IPAs, which are subsequently recognised as part of the National Reserve System and attract government resourcing.
[2] The Aboriginal Land Rights Act (1976) describes 'traditional Aboriginal owners' as local descent groups with primary spiritual responsibility for sites and land.

and resilience (Kelly and Adger 2000; Jones 2001; Füssel and Klein 2005; Brooks, Adger, and Kelly 2005). The forces that enable a system to adapt are the drivers of adaptive capacity (Kasperson and Kasperson 2005; Walker 2005). At the community level, the ability to adapt is influenced by factors such as local knowledge and skills, managerial ability, availability of finances, technology and information, built infrastructure, the institutional and governance features of the environment within which adaptation occurs, political influence and kinship networks (Smit and Pilifosova 2003; Folke et al. 2010). Determinants of degree of adaptive capacity are most often local, for example a robust kinship system that can dissipate stress. They can, however, be the product of general political and socio-economic systems, for example the availability of government funding for Indigenous ranger programs.

Adaptive capacity has been variously analysed, including via coping ranges and thresholds, and has also been defined by a system's ability to deal with, accommodate, adapt to, and recover (Jones 2001). The determinants of adaptive capacity are not independent of each other. For example, strong kinship networks may increase adaptive capacity by garnering more economic resources or increasing managerial ability. Individual determinants are therefore interconnected: adaptive capacity results from the interaction of determinants and these vary in time and space (Smit and Wandel 2006). Furthermore, a system's adaptive capacity is not static. Coping ranges are flexible and influenced by political, social, economic and institutional changes over time. For example resource depletion may reduce a community's coping ability and narrow its coping range. On the other hand, improvements in institutional management, organisational practices or use of technology may lead to an increase in adaptive capacity (Smit and Pilifosova 2003; Folke et al. 2010).

Indigenous adaptive capacity and bottom-up planning

A limited number of studies have investigated the impacts of climate change on Indigenous communities in Australia and elsewhere and the adaptive capacity of those communities. Indigenous communities experience great social and economic disadvantage and various studies document heightened vulnerability because of poor service delivery and political participation (Green 2009; Altman and Jordan 2008; Ford, Smit, and Wandel 2006). In this context, some writers have concluded that while Indigenous Australians are worried about ecological change, it is a peripheral concern for a dispossessed people struggling with poverty and social dislocation (Petheram et al. 2010). Notwithstanding this, Australian and international studies are increasingly engaging local Indigenous stakeholders in discussions around climate change, impacts and adaptation needs (e.g., Bird et al. 2013; Leonard et al. 2013; Ermine and Pittman 2011) and have successfully elicited participation in the writing of formal adaptation plans (Memmott et al. 2013; Nursey-Bray et al. 2013).

The writing of such plans stands to benefit from a bottom-up planning process, that is one in which those for whom the plan is written are primarily its authors. While a bottom-up approach is fundamental to achieving outcomes in a general Indigenous planning context (Walsh and Mitchell 2002), this is no less the case when Indigenous participants are planning climate change adaptation (Pearce et al. 2009; Bird et al. 2013; Leonard et al. 2013; Memmott et al. 2013; Nursey-Bray et al. 2013; Green, Niall, and Morrison 2012). A bottom-up planning process is able to focus on enhancing the capacity of individuals or community groups to cope with or adapt to climate stress on their livelihoods and well-being (Dessai and Hulme 2004; Wilby and Dessai 2010; Raiser 2014), that is increase their adaptive capacity. Bottom-up planning and its sensitivity to the community context is also able to account for social and economic disadvantage (Brooks, Adger, and Kelly 2005; Adger et al. 2004) an important

consideration in the context of Australian Indigenous communities (Green 2009; Altman and Jordan 2008).

Climate change adaptation planning also stands to benefit from combining Western science and local, traditional Indigenous knowledge (Nakashima et al. 2012; IPCC 2014; Nursey-Bray et al. 2013). Indigenous knowledge and in particular land management practices are highly complex and rest on a vast body of knowledge (Rose 1996). Realising adaptation benefits from this knowledge, however, requires strategies that address vulnerability and increase adaptive capacity (Gaillard 2010; Berkes and Jolly 2001). Strategies should recognise local barriers, including resource deficiencies, to climate change adaptation (McNamara et al. 2012). Those barriers that stem from governance issues are an important determinant of the success of climate change adaptation (Smit and Wandel 2006) and this is particularly so in an Indigenous context (Langton et al. 2012). Proactive leadership and the degree of meaningful engagement within the participatory planning process are also important considerations (Burton, Malone, and Huq 2005), as is control over and ownership of outcomes of the planning process (Leonard et al. 2013).

McIntyre-Tamwoy et al. (2012) found that many of the concerns Indigenous people had about climate change were related to cultural values, places and landscapes, and concluded that there remains an urgent need for processes and systems to be developed to promote knowledge sharing and action in this regard.

In considering climate change impacts on Indigenous cultural sites, this thesis focuses on the capacities and potential role of Indigenous ranger groups. Ranger groups not only have responsibilities for cultural sites but they also represent a positive step towards addressing some

of the issues underlying Indigenous disadvantage. The many benefits of ranger programs to Indigenous people are well documented and the further expansion of ranger group programs are promoted by Indigenous communities and peak bodies. Rangers earn wages in remote locations where unemployment is high, become community role models, engage in work that is meaningful to them, and are highly motivated because the work underpins cultural maintenance (DPMC 2015; Bird et al. 2013). Ranger groups address Indigenous poverty and increase health and wellbeing (WalterTurnbull 2010). At the same time their management of natural resources and biodiversity conservation in large, underpopulated regions that are relatively environmentally intact provides a significant 'public good' (Altman 2007).

Indigenous cultural sites

Indigenous cultural sites are variously classified in the fields of archaeology, cultural heritage management, law and anthropology as: (a) sacred, (b) archaeological or (c) historic.

The Aboriginal Land Rights Act (1976) and the Northern Territory Aboriginal Sacred Sites Act (1989) define a sacred site as a place 'of significance according to Aboriginal tradition':

> … a site that is sacred to Aboriginals [sic] or is otherwise of significance according to Aboriginal tradition, and includes any land that, under a law of the Northern Territory, is declared to be sacred to Aboriginals or of significance according to Aboriginal tradition (Aboriginal Land Rights (Northern Territory) Act 1976, Part 1, Sect 3).

This definition necessarily relates sacred sites to Indigenous cosmology, to concepts and doctrines about the origins and properties of the world and its inhabitants, which is known collectively as the Dreaming. Animist Indigenous cosmology generally conceives of creators giving the world its shape (rather than bringing it into being from nothing). Creators are

ancestors or senior kin. Ancestors possess multiple identities and can transform from persons into the substance of, and features of, the landscape, animals, ghosts and back into living people. Western thought's contrast between the 'material' and 'spiritual' is not found in Indigenous cosmologies (Keen 2004).

People's rights to land are based on links to ancestral beings that created the landscape. These mythological beings travelled the land and along the way left something of themselves in topographic and biophysical features. Such sites provide a tangible link to a totemic geography (Smith 2013).

> All things in our country have Law, they have ceremony and song, and they have people who are related to them (M Harvey, a Yanyuwa man from the Gulf of Carpentaria, cited in: Rose 1996 p27).

This cosmology, so concerned with landscape and place, has been and continues to be fundamental to Indigenous traditional economic rights, obligations, prerogatives, prohibitions, ownership and control of access to land, water and resources, and is essential to the enhancing of resource availability (Keen 2004).

Sacred sites might therefore include: a tree or a stand of trees; a rock or a mountain range or a plain; an important place where medicine, tools, food or water are abundant; a law place or a story-telling place or a place for men's or women's business; an ochre pit; a burial place; an ancestral home, Dreaming place, Dreaming track, or because a creation place might become physically and psychologically damaging, a 'dangerous' place (Guse 2009; Australian Heritage Commission 2002; AAPA 2012; Smith and Burke 2007).

Indigenous *archaeological* sites may also be sacred sites, but not necessarily. Types include: stone artefact concentrations, rock shelter occupation sites, rock art sites, human burial sites, shell middens, stone arrangements, earth mounds, and stone tool quarries (Smith and Burke 2007; Brockwell et al. 1995; Guse 2009).

Indigenous *historic* cultural sites are similar to non-Indigenous historic sites. Examples include: mission stations where Indigenous people were born; an orphanage where they were raised; a museum or cultural centre built or initiated by Indigenous people; or sites relating to economic or historical events involving Indigenous people, such as pastoral stations or buffalo hunting camps (Guse 2009; Australian Heritage Commission 2002).

Regional setting

Location of study areas

The two study areas, Kakadu National Park and the Djelk IPA, are located in Arnhem Land, in the north-eastern corner of the Northern Territory, Australia (Figure 1). Kakadu National Park is in Western Arnhem Land, and its main settlement, Jabiru, is 253 km south-east of Darwin by road; the Djelk IPA is in north central Arnhem Land, and its main settlement, Maningrida, is 509 km north-east of Darwin by road.

Climate

Arnhem Land has a tropical climate influenced by coastal factors and characterised by hot, wet, humid summers (the ‘wet’; October to March) and mild, drier winters (the ‘dry’; April to September). The temperature has little seasonal variation; however, it can range from overnight lows of 15°C in the dry season to daily highs of 33°C in the wet season. North-west monsoons

deliver most of the 800 mm to 1 600 mm of the area's annual median rainfall, which comes from occasional tropical cyclonic activity, tropical depressions or scattered thunderstorms.

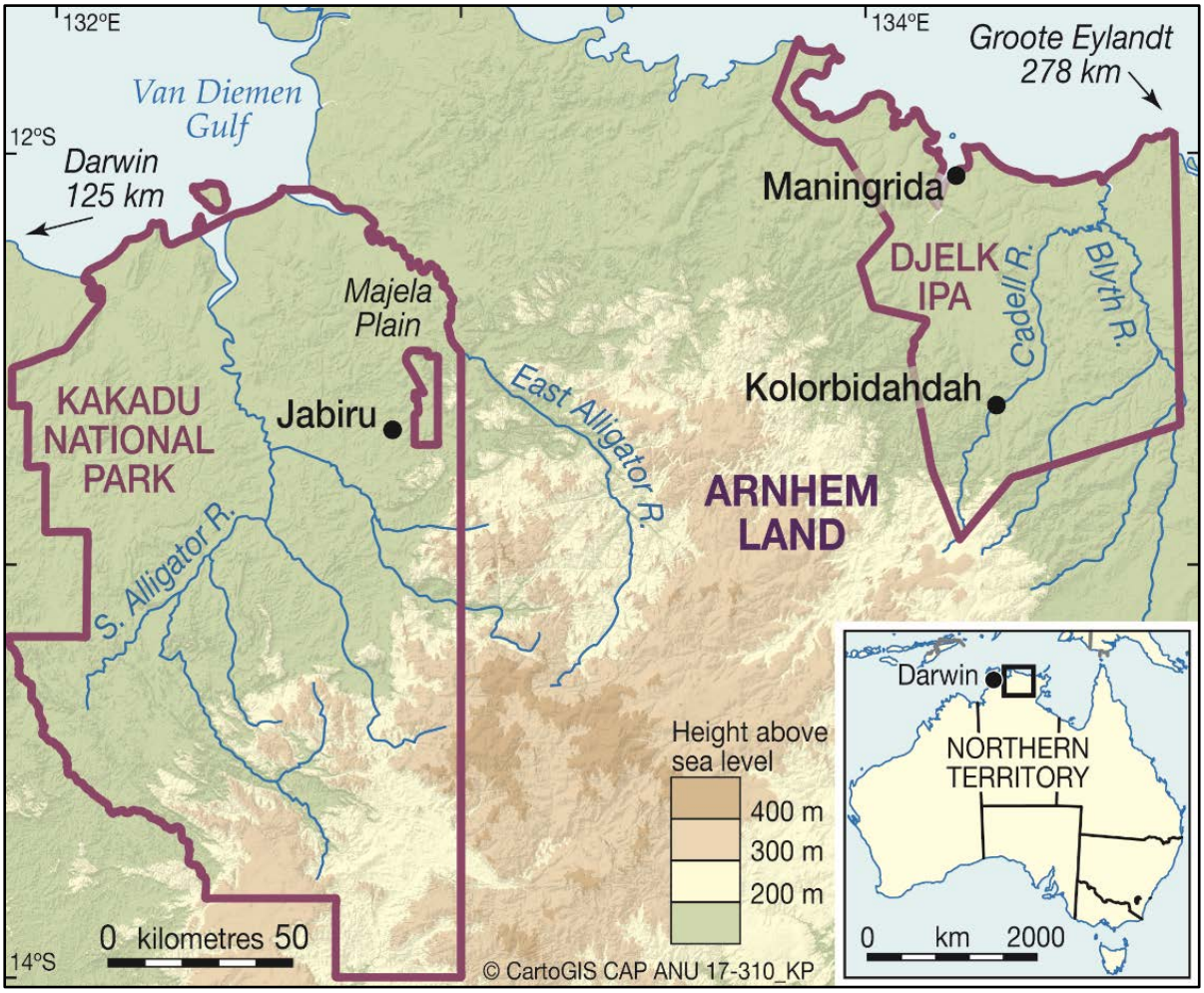

Figure 2. Location and setting of case study sites: Kakadu National Park and Djelk Indigenous Protected Area (courtesy of CartoGIS, College of Asia Pacific, Australian National University)

Geomorphology

The landforms and habitats of Arnhem Land include the sandstone plateau and escarpment, extensive areas of remnant savannah woodlands and open forest, rivers, billabongs, floodplains, mudflats, mangrove forests, and monsoonal rainforest (Russell-Smith, Needham, and Brock 1995).

The current morphology of the coastal plains of Arnhem Land is geologically new, having evolved during the mid to late Holocene in response to sea level rise. Woodroffe et al. (Woodroffe, Thom, and Chappell 1985) demonstrated that mangrove swamps developed around 7 000 years ago and, after flourishing for about 2 000 years (in response to sea-level change and sedimentation), were succeeded by the development of floodplains with tidal river channels and subsequently freshwater wetlands from about 2 000 years ago. Many of the cultural sites discussed in this study are located on the fringes of these coastal floodplains.

Anthropology

Since the area's cultural diversity and wealth of rock art sites were brought to the world's attention by Leichardt (1847), there have been extensive studies conducted among the peoples of western and north central Arnhem Land by anthropologists and ethnographers. Spencer (1914) described social organisation and initiation ceremonies; Basedow (1925) gave a broad description of Aboriginal life; Mountford (1956) described Arnhem Land rock art and art production; and Berndt (1970) defined sacredness and the importance of sites. Much of this early anthropology exhibits a fascination with supposedly untainted traditional Aboriginal life – hunter-gatherers are represented without reference to Indigenous people engaged in less-traditional economies (Widlock 2005). Towards the end of the 20th century, however, anthropology increasingly sought to collaborate with a culture adapting to European colonisation. Chaloupka and Indigenous researchers (Chaloupka et al. 1985) reported on cultural resources, land ownership and site characteristics. Altman (1987) researched economic life in north central Arnhem Land in terms of its relationship with the non-Indigenous economy. Other research engaged with the people of Arnhem Land's traditional ecological knowledge (Scott 2004) and their management of fire (Russell-Smith et al. 1997) in order to incorporate

'two-way' research into conservation management. This study is in keeping with this collaborative approach, conducting Participatory Action Research (Stringer 2014) in which Indigenous participants are active co-researchers.

Archaeology

Arnhem Land's archaeological record provides a window into Indigenous societies from the Pleistocene until the present. Occupation has been dated from up to 65 000 years (Clarkson et al. 2017). Agnew et al. (2015) suggested that while Kakadu National Park contains around 5 000 recorded cultural sites, there may be some 10 to 20 000 in total. There are many thousands of rock art sites in Arnhem Land and recording them is a work in progress. Rock art reveals insights into Indigenous hunting, gathering, societal structure and rituals from at least 28 000 years until the present (Chaloupka 1993; Flood 1997; Lewis 1988; David et al. 2013; Tacon and Brockwell 1995). One of the oldest stone axes in the world, some 35 000 years old, came from Arnhem Land (Geneste et al. 2010).

Indigenous prehistory is a story of adaptation. The coastal plains were of great importance to past Aboriginal economy (Brockwell et al. 1995; Brockwell et al. 2009; Brockwell et al. 2011; Hiscock 1999, 2006). Brockwell et al. (2009; 2011) synthesised a range of archaeological research (documenting shell mounds, shell middens, earth mounds, artefact scatters, rock shelters, and Macassan, European and Chinese contact sites) against paleo-environmental frameworks, concluding that there is a strong accord between the timing of Aboriginal occupation patterns and climatic phases. Hiscock (2008) argued that climate change in the Holocene stimulated economic 'rearrangements' by Indigenous people.

Threats to cultural sites

A number of studies have considered threats other than climate change to cultural sites in Kakadu National Park. Meehan et al.'s (1985) research into Kakadu wetland sites described the effects of saltwater and buffalo (*Bubalus bubalis*) intrusion, and associated loss of biodiversity and erosion. Hughes and Watchman's (1983) research into conservation issues facing Kakadu rock art in the 1980s described issues of water damage, cryptogenic growth, insects, vegetation and vertebrate damage. Gillespie (1983) described early conservation measures employed in Kakadu, such as the use of drip lines, and the removal of wasps and vegetation. There have been no formal studies of threats to cultural sites within the Djelk IPA.

Kakadu National Park

Kakadu National Park covers an area of 19 804 square kilometres within the Alligator Rivers Region of the Northern Territory. Declared in 1979, the Park is inscribed on the UNESCO World Heritage List for both its exceptional natural and cultural values. The Park's database is extensive, reflecting intense surveying over the last 45 years (Kamminga and Allen 1973; Jones 1985; Hiscock et al. 1992; Chaloupka 1993; Schrire 1982; Lewis 1988).

Indigenous owners lease the Park to the Australian Government. The Park is subject to the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth), which provides for joint management by the Director of Parks and Traditional Owners through a Board of Management that has a majority of Indigenous members. The Board has determined that the Chairperson be Indigenous. Joint management at Kakadu has not been without its detractors (Haynes 2009; Palmer 2007; Lawrence 1997). For example, Lawrence (1997) described barriers to Indigenous management participation in terms of: management models that emphasise acceptable maintenance of physical values rather than Indigenous social and

spiritual values; ultimate power residing not with the board but with the Director (the Australian Government); a focus on consultation rather than negotiation; a lack of devolution to Indigenous owners due to both Director outlook and a lack of literacy skills and management experience among Traditional Owners; the domination of formalised, non-Aboriginal administrative procedures; and a lack of pre-meeting consultations:

> Many issues still have to be resolved, not the least the important questions of equitable power-sharing with Aboriginal Traditional Owners, the strengthening of the effectiveness of the Board of Management and the creation of a meaningful and fulfilling role for Aboriginal rangers within the Park's management service (Lawrence 1997, pii-iii).

The current Board of Management Plan seems conscious of these past charges, and it is at pains to underline collaboration:

> An important objective of joint management is to ensure that Bininj/Mungguy [Indigenous custodians] traditional knowledge and skills associated with looking after culture and country, and cultural rules regarding how decisions are made, continue to be respected and maintained (Kakadu Board of Management 2016, p28).

Importantly, collaborative sacred-site maintenance and conservation is a priority:

> The active participation of Bininj/Mungguy [Indigenous custodians] in management of cultural values is integral to the effective protection of them (Kakadu Board of Management 2016, p41).

In 2014, the number of Indigenous people working within the Park amounted to almost half (48 per cent) of all staff employed on ongoing or non-ongoing contracts. Additionally, half of all staff on casual employment contracts identified as Indigenous. The Working on Country funded Kakadu Indigenous Ranger Programme provided 11 hosted community ranger positions in the Park and has engaged over 30 Indigenous community rangers since 2008–09

(Kakadu Board of Management 2016, p35). Indigenous rangers are involved in weed and feral control, crocodile management, fire management, cultural site maintenance and tourist liaison.

Djelk Indigenous Protected Area

'Djelk' is a Gurrgoni word for 'land' and caring for it. The Djelk Rangers began operating in 1991 under the auspices of the Bawinanga Aboriginal Corporation (BAC), which manages some 670 000 hectares of land and sea country, from the central Arnhem Land plateau to the Arafura Sea and includes the Mann, Liverpool and Cadell River districts. Bawinanga Aboriginal Corporation began as an outstation resource agency and, though it has grown to become a large regional development organisation, it continues to service some 32 outstations (BAC 2014). The BAC is directed by an Indigenous Executive Committee, elected annually by members at the Corporation's Annual General Meeting. Policies developed by the Executive Committee are implemented through a management team in conjunction with senior staff in each program area (CAEPR 2009).

Djelk Rangers carry out prescribed burning, feral animal control, weed management, cultural site protection and biodiversity monitoring, and support local Outstation[3] residents (Djelk Rangers 2014). They also monitor illegal fishing and undertake commercial crocodile egg and turtle harvesting. Rangers have carried out some site recording and monitoring in association with Maningrida Arts and Crafts, a cooperative art centre formally established in 1973 (Perkins 2004).

[3] Small settlements on traditional lands. A 'homelands movement', begun in the 1970s, saw small Aboriginal groups – often families or other closely related people – leave larger, mission-run communities and move back to traditional lands.

In 2009 the Djelk Indigenous Protected Area (IPA) was declared. The IPA program commenced in 1997 as a component of the National Reserve System, supporting Indigenous landowners to declare their own IPA reserve on their land and enter into voluntary conservation agreements with the Australian Government that both protect the natural and cultural values of their country and contribute to national conservation objectives (Ross et al. 2009). In return, landowners receive ongoing financial support under the Australian Government's Working on Country Indigenous program (Walker 2010). The Working on Country program aims to support Indigenous aspirations in caring for country, provide opportunities for Indigenous people to deliver environmental services that protect and manage Australia's environmental and heritage values, and provide nationally accredited training and career pathways (DPMC 2017).

There is much affirmative literature on the development of the IPA model, and on the the Djelk IPA (Ross et al. 2009; Smyth and Ward 2007; Smyth 2011; CAEPR 2009):

> Working on Country is highly effective in providing opportunities for Indigenous Australians to manage their country and culture … With the security of funding and full-time employment provided by Working on Country, rangers are now in a position to develop and implement long term strategies and projects for biodiversity and cultural heritage management (Smyth 2011, p2-3).

The Djelk Rangers have published testimonies highlighting the value of the Djelk IPA and its ranger group (Rostron et al. 2012). There is also a literature exploring IPA issues and limitations, particularly in terms of Indigenous planning processes (Walker 2010). While themes broached are similar to those raised above in regard to the management of Kakadu National Park, a major difference between Kakadu National Park and the Djelk IPA is that, in

the latter, ultimate control rests with the Aboriginal controlled Bawinanga Aboriginal Corporation's Board of Management and not the Australian Government.

Thesis – conceptual development

Embarking on the thesis topic, it became apparent that a number of important practical issues had to be addressed. Most of these issues are addressed through heuristic principles central to climate change adaptation studies. These include:

Impacts of climate 'extremes' used as a proxy for those of climate 'change'

Approaches to climate change risk analysis for cultural sites that are partly or wholly reliant on climate change projections (Westley et al. 2011; Dupont and Van Eetvelde 2013; Daly 2014; Johnson, Marrack, and Dolan 2015) are not ideal for local-level adaptation planning. At a local scale, detailed climate trend data and high-confidence, downscaled climate change projections are rarely available, and if so entail a substantial degree of uncertainty. Local stakeholders, however, are likely to be knowledgeable as to the extent and impacts of past and recent extreme weather events (Reid et al. 2009). Given future climate change will see an increase in the frequency of extreme weather events, practical expediency may necessitate planning that responds to present extremes as a first step towards adaptation to future climate change (Smit and Pilifosova 2003; Hofmeijer et al. 2013; IPCC 2014). The research presented here initially attempted to model impacts on the basis of climate change projections, but faced with data limits sought instead to document local perceptions of impacts from current extremes.

Mainstreaming

Producing a Guide that focusses on climate change impacts alone would reduce its value and probably result in poor uptake. Incorporating climate change risk analysis into broader risk analysis (mainstreaming), rather than having it as a standalone process, makes practical action significantly more likely (Huq and Reid 2004; Smit and Wandel 2006). However, for cultural sites no appropriate broader risk analysis existed. The Risk Field Survey presented in this research therefore pointedly considers both non-climate and climate threats.

Valuing Indigenous knowledge in adaptation

Indigenous peoples have traditional understandings and knowledge of the natural environment and are able to provide vital ecological insights into climate change adaptation planning (IPCC 2014; Rose 1996; Nakashima et al. 2012; Nursey-Bray et al. 2013; Bardsley and Sweeney 2008). A Participatory Action Research method (Stringer 2014) used to develop the Guide allowed Indigenous environmental knowledge and observation to be combined with learnings from western science.

Risk and vulnerability

Humans have been dealing with risks, uncertainty and consequences in a sophisticated and quantitative way for millennia. Grier (1981), for example, discusses Babylonians in 3200BC undertaking systematic ranking, evidenced on clay tablets, of alternatives for risky decisions. In the 17th century the roots of modern quantitative risk analysis emerged with Pascal's probability theory. In the 19th and 20th centuries, the explicit management of risks to human health was advanced through scientific techniques that established causal links between different hazards (such as poor plumbing), and adverse health effects (such as cholera) (Covello

1985). In the post WWII period, risk management was enthusiastically embraced by the corporate and disaster-management sectors to manage financial, legal, bureaucratic and bio-physical threats, producing an extensive literature on risk management.

Risk analysis plays a central role in climate change adaptation theory and practice. The International Organization for Standardisation (ISO) defines 'risk' as the consequence of an organisation pursuing objectives within an uncertain environment. Uncertainty from uncontrollable internal and external factors may cause the failure of organisational objectives (ISO 2009). Traditional risk approaches to climate change adaptation combine measures of (a) the *likelihood* of a consequence with (b) the *magnitude* of the consequence (Willows and Connell 2003).

After Hansen et al (1981) first provided evidence for a causal link between anthropogenic carbon emissions and climate change, climate change risk analysis followed (e.g., Shlyakhter, Valverde, and Wilson 1995; Rind, Rosenzweig, and Rosenzweig 1988; UNFCCC 1992); then risk management in terms of developing adaptation options for different climate change contexts (e.g., Jones 2001; Willows and Connell 2003; Burton, Malone, and Huq 2005; Kelly and Adger 2000; Smit et al. 2000); and then systematic evaluation of climate adaptation options (e.g., Schipper, Lisa, and Burton 2009; IPCC 2014).

The traditional risk approach, however, has been criticised for failing to consider the system as a social entity with the capacity to adapt to climate change (Smit and Pilifosova 2003). The socio-economic context of climate change risk management is critical. The successful implementation of practical adaptation outcomes will depend on inclusive stakeholder engagement in the risk assessment process and in generating and selecting adaptation options.

The consideration of barriers to this process, both from within and outside an organisation, and ways to breach them, is fundamental to the process (Jones and Preston 2011; Raihan et al. 2010).

Climate change adaptation is thus bound up with the concept of vulnerability, and the vulnerability of a system is a function not just of its exposure to hazardous climate impacts, but also its resilience or sensitivity to them – its capacity to cope (Smit and Wandel 2006; Adger 2006; Kelly and Adger 2000; Smit and Pilifosova 2003).

In response, a vulnerability approach to risk assessment conceptualises vulnerability (V) in terms of degrees of exposure (E) to climate hazards, sensitivity to them (S) and the system's adaptive capacity (AC) that is its potential for making adjustments that reduce its vulnerability over time (IPCC 2001, 2014). Daly (2014, p271) expresses this concept in the formula:

$$V = (E + S) - AC$$

This research, however, confronted the issue of cultural sites being, in most cases, inanimate and without agency (exceptions might be a sacred tree able to regenerate after a severe storm surge). The capacity of rangers to adapt cultural sites is considered, but separately (during scoping and options analysis) to the assessment of each individual site's degree of risk exposure and risk sensitivity.

The current research also attempts to incorporate significance assessment into assessment of threats to sites. Risk depends on both probability of impact and consequence of impact. In a bottom-up or participatory adaptation context, stakeholders for whom the system under analysis holds subjective values, need to consider the magnitude of the consequence of an

impact as well as its likelihood. The loss or damage of one asset may be of less consequence to them as that of another: the greater the consequence, the greater the risk (Willows and Connell 2003; Jones and Preston 2011 p300). The importance of assessing relative archaeological or scientific significance when considering overall risk is acknowledged by four studies (English Heritage 2007; Bickler, Clough, and Macready 2013; Daly 2014; Dawson 2015). The concept of archaeological or scientific significance, however, poses a major challenge to local non-professional stakeholders and their capacity to assess it for each cultural site. The approach taken here was therefore to adopt an alternative, value-based assessment of significance, i.e., one in which local stakeholders considered each cultural site's relative cultural value in terms of group-identity value, historical value and cosmological value (Australia ICOMOS 2013).

Methodology

The research involved five general methodological research strategies: document analysis, Participatory Action Research (PAR), case studies, ethnography, and the making of an ethnographic documentary video.

Document analysis

Comparative document analysis methods were used to determine the structure of a five-step preliminary Guide and then to select the elements constituting its first three steps (Scoping, Risk analysis and Options analysis). The fourth and fifth steps (Implement and Review) were not designed and tested in this study due to time constraints. Examples of comparative document analysis within a climate change adaptation context can be found in Bird et al. (2013), Preston et al. (2011) and in Webb and Beh (2013).

Construction of the overall five-step framework of the Guide took place in Chapter 2 (the term 'heritage adaptation tool', used in Chapter 2, was changed to 'Cultural Site Adaptation Guide' in later chapters in order to avoid confusion with elements within the Guide that were also termed 'tools'). The document analysis of Webb and Beh (2013) was of particular value in the five-step framework construction. Their study gave a relative rating to a great number of generic adaptation planning guides from around the world, on the basis of a set of 'good climate change adaptation principles' (Webb and Beh 2013 p3). The selection of five generic planning guides, to form the foundations of the Guide, was based on their having been given an exceptionally high rating by Webb and Beh (2013). The majority of the five guides selected had used the same five-step process, and so these same five steps were adopted for the Guide.

Comparative document analysis was then used to construct the preliminary version of the Scoping step (also see Chapter 2) of the Guide: common themes discerned across the same five well-rated generic guides were adopted to form a preliminary Scoping step. A further comparative document analysis was made of Indigenous climate change adaptation literature, and planning considerations unique to those studies were added to the preliminary Scoping step.

The document analysis used for constructing the Options analysis step (see Chapter 5) undertook a similar process and used the same five well-rated generic planning guides. A document analysis was also used to select seven option-assessment criteria.

The comparative document analysis used for constructing the Risk analysis step (see Chapter 4) considered the very limited number of studies of climate change risk analysis for archaeological sites. The document analysis involved creating a typology of methodologies

used by these studies and assessing them on the basis of the unique needs of Indigenous rangers utilising participatory planning processes.

Participatory Action Research

Testing the first three steps in the Guide was undertaken using a Participatory Action Research (PAR) methodology (Stringer 2014). A PAR strategy involves a researcher collaborating with a client to diagnose a problem and develop a solution based on the diagnosis (Bryman 2008). Mercer et al. (2008, p4) define it as a 'systematic inquiry, with the collaboration of those affected by the issue being studied, for purposes of education and taking action or effecting change'.

O'Leary (2005, p139-40) sums up some basic tenets of action research that both define it and outline its procedures:

1. It addresses practical problems and real-life situations, attempting to seek and implement solutions within that context.
2. It generates knowledge to produce change and enacts change to produce knowledge. It rejects a two-stage process of knowledge first and change second, suggesting their integration.
3. It enacts change; change is one of its goals. It aims towards 'situation' improvement.
4. It is participatory. There is an attempt to minimise the distinction between the researcher and the researched. Action research works *with* the researched, not *on* them or *for* them. The nature of participation and collaboration can be varied. It is determined by: the action research approach adopted; the particular context

of the situation being studied; and stakeholder goals. The role of the research is one of facilitation.

5. It is a cyclical process that takes shape as knowledge emerges.

Whether PAR is accepted as scientific depends on ones definition of science. PAR is rigorously empirical insofar as it requires participants to methodically define and document the phenomena being observed. Levin and Greenwood state that that PAR is broadly in keeping with the scientific approach because:

> The nucleus of scientific inquiry is deliberative, democratic, sense-making among professional researchers and local stakeholders (Levin and Greenwood 2011 p. 105).

However, prescribed scientific experimental methods are not followed. Such methods attempt to derive knowledge that is objective, reliable and valid in order to create laws about the physical world that allow the prediction of future events. The technological advances of the modernity are a testament to the power of knowledge and the application of the scientific method. The success of the method in the physical world, however, has not been replicated in the world of social, human behaviour. A science of humanity, social life or individual behaviour has failed to emerge within anthropology, sociology or psychology: humans are hard to predict (Stringer 2014).

In the past ‘experts’ were called on to provide knowledge able to better people’s lives. Researchers are now acknowledging the limits of this perspective. The reductionist, partial or incomplete nature of science can contribute to understanding *elements* of the human world but not provide a comprehensive explanation of events. The recipes and routines that compose professional research practice are imbued with concepts, constructs, values and perceptions

derived from particular social histories and cultural experiences that dominate academic and professional arenas (Winter and Munn-Giddings 2001). As a result programs and services often do not satisfy the needs of stakeholders, especially those stakeholders who are marginalised and disadvantaged. Indeed, they can often aggravate existing policy failures.

Behavioural theorists address capabilities and characteristics of individuals, pointing to motivation, achievement need, intelligence and cognition to explain behaviour. Social theorists, in contrast, stress large scale forces such as class, gender, race and ethnicity. Though useful in many contexts, these approaches are limited in their ability to address the day-to-day problems of individuals working in goal-oriented organisations (Darlington and Scott 2002).

Recent thinking on social theory, known collectively as postmodernism, provides a distinct approach to understanding the social world. Postmodernism questions the notion of social reality and the processes we use to know it. Postmodernism pulls apart mechanisms of knowledge production. Foucault (1972) argues that large-scale analysis must be built from understandings of micro-politics of power at the local level; many of the negative features of society are related to how individuals organise and practice their everyday lives. He suggests research that builds on the open qualities of human discourse, and inquiry that intervenes in the way knowledge is constituted at the sites of local power dynamics. Foucault suggests we 'develop action, thought and desires by proliferation, juxtaposition, and disjunction' (1984 p. xiii). He suggests people cultivate planning practices at the local level, resisting oppressive techniques, and taking on greater agency and control. The theme is reflected in the work of Fish (1980), who describes the human world as made up of 'interpretive communities' composed of 'producers' and 'consumers' of knowledge that control what they consider to be valid knowledge. In defining the ways in which organisations operate and provide services,

such ‘producers' control the boundaries in which ‘interpretive communities’ operate. Fish’s views are echoed in the work of Derrida (1976), whose notion of interlacing discourse provides insights into the continuing tensions between people in power and their subordinates. Both author and reader of knowledge participate in producing ‘meaning’. Writers accept an authority to present reality, but readers deconstruct these meanings and reconstitute them according to their experiences and outlooks. He argues for the need to find new ways of producing texts to minimise the power of people in positions of authority. Such issues are also addressed by Huyssens (1986), who criticises writers whose theories purport to speak on behalf of others. Like West (1989), he advances the notion that there should be a move away from scholarship focussing on foundations and a quest for certainty, to more utilitarian means of producing knowledge. West (1989) advocates ways of cooperating in knowledge production that create opportunities for people to participate in activities affecting their lives and making decisions. Rational deliberation is not irrelevant, it needs to be applied directly to people’s problems, as defined by those people.

In PAR there is a place for techniques usually associated with traditional science, quantitative research can provide very useful data. The meaning and significance of this data, however, can only be determined by those living in its context. Numbers can never dictate what actions should be taken. PAR ultimately, therefore, focusses on events that are meaningful to stakeholders. For this reason, the first hypothesis of this thesis was that Indigenous rangers perceived climate change impacts on cultural sites, and that managing those impacts was a priority for them.

Hill et al. (2011) consider participatory methods to be fundamental to planning on Indigenous Protected Areas (IPAs), while at the same time suggesting participatory methods should be

tailored to Indigenous traditions and customs. This thesis adopts methods described by Walsh and Mitchell (2002 p41-69), including:

- conducting discussions on country;
- working in small groups to share the ideas and experiences of individuals;
- working in bigger groups, to which smaller groups report their findings;
- semi-structured, informal interviews with key participants;
- asking and looking at what has been done before;
- showing people the activities of other people elsewhere;
- prioritising ambitions and tasks;
- making ground maps of knowledge and priorities; and
- linking activities to seasons.

O'Leary (2005) also cites PAR's limitations: the ultimate direction of the research is not in the 'researcher's' hands; it can be difficult to control the pace of the project; facilitating collaboration can be made difficult by individual personalities; and the researcher carries a burden in terms of logistical operations.

Notwithstanding limitations, stakeholder participation is of central importance to the research of this thesis. Rangers affirmed a need to manage climate change impacts on sites but deferred to the facilitator, the author of this thesis, to suggest a model or methodological approach. While 'road-testing' the approach suggested, the preliminary Cultural Site Adaptation Guide, rangers themselves were researching climate change impacts on local cultural sites and devising responses appropriate to their unique circumstances. In testing the first iteration of the Guide, rangers were simultaneously co-researching the development of the Guide with the lead author. The use of PAR increases the likelihood that the adaptation plans devised will be adopted and implemented due to rangers' engagement in their development and resulting 'ownership' of them.

Model for validation of the planning guide

The value of the guide's individual steps and components was assessed using a technique first outlined by Weiss (1995) and later incorporated into a goal-orientated action research method called 'Theory of Change' (Taplin, Collins, and Colby 2013). Using this technique, underlying assumptions or 'theories' inherent in the tool are stated from the outset, along with their expression in academic studies. The theories are linked to proposed corresponding outcomes, or outcome indicators, in an assessment model. As an example, the assessment model, outlined in Chapter 2, used to assess the Scoping step of the guide is presented in Table 3. As rangers progressed through the tool's steps, achievement of outcomes allowed the validation, negation or modification of initial assumptions, and of the guide itself. Where the propositions in the validation model were largely or partly confirmed, subsequent phases could then be tested by the assessment model.

Case studies

The use of case studies allowed for a deeper understanding of social structures and processes, and individual experiences within those structures and processes; a case-study methodology examines particular cases bound in time and place (Denscombe 2007). In particular, case studies can contribute to the analysis of important, contextual 'barriers' to climate change adaptation. Multiple case studies lend themselves to 'triangulation', or the comparison of independently generated results.

Table 3. Validation model

Theories	Source	Outcomes
1. **Problem analysis** Indigenous rangers *are* observing climate change impacts on cultural heritage sites.	Several sources propose that climate change will be or is an issue for Indigenous heritage sites; i.e., Rowland (1992); McIntyre-Tamwoy et al. (2015).	Rangers are able to nominate examples of sites impacted by climate change and justify this nomination.
o These may include: sea level rise and storm surge impacting coastal sites; extreme flooding inundating riparian sites.	Based on CSIRO (2015) climate change projections for the north-west monsoonal tropics.	Rangers cite examples of sites impacted by sea level rise and riparian sites impacted by extreme flooding.
o Cultural heritage site types impacted are: rock art sites; coastal middens; Dreaming sites; and burial sites.	These site types are prevalent in Australia's north-west monsoonal region. See Hiscock (2008) and Keen (2004).	Rangers cite examples of rock art sites, coastal middens, impacted by climate change impacts.
2. **Aims/goals/objectives** The goals set reflect rangers' feelings of responsibility for protecting 'country' and cultural heritage sites.	Indigenous relationships to country and sites is discussed by Keen (2004). The success of Indigenous ranger groups' natural resource management is documented by WalterTurnbull (2010)	Rangers affirm planning for climate change as a priority need. A subsequent list of goals for the conservation of sites is articulated by rangers.
3. **Methodology** Indigenous rangers *are* interested in undertaking a climate change risk analysis and prioritisation process for cultural heritage sites.	This proposition is a function of literature proposing and trialling such a technique; i.e., Dawson (2015).	Rangers provide a reasoned nomination of a particular method.
4. **Stocktaking of resources** Rangers *do* have sufficient resources to undertake adaptation planning for cultural heritage sites.	The importance of stocktaking in adaptation planning is underscored by Webb and Beh (2013).	Enumeration by rangers of resources available and unavailable.
5. **Barriers** There *are* barriers to ranger adaptation planning for cultural heritage sites.	The importance of considering barriers in adaptation planning is underscored by Webb and Beh (2013).	Enumeration by rangers of perceived barriers. Nomination of ways to overcome these barriers by rangers.
6. **Leadership and roles** Within ranger groups, individual rangers *are* prepared to lead an adaptation project.	The importance of considering leadership and roles in adaptation planning is underscored by Webb and Beh (2013).	Rangers establish a climate change adaptation leadership team.
7. **Ownership** Control over outcomes is an issue for rangers.	The importance of establishing ownership over research programs is proposed by Leonard et al. (2013).	Rangers wish to establish research protocols.

In order to use PAR, it first had to be established that Indigenous rangers had a need for the Guide: that they perceived climate change impacts on cultural sites and that managing these impacts was a priority for them. Establishing this, or otherwise, was also one of Chapter 2's research aims.

In initially selecting the two case study groups, five ranger groups were approached: two from central Australia and three from northern Australia. Rangers were approached either by non-Indigenous support staff or via a paid Indigenous consultant. Informal, face-to-face unstructured interviews centred on perceptions of climate change, impacts on cultural sites and whether planning for impacts was a priority need. In central Australia, rangers had limited perceptions of climate change, no perceptions of direct impacts on cultural sites, and did not rate climate change adaptation planning as a priority need. Central Australia's semi-arid deserts experience very extreme natural temperature and rainfall variation. Differentiating anthropogenic climate change from natural variation is possible by way of long-term climate trend data (Race et al. 2014), but is difficult to perceive by those managing natural resources over the short to medium term.

Of the three northern Australian groups approached, one was newly established and members were unfamiliar with the concept of climate change. In contrast, the other two northern Australian groups were familiar with the concept of climate change, had strong perceptions of climate change impacts on cultural sites and considered managing these impacts a priority. They were long established and highly experienced groups, responsible for maintaining rock art, midden and burial sites close to tidal and riverine flood zones.

Ethnography

Ethnographic methodologies aim to understand the reality of a cultural group through first-hand experience of social situations. Multiple techniques seek to provide a holistic reality (Bryman 2008). Techniques employed by this study included: (a) workshops with rangers and focus group discussions with broader community members, (b) semi-structured interviews with key participants; (b) participant observations at cultural sites and participant responses to the preliminary Guide's steps.

Semi-structured interviews allowed a natural flow of inquiry. Focus group discussions with Indigenous workers and managers allowed practitioners to more readily 'negotiate' answers among themselves. Cross-cultural research protocols guided all aspects of the research.

Data collection involved audio recordings, video recordings, field diaries and photographs. There was no predetermined sample size for workshops and interviews: the sampling process evolved incrementally. People taking part in workshops or interviewed were those identified as having a prominent role within ranger groups and as people able to contribute useful insights (typically referred to as a snow-balling sampling technique). There were gender-specific groupings for workshops and interviews where appropriate in order to respect cultural protocols. The semi-structured interviews, participant observations and focus group discussions were based around the questions posed within the component steps of the preliminary Guide. Workshop and interview transcripts were made. NVivo 10 was used to interrogate the transcripts. NVivo is a qualitative data analysis computer software package produced by QSR International. It is designed for qualitative researchers working with very rich text-based information, where deep levels of analysis on small or large volumes of data are required. NVivo aids organisation and analysis of non-numerical or unstructured data. The

software allows users to classify, sort and arrange information; examine relationships in the data; and combine analysis with linking, shaping, searching and modelling. Nvivo allows the coding of text to identify and compare themes and sub-themes. The themes and subthemes used in the coding were determined by the talking points outlined in the Scoping and Options analysis steps of the Guide. For example, the value of cultural sites to Indigenous rangers and Traditional Owners, or the adaptation actions identified participants. Nvivo allowed all references to such themes to be consolidated into one file for ready analysis.

The research was guided by cross-cultural research protocols, as set out in the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) publication Guidelines for Ethical Research in Australian Indigenous Studies (AIATSIS 2012). All people involved in the research were given an information sheet on the research and were requested to sign a consent form before their involvement. Participation in the research was voluntary and potential participants were made aware of the fact that they could pull out of the research at any time, without consequence.

The research was approved by Australian National University and Charles Darwin University Human Ethics Research Committees. Participants were consulted throughout the research on developments and outcomes, and those whose research role was most significant were cited as co-authors on all relevant publications.

Ethnographic documentary video

Production of an ethnographic documentary addressed the question of how effectively to frame and convey to an audience the significance of climate change threats to cultural sites. It was initiated through the PAR process by rangers. Rangers wanted to use the medium to generate

support for adaptive programmes and further research resources. In so doing the documentary sought to feature analysis of the issue by the custodians of cultural sites, and allow them to elucidate the site types currently and potentially impacted, plus the nature of those impacts, within the context of scientific research they themselves were undertaking to address the issue.

Thesis structure

This thesis is the culmination of a series of papers (three published and two submitted for publication) and a video documentary. The papers are presented in chapters 2 to 6 (Table 4).

Chapter 2 conducts a review of generic adaptation guides and proposes (a) the five step Guide and (b) the structure of the Guide's first step, Scoping. It also presents results from preliminary case study investigations.

Chapter 3 critically examines each component of the Scoping step through workshops with the ranger groups, resulting in the co-designed Scoping step of the Guide.

Chapter 4 conducts a review of cultural site risk assessment methodologies and proposes a Risk Field Survey that incorporates an assessment of cultural site significance. It then presents the results of tests of the Risk Field Survey conducted by rangers, including their modifications to it and its resulting prioritisation of around 120 cultural sites (rock art sites and middens).

Chapter 5 conducts a review of options analysis assessment methodologies and proposes the method for the Options analysis step. It then presents the results of tests of the Options analysis step and the resulting options prioritised.

Table 4. Thesis outline

Chapter Nº and name	Case studies conducted	Dates of field-work	Aim of chapter	Link with other chapters	Methods and activities	Journal article publication status	Authors and their respective roles in the research	Other outputs generated
1. Introduction								
2. Supporting Indigenous rangers' management of climate-change impacts on heritage sites: developing an effective planning tool and assessing its value.	• Djelk Rangers, Maningrida; • Kakadu National Park (NP) Rangers, Jabiru; • Djurrubu Rangers, Jabiru	April and July 2014	construction of the broad outline (and Scoping step) of a procedural methodology for climate adaptation of cultural sites by Indigenous rangers (Guide)	the method and its Scoping step proposed here are tested in subsequent chapters	• literature review; • Participatory Action Research; • semi and unstructured interviews;	published 2015: *The Rangeland Journal* 37:597-607.	**Bethune Carmichael** conceptualised and designed the methodology (Cultural Site Adaptation Guide), wrote the paper, collected and conducted all analysis of data.	• National Climate Change Adaptation Research Facility conference presentation 2014.
3. Testing the scoping phase of a bottom-up planning guide designed to support Australian Indigenous rangers manage the impacts of climate change on cultural heritage sites.	• Djelk Rangers, Maningrida; • Kakadu NP Rangers, Jabiru;	May and June 2015	testing the Scoping step of the overall Guide.	The Scoping step of the methodology proposed is tested here.	• Participatory Action Research • structured workshops • semi and unstructured interviews • participant observation	published 2017: *Local Environment* 22:1197-216.	**Bethune Carmichael** conceptualised and designed the Scoping step of the Guide; wrote the paper, collected and conducted all analysis of data; and facilitated all Scoping step workshops. **Greg Wilson**, **Ivan Namarnyilk, Sean Nadji** and **Jacqueline Cahill** participated in the testing of the Scoping step of the Guide; provided cultural site guidance and knowledge; and contributed to the conceptual refinement of the Scoping step of the Guide. **Deanne Bird** contributed to the conceptual refinement of the Scoping step of the Guide.	• Australian Rangelands Society conference presentation 2015; • Charles Darwin University, conference presentation 2015.
4. Local and Indigenous management of climate change	• Djelk Rangers, Maningrida;	April and June 2016	construction of Risk analysis step of the overall Guide;	The Risk analysis step of the methodology	• Participatory Action Research • structured workshops	published 2017: *Mitigation and Adaptation Strategies for Global Change*	**Bethune Carmichael** conceptualised and designed the Risk Field Survey; wrote the paper, collected and conducted all analysis of data; facilitated all workshops and testing of the Risk Field	• European Archaeological Association, conference

risks to archaeological sites.	• Kakadu NP Rangers, Jabiru;		testing of Risk analysis step	proposed is tested here.	• semi and unstructured interviews • participant observation	https://link.springer.com/article/10.1007/s11027-016-9734-8 (1 February 2017):1-25.	Survey. **Greg Wilson, Ivan Namarnyilk, Sean Nadji** and **Fred Hunter** contributed to the testing and further development of the Risk Field Survey; provided cultural site guidance and knowledge; and contributed to the conceptual refinement of the Risk Field Survey. **Sally Brockwell, Bobb Webb** and **Deanne Bird** contributed to the conceptual refinement of the Risk Field Survey.	presentation 2015. • Australian Archaeological Association conference presentation 2016.
5. High Tide for Heritage. Identifying and appraising options for the adaptation of cultural sites to the impacts of climate change.	• Djelk Rangers, Maningrida; • Kakadu NP Rangers, Jabiru;	April and Novem-ber 2016	construction of Options analysis step of the overall Guide; testing of Options analysis step	The Options analysis step of the methodology proposed is tested here.	• Participatory Action Research • structured workshops • semi and unstructured interviews • participant observation	submitted for publication 2017: *Terra Australis,* ANU Press	**Bethune Carmichael** wrote the paper, collected and conducted all analysis of data; facilitated all Option step workshops; and conceptualised the Options step of the Guide. **Greg Wilson, Ivan Namarnyilk, Sean Nadji and Jacqueline Cahill** participated in the testing of the Options step of the Guide; provided cultural site guidance and knowledge; and contributed to the conceptual refinement of the Options step of the Guide. **Sally Brockwell** provided archaeological guidance and knowledge, and practical refinement. **Bob Webb** and **Deanne Bird** provided conceptual refinement of the Options step of the Guide.	• College of Asia Pacific, ANU oral defence of PhD 2017 • Bureau of Meteorology conference presentation 2017 • Blue Shield Australia conference presentation 2018.
6. Communicating Indigenous cultural site vulnerability to climate change – *Places in Peril Archaeology in the Anthropocene* a video documentary case study.	• Djelk Rangers, Maningrida; • Kakadu NP Rangers, Jabiru; • Various cultural sites in the UK	2014-2016	Communicate the threat of climate change to cultural sites to an international audience	The prioritised option of making a communication tool, discussed in the previous chapter, is presented and analysed here.	• Digital video capture; • semi and unstructured interviews	documentary video 2017, available at link https://vimeo.com/203773921; article submitted for publication 2017: *Environmental Communication*	**Bethune Carmichael** directed, filmed and edited the documentary, wrote the paper and conducted all analysis of data.	• National Climate Change Adaptation Research Facility conference presentation 2018.
7. Conclusion								

Chapter 6 presents and discusses the 23-minute ethnographic documentary *Places in Peril: Archaeology in the Anthropocene*. The documentary constitutes prioritisation of an option: namely to communicate widely the issue of climate change impacts on cultural sites (which was discussed in chapter 5).

Appendix 1 gathers together in one place the first three steps of the Cultural Site Adaptation Guide.

Appendix 2 presents an example of cultural site mapping produced by the Risk Field Survey. Part of an index table containing Risk Field Survey data generated for use in ArcGIS is displayed. In the example map, site symbols indicate the management priority for Djelk coastal middens, as determined by the risk assessment undertaken by rangers. For reasons of privacy, the index table and map have had locational elements obscured.

Appendix 3 presents the preliminary adaptation plan devised by Djelk Rangers as a result of using the Option analysis step of the Guide.

Appendix 4 presents Chapter 17 (Carmichael et al. 2017) of *Public Archaeology and Climate Change*. This peer-reviewed book section, for which the author of this thesis was the lead author, summarises all the articles presented as chapters in this thesis. It does not present new findings, but is included as an appendix because it discusses some issues not addressed here, such as the source of Indigenous understandings of climate change science.

The contents and formatting of each paper presented in this thesis have not been modified from the published or submitted versions. Each paper is therefore formatted according to journal

requirements and includes its own reference list. For consistency, reference lists are also provided at the end of this Introduction, the unpublished journal articles and the Conclusion.

My journey

Development of the ideas behind this research began during my tenure as a senior environmental policy officer working for the Northern Territory Government (NTG) Environment Division. I was initially engaged to work on climate change issues, on the strength of a Master's degree in Environmental Science gained from Monash University in the 1990s. I was ultimately tasked with establishing and coordinating the work of an inter-agency working group compiling an NTG Climate Change Adaptation Action Plan, and from 2009–13 I represented the Northern Territory at inter-state forums held by the National Climate Change Adaptation Research Facility (NCCARF), based at Griffith University, Queensland. I also attended and presented at two adaptation conferences: *Adaptation 2014* and *Adaptation 2016*, and at the Northern Australia Indigenous Land and Sea Management Alliance (NAILSMA) *Climate Change Adaptation Workshop – April 2010.* NAILSMA represents the interests of Indigenous land managers across northern Australia.

In compiling the NT's Adaptation Plan I was intrigued by the input of the NTG Heritage Unit, which was keen to raise the issue of the vulnerability of coastal archaeological sites to sea level rise, chiefly Macassan sites but also Indigenous ones. I was struck by the fact that while Indigenous climate change adaptation was a topical subject, adaptation of Indigenous cultural sites was nowhere mentioned, not even in reports dedicated to Indigenous community climate change adaptation (e.g., Langton et al. 2012).

My interest in Indigenous cultural site adaptation was especially piqued because of my previous work for an Indigenous owned and controlled publishing house (Institute for Aboriginal Development Press) in Alice Springs and subsequently at Yuendumu, a remote Indigenous community in the Tanami Desert. Here I spent five years working with Indigenous authors and illustrators producing scholastic texts in the Warlpiri language to support bilingual education and cultural maintenance. The job description's small print required ethnographic research. In the process of coordinating the recording and communication of Indigenous cultural traditions, I was also involved in the conservation of a local monument, an enigmatic and forgotten, derelict museum building on the edge of the community, the history of which I researched and documented with Warlpiri senior men (Carmichael and Kohen 2013). Archived documents testified to the original financing and construction of the museum, including the quarrying of local stone, by newly settled Indigenous men in work gangs during the late 1960s. The men had been highly anxious to preserve and make known their culture and traditions in a period of great social upheaval and transition.

This was Indigenous adaptation to modern Western settlement; extensive animist wall frescos served as a proxy for the now inaccessible, due to distant resettlement, rock art paintings on distant ancestral lands. I worked with senior Traditional Owners to publicise the fate of this important building and to raise money for its eventual conservation.

In 2012 an election in the Northern Territory brought to power a new government that rejected the science on climate change. My work on the NT Climate Change Adaptation Action Plan was terminated, the by now almost complete plan was mothballed and I was transferred to the NT Environment Protection Agency, to undertake waste regulation and compliance.

Though waste management, and in particular writing an Environmental Impact Assessment to head off Coca Cola's legal challenge to the NT's 'cash for containers' scheme, was fascinating, I was motivated to further pursue climate change adaptation research in a way that somehow combined it with Indigenous cultural conservation.

I subsequently encountered an article 'The impact of climate change on the archaeology of New Zealand's coastline – a case study from the Whangarei District', by Simon Bickler et al. (2013), which sought to develop a method for managing climate change impacts on chiefly Maori archaeology. I was struck by the absence of Maori stakeholders in its development and by an absence from the methodology of measures to make it accessible or responsive to the needs of Indigenous cultural custodians.

In 2013, my thoughts and experiences culminated in my beginning this PhD. I contacted Dr Sally Brockwell, then engaged in an ARC Linkage Project – *From Prehistory to History: Landscape and Cultural Change on the South Alligator River, Kakadu National Park*. I was invited by her to consult Indigenous rangers as to the implications of climate change for archaeological sites on the South Alligator River floodplains. I simultaneously contacted Dr Deanne Bird, whose recent research for the National Climate Change Adaptation Facility, 'Future Change in Ancient Worlds: Indigenous Adaptation in Northern Australia' (Bird et al. 2013) had included work with the Maningrida community. Through Deanne I was able to liaise with senior Djelk Ranger Victor Rostron, for whom climate change impacts on cultural sites were a priority management issue.

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Chapter 2

Supporting Indigenous rangers' management of climate-change impacts on heritage sites: developing an effective planning tool and assessing its value.

Figure 1A. Early adaptation to environmental change.

During exploratory field work in 2014, Kakadu National Park Traditional Owner Jimmy Marimowa inspects 'the causeway', the abandoned remains of an earthen barrier constructed by his father and others in the 1970s in an attempt to defend a Canon Hill freshwater lagoon against saltwater intrusion.

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Supporting Indigenous rangers' management of climate-change impacts on heritage sites: developing an effective planning tool and assessing its value

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Abstract. Australian rangelands are rich in Indigenous cultural heritage sites and Indigenous rangers increasingly manage them. It is well documented that climate-change adaptation planning on a local scale benefits from a stakeholder-led or bottom-up process. However, to date, few bottom-up, practical adaptation pathways exist for Indigenous Australians. This paper describes the development of a planning tool that supports Indigenous rangers planning for climate-change impacts on cultural heritage sites. To date, a limited number of methodologies for managing climate-change impacts on heritage sites have been developed internationally. Importantly these are not geared to a bottom-up planning process. By contrast, many generic adaptation decision-support tools exist that support bottom-up planning. These tools commonly begin with a scoping phase. The scoping phase of a tool that supports Indigenous rangers manage climate-change impacts on heritage sites is described. A validation model, consisting of central assumptions behind each element of the scoping phase, is then set out. Future testing in the field would involve assessment of the tool through confirmation or otherwise of these assumptions. The first two assumptions in the validation model are then addressed: that Indigenous rangers perceive climate-change impacts on heritage sites and that planning for them is a priority need. Previous literature has not addressed these questions in detail. Only if positive responses are gained for these foundational assumptions can future testing of the tool be justified. Results from preliminary fieldwork undertaken in northern Australia found Indigenous rangers in two out of three case studies perceive impacts on heritage sites, and regard addressing these impacts as a priority.

Additional keywords: climate-change adaptation, cultural geography, environmental management, heritage studies, Indigenous knowledge.

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'There's more erosion from water, creek side, by bigger floods. Big floods are ruining paintings and making erosion … some of these are really old paintings. Even when paintings are high up, water going right up and ruining the painting.' (Djelk ranger, Manningrida 2014)

Introduction

Adaptation to climate change at a local scale benefits from stakeholder-led or bottom-up planning (Wilby and Dessai 2010). A participatory process is particularly important in an Indigenous planning context (Walsh and Mitchell 2002) and this is no less the case when Indigenous planning aims at adaptation to climate change (Green *et al.* 2012; McIntyre-Tamwoy *et al.* 2013; Bird *et al.* 2013; Leonard *et al.* 2013; Memmott *et al.* 2013; Nursey-Bray *et al.* 2013). Furthermore, adaptation planning stands to benefit from combining western science and traditional Indigenous knowledge (IPCC 2014). Despite these widely accepted propositions, there remains, however, a need for practical and accessible adaptation planning pathways for Indigenous Australians (Langton *et al.* 2012).

My research aims to construct and test an innovative planning tool to help Indigenous rangers independently adapt Indigenous cultural heritage sites, or management of them, to climate-change impacts. By 'planning tool' I mean a procedural framework or decision-support product; and by 'cultural heritage sites' I mean archaeological sites and sites of significance according to Aboriginal tradition, as recognised in the Aboriginal Land Rights (Northern Territory) Act (1976).

The northern rangelands of Australia are home to a rich and diverse cultural heritage (Keen 2004; Hiscock 2008). Cultural heritage sites continue to be valued and maintained by traditional owners (Zander *et al.* 2013*a*) but also by Indigenous rangers and ranger groups. Northern rangelands are experiencing a transition towards multifunctional occupancies, and Indigenous values are often contesting past production values (Holmes 2010). Some 90 ranger groups funded by the Australian government (Department of Environment 2013) bring new approaches to natural-resource management. The participatory planning experience of these groups is well documented (Altman and

Kerins 2012). Notably, 77% of ranger group projects involve managing places of cultural significance (Department of Environment 2013). Ranger groups are also poised to manage an array of significant climate-change impacts confronting the Indigenous estate (Altman and Jordan 2008).

Concerns have been voiced about climate-change impacts on heritage sites since the early 1990s (Rowland 1992). Only very recently, however, have methodologies for managing climate-change impacts on heritage been developed (Bickler *et al.* 2013; Daire *et al.* 2014; Dawson 2015). These methodologies are not designed for stakeholder use.

In contrast, a great many generic adaptation planning tools have been designed to assist bottom-up adaptation planning (Webb and Beh 2013). Importantly, a detailed scoping phase is fundamental to generic adaptation tools. In this scoping phase, stakeholders themselves come to terms with their problem and design the ensuing project accordingly.

The process for developing an innovative planning tool for Indigenous rangers to adapt heritage sites, or management of sites, to the impacts of climate change is indicated in Fig. 1. In this paper I have concentrated on the construction of the initial scoping phase of the tool. I have explained the selection of five generic tools to be used as the new tool's basis; I methodically synthesised their scoping phases; and then further modified the result in the light of Indigenous adaptation studies. I then set out a validation model consisting of central assumptions behind each of the draft tool's elements. The tool will be finalised through testing in the field and assessment that confirms, or otherwise, these assumptions.

The first two assumptions in the validation model are crucial. They are that: (a) Indigenous rangers perceive climate-change impacts on heritage sites, and (b) they regard addressing these impacts as a priority need. Only if these foundational assumptions can be validated is there value in developing such a tool. Although literature to date has documented Indigenous perceptions of climate change in general, none has pointedly addressed this question in relation to climate-change impacts on heritage sites, what kind of impacts are perceived and what kind of sites are impacted.

I have concluded this paper with results from preliminary fieldwork undertaken in northern Australia in which I explored these foundational assumptions.

Conceptual frameworks

The potential threat posed by climate change to heritage sites worldwide began to ring alarm bells for heritage practitioners over two decades ago. Rowland (1992), one of the earliest archaeologists to express concern internationally, observed that in the Australian context:

> 'It will become necessary to discuss with Aboriginal owners the potential impact of greenhouse changes on coastal sites' (1992, p. 31).

Although many authors have documented general perceptions of climate change among Indigenous people (Petheram *et al.* 2010; McIntyre-Tamwoy *et al.* 2013; Leonard *et al.* 2013; Memmott *et al.* 2013; Zander *et al.* 2013*b*), none have pointedly explored perceptions of impacts on heritage sites, what site types are perceived to be affected and what kinds of impacts are involved. Not surprisingly, therefore, no adaptation planning has focussed on the issue. McIntyre-Tamoway *et al.* (McIntyre-Tamwoy *et al.* 2013; p. 106) write of:

> '... an urgent need for [Indigenous] climate change impact and mitigation projects to consider the likelihood of impacts on cultural places and values.'

Internationally, the issue of climate-change impacts on heritage has been under consideration for some time. The many potential climate-change impacts on cultural heritage sites and site types were enumerated by UNESCO (2006), and Cassar

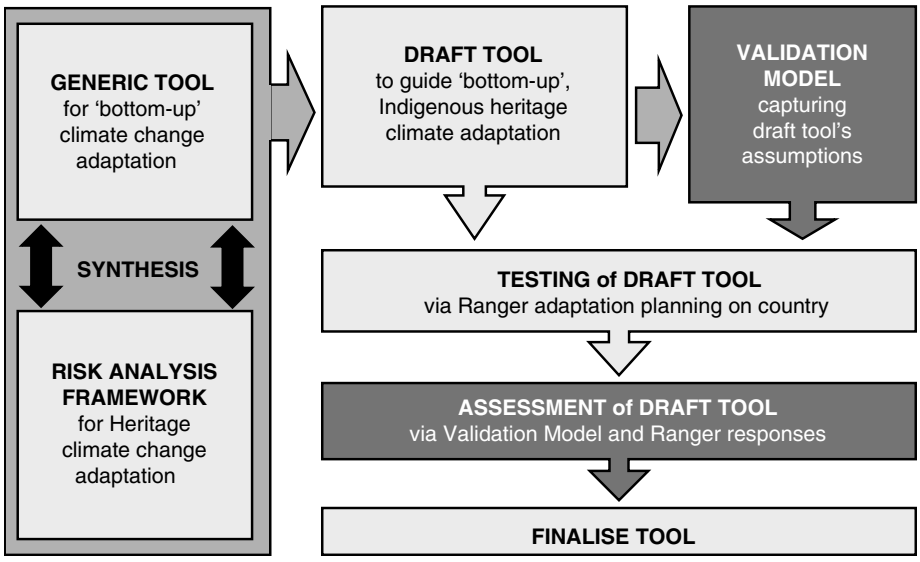

Fig. 1. Process for developing an innovative planning tool for Indigenous rangers to adapt heritage sites, or management of sites, to the impacts of climate change.

(2009) focussed on climate-change impacts on English heritage, pointing to possible management pathways.

Only very recently, however, has work progressed from hypothesising potential impacts and broad strategies to developing management methodologies. These methodologies include the work of: Bickler *et al.* (2013) in New Zealand; Dupont and Van Eetvelde (2013) in Belgium; Daire *et al.* (2014) in France; and Dawson (2015) in Scotland. Here, professionals typically construct a model, usually GIS-based, with a base layer allocating a hazard – such as an erosion class to stretches of coast or inland rivers. This is overlaid with a layer comprised of site or heritage landscape registers. Proximity to hazard and the susceptibility rating of the site type to the given hazard are combined to derive a vulnerability rating. A value for archaeological significance further refines the vulnerability rating. This prioritisation process is followed, in theory, by planning and implementation.

The use of such frameworks for heritage adaptation has been generally top-down, that is by academics and heritage practitioners. Dawson (2015) does, however, attempt to tread what he calls a 'middle path'. After initial risk analysis and prioritisation, a subsequent phase is added in which local community members are recruited to assist in implementation but also to augment data collection and update the values given to sites on the basis of any special meaning particular sites might hold for them. Stakeholder inclusion has been vital to considerable progress in managing climate-change impacts to date. Dawson (2015), however, does not outline the structure of a stakeholder-led process.

In contrast, practical, generic tools have been developed to support bottom-up adaptation planning. Many of these have emerged in response to a burgeoning literature on climate-change adaptation (e.g. Smit and Wandel 2006; Pelling 2011; Adger *et al.* 2012). Within this body of theoretical work, however, studies have found that there is often a disjunct between theory and on-the-ground adaptation planning practice (Preston *et al.* 2011). It may be that generic adaptation tools are not being used by practitioners but it may also be that the tools available are, in some instances, simply too generic. Preston and Stafford-Smith (2009, p. 3) point to the need for developing bespoke adaptation tools:

> 'A central challenge is the identification of assessment approaches that reflect the nested nature of both vulnerability and adaptation, while avoiding paralysis through complexity. This may require the development of a novel framework and set of methods.'

There may also be problems in terms of the quality of individual adaptation tools. Webb and Beh (2013) attempted to assess the quality of a range of generic adaptation tools in terms of their cognisance of adaptation theory. They collected some 90 'adaptation process guides' from Australia and internationally and undertook an assessment of 15 high profile examples. These were assessed on the basis of 'principles of good climate-change adaptation' derived from practical experience reflected in the peer-reviewed and grey literature on climate-change adaptation. Table 1 briefly summarises these principles.

The basis of a heritage adaptation tool

In order to synthesise a model generic adaptation tool that will form the basis of a heritage adaptation tool, I have firstly selected five generic climate-change adaptation frameworks on the basis of their favourable rating by Webb and Beh (2013) against the principles set out in Table 1. These well-rated tools have various strengths:

(1) The UNDP's 'Adaptation policy frameworks for climate change' (Burton *et al.* 2005) is the highest rated in terms of the principles.

Table 1. Principles of good climate-change adaptation, adapted from Webb and Beh (2013)

	Principle of good climate-change adaptation
1	Stakeholder engagement. Ensure a broad range of stakeholder engagement through a bottom-up process in order to: (a) understand the range of motivations, perspectives and values; (b) understand existing perceptions/comprehensions of climate-related issues; and (c) support participation in all processes and actions
2	Sustained leadership. Support stakeholder leadership to ensure commitment and engagement over time, and to define roles
3	Explicit scoping. Undertake 'scoping' from the outset to facilitate shared understandings of the adaptation issue and why it needs to be addressed
4	Articulation of goals. Articulate a clear adaptation vision and intent; outline objectives and goals
5	Appropriate methodologies. Consider the methods to be used, choosing from: (a) direct impact and risk reduction approaches, (b) long-term, transformational change responses, and (c) a broader development of organisational resilience
6	Multiple issues and barriers. Consider (a) social (values, perceptions and equity), (b) institutional ('rules' and roles), (c) environmental (biophysical and natural), and (d) economic issues and barriers. This ensures meeting broader stakeholder objectives and allows for adaptive changes to be made to organisation(s)
7	Methods appropriate to local needs. Choose methods that: (a) address climate risk using local as well as external climate-change knowledge, (b) identify methods of analysis according to different resource constraints, (c) factor in uncertainty by considering the optimum timing of decisions, (d) support an iterative process by developing cumulative data-management processes, (e) consider how to integrate adaptation planning into the organisation's structure, and (f) allow for non-linear and context-specific planning sequence
8	Related initiatives. Learn from similar initiatives, to enhance confidence and progress
9	Spatial and temporal scales. Address spatial (local/regional/broader) and temporal (short/medium/longer-term) scales
10	Options assessment and decision-making processes. Evaluate adaptation options by considering: (a) both their positive and negative effects, (b) which stakeholders will experience each of the effects, (c) their implications for other policy objectives, and (d) their likely feasibility, robustness to uncertainty, and cost-effectiveness
11	Adaptive management approaches. Develop monitoring, evaluation and learning programs – climate-change adaptation should be an evolving process not a single project

(2) The UKCIP's 'Adaptation Wizard' (UKCIP 2013) does well in terms of principles; and is also rated highly in terms of user features.
(3) Care International's 'Climate change vulnerability and capacity analysis handbook' (Dazé *et al.* 2009) is a good performer in terms of principles – sustained leadership and stakeholder engagement in particular.
(4) The UNEP Provia's 'Guidance on assessing vulnerability, impacts and adaptation to climate change' (Hinkel *et al.* 2013) is a strong performer in terms of principles; it also rates highly in terms of functionality across the options phase.
(5) The UKCIP's 'Climate adaptation: risk, uncertainty and decision-making' (Willows and Connell 2003) is a good performer in terms of principles; and it also rates highly in terms of functionality across phases.

Adaptation planning phases

The majority of the well-rated tools employ a five-phase process, namely: (1) scoping, (2) risk analysis, (3) options analysis, (4) planning/implementation, and (5) monitoring/review. This adaptive management structure is inherited from standardised risk-analysis methods. Indeed, as adaptation studies note, a risk-analysis approach is at the heart of most adaptation assessment methods (Jones and Preston 2011). Most of the five well-rated tools proceed on the basis of posing a chain of questions for their users across these five phases. In keeping with this pattern, the tool developed will ultimately follow a five-phase process.

The first phase, the scoping phase, is all important. The scoping phase requires stakeholders to negotiate among themselves the design of the entire project. This phase is most obviously missing from the recently developed methodologies for heritage climate-change adaptation. It is primarily the scoping phase that marks support-tool-guided adaptation planning as bottom-up. In bottom-up planning, participants effectively become 'action' researchers, studying their own work practice, identifying their problems and devising their solutions (Stringer 2014).

Developing the scoping phase of the tool

My second step in constructing the tool is to distil themes within the scoping phases of the well-rated tools. Six common themes can be identified:
(1) Defining the nature of the climate-change problem;
(2) Setting aims, goals and objectives;
(3) Choosing the approach or method to be used;
(4) Conducting a stocktake of resources available to the planning process;
(5) Considering and analysing potential barriers to the process; and
(6) Assembling a suitable team, leadership and roles.

These six themes form the structure of the initial iteration of the scoping phase in my planning tool. My third step in developing the tool is to identify questions across the scoping phases in the well-rated tools that have the same intent. These are combined and consolidated into the planning tool under their appropriate thematic headings. There are, of course, numerous questions unique to one or more well-rated tools. Importantly, these unique questions are not discarded but added to the tool along with the common questions. In this way the tool retains elements of all the well-rated tools.

The theme of 'choosing the approach or method to be used' is salient. Stakeholders can choose between, for example, a biophysical hazard-reduction approach, or one that focuses on building the adaptive capacity of the parent organisation. The recently developed heritage climate-change adaption methodologies discussed earlier might be described as purely biophysical hazard-reduction methods. It follows then that in choosing their approach, rangers are given the option to actually reject a biophysical hazard-reduction method and, therefore, these approaches. However, if a biophysical hazard-reduction approach is chosen by stakeholders, the scoping phase in most of the well-rated tools still requires an integrated approach; i.e. one that considers context and the incorporation of planned interventions into the social, economic and organisational context. This allows for the possibility that, in order to adapt, changes may be required of the overarching organisation or related organisations.

Validation of the tool in light of findings from Indigenous adaptation studies

Being intended for use in an Indigenous climate-change adaptation context, the tool is now scrutinised against recommendations, learnings and principles from the Indigenous climate-change adaptation literature. This literature is not extensive. Although it is wide-ranging, major studies encompass six broad objectives:
- ascertaining climate-change adaptation research gaps (Langton *et al.* 2012);
- ascertaining Indigenous communities' vulnerabilities to climate change (Green *et al.* 2009; AECOM 2010);
- understanding how Indigenous communities perceive and respond to climate change (Petheram *et al.* 2010; McIntyre-Tamwoy *et al.* 2013; Leonard *et al.* 2013; Memmott *et al.* 2013; Zander *et al.* 2013*b*);
- understanding Indigenous communities' resilience to climate-change impacts (Bird *et al.* 2013);
- identifying general strategies to help Indigenous communities adapt to climate change (Green *et al.* 2012; McNamara *et al.* 2012; Leonard *et al.* 2013); and
- producing formal Indigenous community-generated and -owned plans or strategies aimed at building adaptive capacity (Butler *et al.* 2013; Memmott *et al.* 2013; Nursey-Bray *et al.* 2013).

Although a majority of the studies conducted research in Indigenous communities, few of those communities actually had ranger groups up and running. Interestingly, Indigenous participants in these communities often nominated the establishment of ranger groups as a key climate-change adaptation strategy.

Although broad recommendations for Indigenous adaptation planning appear throughout the studies, few of the principles seem unique to an Indigenous adaptation context. The principles of Webb and Beh (2013) and, therefore, the planning tool, expressly or tacitly, incorporate most of them. Table 2 presents principles of good Indigenous adaptation from the indigenous

Table 2. Principles of good Indigenous climate-change adaptation

Principle of good Indigenous adaptation	Source	Consistency with criteria described by Webb and Beh (2013) and with the tool
Engage local organisations, use participatory approaches and support the localised development of priorities	Green *et al.* (2012); McIntyre-Tamwoy *et al.* (2013); Bird *et al.* (2013); Leonard *et al.* (2013); Memmott *et al.* (2013) Nursey-Bray *et al.* (2013)	This is consistent with Webb and Beh's criteria. The development of a tool for autonomous bottom-up use by ranger groups necessitates a 'radically' participatory approach. Each project will be pointedly designed by its participants, not outsiders
Combine scientific with traditional Indigenous knowledge	Green *et al.* (2009); Leonard *et al.* (2013); McNamara *et al.* (2012); Nursey-Bray *et al.* (2013)	Webb and Beh underscore the need to harness local knowledge. The ranger-focussed tool places traditional knowledge of country at its core
Consider socioeconomic inequality, justice and the colonialist legacy	Green *et al.* (2009); Nursey-Bray *et al.* (2013)	Many studies commend ranger groups for their wide-ranging community development benefits and participant empowerment (WalterTurnbull 2010). Webb and Beh's criteria also include consideration of multiple socioeconomic issues, including equity, and barriers. The tool's support of ranger groups aligns with the above
Allow discussion of subjects not directly related to climate change	Leonard *et al.* (2013); Nursey-Bray *et al.* (2013)	The criteria require consideration of multiple issues and barriers to adaptation
Avoid focusing entirely on vulnerability as this is disempowering	Leonard *et al.* (2013); Nursey-Bray *et al.* (2013)	The criteria and the tool require the adaptation focus of the project to be determined entirely by the participants themselves
Consider uncertainty	Green *et al.* (2012)	The criteria and the tool incorporate risk and options analyses – by their nature, these approaches necessitate consideration of uncertainty
Catalogue, share and learn from other adaptation successes	Bird *et al.* (2013); Leonard *et al.* (2013)	The criteria include learning from the experiences of adaptation initiatives that are similar. Central to the tool is a consideration of recently developed heritage climate-change adaptation methodologies
Provide practical, accessible pathways to accompany more long-term planning	Langton *et al.* (2012)	The criteria include consideration of spatial and temporal scales. Heritage adaptation using the tool might represent a useful short-term focus that is able to complement a simultaneously running, long-term community-wide planning project
Consider limits to climate-change adaptation	McNamara *et al.* (2012)	The criteria include consideration of barriers, as does the tool

adaptation literature, and highlights convergence with principles of good adaptation described by Webb and Beh (2013).

As noted, a number of studies from the Indigenous adaptation literature used participatory research methods to produce formal Indigenous community-generated and -owned plans or strategies. None of these, however, explicitly used an existing, generic climate-change adaptation planning tool or sought to modify one for use by Indigenous stakeholders.

Leonard *et al.* (2013), however, engaged particularly deeply with theoretical questions around a range of alternative climate-change adaptation planning frameworks one might use in an Indigenous adaptation planning context. They sought to characterise three markedly different types of adaptation framework: (1) narrow, biophysical-focussed risk management; (2) broad, social-context-focussed integrated development; and (3) community-based adaptation in which climate adaptation is one concern within an overall community development project. Although Leonard *et al.* (2013) attempted to clearly distinguish, on a conceptual level, between these three approaches, they concluded that they are convergent, and recommend a 'balanced approach' that combines elements from each, depending on the specific context of adaptation. They stated:

> 'Given the limited experience with Indigenous adaptation conducted in Australia to date, it is not possible to assert which of these frameworks is more suitable or desirable. A better understanding of the effectiveness of these approaches could be obtained through action-learning research initiatives ...' (Leonard *et al.* 2013 p. 42).

Leonard *et al.* (2013) argued that all three approaches necessitate a scoping phase but they did not elucidate what constitutes this phase, only recommending a number of amendments to each one's scoping phase. The majority of these amendments are familiar from the scoping phases of the well-rated tools. Those that are unique, however, can be summarised as:

(1) Include cultural protocols in the design of the planning activity;
(2) Spell out the potential benefits for the local community, or the risks to the community in conducting adaptation planning, or the risks of not conducting adaptation planning; and
(3) Establish who will have ownership of any outcomes, such as an adaptation plan; how Indigenous knowledge will be

protected; and how intellectual and cultural property rights in that knowledge will be secured by traditional owners. Consider enshrining these in a legal document.

Leonard *et al.* (2013), and the other Indigenous adaptation research cited, implicitly focussed on non-community-based policy researchers planning consultatively for whole-of-community adaptation. Yet in a stakeholder-led process mediated through a bottom-up tool, to a large extent the above amendments lose their relevance. There is, however, the possibility that the tool's bottom-up process might be facilitated by an outsider with an unstated agenda – as opposed to a head indigenous ranger or non-Indigenous ranger-group coordinator. For this reason these unique amendments will be included in the tool.

The indigenous heritage adaptation planning tool

To generate the final iteration of the scoping phase for the tool, my synthesis of scoping questions from the well-rated tools of Webb and Beh (2013) have been adjusted to a heritage context and combined with the unique amendments of Leonard *et al.* (2013). The result is set out in Table 3.

Model for validation of the planning tool

The value of the tool will be assessed using a technique first outlined by Weiss (1995) and later incorporated into a goal-orientated action research method called 'Theory of Change' (Taplin *et al.* 2013). Underlying assumptions or 'theories' inherent in the tool are stated along with their expression in academic studies. The theories are linked to proposed corresponding outcomes, or outcome indicators, in an assessment model (Table 4). If rangers progress through the tool's steps, achievement of outcomes will allow the validation, negation or modification of these theories, and of the tool itself.

If they progress through the tool, rangers will be given the opportunity to set goals and undertake a chosen methodology; the methodology will generate an analysis and lead to a set of

Table 3. Scoping phase of a tool for Indigenous heritage site climate-change adaptation

1	**Problem analysis** • Is there a climate-change problem for sites? • If so, where is it happening? What kinds of sites are being affected? How are they being affected? • How are sites currently being looked after? How often are sites visited? How often is maintenance done? Often enough? Health of sites? What gets in the way? • Is what's being done now enough to make sites strong against climate change?
2	**Aims, goals and objectives** – What do you want for and feel about sites? • Why are sites important to you? What do you want for sites and for the next generation? • What are the goals of this project?
3	**Methodology** – How will we make sites strong against climate change? • Do you know of other projects looking at sites and climate change? What have these projects achieved? If not, facilitator describes risk-analysis approach for heritage sites. • What do people think of this? Instead we could: (a) Not focus on sites, but talk about how to make ranger jobs strong against climate change? (b) Not focus on sites or jobs, talk about how to make Park or Aboriginal Corporation natural-resource-management policies strong against climate change? • Could the chosen approach fit in with current work? • What cultural protocols should be considered? • Would this benefit for the community? Could this be bad for the community? • How will we know when what we do is working or checks out with sites? i.e. that sites on maps are where the map says they are or sites we think are in big danger on a map seem so on the ground. (i.e. develop monitoring and evaluation strategy?) • What's our time frame? • Do we need a communication plan?
4	**Stock-taking** of resources – What do you have that will help? • What physical resources do you have? • What people/skill resources do you have? • What money resources do you have? • What maps do you have: For sites? For places where climate change is happening? • What is in the Park/ranger data base? • Can the facilitator access it to build up a map of sites?
5	**Barriers** – What might get in the way? • What difficulties might you face? What are your strengths and weaknesses? • Does the Park/ranger group support the project? • Might the management plan stop us doing the project?
6	**Leadership** and roles – Getting the full team together. • Who inside the ranger group might also be on the project team? Who else has special authority? • Who else needs to be involved and why? Who outside the ranger group in the Park or Indigenous Protected Area (IPA)? Who outside the Park or IPA? • Who will do what? • How will we record what is said and decided?
7	**Ownership** – How will knowledge be protected? Who will have ownership of any outcomes, such as an adaptation plan or documented traditional knowledge?

Table 4. Assessment model for the scoping phase of the tool

Theories	Source	Outcomes
1. **Problem analysis.** Indigenous rangers are observing climate-change impacts on cultural heritage sites	Several sources propose that climate change will be or is an issue for Indigenous heritage sites; i.e. Rowland (1992); McIntyre-Tamwoy *et al*. (2015)	Rangers are able to nominate examples of sites impacted by climate change and justify this nomination
These may include: sea-level rise and storm surge impacting coastal sites; extreme flooding inundating riparian sites	Based on CSIRO and Bureau of Meteorology (2015) climate-change projections for the north-west monsoonal tropics	Rangers cite examples of coastal sites impacted by rise in sea level and increased storm surge, and riparian sites impacted by extreme flooding
Cultural heritage site types impacted are: rock art sites; coastal middens; Dreaming sites; and burial sites	These site types are prevalent in Australia's north-west monsoonal region. See Keen (2004) and Hiscock (2008)	Rangers cite examples of rock art sites, coastal middens, Dreaming sites, and burial sites impacted by climate-change impacts
Rangers are meaningfully engaged in the management of heritage sites.	The Australian Government has claimed 77% of ranger projects involve managing places of cultural significance (Department of Environment 2013)	Rangers manage a range of sites
2. **Aims/goals/objectives.** The goals set reflect rangers' feelings of responsibility for protecting 'country' and cultural heritage sites	Indigenous Australians' relationship to country and sites is discussed by many authors; i.e. Keen (2004). The success of Indigenous ranger groups' natural-resource management is widely documented; i.e. WalterTurnbull (2010)	Rangers affirm planning for climate change as a priority need. A subsequent list of goals for the conservation of sites is articulated by rangers
3. **Methodology.** Indigenous rangers are interested in undertaking a climate-change risk analysis and prioritisation process for cultural heritage sites. They see value in focusing adaptation work on those sites identified as being most in danger	This proposition is a function of literature proposing and trialling such a technique; i.e. Dawson (2015)	Rangers provide a reasoned nomination of a particular method
4. **Stock-taking** of resources. Rangers do have sufficient resources to undertake adaptation planning for cultural heritage sites. These take the form of: traditional knowledge about sites and site maintenance; cultural authority; planning skills; mapping skills; electronic data sets held by ranger groups	The importance of stocktaking in adaptation planning is underscored by Webb and Beh (2013)	Enumeration by rangers of resources available and unavailable. Consideration by rangers of either their use or, if absent, their procurement
5. **Barriers.** There are barriers to adaptation planning by rangers for cultural heritage sites. However, existing governance structures and management frameworks do not represent a significant barrier	The importance of considering barriers in adaptation planning is underscored by Webb and Beh (2013)	Enumeration by rangers of perceived barriers. Nomination of ways to overcome these barriers by rangers
6. **Leadership** and roles. Within ranger groups, individual rangers are prepared to lead a climate-change adaptation project	The importance of considering leadership and roles in adaptation planning is underscored by Webb and Beh (2013)	Rangers establish a climate-change adaptation leadership team
7. **Ownership.** Control over outcomes is an issue for rangers	The importance of establishing ownership over research programs is proposed by Leonard *et al.* (2013)	Rangers wish to establish research protocols

nominated interventions. These interventions might become the basis of a future implementation assessment.

If the propositions in Table 3 are largely or partly confirmed, subsequent phases can be tested by the assessment model. Table 5 sketches theories and outcome indicators for a risk-analysis phase and options-analysis phase.

Validating the two primary assumptions of the adaptation planning tool with Indigenous rangers

For the tool to be meaningfully tested, it needs to be determined if the first two assumptions in the validation model can be verified. Before the tool can be fully explored, rangers must: (1) perceive there to be existing climate-change impacts on sites; and (2) consider there to be a priority need for planning. If these assumptions are not borne out, there is no value in further testing the tool.

Methods

Fieldwork was conducted in December 2014 in three case studies. The first case study was with the Djelk rangers and traditional owners working and living on an Indigenous Protected Area covering lands administered by the Bawinanga Aboriginal Corporation (BAC) in north-central Arnhem Land, Northern Territory. The second case study was with Indigenous rangers and traditional owners within Kakadu National Park (KNP), Western Arnhem Land, Northern Territory. Parks

Table 5. Assessment model for the risk-analysis phase and option-assessment phase of the tool

Theories	Source	Outcomes
1. Risk analysis. Indigenous rangers have the operational capacity to prioritise sites nominated as being in climate-change danger zones. They can do so in terms of relative vulnerability and relative significance	This proposition is a function of literature trialling such techniques; i.e. Dawson (2015)	Production of a map or lists prioritising sites relative to climate-change hazard zones
2. Options analysis. There are adaptation options acceptable to and practical for Indigenous rangers to apply. These include: detailed recording of sites rated as being at high risk of destruction; bund protection from flooding; relocation of movable aspects of sites; an ongoing monitoring program	UNESCO (2006) outlined a range of possible options for mediating the climate-change impacts on cultural heritage sites	Production of an adaptation plan in which a range of options are considered and prioritised

Australia leases the Park's lands from its Indigenous owners. A third case study, Case Study Three (CST), was conducted with another Indigenous ranger group and associated traditional owners in Western Arnhem Land, Northern Territory.

Informal conversations and semi-structured interviews were conducted face-to-face in various location types: on traditionally owned country; at traditional-owner Healthy Country Planning consultation meetings (Djelk); at heritage sites; in ranger stations; in ranger work sheds; or in private homes. For most interviews, the participant's comprehension of English was high and a translator was not required. In the case of one elderly traditional owner, a translator was used.

Interviews were digitally recorded, transcribed and analysed using Nvivo software. The research was conducted with ethics approval from the Australian National University and Charles Darwin University, a KNP research permit, and Northern Land Council research permit. Interviews were conducted with 30 rangers who are all traditional owners (16 Djelk rangers, seven Kakadu rangers, and seven rangers from CST); 12 traditional owners not currently serving as rangers (five associated with Djelk, two Kakadu, and five CST) and nine non-Indigenous ranger support staff (four with Djelk, one from Kakadu, four from the third case study).

Of the 16 Djelk rangers, four were women; of the seven Kakadu rangers one was a woman; of the seven CST rangers none were women. Of the five Djelk-associated traditional owners not currently serving as rangers, one was a woman; both the Kakadu traditional owners not currently serving as rangers were women; all the CST traditional owners were women. Rangers spanned an age range from ~16–50 years. The age range of the CST rangers was exceptional: all were under 20 years.

Questions revolved around: climate-change threats to country generally; climate-change threats to heritage sites specifically; types of threats to heritage sites; types of heritage site impacted; the significance of threats; the value of heritage sites; the nature of an appropriate response; and the need for appropriate planning. Interviews lasted between 3 min and 1.5 h, depending on the interest of the interviewee. The older and more experienced the interviewee, the more forthcoming they were with responses.

Indigenous ranger perceptions of climate-change impacts on heritage sites

Djelk rangers

Of the 16 Djelk rangers interviewed, nine perceived there to be climate-change threats impacting BAC lands generally. These were all older rangers. Manifestations of climate change and impacts cited included: rise in sea level; erosion from rise in sea level; intrusion of salt water resulting from a rise in sea level; extreme precipitation; higher riparian flooding; erosion from higher riparian flooding; increase in temperature; seasonal changes with corresponding changes to availability of bush food; changes in animal behaviour; and a change to fire regimes.

Six senior Djelk rangers perceived there to be climate-change impacts on cultural sites. The impacts cited included: extreme precipitation; riparian flooding; post-flooding algae growth and salt impregnation; rise in sea level and coastal flooding or erosion. The site types involved in these concerns included: rock art, shell middens, sacred forests, sacred trees, sacred billabongs, sacred swamps and ceremonial grounds. Three senior rangers reported unprecedented inundation and obliteration of riparian rock art as a result of extreme flooding. A fourth related witnessing the loss of coastal shell middens after extreme storms. The most senior ranger was acutely concerned about climate-change impacts on sites, saying:

> 'Climate change is really quick for us and really shocking for us, especially real bush mob – country men. . . . When we are on country, we record things with our mind – you see water mark gone right up, ruining the painting.'

Interestingly, one traditional owner associated with Djelk insisted rock art was not being impacted by flooding. When this perception was reported back to rangers they adamantly affirmed their initial responses and suggested that their opinions benefited from both the greatly extended time rangers spend on country and the time they also spend on country for which they are not the traditional custodians.

Kakadu National Park rangers

All the KNP rangers perceived there to be climate-change threats generally impacting KNP. General impacts cited included: rise in sea level and associated extreme flooding, intrusion of salt water and erosion; changes to precipitation; changes to wind and wind direction; increase in temperature; seasonal changes with corresponding changes to availability of bush food; and changed fire regimes. One ranger was concerned about climate change exacerbating the environmental impacts of uranium mining in the park.

All the rangers perceived there to be climate-change impacts on cultural sites. Impacts cited included: rise in sea level and associated extreme flooding and erosion; changes to precipitation; increased temperature and rock flaking; and

changes to wind (bearing dust) and wind direction. The site types identified were floodplain fringing: rock art, earth mounds, shell middens and burial sites. Three rangers related seeing unprecedented inundation of floodplain-fringing rock art during major flooding in 2006. New flooding in very close proximity to rock art – without inundating it – was said to be encouraging new damage from wet-earth foraging birds depositing earth onto art surfaces. One ranger said:

> 'People worrying a lot; people worrying about the sea, but you got to worry about what's coming from on top [i.e. freshwater flooding from the escarpment] once you've got that high tide doubled up. . . . At Canon Hill in last big wet in 2006 a few art sites there, which have never had artwork go under, went underwater. This art never went underwater before. I did not see the water go up, but I saw the damage in the dry season; saw the level of the water on the rock itself and on the trees.'

Another concerned senior ranger stated that:

> 'We're seeing a lot of changes. The big one, that's the climate change! We're savvy, we know! We're trying to tell the balanda [non-Indigenous person] what's going to happen in the future . . . I'm worried about sites down South Alligator River . . . our ancestors are there . . . very important to us, we see it's all changing, very important to us, it's all changing.'

Case Study Three rangers

Only one CST ranger had heard of climate change. He did not perceive impacts on heritage sites. Traditional owners associated with the group reported perceptions of climate change in general but not in regard to heritage sites.

Is adaptation planning for sites a priority need?

Djelk rangers

Senior rangers expressed enthusiasm for addressing climate-change impacts on heritage sites via strategic planning within the context of the importance of sites to Indigenous cultural identity and the fulfilling of traditional responsibilities. That rangers would be central to planning for adaptation to climate change goes without saying given Djelk's institutionalised bottom-up planning process. Rangers were keen to visit sites perceived as being impacted and were forthcoming with options that they had already considered for their protection. The most senior Djelk ranger said:

> 'If you visit [sacred sites], you'll get surprised and sad . . . big floods are ruining paintings and making erosion . . . changing things really fast . . . we have to act really quickly . . . bring all the people and we can do it together, like one . . . really important to do something: put it in writing, something.'

Kakadu National Park rangers

Discussions with rangers demonstrated perceptions that 'potential' climate-change threats are being realised now, and an anxiety to undertake planning as soon as possible. All rangers spoke of the importance of traditional stewardship, the proper maintenance of sites, and responsibilities to ancestors. These concerns are an impetus for planning for climate-change impacts. One ranger said:

> 'The water is coming up to the rocks [where there is art] . . . it used to only come up the creek . . . people in town just see it raining, can't see the difference . . . really old paintings going under . . . we always want to do things, but no funding. Planning is good – how long, how big the sites – we got to do all those things.'

Case Study Three rangers

A lack of perceptions of climate-change impacts on heritage sites meant that managing them was not a priority for CST.

Discussion

This paper describes the development of a methodology for constructing the scoping phase of a tool to support Indigenous management of climate-change impacts on heritage sites. At its heart, the resulting tool assumes that Indigenous rangers are observing climate-change impacts on cultural heritage sites. If they are not the value of the tool is limited. Fieldwork in two of the case studies resulted in a confirmation that Indigenous rangers do perceive there to be climate-change impacts on cultural sites. Sites nominated included rock art sites, coastal middens, Dreaming sites, and burial sites. Coastal middens, Dreaming sites and burial sites are perceived to be currently impacted by a rise in sea level and an increase in storm surges, and inland rock art, Dreaming and burial sites by extreme riparian flooding.

The tool also assumes rangers are concerned enough to want to undertake planning that will lead to some kind of action that will address these impacts. As Preston *et al.* (2015) pointed out, it cannot always be assumed that stakeholders will want to participate in adaptation planning. In the two case studies affirming perceptions of impacts on sites, planning for the impacts was regarded as a priority. Interviews found traditionally held cultural responsibilities for the maintenance of sites motivated rangers to want to undertake planning. CST was the exception. It is a nascent group consisting of inexperienced rangers all under the age of 20 years. At the time of research, CST was focussed on addressing challenging social issues confronting its program, and the group's relationship with its governing Aboriginal Corporation was also still evolving. If the group was more experienced, it might conceivably have been at variance with traditional owner perceptions of impacts on sites, as happened with the Djelk rangers.

Wolf and Moser (2011) discuss the importance of context to perceptions of climate change. The Djelk and KNP rangers' general perceptions of climate change are influenced by observations on country but undoubtedly also by past dialogue around climate-change impacts during natural-resource-management planning with scientists and consultants. In 2015, KNP is writing a new Management Plan. The draft (Kakadu Board 2014), which has involved consultation with rangers and traditional owners, describes climate change as a 'potential threat' that is 'highly significant'. Similarly, Djelk follows a

natural-resource-management-planning framework adapted from a Nature Conservancy framework (Baumgartner *et al.* 2006). This involves identifying targets and prioritising threats to targets. In 2014, Djelk prioritised threats for targets through participatory planning workshops and traditional owner consultations on country (Djelk Rangers 2014). Eleven threats for the target entitled 'cultural resources' were listed and classified as 'very high', 'high', 'medium' or 'low'. Climate change was classified as a 'very high' threat. Djelk ranger coordinators expressed a concern that although most 'very high' threats to all targets are currently being addressed by the Djelk program, climate change is not. This is because no specific impacts had previously been actively considered and climate change was simply regarded as a factor that exacerbates existing threats or 'makes all the other things worse'. Other factors influencing perceptions of climate change among rangers included senior Djelk and KNP rangers attending the IUCN World Parks Congress in 2014, where they took part in a panel discussion on climate-change impacts on biodiversity; and the fact that Djelk rangers receive significant funding through the sale of carbon credits generated by its program on bush fire reduction.

As a mark of their enthusiasm to plan for climate-change impacts on heritage sites, both Djelk and KNP rangers agreed to undertake scoping workshops using the tool in 2015. Results from these workshops will be scrutinised against the entire assessment model presented here. This and subsequent phases will be discussed elsewhere, including the final form of the risk-analysis and options-analysis phases. Questions remain as to how transferrable these results are to areas that do not experience coastal impacts or with greater year-to-year climatic variability. Results of planning for Djelk's inland riparian rock art, however, may produce more widely applicable learnings.

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Chapter 3

Testing the scoping phase of a bottom-up planning guide designed to support Australian Indigenous rangers manage the impacts of climate change on cultural heritage sites.

Figure 1A. Djelk Ranger Scoping workshop.

During field work in 2015, Djelk Rangers test the Scoping step of the Cultural Site Adaptation Guide with the author.

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Bethune Carmichael Conceptualised and designed the Scoping step of the Cultural Site Adaptation Guide (the Guide); wrote the paper, collected and conducted all analysis of data; and facilitated all Scoping step workshops.

Signed .....

Greg Wilson Participated in the testing of the Scoping step of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Scoping step of the Guide.

Signed .....

Ivan Namarnyilk Participated in the testing of the Scoping step of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Scoping step of the Guide.

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Sean Nadji Participated in the testing of the Scoping step of the Guide; provided cultutal site guidence and knowledge and contributed to the conceptual refinement of the Scoping step of the Guide.

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Jacqueline Cahill Participated in the testing of the Scoping step of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Scoping step of the Guide.

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Deanne Bird Contributed to the conceptual refinement of the Scoping step of the Guide.

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Testing the scoping phase of a bottom-up planning guide designed to support Australian Indigenous rangers manage the impacts of climate change on cultural heritage sites

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ABSTRACT

Since the early 1990s archaeologists have suggested archaeological and cultural heritage sites (cultural sites) will face major challenges from anthropogenic climate change. While techniques to manage such impacts are emerging, no planning tools exist for bottom-up, community-based management of the issue. This paper forms part of an overarching research project that aims to fill this gap by developing a bottom-up planning guide (the Guide). The paper tests the first of the proposed Guide's five phases: the scoping phase. It presents the results of workshops conducted with two Australian Indigenous rangers groups. While existing studies document Indigenous peoples' perceptions of climate change in general, none have focussed on their perceptions of impacts on cultural heritage sites. Here, Indigenous rangers related strong perceptions of particular climate change impacts on specific cultural sites in particular bio-regions. While the rangers were actively engaged with sites, they felt site management should be extended in the face of additional threats from climate change. Rangers were able to nominate a preferred methodological approach, based on a risk analysis of biophysical hazards, as well as local adaptive capacity building in the face of governance challenges. Various barriers to adaptation planning and resource limitations were identified but these were not regarded as insurmountable in terms of the current project. Testing of the scoping phase of the Guide suggested rangers had a strong organisational capacity to achieve practical adaptation results.

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1. Introduction

The vulnerability of archaeological and cultural heritage sites (cultural sites) to anthropogenic climate change has been identified as an impending global issue (Cassar and Pender 2005, UNESCO 2006, IPCC 2014, Harvey and Perry 2015) and an issue of particular import for Indigenous intangible culture and cultural sites (Rowland 1992, McIntyre-Tamwoy *et al*. 2012, Nursey-Bray *et al*. 2013, Wolf *et al*. 2013).

In Australia, Indigenous ranger groups increasingly manage an extensive range of cultural sites (Department of Environment 2013). Those operating in northern Australia, the focus of this paper,

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oversee a particularly rich suit of sites that includes many thousands of rock art, midden, Dreaming[1] and burial places (Jones 1985, Brandl 1988, Chaloupka 1993, Keen 2004, Hiscock 2008). Over recent decades Indigenous ranger programs have expanded in number and impact. In 2015, 108 Australian Indigenous ranger groups managed 70 Indigenous Protected Areas[2] (IPAs) covering some 63 million hectares of land (Pew Charitable Trusts 2015). These ranger programs base their work on bottom-up participatory planning, and their skills in doing so, and the community development benefits that flow from their work are well documented (WalterTurnbull 2010, Allen Consulting Group 2011, URBIS 2012, Pew Charitable Trusts 2015).

Northern Australia is particularly vulnerable to climate change impacts, which include those associated with sea level rise at rates significantly above global averages, subsequent extreme storm surge and extreme precipitation events that exacerbate inland flooding (CSIRO and Bureau of Meteorology 2015). In this context, some Indigenous ranger groups have strong perceptions of climate change impacts on sites and regard site adaptation as a priority need (Carmichael 2015).

Climate change adaptation planning, however, rarely makes cultural assets a primary concern. Adger *et al.* (2011, 2013) argue that this is a mistake, and it is vital that climate change adaptation considers local material contexts that give meaning to people's lives, including cultural heritage sites, if adaptation planning is to be widely adopted.

Nevertheless, there are methodologies being developed that might assist adaptation planning for cultural sites. For example, climate change risk analysis methods for archaeology are being pioneered in the UK (English Heritage 2007, Dawson 2015), Ireland (Daly 2014), France and Belgium (Dupont and Van Eetvelde 2013, Daire *et al*. 2014), New Zealand (Bickler *et al*. 2013) and the U.S.A. (Westley *et al.* 2011, Johnson *et al*. 2015, Reeder-Myers 2015).

These risk analysis methods are generally aimed at archaeological or heritage professionals working in a top-down planning context. In much of remote Australia, however, archaeological services and expertise are not available (Tacon and Marshall forthcoming). In this instance, strategies that embed risk analysis systems into bottom-up participatory planning processes would be more appropriate.

A bottom-up planning process is able to focus on enhancing the capacity of individuals or community groups to cope with or adapt to climate stress on their livelihoods and well-being (Dessai and Hulme 2004, Wilby and Dessai 2010, Raiser 2014). Bottom-up planning and its sensitivity to the community context is also able to account for social and economic disadvantage (Adger *et al*. 2004, Brooks *et al*. 2005) an important consideration in the context of Australian Indigenous communities (Altman and Jordan 2008, Green 2009). While a bottom-up approach is fundamental to achieving outcomes in a general Indigenous planning context (Walsh and Mitchell 2002), this is no less the case when Indigenous participants are planning climate change adaptation (Pearce *et al*. 2009, Green *et al*. 2012, Bird *et al*. 2013, Leonard *et al*. 2013, Memmott *et al*. 2013, Nursey-Bray *et al*. 2013).

Climate change adaptation planning also stands to benefit from combining Western science and local, traditional Indigenous knowledge (Nakashima *et al*. 2012, Nursey-Bray *et al*. 2013, IPCC 2014). Indigenous knowledge and in particular land management practices are highly complex and rest on a vast body of knowledge (Rose 1996). Realising adaptation benefits from this knowledge, however, requires strategies that address vulnerability and increase adaptive capacity (Berkes and Jolly 2001, Gaillard 2010). Strategies should recognise local barriers, including resource deficiencies, to climate change adaptation (McNamara *et al*. 2012). Those barriers that stem from governance issues are an important determinant of the success of climate change adaptation (Smit and Wandel 2006) and this is particularly so in an Indigenous context (Langton *et al*. 2012). Proactive leadership and the degree of meaningful engagement within the participatory planning process are also important considerations (Burton *et al*. 2005), as is control over and ownership of outcomes of the planning process (Leonard *et al*. 2013).

This paper is part of an overarching study that aims to support local and Indigenous communities to manage climate change impacts on cultural sites. The objective is to develop a cultural site adaptation guide (the Guide), a procedural decision tool, for use by Indigenous land managers planning cultural site adaptation.

Table 1. The five phases of a planning tool to aid Indigenous rangers manage the impacts of climate change on cultural heritage sites.

	Phase	Description	Aim
1	Scoping	Rangers design their project.	Comprehensively plan the project, consolidate ranger groups' understanding of the problem and anticipate practical challenges.
2	Risk analysis	Rangers assess threats to sites and determine which are likely to experience damage or loss.	Determine which sites are management priorities.
3	Options analysis	Rangers assess adaptation options for sites.	Identify and appraise options for sites determined to be a management priority.
4	Document and implement	Rangers write and execute a plan.	Effective, program-coordinated action.
5	Review	Rangers assess progress and update their plan	Ensure responsive adaptive management over time.

To this end, Carmichael (2015) proposed a Guide, consisting of five separate steps: scoping; risk analysis; options analysis; planning and implementation; and review (see Table 1). Carmichael (2015) also constructed the first step in the Guide, the scoping phase (see Table 2). The proposed scoping phase was based on a synthesis of existing generic guides, refined for an Indigenous, cultural site context. The model consisted of seven elements or discussion points: analysing the problem; setting goals; selecting a methodology; conducting a stocktake of resources; conducting a stocktake of barriers; considering leadership; and considering ownership.

Carmichael (2015) constructed the Guide and its scoping phase by way of a synthesis of the scoping phases of five generic climate change adaptation planning guides. The guides were: the *United Nations Development Programme's adaptation policy frameworks for climate change* (Burton

Table 2. The seven elements of the scoping phase – summary of Carmichael (2015).

	Element	Description	Aim
1	Analysing the problem	Consider perceptions of climate change impacts: hazard zones, and site types impacted. Assess current site management.	Generate a shared understanding of the issue, and determine if current maintenance is sufficient to build site resilience to climate change.
2	Setting goals	Reach consensus around project goals. Discuss the cultural importance of sites and aspirations for site management.	Establish shared expectations for project outcomes.
3	Selecting a methodology	Select a methodology from a range of possibilities: (1) biophysical risk analysis; (2) organisational adaptive capacity building; or (3) work-role adaptive capacity building. • Consider the selected method's compatibility with: (a) current work schedules; (b) cultural protocols; (c) community ideals. • Consider (d) how outcomes will be monitored; (e) a time frame; and (f) a communication plan.	Develop an understanding of various methodological options, allow rangers to take ownership of the method ultimately used, explore its practicality, consider its cultural implications and how to inform others of intent and progress.
4	Conducting a stocktake of resources	Consider finances; physical resources; people skills; maps and data. Consider the role of a facilitator.	Identify resource shortages that might jeopardise the project.
5	Conducting a stocktake of barriers	Consider difficulties the project might face and ways to overcome them. Focus on governance issues and the project's compatibility with existing management frameworks.	Identify barriers to the project and if these are surmountable.
6	Considering leadership	Explore leadership and its availability and who else to involve, such as other rangers, traditional owners and advisors. Discuss how to record what is said and decided.	Identify leaders who able to carry the project forward.
7	Considering ownership	Review ownership of traditional knowledge, as well as protection of intellectual outputs.	Secure legal control over research outputs.

et al. 2005); CARE International's *Climate vulnerability and capacity analysis handbook* (Dazé *et al*. 2009); The United Nations Environment Programme's *PROVIA guidance on assessing vulnerability, impacts and adaptation to climate change* (Hinkel *et al*. 2013); the UK Climate Impacts Programme's *Climate adaptation: risk, uncertainty and decision-making* (Willows and Connell 2003); and the UK Climate Impacts Programme's *Adaptation Wizard* (UKCIP 2013).

These were selected on the basis of their favourable rating against a set of good adaptation practice principles set out by Webb and Beh (2013). The scoping phase synthesis incorporated elements both common and unique to each of the selected generic planning guides. The synthesis was further adjusted by Carmichael (2015) to reflect an Indigenous context – elements on cultural protocols, community benefits and risks and protection of traditional knowledge were added in light of findings from Leonard *et al*. (2013). The synthesis was also fine-tuned for a cultural site conservation context (Pearson and Sullivan 1995).

The scoping phase of the cultural site adaptation Guide aims to generate a shared understanding of climate change impacts, negotiate group expectations for cultural site adaptation, consider methodological options, and anticipate and assess challenges (see Table 2). As Jones and Preston (2011) argue, scoping is fundamental to building climate resilience: without defining system boundaries and asking appropriate questions in the initial stages, adaptation planning and thus adaptive capacity building is likely to fail.

The purpose of the current paper is to test the scoping phase proposed by Carmichael (2015) with Australian Indigenous rangers, in order to ensure that any issues, defects or user misinterpretations are picked up and corrected before it is rolled out (e.g. see Bird 2009). The testing of the scoping phase aims therefore to:

(1) determine whether the discussion points comprising the scoping phase are effective in eliciting comprehensive responses from rangers;
(2) determine Indigenous rangers' organisational capacity to fulfil the requirements of the scoping phase; and
(3) confirm or negate the validity of inherent assumptions within the scoping phase.

2. Methodology

In testing the scoping phase, the current study applied a participatory action research (PAR) methodology during two workshops with key ranger groups. PAR is utilised by a group, organisation or community to solve an immediate problem that members themselves experience. Members of an organisation use an iterative cycle of investigation that aims to develop better work practises, often developing best-practice guidelines (Lewin 1946, Stringer 2014). The following sections first describe the selection process and regional settings of the key ranger groups, followed by the workshop activities.

2.1. Ranger group selection and regional settings

Five ranger groups were initially approached. Two were located in central Australia: the Warlpiri Rangers and the Tjuwampa Rangers (CLC 2013). The remaining three were located in northern Australia: Djelk Rangers from the Djelk Indigenous Protected Area (Djelk IPA) (Djelk Rangers 2014); a now defunct group associated with the Gundjeihmi Aboriginal Corporation (Masterson 2010); and a cohort of Indigenous rangers from Kakadu National Park (KNP) (Kakadu Board of Management 2016), of whom some were simultaneously members of a newly formed sixth ranger group, the Njanjma Rangers (Djabulukgu Association 2010).

Rangers and Indigenous support staff of the five ranger groups were approached via an Indigenous intermediary acting in a consultative role. Informal, face-to-face unstructured interviews centred

on perceptions of climate change, whether climate change was impacting cultural sites and if planning for impacts was a priority need for rangers. In central Australia, Warlpiri Rangers, a relatively new and inexperienced group, had very limited perceptions of climate change and no perceptions of impacts on cultural sites. Tjuwampa Rangers had perceptions of increased temperatures resulting from climate change, but the perceptions of impacts were limited, and like the Warlpiri Rangers, focused climate change adaptation planning was not a priority for Tjuwampa Rangers. Central Australia experiences a climate prone to extreme natural variation, so discerning climate change from natural change is possible by way of studying long-term trends (Ninti One 2014) but more difficult to perceive by those managing natural resources over the short-to-medium term.

Of the three northern Australian groups approached, the team associated with the Gundjeihmi Aboriginal Corporation was newly established. Its members, all under the age of 25, were largely unfamiliar with the concept of climate change, and while their associated Traditional Owners[3] did have strong perceptions of climate change, such as seasonal changes and changes in food sources, these did not extend to impacts on cultural sites.

In contrast, Indigenous rangers from Kakadu National Park (KNP Rangers) and rangers from the Djelk IPA (Djelk Rangers) are long established and highly experienced groups. They are exposed to a climate with regular and distinct seasons (Hennessy *et al*. 2011) as well sea level rise trends that are significant and well documented (National Tidal Centre 2011). KNP and Djelk Rangers had very strong perceptions of a range of impacts and types of sites impacted. Both explained recent site destruction as the result of climate change, and were very anxious about the continuation and intensification of these impacts. They considered managing the problem as a priority need. These two ranger groups agreed to undertake testing of the scoping phase and, if this were to prove valuable, continue on with the Guide's subsequent phases.

KNP Rangers manage an area of 19,804 square kilometres within the Alligator Rivers region of western Arnhem Land in the Northern Territory of Australia. The first stage of the park was declared in 1979, and further stages added in 1984 and 1987. The Australian Government leases the Park from its Indigenous owners. In 2015, 43,000 tourists visited the park (Parks Australia 2016). The Park is jointly managed by Parks Australia and Traditional Owners through a Board of Management, which has a majority of Indigenous members. Final decisions, however, must be endorsed by Parks Australia. Many cultural heritage surveys and site recording projects have been conducted by archaeologists and Traditional Owners both prior to and since the Park's inception (Kamminga and Allen 1973, Chaloupka *et al*. 1985, Jones 1985).

Djelk Rangers manage some 14,000 square kilometres of land and sea country in north central Arnhem Land, Northern Territory. Djelk Rangers began operating in 1991 under the auspices of the Bawinanga Aboriginal Corporation (BAC). BAC is directed by an Indigenous executive committee elected annually by BAC members. In 2009, the Djelk IPA, which encompasses the BAC region, was declared. Principle funding for management of the Djelk IPA comes from the Australian Government's *Working on Country* program. There is no significant tourism in the Djelk IPA. Final management decisions rest with BAC. While a limited number of studies of archaeology and rock art in Djelk territory exist (Brandl 1988, Saulwick 2000, Brockwell *et al*. 2005), there is no comprehensive catalogue of cultural heritage sites, which would likely run into the thousands.

2.2. Workshops

The lead author facilitated two workshops in April 2015, one with Djelk and one with KNP Rangers, utilising a full version of the scoping phase summarised in Table 2. Participants were either self-selected or invited to participate on the basis of their contribution to preliminary research conducted in 2014–2015 (Carmichael 2015). Their knowledge of English was high, so there was no need for a translator. The Djelk Ranger workshop was conducted with seven Indigenous rangers (all male) and one non-Indigenous ranger coordinator (female). The KNP Ranger workshop was conducted with five rangers (four male, one female). A sixth KNP Ranger (male) and one former ranger

(female) were interviewed outside the workshop. The workshops lasted 1.5 hours (KNP Rangers) and 2.5 hours (Djelk Rangers).

Workshops involved plotting hazard zones on maps, identifying vulnerable site types found in the hazard zones, and generally assessing the depth and detail of responses elicited by each of the seven elements of the scoping phase. The proposed scoping phase contains a set of inherent assumptions about rangers. For the scoping phase to be capable of producing practical outcomes, these assumptions need to be validated. The degree to which these assumptions were verified by ranger responses, therefore served as a means of assessment. Table 3 sets out these assumptions and support for them in relevant studies. Anticipated workshop outcomes that might validate the assumptions are provided. These are then contrasted to the workshops' actual outcomes. This process, which is based on an assessment method developed by Weiss (1995) for use in goal-orientated action research (Taplin *et al*. 2013), informs the paper's Discussion section.

Workshops were audio and video recorded, transcribed and then analysed with the aid of NVivo qualitative data analysis software.

3. Results

Overall, the workshops were met with a very high degree of enthusiasm. Considered and detailed responses were made by rangers, who spoke among themselves to negotiate answers that all agreed with. The Djelk workshop elicited particularly detailed and reasoned responses despite the late arrival of the group's most senior ranger, whose responses had been integral to the original decision to engage that group. After the workshops, both ranger groups agreed to continue on with the Guide's subsequent phases.

Results are presented under a section for each of the seven elements of the scoping phase. Each section describes the aim of the element. It then examines: how effective the element was in eliciting comprehensive responses, addressing the first aim of the paper; Indigenous rangers' organisational capacity to fulfil the requirements of the element, addressing the second aim of the paper; and the validity of underlying assumptions within the element, addressing the third aim of the paper.

3.1. Analysing the problem

The problem analysis aims to specify the location, asset type and nature of the impacts perceived; to pool ranger knowledge, generate shared understandings and determine if current maintenance is building site resilience to climate change. The workshops confirmed assumptions that impacts would be coastal and riverine and that rock art and middens were the most at risk, and they successfully generated a shared understanding of impacts. While the workshops also confirmed site resilience was not being built adequately, they also found that the sites managed by rangers represent only a very small proportion of the total number of sites in their respective territories. This places a limit on the potential value of the scoping phase. For the scoping phase to be effective, the extent of rangers' site management needs to be drastically increased. This problem, however, is mediated to some degree in the Djelk case: that group sees itself as enabler of Traditional Owner site management.

3.1.1. Djelk Rangers – extreme coastal flooding

Djelk Rangers identified the entire coast of the Djelk IPA as a climate change hazard zone due to extreme flooding. Shell middens, earth mounds, sacred billabongs, sacred trees and ceremonial grounds were perceived to be vulnerable. Areas around the Blyth River entrance (near Kopanga), the floodplains of the Ji-bana area, Rocky Point, Maningrida and east of Djutta Point were highlighted by rangers as particularly vulnerable for shell middens (see Figure 1). According to rangers, while the Djelk IPA has changed dramatically over their lives, sea level changes are particularly pronounced. One ranger said:

Table 3. Summary of findings/outcomes.

	Scoping phase element	Inherent assumptions	Source of assumptions	Anticipated outcome	Confirmation of anticipated outcome
1	Analysing the problem				
	Climate impacts	Rangers have perceptions of climate change impacts on sites.	Rowland (1992) and Nursey-Bray *et al.* (2013)	Rangers confirm perceptions.	✓
		Hazard zones are: coasts – due to sea level rise/storm surge; river frontages – due to extreme precipitation events.	CSIRO and Bureau of Meteorology (2015)	Rangers assert these zones are impacted.	✓
		Sites impacted are: rock art, middens, Dreaming and burial sites.	Hiscock (2008), Brandl (1988), Chaloupka (1983, 1993), Chaloupka *et al.* (1985) and Meehan (1982)	Rangers assert such sites are impacted.	✓
	Current site management practice	Rangers manage extensive number of sites.	The Australian Government (Department of Environment 2013)	Rangers manage an extensive number of sites.	✗ Neither group was satisfied with the extent of site management.
2	Setting goals	Rangers can reach consensus on management goals for sites.	WalterTurnbull (2010) and Pew Charitable Trusts (2015)	Rangers articulate goals for site adaptation.	✓
		Sites are important to rangers (managing them is a priority).	Keen (2004)	Affirm planning for climate change a priority need.	✓
3	Selecting a methodology	Indigenous rangers want to undertake a climate change risk analysis and prioritisation process for cultural heritage sites.	Dawson (2015) gained community support for risk assessment of sites.	Rangers support a climate change risk analysis and prioritisation process for sites.	✓ But also want to undertake adaptive capacity building.
4	Conducting a stocktake of resources	Rangers have sufficient resources for adaptation planning.	Kakadu Management Plan (Kakadu Board of Management 2016), Australian Government (Department of Environment 2013), Rose (1996), Pew Charitable Trusts (2015) suggested financial, knowledge and planning resources are available.	Rangers confirm sufficient resources for adaptation planning.	✗ KNP Rangers have limited staffing. Djelk have site data shortfalls.
5	Conducting a stocktake of barriers	There are no major barriers to Indigenous adaptation of cultural sites.	Webb and Beh (2013) and Langton *et al.* (2012) emphasised the import of barriers to climate change adaptation.	Rangers do not cite major barriers.	✓/✗ KNP Rangers cite major governance issues.
6	Considering leadership	Individual rangers are prepared to lead a climate change adaptation project. Participation will be active rather than passive.	Webb and Beh (2013) underscored import of leadership. Burton (2005) discussed variables in the degree of active participation in adaptation planning.	Individual rangers take up key leadership roles.	✓
7	Considering ownership	Control over research outcomes is an issue for rangers.	Leonard *et al.* (2013) proposed codifying ranger ownership over research programs.	Rangers wish to establish legal agreements for researchers.	✓/✗ Rangers ambivalent within context of land council controls.

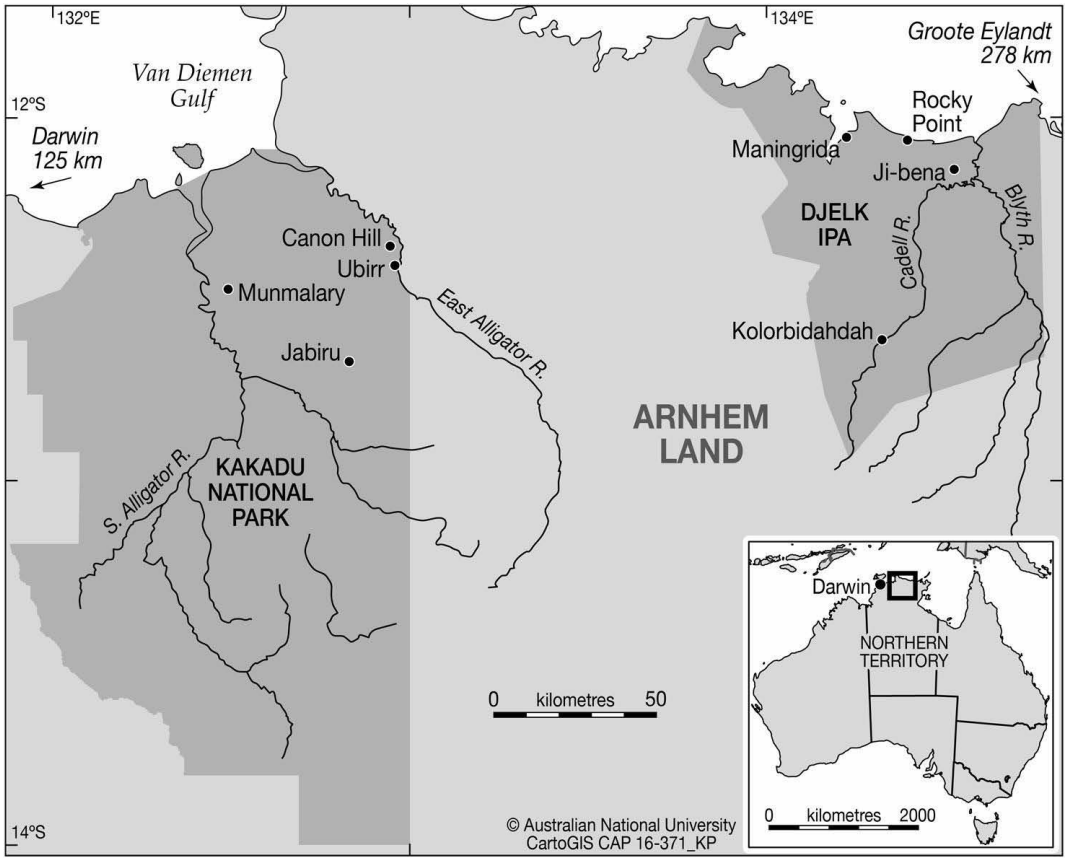

Figure 1. Location of the Indigenous ranger groups.

> I can tell you about when I was young. Everything was there, but now it's changed. The tide has changed, the weather has changed. When I was a boy, the low tide used to go right out. Now it goes out about halfway.

Another ranger explained this as the result of:

> Pollution … sea level is up: because of those icebergs melting.

Rangers attribute saltwater intrusion into floodplains and dead trees along eroded stretches of coast to sea level rise and more extreme storms. Some lost trees are said to have been sacred trees. Rangers describe eroded coastal shell middens at various points along the coast as well as the wholesale loss of shell middens at one site after Tropical Cyclone Nathan on 23 March 2015. One ranger said:

> They're gone, all gone. From cyclone and wind. Big wind! They're falling down from the top.

Shell middens and earth mounds are regarded as significant sites because they were produced by "the ancestors" and many have corresponding Dreaming stories.

3.1.2. Djelk Rangers – extreme inland flooding

Djelk Rangers identified the upper Cadell River as a climate change hazard zone, specifying six rock art sites that have been impacted by unprecedented flooding and are therefore considered vulnerable. None of the Cadell sites nominated were recorded in the Djelk cultural database, which means that they are not scheduled for maintenance. Nevertheless, rangers were able to imprecisely locate them on a map. One ranger said:

> One year we went to the Cadell, right on the IPA border, for ceremony; there were really old paintings there; on a second visit the paintings were damaged; on a third visit they were gone; water marks were there … when we are on country we record things with our mind.

Rangers discussed childhood memories of rivers coming up but stopping short of outstations. In contrast, rivers are said to be increasingly flooding outstations, and evacuation by helicopter is becoming a more regular occurrence. They reported more erosion and the formation of new creeks and channels. This was pointedly described as happening despite no overall increase in rainfall: rainfall intensity alone had increased. One ranger said:

> Not more rain, but bigger floods!

Rangers also associated increased algal growth on paintings with increased flooding.

3.1.3. Djelk Rangers – current site management practice

Djelk Rangers have a cultural heritage management plan that maintains 132 sites. Rangers explained their role as assisting Traditional Owners to achieve "healthy country" and therefore healthy sites. Four of the seven participants said they did not visit sites for which they were the Traditional Owner frequently enough. Their work as Djelk Rangers, which takes up most of their time, usually took them elsewhere. Even those happy with the frequency of visits were concerned that they were not doing enough to address problems that they encountered at the sites, such as erosion.

All the rangers emphasised the vital importance of getting out to sites. One said:

> Got to keep going back there and checking it; got to do that; keep checking the sacred area.

Rangers experience the pressures of leading both a traditional and Western life, and juggling their respective laws:

> I'm not spending much time in my area; most of the time I go out to other places to work. I don't have a [private] vehicle to get out there [to personal sites] to see whether the country's being damaged or not.

As a result of concerns around frequency of site visits, a major initiative that came out of the Djelk workshop was a detailed plan to visit sites perceived as in danger in order to further confirm impacts.

3.1.4. KNP Rangers – extreme wetland flooding

KNP Rangers identified Canon Hill and the area around the Ubirr rock art gallery as climate change hazard zones (Figure 1). In 2006, there were two extreme flood events affecting these areas. Rangers were able to explore the area by boat at the time and witness what were, for them, unprecedented high water levels. During the following dry season they observed the resultant damage, including new watermarks on rock surfaces, and flood debris in close proximity to sites. One ranger said:

> It's not normal. It's getting worse. The old people, our ancestors, would not have put it there [burial sites and rock art] if it was going to go under water.

Rangers said that when the rain comes, it's extreme, and its impact is magnified when it coincides with a high tide. One ranger noted that

> We're getting heavier rain: used to be more spread out; but now we're getting it all at once. Then we get that water rising really quickly … when you get the king tides, and you get a big rain on top, there's nowhere for that water to get out, so it just backs all up onto the floodplains. … That's when these sites are going underwater.

The South Alligator floodplain was also perceived to be a climate change hazard zone, with unprecedented flooding in recent decades. Earth mounds and associated stone artefact scatters were considered vulnerable. One ranger said:

> Climate change is really huge! A lot of people talking about it. Things might change [on the South Aliigator River floodplain], site might have gone … where's all the things, tools and everything?

> Nobody, nothing … I break down … I see that long history there from our ancestors, and it's hard. I don't want to see it gone.

3.1.5. KNP Rangers – current site management practice

KNP Rangers were unanimously unhappy with the amount of maintenance carried out at sites. Sites open to tourists and close to the ranger station are adequately maintained, but site maintenance outside these areas is no longer performed: competing Park interests get in the way. As one ranger said,

> When it comes to it, I think Traditional Owners and their own families are taking the initiative to get out and check each site.

The ability of Traditional Owners to look after Park sites outside work hours is seriously circumscribed by the expectations placed on them by Western societal norms and law. A lack of vehicles and equipment adds to the problem. Furthermore, they must earn a living as rangers. The situation results in some unease as the park is leased to the Australian Government on terms that explicitly require Parks Australia to maintain sites.

For KNP Rangers, however, the degree of compromise on site maintenance does not invalidate the use of the scoping phase of the Guide. KNP Rangers felt that by assessing the vulnerability of sites to climate change impacts, grave risks will be highlighted and act as a stimulus for increased government resourcing.

3.2. Setting goals

Discussion of goals aims to establish shared expectations for project outcomes. The workshops were particularly successful in eliciting responses in this regard and aspirations for sites were unanimous. Responses confirmed the assumption that rangers were bound by traditions to protect sites. Responses were often heart felt and many rangers lamented their inability to counter the impacts of climate change.

3.2.1. Djelk Rangers

Discussing goals quickly unified the group: Djelk Rangers care deeply about sites. The climate change project must help keep sites "healthy" and "safe". One ranger said:

> We have to look after it for our ancestors … it's from my father and my grandfather, I have to keep it here, in my heart; always.

They feel at one with their sites; sites are "their spirit". Their identities as Aboriginal people are bound up with sites. One ranger said:

> 'They're in our blood, all those sacred sites … our body and spirit'.

Sites record their history: keeping sacred sites safe is "keeping the Dreamtime there". If a site is not kept healthy, it causes rangers anguish. One said:

> That damage makes me cry inside … I ask myself, 'what am I going to do'?

Monitoring sites is vital. One ranger said:

> We have to keep going back and checking it; keep talking to the spirit, making it settle down, making it good [else country will die].

Above all else, the rangers expressed the view that sites should ideally be made safe (from damage), rather than simply being recorded and data stored in a museum for posterity. They all echoed one ranger's statement:

> We want them to be safe! Safe! To be safe!

3.2.2. KNP Rangers

The sentiments expressed by KNP Rangers were equally heartfelt. Discussing goals similarly unified the group, and they shared the same views as Djelk Rangers: that the project must help keep sites "strong" and "safe". One ranger said:

> If we lose these sites then a lot of us will lose connection to land … if you don't have that place to feel safe, you can't grow and make others feel safe around you.

Sites are vital to identity. One ranger said:

> Sites are who I am … we want to see sites strong, to pass on to our kids … how will we know what to paint if the rock art goes?

Sites are like history books: "without those paintings, we've got no story to tell". But sites also contain instruction for the future. One ranger said:

> I would like [sites] to be there in the future for my great, great grandchildren, for them to know that, yes, they were strong, proud Indigenous people that lived on this land; the stories are about how we lived off the land, and some of them may point to how we still need to care for the land.

3.3. Selecting a methodology

This element aims to engender an understanding of various methodological options, allow rangers to take ownership of the method ultimately used, explore its practicality and consider its cultural implications. The scoping phase of the Guide successfully fulfilled all of these aims. It had been assumed that a biophysical risk analysis would be chosen. However, while adamant at first that such an approach was ideal, both groups later revised their nominated mode of analysis to encompass a mix of methods: biophysical risk analysis plus adaptive capacity building. This outcome does not invalidate the scoping phase of the Guide, but confirms the high degree of engagement the scoping phase is able to engender. The ensuing sub-sections combine both groups' results to avoid repetition considering each group gave similar responses.

3.3.1. Djelk and KNP Rangers – considering alternative models

Rangers were asked if they were aware of similar attempts to deal with climate change impacts on cultural sites. In response to an anticipated negative rejoinder, a biophysical hazard- or risk analysis method was described as well as alternative approaches that focus on organisational vulnerability assessment and capacity building (see Table 2).

Both ranger groups were initially adamant that a risk analysis approach alone should be undertaken, insisting they must work directly with sites. As one KNP Ranger said:

> We couldn't just stop worrying about the sites … we have to look after those sites, it's what the old people say needs to happen.

Risk analysis might prioritise sites according to (a) proximity to hazard, (b) site type sensitivity to hazard and (c) significance. One KNP Ranger said:

> That's the good one: risk analysis … for future generations; Jimmy [a Traditional Owner] can pass that information onto his kids.

Both groups, however, ultimately opted for capacity building as well. The KNP Rangers insisted the resulting plan should focus on increasing Parks Australia's provision of resources for maintaining sites. Djelk Rangers were concerned to modify BAC policies in order that perceived governance issues be resolved. Both groups wanted training in site maintenance.

3.3.2. Djelk and KNP Rangers – fitting in with current work

For Djelk Rangers, fitting a risk analysis method in with current work presented no problems. For KNP Rangers, however, the question was more pressing, given their dissatisfaction with the time currently

allocated to site maintenance. KNP Rangers expressed the hope that the risk analysis approach might be a catalyst for organisational change within Parks Australia. One ranger said:

> It'd be good if we do get this in place, we can hand this to management and say that we need to do this as well as look after the ranger station.

3.3.3. Djelk and KNP Rangers – cultural protocols

The most important concern was that conducting a risk assessment for sites should involve full consultation with elders. The majority of the KNP Rangers around the table were either Traditional Owners or *djunkai* (traditional caretakers) for the Canon Hill and Ubirr sites. They would therefore take care of this consultation as a matter of course, as they would for protocols such as those around accessing exclusively men's or women's sites.

For Djelk Rangers, potentially working with sites for which they have no traditional responsibilities, consultation with Traditional Owners and *djunkai* was more of an issue. The workshop participants went to great lengths to emphasise that the risk analysis approach used in areas for which they have no traditional responsibility could only work after consultation with the appropriate Traditional Owners and *djunkai*. Moreover, the approach should be flexible enough that Traditional Owners are able to declare that secret or dangerous sites are not entered onto maps if need be.

3.3.4. Djelk and KNP Rangers – benefits to the community

With due consultation, risk assessment was deemed to be potentially highly beneficial by both ranger groups, due to the already elaborated value of keeping sites strong, healthy and safe.

3.3.5. Djelk and KNP Rangers – knowing what's working

The KNP Rangers raised the need for a broad monitoring program, regardless of a climate change project. One ranger said:

> If we ran normally [i.e. without current financial shortfall], we would be out there monitoring all the time. We would be looking at each site and a photo of the site, to see whether [the rock art] had faded in that time.

Again, the climate change project was commended as a possible catalyst for change. For Djelk Rangers the climate change project could easily be incorporated into the existing program of monitoring sacred sites.

3.3.6. Djelk and KNP Rangers – time frame

Djelk Rangers responded to the question of an appropriate time frame with:

> Forever … until we die; just keep going!

Their planning experience had obviously made them aware of the ongoing nature of adaptive planning. For both groups, however, a two-year time frame for the first cycle of the project was "good". For KNP Rangers, it meant they would not be, "too rushed".

3.3.7. Djelk and KNP Rangers – communication plan

Both groups were extremely enthusiastic about communicating the project widely. Both suggested a documentary be made about the project, and could envisage people coming from around the world to learn how to manage climate change impacts on sites:

> We have to involve other indigenous people, Indians, Muslim, not only Aborigines. Indigenous people from all over the world; they have got the same problem, with climate change … it is making culture drop down really quickly, all over the world, not only us mob.

3.4. Conducting a stocktake of resources

The aim of this element was to identify resource shortages that might jeopardise the project. The scoping phase assumes that while shortages exist, they are not serious enough to terminate the project. For KNP Rangers, resources were a particular problem. However, rather than negating the value of the scoping phase and its ability to foster adaptation, KNP Rangers saw the phase as a means to foster opportunities and stimulate greater resource provision from its governing body.

3.4.1. Djelk Rangers

For Djelk Rangers, finances and equipment were of concern, but not the primary issues. Data, and its proper storage, were identified as the resource most lacking. The lack of site registers is a potential problem for a risk analysis approach. The six sites on the upper Cadell River nominated as "vulnerable" were not in the Djelk heritage site database. A plan was spontaneously devised in the workshop to visit vulnerable sites later in the dry season to address this issue. Skill within the ranger group was seen as abundant, but rock art conservation training was raised as a needed resource.

3.4.2. KNP Rangers

KNP Rangers spoke at length of insufficient staff, and the Park's financial constraints. In their view, financial resources are directed to tourism at the expense of site maintenance. This problem was seen as a reflection of the governance structure associated with joint management. Indigenous rangers spend too much of their time undertaking tourism duties such as tourist camp maintenance. A climate change adaptation project that drew attention to serious threats to sites, however, was seen as a potential stimulus to resourcing.

In contrast to the Djelk IPA, data is one of KNP's greatest assets, a benefit flowing from long-term Australian Government involvement. Rangers brought comprehensive site maps to the workshop table. A digital database made operational in 2014 links thousands of site registers dotted across the Park.

The KNP Rangers discussed and welcomed identification and mapping of sites in hazard zones for sea level rise, storm surge and extreme precipitation. They were enthused by the prospect of assessing sites themselves in terms of traditional significance, but also expressed interest in considering Western archaeological perspectives. They discussed the need for refresher skills in site maintenance, agreeing that training being organised by the Park's Natural and Cultural Programs team at the time of consultation would indeed be beneficial.

3.5. Conducting a stocktake of barriers

The aim of this element was to identify barriers to the project and ascertain if these were surmountable. The scoping phase assumes barriers can be overcome. Again KNP Rangers were pessimistic as to their governing body's willingness to divert resources from tourism, but they nevertheless thought the scoping phase of the Guide worth pursuing as a means to ring alarm bells around the seriousness of the issue.

3.5.1. Djelk Rangers

For Djelk Rangers there were some concerns around "office mob" input. They reported that Djelk Rangers sometimes have different priorities from those of non-Indigenous administrative officers employed by Djelk's parent organisation, BAC. This has in the past resulted in compromises to *Healthy Country* plans developed through Traditional Owner consultation. While the "office mob" is, in principle, entirely answerable to an Indigenous board, compromise has nevertheless led to some rangers questioning the worth of planning per se:

> If we make this plan, office mob could do the same thing; put it over us.

It was felt, however, that these governance issues would not hamper the current project. Since the workshop was conducted, BAC has taken steps to address this issue.

The climate project was welcomed as supportive of the existing land and sea management framework in place on Djelk country. Its bottom-up planning approach mirrored the existing framework in many respects. To date climate change had continually come up as an issue but had never been directly addressed by the group.

Djelk also spoke at length of government policy in general being a barrier:

> Right now the government is talking about closing all the community outstations, and that's where we are going to have a big problem; how are people going to look after their land?

3.5.2. KNP Rangers

KNP Rangers nominated barriers to autonomous planning as a significant issue. Rangers have communicated concerns to Parks Australia about increasing the number of sites managed. No action, however, has resulted. They felt that this was bound up with a tendency for "talk but no action". Rangers were:

> … sick and tired of talking about problems, because not many things end up happening.

While resourcing is a significant issue in terms of managing climate change impacts on an extensive number of sites, it is not seen as an issue for the sites that are currently scheduled for maintenance. Again, the project, it was hoped, might provide a pathway for change by underscoring the serious nature of threats to sites. One Traditional Owner, consulted outside the workshop, felt disillusioned with joint management. The wishes of the KNP Board were not always implemented. This Traditional Owner envisaged Kakadu managed by independent Aboriginal Corporations.

3.6. Considering leadership

This element aims to ascertain whether leaders emerged who are able to carry the project forward. The scoping phase of the Guide assumes this will be the case. If it cannot engender leaders, the value of the scoping phase will be negated. Leaders emerged during the workshops and demonstrated a proactive commitment.

3.6.1. Djelk Rangers

The Djelk Ranger workshop was comprised of seven rangers who had already come forward as committed leaders for the project. Having nominated areas where climate change risks were perceived greatest, they then planned visits to verify perceptions. In doing this, particular rangers were nominated to lead in each area.

3.6.2. KNP Rangers

The KNP Ranger workshop was also composed of rangers who had come forward as committed leaders. They wanted further discussions with the KNP Board to elicit wider support from Traditional Owners around the Park. There was also a feeling that a leader or leaders should not be formally declared in order that the highly consultative approach taken would not be interpreted as one person's initiative.

3.7. Considering ownership

Discussing ownership aimed to secure legal control over research outputs by way of a formal agreement with a facilitator of the Guide from outside the community.

3.7.1. Djelk and KNP Rangers

Securing legal control over outputs did not engender great enthusiasm from either group. While the scoping phase assumes it would, ambivalence was likely the result of the research permit process required by the Northern Land Council in both groups' territories. The element is worth maintaining for Indigenous groups in areas without a land council.

Both groups, however, resolved that they should have ownership of outputs such as risk analyses and adaptation plans. Outputs would ideally contain no traditional knowledge; however, if it were essential for traditional knowledge to be included in a report of discussions, it could only happen with the full and appropriate consent of relevant traditional owners. Both ranger groups agreed to the lead author and facilitator writing up discussions and decisions, and welcomed co-authorship of any academic outputs from workshops.

4. Discussion

This study tested the scoping phase of a proposed Cultural Site Adaptation Guide. It did so by facilitating its use with two Indigenous ranger groups and assessing whether workshop elements could elicit meaningful and comprehensive responses, and whether Indigenous rangers had the organisational capacity to fulfil the requirements of the discussion points. It found the rangers were highly engaged by the approach and that they had the organisational capacity and planning skills to supply detailed and considered responses born of direct observation and insightful appreciation of the climate challenges confronting their cultural sites. Rangers felt the tool useful to the extent that they were enthusiastic to undertake the subsequent phase of the tool, the risk analysis phase.

This study represents the first cross-cultural attempt at a focused dialogue on the issue of climate change impacts on cultural sites with Indigenous stakeholders, doing so within a context that aims to enhance Indigenous decision-making and climate change resilience. As highlighted by Rowland (1992), a cross-cultural dialogue with Indigenous land owners around climate change impacts on their cultural sites is critical if adaptive outcomes are to be developed. This paper reveals that rangers had already begun a dialogue among themselves, having had direct experience of damage to sites they had independently interpreted as due to climate change.

Djelk and KNP Rangers confidently and authoritatively engaged in the testing of the Guide's scoping phase, affirming studies that have found their planning capacity and land management skills to be sophisticated and meaningful (WalterTurnbull 2010, Pew Charitable Trusts 2015).

Rangers asserted that sea level rise, more extreme storm surge, precipitation and cyclones were damaging or entirely destroying particular rock art, coastal and floodplain-fringing middens, and sites of cosmological significance. Their observations were consistent with scientific climate change projections (CSIRO and Bureau of Meteorology 2015), which rangers had no familiarity with. They were able to discern vulnerable geospatial zones, generalise about site types impacted and describe the nature of the impacts. In doing so they relied on traditional understandings, and modes of observation consistent with studies exploring the value of Indigenous ecological insights (Rose 1996, Nakashima *et al*. 2012). Their observations built on and significantly extended Nursey-Bray *et al*.'s (2013) documentation of displaced Arabana people's fears that climate change might one day damage cultural sites. Greater specificity is understandable given Djelk and KNP Rangers' observations are informed by the traversing of country on a daily basis over decades. Indeed, an Arabana response envisaged a return to country, establishment of a ranger group and monitoring (Nursey-Bray *et al*. 2013).

As Adger *et al*. (2013) note, impacts on cherished cultural values often represent the strongest spur to climate change adaptation planning. Both ranger groups were highly motivated to plan for impacts on sites, in keeping with traditional upbringings that emphasised the value of maintaining connection to country and the role cultural sites play in cosmology, socio-economic rights and obligations (Keen 2004).

There are various methodologies for climate change risk assessment. Biophysical, or hazard approaches (Willows and Connell 2003) consider the likelihood and magnitude of the consequence of impacts for assets. A vulnerability approach seeks to focus on exposure and sensitivity to risks confronting communities, as well as collective adaptive capacity (IPCC 2001, Smit and Pilifosova 2003). Rangers were able to provide a reasoned nomination of a preferred risk assessment methodology. Concerned to work directly with sites they were drawn to a hazard approach, but when governance issues and resource shortfalls were discussed, opted to also focus on increasing adaptive capacity in terms of changes to the policies of their governing bodies.

Smit and Wandel (2006) and Langton *et al.* (2012) argue that a key feature of adaptation is its demonstration of how the adaptive capacity of individuals is shaped and constrained by socio-economic and political processes at higher scales. There were important governance challenges and resource issues for both groups. KNP Rangers sought a rebalancing of resources between tourism and cultural maintenance. They affirmed studies (Haynes 2009) characterising the joint management model within KNP as conflicted by competing interests: cultural maintenance and tourism. Djelk Rangers, working under an Aboriginal Corporation and with no significant tourism demands, had some concerns about administrative interference from non-indigenous administrators, but these were less pronounced than those of their Kakadu counterparts. Djelk Rangers' main concern was their sparsity of consolidated site data, which reflected the paucity of codified archaeological research in their area alluded to at the outset of this paper. Tacon and Marshall (forthcoming) discuss a lack of professional archaeological support for remote Indigenous communities, and this was attested to by rangers' requests for more site maintenance training.

Burton *et al.* (2005) described the degree of engagement among participants in a bottom-up planning process as typically falling somewhere within a range spanning passive to proactive. Both ranger groups were highly proactive, with leaders readily emerging. During the Djelk workshop, individual rangers initiated and organised planning for a targeted trip to further confirm impact perceptions. A need for a high degree of consultation with Traditional Owners and caretakers, however, underscored leadership that is shared, communal and consensual. This notion of leadership lends itself well to the Guide's bottom-up approach.

Leonard *et al.* (2013) emphasised the need for formal agreements stipulating control over planning outputs. Both groups, however, were satisfied that their respective governing bodies and land council provided sufficient controls over research processes. However, no controls may exist in a setting where no Indigenous land council presides.

5. Conclusions

Risk analysis approaches to address climate change impacts on cultural sites are evolving in some countries, notably the UK and France. These are, however, very much top-down approaches, initiated and controlled by academic institutions and heritage professionals. These risk *analysis* approaches have little to say about the overall process of risk *management*. Fundamental to risk management is a scoping phase, a process of project framing without which adaptation planning is likely to falter. Australian Indigenous rangers see a Guide for site adaptation as a priority need. Their involvement in and control over the scoping of an adaptation process is vital given the Indigenous origins, continued custodianship, cosmological importance of, and remote locations of many cultural sites. While this research focused on an Australian setting, these findings may well be relevant to Indigenous groups elsewhere. Support for climate change adaptation strategies that involve ownership and control by Indigenous stakeholders, that is, bottom-up planning, needs to be incorporated into contemporary climate change policy.

While this study will support Indigenous rangers to scope their own adaptation projects for sites, it also has the potential to provide valuable adaptation planning experience applicable to whole-of-community projects. It might also allow the scoping experience of Indigenous people to be accommodated in national policy decisions concerning adaptation investment.

Notes

1. The term "Dreaming" represents many Australian Indigenous cosmologies in which the land was once inhabited by ancestral figures, often of heroic proportions or with supernatural abilities.
2. Indigenous land owners nominate their estates as IPAs, which are subsequently recognised as part of the National Reserve System and attract government resourcing.
3. The Aboriginal Land Rights Act (1976) describes "traditional aboriginal owners" as local descent groups with primary spiritual responsibility for sites and land.

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Chapter 4

Local and Indigenous management of climate change risks to archaeological sites.

Figure 1A. Extreme flooding impact at a riverine rock art site (I).

During field work in 2015, Djelk Ranger Ivan Namarnyilk tests the Risk Field Survey at a rock art site on the Cadell River, south of Kolorbidahdah. Flood debris can be seen (circled top-left and bottom-left) caught on an outcrop level with an erosion line through the rock painting.

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Greg Wilson Contributed to the testing and further development of the Risk Field Survey; provided cultural site guidence and knowledge; and contributed to the conceptual refinement of the Risk Field Survey.

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ORIGINAL ARTICLE

Local and Indigenous management of climate change risks to archaeological sites

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Abstract Hundreds of thousands of significant archaeological and cultural heritage sites (cultural sites) along the coasts of every continent are threatened by sea level rise, and many will be destroyed. This wealth of artefacts and monuments testifies to human history, cosmology and identity. While cultural sites are especially important to local and Indigenous communities, a stall in coordinated global action means adaptation at a local scale is often unsupported. In response, this paper produces a practical climate change risk analysis methodology designed for independent, community-scale management of cultural sites. It builds on existing methods that prioritise sites most at risk from climate impacts, proposing a field survey that integrates an assessment of the relative cultural value of sites with assessment of exposure and sensitivity to climate impacts. The field survey also stands as a monitoring program and complements an assessment of organisational adaptive capacity. The preliminary field survey was tested by Indigenous land managers in remote northern Australia at midden and rock art sites threatened by sea level rise, extreme flood events and a range of non-climactic hazards. A participatory action research methodology—incorporating planning workshops, semi-structured interviews and participant observations—gave rise to significant modifications to the preliminary field survey as well as management prioritisation of 120 sites. The field survey is anticipated to have global application, particularly among marginalised and remote Indigenous communities. Well-planned and informed participation, with community control, monitoring and well-informed actions, will contribute significantly to coordinated global and regional adaptation strategies.

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1 Introduction

Since the early 1990s, archaeologists and cultural heritage managers have been expressing grave concern about the potential for climate change and sea level rise to impact the great many significant archaeological and cultural heritage sites (cultural sites) around the world (Rowland 1992). The conservation of those that can be saved or otherwise digitally documented should be a major topic in international adaptation planning and advanced as a major incentive to mitigate emissions.

Cultural sites hold a central position in the narratives and collective memories of societies and play a significant role in cultural identity, community cohesion and sense of place. Adger et al. (2013) argue that adaptation and mitigation responses will fail if they do not connect with the cultural values, including material values, of individuals and communities.

Cultural sites are especially important to Indigenous peoples (McIntyre-Tamwoy and Buhrich 2012). While this is particularly the case for colonised Indigenous communities in North America, Australia and New Zealand (Murray 2011), it is also the case for ethnic minorities in Asia (Xu 2007) and Africa (ICCROM 2008).

While a wide range of possible climate impacts and cultural resource vulnerabilities have been identified (Cassar and Pender 2005; Sabbioni et al. 2006; UNESCO 2006), increased coastal erosion remains the impact of greatest concern. In itself, coastal erosion is a major threat to cultural sites (Jones et al. 2008; Rick and Fitzpatrick 2012; Rowland and Ulm 2012). Because the sea has provided resources and a means of transport for millennia, a high proportion of significant cultural sites, perhaps numbering millions, are located near coastlines (Erlandson 2012). Rising sea levels will, however, extend the reach of storm surge (IPCC 2013), resulting in greater beach, cliff and sand barrier retreat and salt water inundation of floodplains, which in turn will increase rates of destruction of archaeological sites (FitzGerald et al. 2008; Murphy et al. 2009).

Internationally, archaeologists have begun developing methods to assess climate change risk to individual cultural sites. The general strategy has been to dedicate limited conservation resources to those determined to be most at risk of loss or damage. Approaches have been independently developed in England (English Heritage 2007), mainland and island states of the USA (Westley et al. 2011; Johnson et al. 2015; Reeder-Myers 2015), Scotland (Dawson 2015), France (Daire et al. 2012), Belgium (Dupont and Van Eetvelde 2013), Ireland (Daly 2014) and New Zealand (Bickler et al. 2013). The various approaches tend to be top-down, that is, designed primarily for implementation by government heritage managers and academic researchers. However, in some cases, citizen scientists from local communities have been invited to review prioritisation and contribute to monitoring and conservation plan implementation (e.g. ALeRT 2016; CITiZAN 2016; Shorewatch 2016) or to record threats to neglected sites on private property (Mazel et al. 2014).

UNESCO (2006) argued that involving local communities in the investigation of climate impacts on cultural sites and in developing adaptation strategies is fundamental if action is to be successful. Heritage resources are scarce, and when there is a lack of down-scaled climate projections, community experiences of extreme weather impacts become important sources of information (IPCC 2014). In an Indigenous context, cultural site custodians tend to have a

greater exposure to the natural environment and are able to share vital traditional knowledge (IPCC 2014). Indigenous custodians in Australia, for example, are particularly concerned about the consequences of climate change for their cultural sites and regard managing impacts as an unfulfilled, priority need (Carmichael 2015).

Many communities, however, are not given the opportunity to participate in a cultural site adaptation program. Not because consultation is off the agenda, but simply because no program exists (Cassar et al. 2006). This is particularly the case for Indigenous communities. Socio-economic disadvantage, remoteness and political marginalisation increase vulnerability to climate change (Ford et al. 2006; Altman and Jordan 2008; Green et al. 2009). A lack of archaeological management resources and cross-scale heritage conservation support contribute to cultural vulnerability (Tacon and Marshall 2015).

In the continued absence of outside support, local and Indigenous land managers stand to benefit from planning tools or decision-support products aimed at guiding local management of climate impacts on cultural sites (Carmichael 2015; Carmichael et al. 2017).

In light of the above, the objective of this study is to develop a standard climate change risk-assessment methodology for cultural sites, suitable for practical use within adaptation planning processes controlled by local and Indigenous communities. It does so by reviewing the diversity of existing approaches in terms of suitability to a bottom-up planning process and synthesising a method likely suitable for independent community application. The synthesised method, an in situ field survey approach, was subsequently tested in two case study locations by Australian Indigenous natural resource managers and custodians of rock art and midden sites. These custodians' findings led to revised iterations of the tool, producing a final version significantly different to the progenitor. This paper reports on the modifications, as well as the prioritisation results it generated. It concludes with a discussion about the vital role of community managed adaptive measures within a global strategy for cultural sites, viewed through the lenses of Indigenous land management, cultural heritage and good climate adaptation practices.

2 Conceptual and methodological frameworks

2.1 Planning tools

Community stakeholder involvement is critical to successful adaptation (Jones and Preston 2011; Raiser 2014). Limited studies of Indigenous community adaptation make the same point (Bird et al. 2013; Leonard et al. 2013 Nursey-Bray et al. 2013).

There can, however, be a disjunct between adaptation planning and adaptation theory (Preston et al. 2011). Many planning tools, including procedural frameworks or decision-support products, have therefore been developed to assist local communities plan (e.g. Dazé et al. 2009; UKCIP 2013; Hinkel et al. 2013). Where planning faces unique challenges, it is useful to produce tools focused on those demands (Preston and Stafford-Smith 2009).

The risk tool developed by this paper is conceived of as one component in a larger, five-step planning guide (Cultural Site Adaptation Guide) set out by Carmichael (2015). The five steps of the Cultural Site Adaptation Guide are as follows: (1) scoping, (2) risk analysis, (3) option analysis, (4) planning and implementation and (5) review. This paper focuses on the second step, risk analysis, while Carmichael et al. (2017) focuses on the scoping step.

2.2 Risk analysis and climate change

Traditional approaches to climate risk analysis combine measures of (a) the *likelihood* of a consequence with (b) the *magnitude* of the consequence (Willows and Connell 2003). An overemphasis on biophysical or hazard approaches has been criticised for failing to consider the system's social context and therefore its capacity to adapt (Smit and Pilifosova 2003). In response, a vulnerability approach to risk assessment conceptualises vulnerability in terms of degrees of *exposure* and *sensitivity* to climate hazards and, additionally, upon the system's *adaptive capacity* over time (IPCC 2001, 2014). A vulnerability approach has been used in assessing climate change impacts among Indigenous communities in the Canadian Arctic (Ford and Smit 2003), the Peruvian Amazon (Hofmeijer et al. 2013) and northern Australia (Bird et al. 2013).

2.3 Risk analysis, climate change and cultural sites

A limited number of archaeological studies have explored systematic climate change risk analysis for cultural sites. The most common approach prioritises sites on the basis of likelihood of impact alone (Table 1), in regard either to the site's proximity to the coast (Reeder-Myers 2015) or to hazard zones mapped on the basis of a climate change projection model (Westley et al. 2011; Dupont and Van Eetvelde 2013). These approaches are particularly useful for broad regional scale landscape assessment but can equally be performed at a local scale (Johnson et al. 2015).

Other studies have taken a traditional hazard or biophysical risk approach, considering the *likelihood* of damage or loss of sites, *sensitivity* to *exposure* and/or the *magnitude of the consequence*. Bickler et al. (2013), for example, used a remote geographic information system (GIS)-based analysis of likelihood of impact complemented by a standardised formula for the consequence of impact for particular site types. Daire et al. (2012) used a field survey to collect data in situ measuring a site's exposure and sensitivity to exposure. Dawson (2015) and English Heritage (2007) used remote GIS analysis and data collected in situ to assess likelihood of damage, combining results with an assessment of the relative archaeological significance of a site.

A third stream, represented by a single study (Daly 2014), engages with vulnerability literature, proposing a framework for an in situ, qualitative vulnerability approach based on *exposure*, *sensitivity* and *adaptive capacity*. An expert assessor interviews managers and local stakeholders to produce a qualitative vulnerability assessment based on stakeholder reactions to climate projections for the site's location.

2.3.1 Amenity to bottom-up planning

Models partly or entirely using remote mapping techniques and computer applications such as ArcGIS (e.g. English Heritage 2007; Westley et al. 2011; Bickler et al. 2013; Dupont and Van Eetvelde 2013; Dawson 2015; Johnson et al. 2015; Reeder-Myers 2015) do not readily avail themselves to independent use by non-professionals. A standardised field survey approach is, however, amenable to non-professional use (Daire et al. 2012; Mazel et al. 2014). Daire et al.'s approach (2012) requires surveyors in situ to choose from a range of given options corresponding to a set of fixed variables in order to generate a standardised score for each site.

Table 1 Review of methodologies for climate change risk assessment of cultural sites

	Reeder-Myers et al. (2015), Johnson et al. (2015), and Westley et al. (2011) *USA* Dupont et al. (2013) *Belgium*	Bickler et al. (2013) *New Zealand*	Daly (2014) *Ireland*	Dawson (2015) *Scotland* English Heritage (2007) *England*	Mazel et al. (2014) *England*	Daire et al. (2012) *France*	KNP-Djelk rangers (2017) *Australia*
Amenity to non-professional use					✓	✓	✓
Risk based on consequence of impact		✓					✓
Risk based on likelihood of impact	✓	✓		✓	✓		✓
Risk based on significance				✓			✓
Risk based on exposure and sensitivity			✓			✓	✓
Considers adaptive capacity			✓				✓
Includes non-climate impacts					✓	✓	✓

2.3.2 Mainstreaming

Mainstreaming climate change risk analysis into broader risk analysis makes practical action significantly more likely (Huq and Reid 2004; Smit and Wandel 2006). The field survey approach (Daire et al. 2012; Mazel et al. 2014) is unique in that it includes exposure and sensitivity to additional non-climate threats, avoiding a scenario in which a site rated as a low climate change priority is lost to another threat not considered.

2.3.3 Uncertainty and adaptation to current extremes

Approaches partly or wholly reliant on climate change projections (Westley et al. 2011; Dupont and Van Eetvelde 2013; Daly 2014; Johnson et al. 2015) are not ideal for local-level adaptation planning. At a local scale, detailed climate trend data and high-confidence, downscaled climate change projections are rarely available and, if so, entail a substantial degree of uncertainty. Local stakeholders, however, are likely knowledgeable as to the extent and impacts of past and recent extreme weather events (Reid et al. 2009). Given future climate change will see an increase in the frequency of extremes, practical expediency may necessitate reducing exposure and sensitivity to *present extremes* as a first step towards adaptation to future climate change (Smit and Pilifosova 2003; Hofmeijer et al. 2013; IPCC 2014).

2.3.4 Monitoring

Where data is scarce, one of the first options in managing climate change is developing appropriate monitoring systems (Rowland et al. 2014). While all the assessment systems not based on climate change projections avail themselves to a monitoring function, a field survey's in situ gathering of a fixed range of data and consideration of non-climate as well as climate exposure (Daire et al. 2012) recommends itself in this capacity also.

2.3.5 Significance

The importance of integrating an assessment of a site's archaeological significance with an assessment of the risk of damage or loss is acknowledged by four studies (English Heritage 2007; Bickler et al. 2013; Daly 2014; Dawson 2015). When immovable sites confront an impact such as sea-level rise, their loss may be inevitable (Cassar et al. 2006). The loss is likely to take place over a very short time period rather than by a slow degradation over an extended time (Bickler et al. 2013) or in a non-linear step process in response to discreet episodes of extreme conditions or changes (Giesen et al. 2013). The loss of one cultural site may be of far greater consequence than that of another. Only Dawson (2013) and English Heritage (2007) incorporate significance assessment into risk assessment. Dawson assesses each site in terms of 'rarity', 'period', 'condition', 'group value' and 'potential' (Dawson 2013; p. 80).

2.3.6 Adaptive capacity

Only Daly (2014) outlines a framework for cultural site climate change risk assessment that includes assessment of adaptive capacity. This vulnerability approach aims to address organisational barriers to adaptation and build resilience.

2.4 The preliminary model: a field survey incorporating cultural consequence

We propose that a field survey based on Daire et al.'s (2012) numerical ranking system incorporate significance assessment in light of Dawson's (2013) and English Heritage's (2007) approach and adaptive capacity in light of Daly's model (2014). The challenge is how to integrate all three approaches.

We find it expedient to assess the adaptive capacity of stakeholders separately from assessment of risks to sites. In a context where sites are being prioritised for management purposes, there is a danger that assessment of the adaptive capacity of stakeholders be confused with the adaptive capacity of sites, which in themselves have no adaptive capacity. Prioritised sites, in many instances, will need to be recorded before their demise. We propose that adaptive capacity assessment focus on workshops discussing stakeholder adaptive capacity, held during the first step, the scoping phase, in the Cultural Site Adaptation Guide. During the third step, the option analysis phase, participants can more clearly focus on ways to increase stakeholder adaptive capacity and thus their overall level of resilience. Hence, assessment of adaptive capacity is not part of the risk analysis phase of the Cultural Site Adaptation Guide presented in this paper.

2.4.1 Indigenous rangers assessing significance

Assessing significance is not without its own challenges. A field survey for non-professional application, for example, would have difficulties in replicating Dawson's (2013; p. 80) assessment of rarity, period, condition, group value and potential.

Absolute notions of scientific significance were abandoned in the post war period in favour of determining which sites best represent a range of archaeological variation (Briuer and Mathers 1996). Assessing the significance of Australian Indigenous sites, Bowdler considered a site's 'representativeness' and ability to 'answer timely and specific research questions' (Bowdler 1981; p. 1). In one of our case studies (see below), research has been prolific, but in the other, no comprehensive survey for each site type has been undertaken to date. This is likely to be the case in many Indigenous contexts internationally.

Although the relativistic approach acknowledges that significance is mutable and dynamic, it still sees significance residing in the physical fabric of the place, rather than something given to a place by those who value it (Little et al. 2005). However, as Sutton et al. (2013; p. 3) eloquently state:

> Values cannot be objectively identified within places, landscapes or objects; they originate and dwell within the hearts and minds of people.

A solution is to determine significance according to cultural values rather than scientific ones and then, where possible, invite archaeologists to review the results. This approach has merit in contemporary thinking on archaeological significance, which questions privileging archaeological significance over Indigenous values (Byrne et al. 2003; Little et al. 2005; Owen and Veale 2015).

Unfortunately, there is currently no rigorous methodology for assessing the cultural value of Australian Indigenous cultural sites (Brown 2008). The simplest solution, therefore, seemed to be for Indigenous land managers to ask Traditional Owners[1] or traditional custodians to rate relative cultural value during the field survey. The preliminary risk tool proposed asking

[1] The Aboriginal Land Rights Act (1976) describes 'traditional aboriginal owners' as local descent groups with primary spiritual responsibility for sites and land.

custodians if cultural sites were (a) very important, (b) quite important, (c) important, (d) a little important or (e) not important.

3 Case studies

Australian Indigenous rangers manage an Indigenous-owned and controlled estate that constitutes almost 20% of the Australian continent (Altman and Jordan 2008). Indigenous rangers undertake natural and cultural resource management including fire, feral animal and weed management. Two ranger groups took part in the project: Indigenous rangers from Kakadu National Park and rangers from the Djelk Indigenous Protected Area, both in far north Australia.

3.1 Kakadu National Park rangers (Fig. 1)

Kakadu National Park covers 19,804 km^2 (the approximate size of Wales, UK) within the Alligator Rivers region in the Northern Territory. Declared in 1979, the Park is inscribed on the UNESCO World Heritage List for both its exceptional natural and cultural values. While around 5000 rock art sites have been recorded, it is likely 10,000 to 20,000 remain unrecorded (Agnew et al. 2015). Occupation has been dated from at least 50,000 years (Clarkson et al. 2015; Roberts et al. 1990), and rock art reveals insights into Indigenous hunting, gathering, societal structure and rituals from 28,000 years until the present (David et al. 2013). The Park

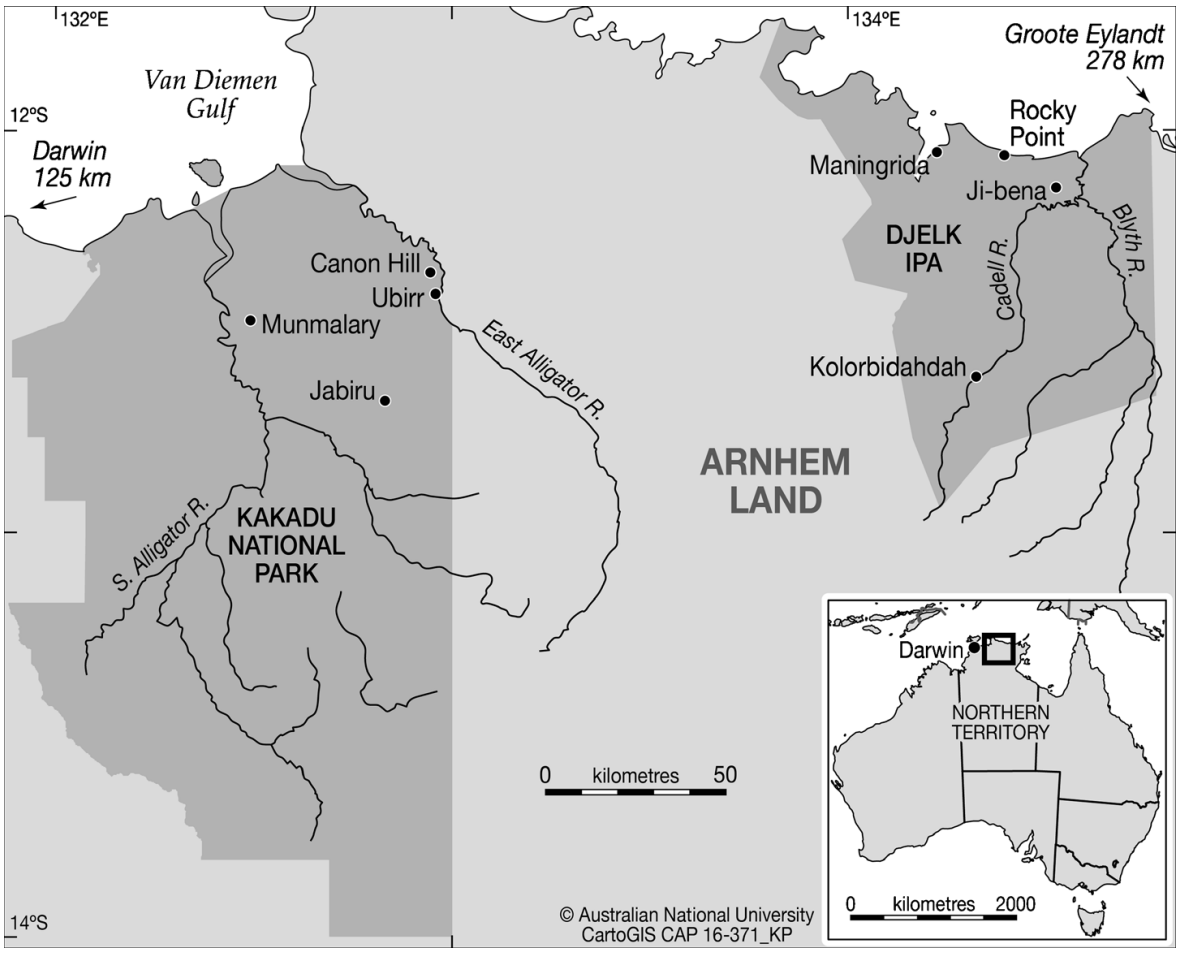

Fig. 1 The locations of the two case studies in the Northern Territory, Australia

database is extensive, reflecting intense survey over the years (e.g. Kamminga and Allen 1973; Jones 1985; Hiscock et al. 1992; Chaloupka 1993; Tacon and Brockwell 1995). Around a third of Kakadu's rangers are Indigenous men and women (Kakadu Board 2014). The Park has been administered jointly by the Australian Government and Traditional Owners since its inception, though all decisions must be ratified by the former.

3.2 Djelk rangers (Fig. 1)

The Djelk Indigenous Protected Area[2] (Djelk IPA) covers over 14,000 km^2 of land and sea country. It too contains exceptional natural and cultural values, including 12 separate language groups. Remoteness and a lack of formal scientific exploration have meant that site documentation has been limited (Brandl 1988; Meehan 1982; Brockwell et al. 2005). The Djelk rangers began operating in 1991 with the IPA being declared in 2009. Djelk employs over 30 men and women full time, almost all of whom are Traditional Owners. As a subsidiary of Bawinanga Aboriginal Corporation (BAC), Djelk is directed by an Indigenous executive committee. Djelk receives funding under the Australian Government's 'Caring for our Country' initiative (Kerins 2012, Australian Government 2013), as well as through sales of carbon credits from broadscale fire management.

3.3 Climate change projections for the case studies

Ranger perceptions of climate related impacts are consistent with climate change projections for Australia's monsoonal north (Carmichael 2015). These projections (Moise et al. 2015) are as follows:

- Mean sea level will continue to rise (*very high confidence*).
- Height of extreme sea-level events (storm surge) will increase (*very high confidence*).
- Intensity of extreme rainfall events will increase (*high confidence*).
- Tropical cyclones will be fewer but more intense (*medium confidence*).
- Total rainfall changes are possible but unclear.
- Average temperatures will continue to increase (*very high confidence*).
- Numbers of hot days and warm spells will increase (*very high confidence)*.

In 2011, sea-level rise off the northern Australian coast was averaging 8.6 mm per year at Darwin and 9.0 mm per year at Groote Eylandt (National Tidal Centre 2011), with rates significantly above global averages.

4 Methods

4.1 Participatory action research

This study used a participatory action research (PAR) methodology. PAR is initiated by a group, organisation or community to solve an immediate problem that members themselves experience.

[2] Indigenous land owners nominate their estates as IPAs, which are subsequently recognised as part of the National Reserve System and attract government resourcing.

Members of an organisation use an iterative cycle of investigation that aims to develop better work practises, often developing best-practice guidelines (Lewin 1946; Stringer 2014).

Preliminary trips were made to three potential case study areas. Semi-structured interviews were conducted with community leaders, rangers, Traditional Owners and organisational support staff to determine if climate change impacts on cultural sites had been perceived, and if so, whether addressing them was a priority need. Respondents in the current two case studies were keen to address their strong perceptions of rapid sea-level rise and increased inland flooding impacting cultural sites (Carmichael 2015). Respondents in a third case study perceived climate changes, but no resulting impacts on cultural sites.

The main body of fieldwork began with the testing of the scoping phase of the Cultural Site Adaptation Guide. Participants were either self-selected or selected by the ranger groups. The scoping workshops included discussion of several methodological options. Site-based risk analysis was selected by participants in both case studies as the primary mode of investigation, with organisational adaptive capacity an additional priority. As one ranger put it:

> That's the good one: risk analysis … for future generations; so [X, a Traditional Owner] can pass that information [i.e. sites assessed as most at risk] on to his kids.

Further workshops were conducted during development of the risk analysis tool and during analysis of adaptation options. Seven workshop and result-reporting meetings took place with Djelk rangers. These involved 35 participants, of which four were female. Five focus group and result-reporting meetings took place with Kakadu National Park (KNP) Indigenous rangers. These involved ten participants, one of whom was female. The workshops lasted between 1.5 and 2.5 h.

Semi-structured and informal interviews took place throughout all phases of the research. Multiple interviews with Djelk rangers, support staff and Traditional Owners involved 12 participants, of whom three were female. Interviews with KNP Indigenous rangers, support staff and Traditional Owners involved 16 participants, of whom 11 were female.

Identification of site types perceived as in danger, their general locations and the nature of the climate change threats impacting them, took place in the workshops cited above. These perceptions were then investigated in the field. Site types in locations of concern were visited and assessed using the preliminary risk analysis tool. Observations of participant use of the tool, their difficulties, concerns and suggested modifications were recorded via field notes and voice recordings. Field testing of the risk analysis tool involved six Djelk and seven KNP Indigenous rangers, selected during scoping workshops.

4.2 Data analysis

Workshop and interview audio recordings and audio recordings of participant observations were transcribed and, along with field notes, organised digitally according to participant and date using NVivo 10 qualitative data analysis software. Content analysis framed by the scoping and risk analysis frameworks was performed to identify themes relating to impacts, goals, methods, resources, barriers, leadership and ownership, as well as field survey variables for cultural value, site exposure and site sensitivity. Strategies to manage potential biases in data collection included reports back to participants and reviews of manuscripts and of quoted dialogue by participants and support staff. Cross-referencing of narratives obtained in the workshops with interviews and participant observation enabled assessment of consistency and credibility of findings.

4.3 Ethics

The study followed standard ethical norms, including obtaining university ethics approval (Australian National University no. 2014-342, Charles Darwin University no. H14022), eliciting informed consent from all study participants, reviewing results with and presenting results back to communities prior to publication and not divulging the locations of 'sacred' sites.

5 Results

Three sets of results are presented: (a) confirmation of rangers' perceptions of the types of cultural sites impacted, the impacts and the locations of these sites; (b) changes made to the preliminary field survey; and (c) the prioritisation of sites produced by the tool.

5.1 Confirmation of perceptions and establishing exposure units

During research for the Scoping phase of the Cultural Site Adaptation Guide, rangers identified site types they perceived to be at risk, the climate change impacts such sites were being exposed to and the types of land forms in which such sites might be found (Carmichael et al. 2017). During field explorations, the following sites were found that provided confirmation of these perceptions.

5.1.1 Riverine rock art

Djelk rangers investigating rock art sites on the upper Cadell River, south of Kolorbidahdah (Fig. 1) found five sites within 5 m of the river, less than 5 m above it and in sections of the river that pass through narrow gorges. At one of these sites, white-ochre paintings of kangaroos in x-ray style were almost entirely faded below a distinct line horizontally dissecting them. The location of the paintings on a rock face inaccessible to buffalos confirmed that the line dissecting the paintings did not represent the height limit of feral-animal rubbing. Flood debris caught on an adjacent elevated rock outcrop at the same level as the art work confirmed that the dissecting line resulted from an extreme flood event or events. The presence of water-compacted, fine-grade leaves and twigs among large logs suggested that the flood event was quite recent. Another four sites in close proximity to the river also had fine-grade flood debris in the stems of immature saplings at heights level with the art. While heavily faded red-ochre art was present at levels below those of the flood debris, no white ochre art work existed below these lines.

5.1.2 Floodplain rock art

KNP Indigenous rangers found floodplain-fringing rock art at close proximity to and at a low elevation above a floodplain near a creek inflow south of Ubirr (Fig. 1). A large log, likely flood debris, was stranded on a rock outcrop at a height less than 2 m below an adjacent rock art painting.

5.1.3 Coastal middens

In the Djelk IPA, in the vicinity east of Rocky Point (Fig. 1), severely eroded coastal middens on beaches fronting dune barriers were located. At a severely eroded coastal river mouth in the vicinity of Rocky Point, rangers located a site at which cyclonic storms only months earlier

(Tropical Cyclone Nathan, March 2015) had cut a visible swathe 20 m wide through riparian trees, destroying all traces of a river- and beach-based midden complex observed intact by rangers in the months prior to the cyclone.

5.1.4 Floodplain middens

KNP Indigenous rangers also found evidence of erosion from extreme flooding at floodplain midden sites. A very large, 50 m × 50 m, deflated earth midden was located on a slight rise within the South Alligator River floodplain north of Munmalary (Fig. 1). The substantial midden had substrate flood erosion at its perimeter. It was located very close to a channel, along which new colonisation by mangroves was taking place. Mangrove encroachment in freshwater areas is an evidence of salt water intrusion (Winn et al. 2006). Deflation of the midden had exposed human skeletal remains of two individuals, numerous stone artefacts, a stone axe head and the ochre cache perhaps of an ancestral artist.

5.2 Changes to the preliminary model

The preliminary field survey was therefore applied to and modified to accommodate the characteristics of (a) floodplain and riverine rock art and (b) coastal and floodplain middens. The preliminary model contained *ten exposure and sensitivity variables*, each with *five assessment options* from which surveyors could choose. The changes, discussed in the following sections, resulted in a revised model (Table 2) that replaced these with 15 *exposure and sensitivity variables*, each with *three assessment options*. The preliminary significance assessment contained *five assessment options*; the revised significance assessment method replaced these with *three assessment classes*.

5.2.1 Reduction of the range of assessment options

The preliminary model required surveyors to choose one of five possible assessment options for each variable. Qualitatively assessed variables, such as that for biological hazards, required the surveyor to choose from either ‘very active’, ‘active’, ‘moderately strong’, ‘weak’ or ‘almost inactive’. Rangers, however, found distinguishing between the options difficult. We experimented with binary options of either ‘yes’ or ‘no’, but in variables concerned with qualitative assessment of impacts, rangers were confronted with sites at which a midway measure was required. The range of options was finally changed to three: ‘strong’, ‘some’ or ‘none’ (Table 2). Wherever possible, however, strong, some or none were replaced with questions specific to rock art and middens. For example, the sensitivity of rock art was gauged on the basis of the painting’s ochre type: ‘red’ stood in for ‘strong’; ‘yellow’ for ‘some’; and ‘black/white/wax’ for (almost) none (Wesley et al. 2014). Similarly, the sensitivity of middens was gauged by the solidity of the structure: ‘solid’ stood in for strong, ‘soft’ for some and ‘scattered’ for none.

To be consistent, quantitative assessment options, mainly the proximity of hazards, were also reduced to three (see Table 2). The three increments of proximity used were chosen on the basis of local conditions. Rangers observed dune systems extending up to 400 m from the tidal edge. Because the Arnhem Land coast generally has a very shallow incline, with a slope value of <6°, we rated sites up to 100 m from the tidal edge as being the most exposed and those beyond 400 m as the least.

Table 2 A methodology for local-scale, climate change risk assessment of Indigenous cultural sites

A—Exposure				
Hazard types	Variables	Assessment options		
		Option A	Option B	Option C
Human	Proximity of township or outstation	Township <4 km	Outstation <4 km	Neither <4 km
	Proximity of tourism or hunting/gathering	Tourism <4 km	Hunt/gather <4 km	Neither <4 km
	Proximity of graded road or track	Graded road <4 km	Track <4 km	Neither <4 km
Climate change and extremes	Proximity to tidal edge/river	<100 m	100 to 400 m	>400 m
	Height above tidal edge/river	<2 m	2 to 6 m	>6 m
	Geomorphology:	Narrow gorge	Wide gorge	None
	◦ *Rock art*—gorge: location and breadth	<100 m	100 to 400 m	>400 m
	◦ *Floodplain midden*—proximity of channel	<100 m	100 to 400 m	>400 m
	◦ *Coastal midden*—proximity of river mouth			
Biological	Feral animals and weeds—impact	Strong	Some	None
	Native flora/fauna—impact	Strong	Some	None
	Fire hazard—vegetation and detritus build up	Large	Some	None
Natural weathering	◦ *Rock art*—fading	Very faded	Some fading	None
	◦ *Midden*—degree of deflation	Completely flat	Minor elevation	Steep sided
B—Sensitivity				
Sensitivity factors	Variables		Assessment options	
		Option A	Option B	Option C
Nature of remains	◦ *Rock art*—ochre type	Red	Yellow	Black/white/wax
	◦ *Midden*—structure	Solid	Soft	Scattered
Nature of substrate	◦ *Rock art*—rock hardness	Hard	Soft	Crumbling
	◦ *Midden*—doil type	Clay	Soil	Sand
Natural protection	◦ *Rock art*—rock overhang	Deep rock shelter	Some overhang	No overhang
	◦ *Midden*—tree consolidation	Strong	Some	None
Built protection	Fence—effectiveness	Well maintained	Unmaintained	None
Legal protection	Site is (a) on Indigenous owned land or (b) listed under heritage protection legislation	Both (a) and (b)	Either (a) or (b), but not both	Neither (a) nor (b)

5.2.2 Additional exposure and sensitivity variables

The height of a site above the tidal edge or river was a concern. While the Arnhem Land coast generally has a shallow incline and unconsolidated sediment, cliffs do exist and rangers recorded some middens within metres of the tidal edge but atop relatively high consolidated cliffs. At the same time, cyclone-derived storm surge can potentially extend very great distances in areas where there is an exceptionally low coastal slope, putting low lying shell middens more than 400 m from the tidal edge at an accentuated risk.

The height of rock art above rivers and floodplains was also a concern. While rangers documented rock art located very close to rivers, some sites were relatively high on the rock face and probably out of reach of even the most extreme floods.

We therefore complemented the variable of *proximity to* tidal or river edge, with a second climate change hazard exposure variable, *height above* tidal or river edge (see Table 2). Sites more than 6 m above the tidal or river edge were rated as the least sensitive and those less than 2 m above it as the most sensitive.

Observations of particular geomorphological risk factors at sites prompted addition of a third climate change risk variable, geomorphology. The assessment was modified to account for the location of: (a) rock art in a gorge, where a bottleneck-effect extenuates the height of flooding; (b) a floodplain midden's proximity to a channel, where water moves at speed; and (c) a coastal midden's proximity to a river mouth, where salt water flooding can be accentuated by simultaneous fresh water flooding.

The catch-all variable of 'biological' hazards was another issue for rangers. They indicated that the field survey should account for extreme damage done by feral buffalos and pigs observed at many shell midden and rock art sites. Rangers also related instances of damage to sites from fire, and many sites were observed to have a significant build-up of detritus and vegetation, sometimes exotic. Rangers concluded that the hazard of vegetation burning should be distinguished from the threat of mechanical damage (rubbing) to a site by vegetation animated by wind. The biological hazard variable was therefore divided in three: (a) feral animals and weeds, (b) fire and (c) native flora and fauna.

By the same token, it was noted that the best preserved coastal middens often had trees growing in them and that rock overhang at rock art sites also leant protection to rock art sites. A new sensitivity variable was therefore added: natural protection.

5.2.3 Cultural significance assessment options

Initially, rangers asked Traditional Owners to rate sites as either (a) very important, (b) quite important, (c) important, (d) a little important or (e) not important. Invariably, however, all sites were described as 'very important'. Shell mounds and middens in the Djelk IPA have a wide range of age and dimensions. We dated a small, shallow midden with burnt shell deposits, without an associated Dreaming story[3] or surface implements, at 149 cal. BP (Wk-42262). In contrast, a shell mound Dreaming site over 4 m tall and 40 m in diameter with stone tools on its surface was dated at 789–467 cal. BP (ANU-2021 Brockwell et al. 2009); its age at ground level might be considerably more, but no older than the establishment of the chenier beach ridge, with which it is associated, at c. 1000 years BP (Brockwell et al. 2005). Both these

[3] The term 'Dreaming' represents many Australian Indigenous cosmologies in which the land was once inhabited by ancestral figures, often of heroic proportions or with supernatural abilities.

middens, however, were described as 'very important sites' by their respective Traditional Owners.

In rethinking the issue, it was found that other studies documented similar difficulties. Sutton learnt that when asked, Indigenous Traditional Owners insisted that 'all our sites are of high significance' (Sutton et al. 2013; p. 9). The context of Sutton's inquires was destructive development (coal mining), a context in which an Indigenous statement of relative cultural significance might save a site or doom it to destruction. Yet, in a conservation context, Djelk and KNP rangers and Traditional Owners expressed the same very important evaluation of all sites.

The International Council on Monuments and Sites (ICOMOS) in Australia defines 'cultural significance' in terms of 'aesthetic, historic, scientific, social or spiritual value' (Australia ICOMOS 2013). 'Social' is defined in terms of 'group' or 'community identity'. There is, however, little in the way of detailed guidance in assessing site cultural significance beyond this. During the scoping phase, rangers and Traditional Owners discussed why cultural sites were important to them, without reference to the five ICOMOS categories. The explanations provided, however, were broadly in keeping with three of the five ICOMOS indicators of cultural significance (Table 3). Notably, no aesthetic or scientific explanations of value were provided.

Accordingly, questions were developed (Table 4) to gauge the cultural significance of sites in terms of three priority *classes* of evaluation rather than a scale, i.e. group identity value, historic value, and spiritual value. As middens and rock art sites are the focus of the climate change project, cultural significance questions specific to these site types were developed.

The schema therefore assumes *all sites* are very important from the outset: Group identity value is taken as a given for all middens and rock art and is the default position. If a site was not classified as culturally significant in terms of historical value but culturally significant in terms of spiritual value, it was rated class three. The schema was workshopped and discussed individually with rangers and Traditional Owners. All respondents were happy to prioritise the

Table 3 Ranger explanations of cultural significance allotted to ICOMOS significance categories

ICOMOS categories of significance	Example statements from interviews and workshops with Indigenous rangers from KNP and Djelk IPA
Group identity	◦ 'It's very important because I think a lot of those sites they may not define a single person, but they define a whole clan group, sometimes they make a clan group who they are'. ◦ 'Sites are who I am'; ◦ 'They are in our blood, all those sacred sites … our body and Spirit';
Historic	◦ 'The stories are about how we lived off the land, and some of them may point to how we still need to care for the land'; ◦ 'If we lose these sites then a lot of us will lose connection to land'; ◦ 'How will we know what to paint if the rock art goes?'
Religious	◦ '[If] I see everything damaged I might feel myself bad, and I might see the country dying, slowly; all that Dreamtime there, that country, you have to keep it healthy. If that all gone, then we lose everything. We will probably lose our Song Lines if all that country gets damaged'; ◦ 'For our ancestors, we have to look after [sites] for our ancestors. We have to keep going back and checking it. Keep talking, keep talking to the Spirit, making it settle down, making it good'.
Scientific	◦ Nil
Aesthetic	◦ Nil

Table 4 A method for assessing Indigenous values for cultural sites

Value type	Questions for Traditional Owners and Caretakers about midden and rock art sites	Cultural significance class
Group identity value	No questions: ◦ Group identity value is a given for all midden and rock art sites.	One
Historic value	Does the midden or rock art site contain or have: ◦ a name, traditional or modern? ◦ tools (or tool impacts, such as grind holes), which show us how old people lived on country? ◦ pictures that show us: how old people looked, hunted, gathered, fought, their tools, and what they noticed about white fellas? ◦ pictures good for showing us how to paint things?	Two
Spiritual value	Does the midden or rock art site have: ◦ a Dreaming story? ◦ a burial (bones) in it or nearby? ◦ a ceremony site at it or nearby? ◦ secret or 'dangerous' knowledge? ◦ pictures showing spirits, half-animal half-people beings, sacred animals, or a ceremony?	Three

three classes, with spiritual value as the highest priority and group identity value as the foundational priority but both *within* the overall category of very important.

5.3 Prioritisation outputs

In the original model conceived by Daire et al. (2012), the five assessment options are each represented by a numerical score: very active = 1, active = 0.8, moderately strong = 0.6, weak = 0.4 and almost inactive = 0.2. In our revised model, strong = 1, some = 0.6, and none = 0.2. As in the original model, the exposure scores were added together to create a score for total exposure, as were the sensitivity scores to create a score for total sensitivity. The total score for sensitivity was deducted from the total score for exposure to produce a total score for likelihood of loss or damage. Unlike the original model, we were then able to combine likelihood of loss or damage and cultural significance (consequence) scores for each site in a management priority matrix, giving rise to one of five possible management priorities: 'very low', 'low', 'medium', 'high' or 'very high'.

It should be noted that combining the potential impact components of vulnerability assessments (exposure and sensitivity) in this way, as a proxy for 'likelihood' of loss, with an independent and innovative assessment of 'consequence' of loss, provides a natural and practical reconciliation between the traditional risk assessment method (e.g. Willows and Connell 2003) and the climate vulnerability methods and thus combines the advantages and insights of both approaches.

As an example, rangers assessing a site near a creek in the Canon Hill area of Kakadu National Park (Fig. 1) gave it a very high management priority (Table 5). Firstly, its likelihood of loss or damage score equalled 2.6. Secondly, it was assessed as 'class three' cultural significance, due to paintings depicting spirits and ceremony and the site's associated Dreaming story. In the field survey's management priority matrix, a likelihood of loss or damage score greater than 2 and a cultural significance score of 3 converge on a very high management priority rating.

Table 5 Prioritisation case study: a rock art site in Kakadu National Park. Management priority: 'very high'

Likelihood of loss or damage				**Consequence**	
EXPOSURE	score				
Town/outstation	.6				
Tourism/hunting	.2				
Graded road/track	.6				
From tidal zone	1				
Above tidal zone	.6	**SENSITIVITY**	score		
Gorge	.2	Ochre type	1		
Feral damage	.2	Rock hardness	.6		
Native damage	.6	Rock overhang	.6	**CULTURAL SIGNIFICANCE**	score
Fire hazard	1	Fence	.2		
Weathering	.6	Legal gazette	.6	Pictures of spirits/ ceremony; site has a Dreaming story	**class 3**
Total Exposure	**5.6**	**Total Sensitivity**	**3.0**		
score for **Likelihood of loss or damage = 2.6** (Total Sensitivity subtracted from Total Exposure)				score for **Consequence = 3**	

		Management priority		
Likelihood of loss or damage	**> 2**	medium	high	very high
	1-2	low	medium	high
	< 1	very low	low	medium
		1	**2**	**3**
		Consequence		

Using this process, over 120 sites were assessed by rangers across the two study areas (Table 6). Of these, 13 sites are rated as a very high management priority and 25 a high priority. These preliminary assessments are a very small fraction of total sites within each ranger group's domain. The majority of the shell middens and many of the rock art sites assessed were formally recorded for the first time. It is beyond the scope of this paper, however, to provide a detailed analysis of these results.

6 Discussion and Conclusion

Despite extensive discussion of global warming, rising seas and coastal erosion, there has been relatively little global recognition of the perils facing possibly millions of cultural resources along the world's coastlines.

This study contributes to a small but growing body of scholarship examining practical responses to this grave issue (English Heritage 2007; Westley et al. 2011; Daire et al. 2012;

Table 6 Prioritisation results for Djelk IPA and Kakadu National Park cultural sites

	Exposure/ sensitivity score			Cultural significance class			Management priority rating				
	Low	Med	High	One	Two	Three	Very Low	Low	Med	High	Very High
No. of rock art sites (25 in total)	6	7	12	2	2	21	0	2	7	6	10
No. of midden sites (101 in total)	2	8	91	76	22	3	1	5	73	19	3
Total	8	15	103	78	24	14	1	7	80	25	13

Bickler et al. 2013; Dupont and Van Eetvelde 2013; Daly 2014; Dawson 2015; Johnson et al. 2015; Reeder-Myers 2015). The majority of this scholarship has been conducted in relation to non-Indigenous heritage, and as such, the focus on adaptive approaches to Indigenous cultural sites by Indigenous custodians in our study contributes some unique insights. These insights have significant values at various levels—locally in the case study areas themselves, more generally to Indigenous heritage locations around Australia and more broadly again in international/global approaches and strategies. As our study combined several disciplines, the insights can also be viewed through these lenses—particularly for Indigenous land management, for archaeological heritage studies and for climate adaptation approaches.

6.1 Local case study insights

Lack of local-scale support for Indigenous custodians necessitates the development of tools for independent risk analysis and responses.

This study identified a field survey approach to risk assessment as the most appropriate for local application. A preliminary field survey considered non-climate as well as climate impacts, allowing under-resourced communities and 'citizen scientists' to integrate assessment of climate change threats to cultural sites, with general threats.

The overly generic approach of the preliminary field survey, originally designed to assess potential impacts on everything from Neolithic burial tombs to post Medieval and twentieth century military features, was problematic. Indigenous land managers had a relatively narrow focus—rock art and middens. Nevertheless, they had the organisational capacity to significantly modify the preliminary model and ultimately allot sites to one of five management priority rankings. Reducing the range of assessment options from five to three greatly improved the consistency between independent assessments. Indigenous land managers also added two additional variables for climate change threats: geomorphology and height above hazard. Tourist activity in one of the case studies justifies the inclusion of the three separate human impact variables: proximity of township or outstation, proximity of tourism or hunting/gathering and proximity of graded road or track. However, the remoteness of the locations and their propensity for monsoonal climatic extremes warranted a greater weighting to climatic impacts. The additional variables are considered in some GIS-based models: geomorphology by Dawson (2015) and Reeders-Myer (2015) and height above hazard by Reeders-Myer (2015) by way of coastal slope.

Indigenous land mangers' concerns about fire damage to cultural sites are supported by studies underlining fire's destructive potential for rock art (e.g. Gunn 2011). Further studies also suggest that fire regimes in northern Australia are impacted, indirectly, by climate change

(e.g. Russell-Smith and Edwards 2008). Similarly, the IPCC (2007) and others (e.g. Sheppard et al. 2008) argue that climate change will increase the spread of feral-animals and weeds, hence the importance of this research.

The cultural assets at threat from changing climatic conditions considered here are highly valued and vital to identity and ongoing cultural practice. Assessing risks and planning for future impacts must take the cultural value of sites into consideration. The research identified this as a deficit in the field survey approach, modifying the survey to include a novel assessment of cultural significance in line with broad cultural significance categories. Although these categories were derived from the world body tasked with setting standards for cultural conservation, ICOMOS, they proved applicable at the local level.

The innovations and improvements that emerged organically from field testing, and the usability of the outcomes, confirm the utility of the participative action research approach used. Results also represent an early affirmation of the high adaptive capacity of Indigenous land managers, not only in terms of conducting independent risk assessments but also in terms of formally recording previously undocumented sites and undertaking a monitoring process. Results also evidence the potential of Indigenous land managers within those locations to advance to the next stages of site management. These include an option analysis phase in which adaptive capacity is overtly workshopped and plans developed for capacity building and delivery of adaptation actions.

6.2 Broader insights

6.2.1 Indigenous land management

Insights from this study have implications for global responses, not only just in terms of Indigenous stakeholders but also for independent endeavours among any local community bereft of professional, state or non-government organisation (NGO)-based cultural site management coordination. Furthermore, where there *is* a context of regional coordination, there are implications for increasing local ownership and influence over policy development and planning.

Further testing of the risk survey tool in different contexts might result in the accumulation of variants on the model for different site types. These variants could conceivably be shared among a community of users, regionally, nationally and globally. The testing and use of the field survey by land managers at inland riverine cultural sites mean that its application can go beyond a purely coastal application and have more widespread application around Australia and elsewhere.

The cultural significance assessment component of the field survey developed here was not inclusive of the aesthetic and scientific classes of significance outlined by ICOMOS. In other contexts, these factors might be seen as important, and the survey accordingly reconfigured to include them.

The success of the field survey developed here recommends it to digitalisation and application in GPS-controlled tablets that are designed to log natural resource management data. Such devices have been taken up by Indigenous land managers across northern Australia and by other Indigenous land managers elsewhere in the world (NAILSMA 2014). Digital application of the risk tool has the potential to seamlessly incorporate assessment of impacts on cultural sites into the broader workflow of local land managers. If digitalisation is successful, making these relatively inexpensive devices available to local and Indigenous land managers might be a priority for governments and NGOs globally.

6.2.2 Archaeology, cultural heritage and climate studies

The study confirms that a global strategy for addressing climate change impacts on cultural sites cannot be focused exclusively on measuring impacts, it must also highlight the value of what is at risk. Article 8 of the COP21 Paris Agreement introduced a notion of residual climate risks and climate impacts, dubbed 'loss and damage'. There is now a need to address the valuation of loss and damage to cultural sites for the purposes potential recompense.

Lessons learnt and experiences gained by local people adapting sites to climate impacts, particularly Indigenous people battling economic marginalisation, represent the development of skills valuable not just to their own communities but also to the global community. Indigenous land managers may be able to develop and provide adaptive heritage services worthy of financial support on the basis of supplying a valuable public good, as they do in terms of natural resource management (Altman 2009). Their cultural sites are, after all, of value to the world community.

Work in this area must entail publicising the impacts and potential losses that local communities highlight not just in order to attract support for cultural site adaptation but also to inspire greater global efforts to mitigate greenhouse gas emissions.

6.2.3 Climate adaptation approaches

Our study has shown that many of the principles and approaches developed and applied in other climate change adaptation contexts (e.g. Webb and Beh 2013; pp. 16–19) can be equally and usefully applied to less studied, remote Indigenous environments. Examples include the following:

- Incorporation of non-climate as well climate driven risks into the process, consistent with preferred 'mainstreaming' approaches and 'integrated solutions' to adaptation
- Locally driven and owned approaches consistent with 'community-based adaptation' approaches, with high levels of local engagement and leadership that can reflect local values, knowledge and capacities. Such 'bottom-up' approaches are a crucial starting point that can be complemented by 'top-down' approaches (e.g. regional coordination or expert archaeological review of cultural significance assessment) in subsequent stages
- The importance of understanding both social and institutional contexts, noting, for example, the distinction between the two case studies with whom the research described here was undertaken, and a third in which there was a lack of perceptions of climate change impacts on cultural sites
- Building an approach that facilitates reflexive learning and continued iteration, which can continue through the field survey's ongoing monitoring process as well as continued improvement and modification of the field survey itself
- The applicability of standard risk and vulnerability assessment approaches as a cornerstone of local community adaptation practice.

Further to the latter point, it was found that by using consistent and practical definitions of key concepts, it was possible to effectively use and completely reconcile risk management and vulnerability methodologies. This is counter to the view often expressed in the literature and practice that concepts such as *likelihood of damage or loss* and *vulnerability* are alternative or even competing paradigms.

6.3 Conclusion

The multiple insights and outcomes from our study support the view that practical and rigorous approaches can be taken to climate adaptation of cultural heritage sites even where resources are likely to be severely constrained.

The development of global strategies to combat climate impacts on local and world heritage has stalled since first steps were taken at the beginning of the millennium (UNESCO 2006). Renewed efforts need to adopt standard climate change risk terminology for cultural sites; facilitate risk analysis across global, regional and local scales; and create links between those working independently at a local scale in order to share knowledge and insights born of empirical experience. Future reports of the IPCC and programs of the UN Framework Convention on Climate Change need to increase incorporation of archaeological resources and research.

Work in the field of Indigenous community adaptation to climate change is also in its infancy, and there remains a need for practical and accessible adaptation planning pathways for Indigenous peoples in general. Essential for further work in this area is the integration of communities and Indigenous organisations that combine local knowledge, experience and scientific practice, with global planning efforts to confront climate change.

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Chapter 5

High tide for heritage

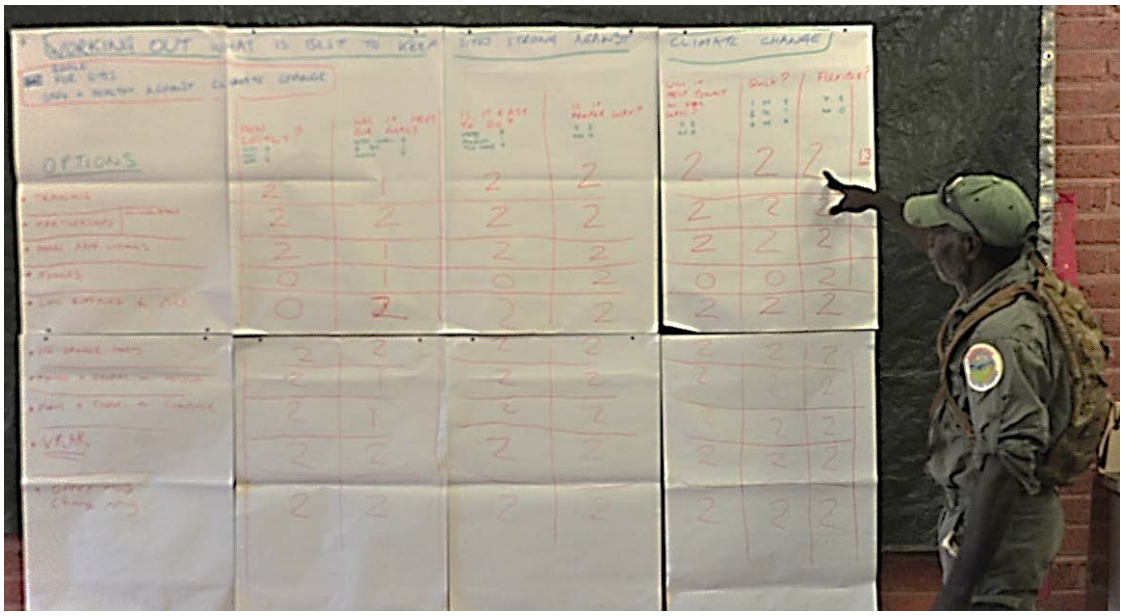

Figure 1A. Using the option appraisal matrix.

During field work in 2015, Djelk Ranger Greg Wilson scores options using a matrix comprising, on one axis, identified options and, on the other, seven assessment criteria.

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Bethune Carmichael Wrote the paper, collected and conducted all analysis of data; facilitated all Option step workshops; and conceptualised the Options step of the Cultural Site Adaptation Guide (the Guide).

Signed .....

Greg Wilson Participated in the testing of the Options step of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Options step of the Guide.

Signed Greg Wilson

Ivan Namarnyilk Participated in the testing of the Options step of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Options step of the Guide

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Sean Nadji Participated in the testing of the Options step of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Options step of the Guide

Signed .....

Jacqueline Cahill Participated in the testing of the Options step of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Options step of the Guide

Signed .....

Sally Brockwell Provided archaelogical guidence and knowledge, and practical refinement.

Signed .....

Bob Webb Provided conceptual refinement of the Options step of the Guide.

Signed .....

Deanne Bird Provided conceptual refinement of the Options step of the Guide.

Signed .....

High tide for heritage

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Abstract Climate change threatens to destroy hundreds of thousands of the world's cultural heritage sites. Cultural sites are particularly important to Indigenous peoples, their identity, cosmology and socio-political traditions. The benefits of local control, and a lack of professional resources, necessitate developing planning tools that support independent Indigenous cultural site adaptation. We devised and tested a methodology for non-heritage professionals to analyse options that address site loss, build site resilience and build local adaptive capacity. Indigenous rangers from Kakadu National Park and the Djelk Indigenous Protected Area, Arnhem Land, Australia, were engaged as fellow researchers via a participatory action research methodology. Rangers rejected coastal defences and relocating sites. Options prioritised included routine use of a risk field survey, documentation of vulnerable sites using new digital technologies, and widely communicating the climate change vulnerability of sites via a video documentary. Results support the view that rigorous approaches to cultural site adaptation can be employed autonomously by local Indigenous stakeholders.

Indigenous participatory planning for cultural site adaptation

Cultural heritage sites (hereafter 'cultural sites'), including historic monuments, archaeological sites and cultural landscapes, play a significant role in community identity, cohesion and sense of place, and this is particularly the case for Indigenous peoples (Keen 2004).

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There is a growing global awareness, however, that climate change impacts threaten cultural sites (Rowland 1992; Harvey and Perry 2015; Cassar and Pender 2005). While the potential impacts are diverse (UNESCO 2006), sea level rise and increased coastal erosion will have the most dramatic impact, leading to the destruction of hundreds of thousands of cultural sites globally (Erlandson 2012). Adger et al. (2013; Adger et al. 2011) argue that general adaptation responses will fail if they do not connect with communities' cultural values. It is vital that assessment of potential cultural loss focus on place-based decision making and engaging local visions for the future (Tschakert et al. 2017).

In northern Australia, Indigenous perceptions of climate change impacts on cultural sites are growing (Carmichael 2015; Carmichael, Wilson, Namarnyilk, Nadji, Cahill, et al. 2017), and a number of Indigenous land managers (hereafter 'rangers') and Traditional Owners (local descent groups with spiritual responsibility for land and sites) consider addressing them to be a priority (Carmichael 2015). However, remote Indigenous communities lack professional heritage management support (Tacon and Marshall 2014) and are constrained by socio-economic disadvantage (Altman and Jordan 2008).

In response, Carmichael (2015) proposed a five-step Cultural Site Adaptation Guide (the Guide; Figure 1) to help Indigenous rangers independently determine the adaptive needs of thousands of individual sites across hundreds of square kilometres.

Step 1 of the Guide, scoping, was tested in northern Australia (Figure 2) by Carmichael (Carmichael, Wilson, Namarnyilk, Nadji, Cahill, et al. 2017) with Indigenous rangers from Kakadu National Park (KNP Rangers) and the Djelk Indigenous Protected Area (Djelk Rangers).

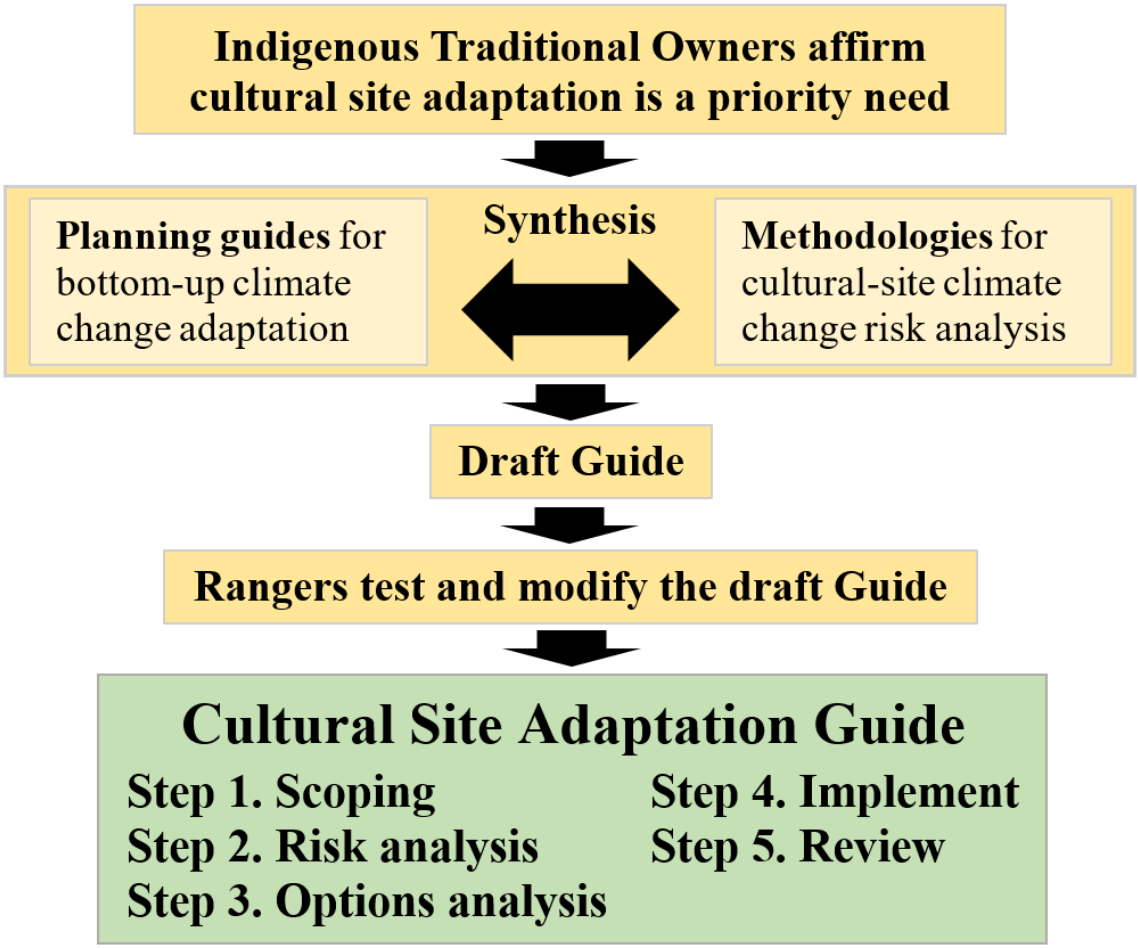


Figure 1. Construction of a Cultural Site Adaptation Guide
Traditional Owners affirmed adaptation of cultural sites to be a priority need via initial interviews with the lead author; the lead author subsequently undertook a literature review of (1) generic adaptation planning guides and (2) methodologies for cultural site climate change risk analysis, synthesising elements from each into a preliminary Guide; rangers tested and endorsed/modified the preliminary Guide via workshops, focus groups and fieldwork.

Testing found the scoping step elicited comprehensive responses from rangers. Sea level rise and more extreme storm surge were perceived to be increasing erosion of coastal middens (Figure 3) and floodplain-fringing middens and rock art. More intense cyclones were also perceived as impacting coastal middens. More extreme and frequent precipitation events were perceived to be eroding inland riverine rock art and contributing to the erosion of floodplain-fringing middens and rock art.

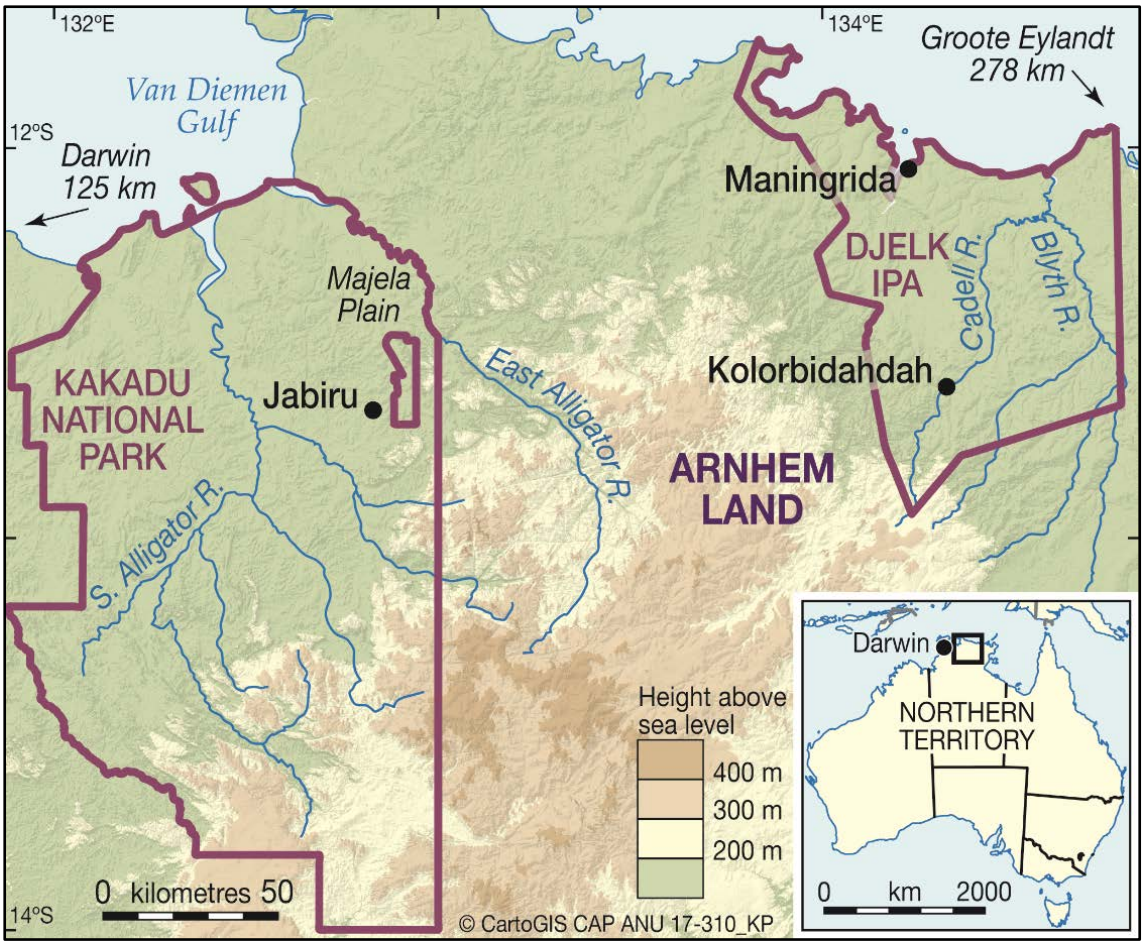


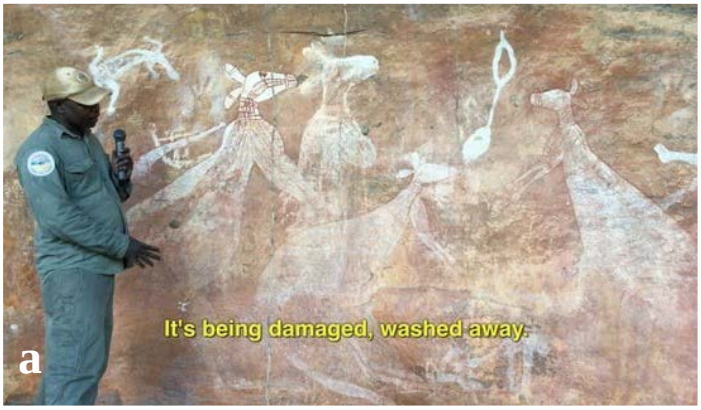
Figure 2. Location and setting of case study sites: Kakadu National Park and Djelk Indigenous Protected Area

Step 2 of the Guide, risk analysis, was subsequently investigated by the same ranger groups. A risk field survey, combining and building on methods pioneered in France by Daire et al. (2012) and in Scotland by Dawson (2015), was proposed by the lead author and further modified with Djelk and KNP Rangers via testing at 126 rock art and midden sites (Carmichael, Wilson, Namarnyilk, Nadji, Hunter, et al. 2017).

The risk field survey and scoping step follow the IPCC (Intergovernmental Panel on Climate Change) recommendation (IPCC 2014) of confronting a lack of downscaled climate change projections by basing adaptation on local observations of impacts from extreme climate events and variability. Notwithstanding this, Indigenous perceptions of climate change impacts were

generally consistent with documented sea level trends and climate change projections for Australia's extensive monsoonal north (National Tidal Centre 2011; Moise et al. 2015) and research into cyclone impacts on the archaeological record under conditions mediated by climate change (Bird 1992).

Figure 3. Climate change threats to rock art and middens



a Screenshot from the documentary *Places in Peril. Archaeology in the Anthropocene* (Carmichael 2017) a ranger-initiated communication tool aimed at conveying the gravity of the threat of climate change to cultural sites to a global audience. Viewable at link: https://vimeo.com/203773921. Djelk Ranger Ivan Namarnyilk inspects flood damage to a rock art site close to the Cadell River, south of Kolorbidahdah.

b A KNP Ranger uses the risk field survey at a rock art site on the fringes of the Majela Plain. Flood debris (i) has been deposited on top of an outcrop adjacent to rock art (ii).

c A Djelk Ranger surveys coastal erosion.

d Djelk Ranger Greg Wilson records the location of an eroded coastal shell midden.

Successful mapping of ‘high’ and ‘very high’ risk cultural sites (Carmichael, Wilson, Namarnyilk, Nadji, Hunter, et al. 2017) made the rangers eager to explore Step 3 of the Guide, options analysis, which is the subject of this paper.

An options analysis methodology for local and indigenous cultural site adaptation planning

Options analysis represents the high point of the adaptation cycle’s decision-making process. When local stakeholders play the central role, adaptation plans gain political legitimacy, become responsive to local vulnerabilities and values, and build local adaptive capacity and resilience (Carter and Mäkinen 2011).

While some archaeological studies responding to climate-change risks envisage a role for local stakeholders in site adaptation (Dawson 2015), none considers a scenario in which they are central. None therefore explores methodologies to assist stakeholders to select locally appropriate options.

This study responds directly to this deficit: it aims to propose an options analysis methodology for Indigenous ranger cultural site adaptation and then, working again with KNP and Djelk Rangers, determine if it can elicit meaningful and comprehensive responses from rangers, and whether rangers have the organisational capacity to fulfil its requirements.

All steps in the Guide, including the options analysis step discussed here, constitute a participatory action research (PAR) methodology (Stringer 2014): in using the Guide the rangers themselves research climate change impacts on local cultural sites and devise responses

appropriate to their unique circumstances. In testing the first iteration of the Guide, rangers were simultaneously co-researching the development of the Guide with the lead author.

Case study sites and selection

Of the two ranger groups participating in this study, the Kakadu National Park Rangers (KNP Rangers) are located in a national park administered jointly by the Australian Government and Indigenous land owners; and the Djelk Rangers are based in an Indigenous Protected Area (IPA), the Djelk IPA, administered by an Aboriginal corporation.

Kakadu National Park

Indigenous rangers are employed alongside non-Indigenous rangers across Australia's conservation estate, which includes national and state-administered parks. Indigenous rangers undertake natural and cultural resource management, including fire, feral animal and weed management, cultural site maintenance and tourist liaison.

Kakadu National Park covers 19 804 square km (approximately half the size of Switzerland) within the Alligator Rivers Region in the Northern Territory. Stage one of the Park was inscribed on the UNESCO World Heritage List in 1981 for its natural and cultural values. While around 5 000 rock art sites have been recorded, it is likely that 10 000 to 20 000 remain unrecorded (Agnew et al. 2015). Occupation has been dated from up to 65 000 years (Clarkson et al. 2017) and rock art reveals insights into Indigenous hunting, gathering, society and rituals from 28 000 years until the present (David et al. 2013). Around a third of KNP Rangers are Indigenous men and women. The Park is administered by a Board of Management, comprising

Traditional Owners but also Australian Government and non-Indigenous tourism sector representatives (Kakadu Board of Management 2016).

Djelk Indigenous Protected Area

In 2015, 70 IPAs across Australia covering some 630,000 square km of land (Pew Charitable Trusts 2015) were managed by 108 Australian Indigenous ranger groups. IPAs require Indigenous landowners to nominate their estates for inclusion. These are subsequently recognised as part of the National Reserve System and attract government resourcing. Indigenous rangers undertake natural and cultural resource management, including fire, feral animal and weed management.

The Djelk IPA covers over 14 000 square km of land and sea country. During the wet season, Maningrida, the main township in the Djelk IPA, is inaccessible by land transport. It too contains exceptional natural and cultural values, including 12 separate language groups. Apart from archaeological studies on the Blyth and Cadell Rivers several decades ago (Brandl 1988; Brockwell, Meehan, and Ngurrabangurraba 2005; Meehan 1982; Jelinek 1979), cultural site documentation has been limited. The Djelk Rangers began operating in 1991, with the IPA being declared in 2009. Djelk employs over 30 men and women full-time, almost all of whom are Traditional Owners. As a subsidiary of Bawinanga Aboriginal Corporation, Djelk is directed by an Indigenous executive committee. Djelk receives funding under the Australian Government's 'Caring for our Country' initiative (National Land Care Program 2017).

Case study selection

Both KNP and Djelk Rangers participated in testing earlier phases of the Guide, scoping (Carmichael, Wilson, Namarnyilk, Nadji, Cahill, et al. 2017) and risk analysis (Carmichael, Wilson, Namarnyilk, Nadji, Hunter, et al. 2017). In initially selecting the two groups, five ranger groups were approached: two from central Australia, the Warlpiri Rangers and the Tjuwampa Rangers; and three from northern Australia, Djelk Rangers, Gundjeihmi Rangers, and a cohort of Indigenous rangers from Kakadu National Park, some of whom were also Njanjma Rangers.

Rangers were approached either by non-Indigenous support staff or via a paid Indigenous consultant. Informal, face-to-face unstructured interviews centred on perceptions of climate change, impacts on cultural sites and whether planning for impacts was a priority need. In central Australia, the Warlpiri Rangers were a relatively new and inexperienced group with limited perceptions of climate change and no perceptions of impacts on cultural sites. Tjuwampa Rangers had perceptions of increased temperatures resulting from climate change, but the perceptions of impacts were limited to increased feral animal damage to sacred trees as a result of an increased need for shade. Neither group rated climate change adaptation planning as a priority need. Central Australia's semi-arid deserts experience very extreme natural temperature and rainfall variation. Differentiating anthropogenic climate change from natural variation is possible by way of long-term climate trend data (Race et al. 2014), but is difficult to perceive by those managing natural resources over the short to medium term. Of the three northern Australian groups, the Gundjeihmi Rangers were only newly established; all members were under the age of 25 and unfamiliar with the concept of climate change.

In contrast, KNP rangers and Djelk Rangers were familiar with the concept of climate change, had strong perceptions of climate change impacts on cultural sites and considered managing these impacts a priority (Carmichael, Wilson, Namarnyilk, Nadji, Cahill, et al. 2017). They are long established and highly experienced groups, responsible for maintaining rock art, midden and burial sites close to tidal and riverine flood zones.

Methodology

An options analysis methodology was derived from a review and synthesis of option analysis methods outlined within five generic climate change adaptation planning guides (Burton, Malone, and Huq 2005; Dazé, Ambrose, and Ehrhart 2009; Hinkel et al. 2013; UKCIP 2017; Willows and Connell 2003). These five were selected on the basis of their positive rating against a set of assessment criteria by Webb et al. (Webb and Beh 2013). The same five had been used in the construction of the scoping step of the Guide (Carmichael, Wilson, Namarnyilk, Nadji, Cahill, et al. 2017).

Option identification

In line with the method commended by three sources (UKCIP 2017; Willows and Connell 2003; Burton, Malone, and Huq 2005), a preliminary options list was derived from the results of the preceding scoping and risk analysis steps of the Guide (see Table 1: item 1.1). During both steps, rangers regularly proposed adaptation options. An analysis was therefore then conducted of transcripts from workshop discussions, semi-structured individual and small group (two to three participants) interviews, audio recordings of participant observations, and field notes, all accumulated during these steps. Data was analysed and grouped into themes with the aid of NVivo qualitative data analysis software.

	Generic adaptation planning guides					Methods pre-selected for KNP / Djelk workshops	
	Burton et al. (2005)	Dazé et al. (2009)	Hinkel et al. (2013)	UKCIP (2017)	Willows et al. (2003)		
1. Methods for *identifying* options							**Comments on rejected steps**
1.1 Use options suggested during scoping / risk analysis.	+			+	+	✓	
1.2 Use a generic list of options.				+		✗	No generic list exists for cultural sites.
1.3 Use free brainstorming.		+	+	+		✓	
1.4 Use prompts to elicit options, ie:							
a) Option qualities: i.e., 'low regrets', 'flexibility', etc.;				+	+	✗	Better addressed during: 2. Methods for appraising options (below).
b) Options addressing limits of existing program/strategy;		+				✗	Existing programs assessed as inadequate during scoping step of Guide: option responses captured at 1.1 (above).
c) Options to build adaptive capacity of stakeholders.			+			✗	Not comprehensive. Will be used in final guide alongside: (ii) options to build site resilience; and (iii) options that directly intervene at sites.
2. Methods for *appraising* options							**Comments on rejected steps**
2.1 Conduct first-pass option screening.				+	+	✓	
2.2 Choose formal or informal method.	+		+		+	✗	Formal is unable to monetise site value.
2.3 If informal chosen, assess options against resources / constraints.		+	+			✗	Use more than just these two criteria.
2.4 Select assessment criteria from a generic list.	+			+		✗	No generic list available for cultural sites.
2.5 Identify a set of *assessment criteria*; devise a *scoring system*; and then rank options.	+			+		✓	

2.5.1 Identified *assessment criteria*:

Criteria	Source	Questions put to stakeholders
1. Cost efficiency	Chambwera et al. (2014)	'Is the option affordable?'
2. Goal orientation	Noble et al. (2014)	'Does the option meet our goals?'
3. Practicality	Klein et al. (2014)	'Does option require available skills & capacities?'
4. Cultural appropriateness	Adger et al. (2014)	'Is the option "proper way"?'
5. Co-benefit provision	Huq and Reid (2004)	'Will option benefit the community in other ways?'
6. Timeliness	Stafford Smith et al. (2010)	'Can we implement option in a short time frame?'
7. Robustness	Lempert et al. (2013)	'Will option work if CC is worse than expected?'

2.5.2 *Scoring system* for responses to questions put to stakeholders: **'Yes' = 2pts. 'Possibly' = 1pt. 'No' = 0pts.**

Table 1. Comparison and selection of options-analysis methods

A plus (+) indicates the method features in a given generic adaptation planning guide. A tick (✓) indicates that the lead author adopted the method for the Djelk and Kakadu Ranger workshops, during which rangers endorsed its use. A cross (✗) indicates that a given method was not adopted by the lead author, and comments indicate why. Method 2.5.1 sets out the assessment criteria used, their source in climate change adaptation literature and the resulting questions posed to rangers.

In line with the method commended by three sources (Dazé, Ambrose, and Ehrhart 2009; Hinkel et al. 2013; UKCIP 2017), workshops began with a brainstorming exercise in which participants were invited to add additional options to the preliminary list.

In order to generate a comprehensive list of possible climate change adaptation options as a point of comparison for those identified by rangers, a literature review of archaeological studies addressing climate change adaptation was conducted. Studies addressing the issue of climate change impacts on cultural sites are largely concerned with risk assessment, while only a limited number consider adaptation options. We identified six studies with substantive consideration of adaptation options for cultural sites facing climate extremes, variability or change (Ashmore 2005; Barclay and Fojut 1995; Dawson 2015; Rowland 1992; Cassar and Pender 2005; Rockman et al. 2016) (see Table 2 in the Results section).

Option appraisal

In line with the method commended by two sources (UKCIP 2017; Willows and Connell 2003), a first-pass screening of the preliminary list was conducted with the aim of removing options considered, in retrospect, unworthy of formal appraisal.

Contrary to the method commended by three sources (Burton, Malone, and Huq 2005; Hinkel et al. 2013; Willows and Connell 2003), a decision by participants as to whether to employ a formal or informal option appraisal system was not included (see Table 1: item 2.2). Formal methods, such as cost-benefit analysis or multi-criteria analyses, focus in the main on financial implications. They are most often employed in a top-down planning context in which local values are rarely considered (Getzner, Spash, and Stagl 2005). In a bottom-up, participatory planning process, however, cost should be one consideration among other planning

implications. Analysis of measures to ameliorate the consequences of loss or damage to social values is better served by a deliberative, qualitative approach informally ranging across multiple non-monetary criteria (Chambwera et al. 2014). This is especially important in a cultural heritage context. Attempts have been made at monetising individual cultural site value by, for example, using willingness-to-pay determinants (Kim, Wong, and Cho 2007). However, cultural sites with a pure, market-based value are usually those generating tourism revenues (Choi et al. 2010). This applies to a fraction of the total number of cultural sites. An informal, qualitative approach to decision making, as opposed to a formal approach, can be exceptionally effective, and when there is limited information, produce better results than formal methods (Gigerenzer 2000).

The identification of a set of assessment criteria for the appraisal method (see Table 1: point 2.5.1) by the lead author offered the opportunity to develop a comprehensive list of criteria appropriate to the cultural site adaptation that capture concerns central to climate change adaptation literature. Preselecting assessment criteria, as opposed to requiring rangers to select their own criteria during workshop testing of the appraisal method, enabled comparison between the results of independent testing. Verification of the usefulness of a wide range of criteria also maximised the opportunity for the formulation of a broad generic list of criteria, for insertion into the final form of the Guide. Future users of the Guide will be able to choose from a generic list verified as being comprehensible by cross-cultural participants.

Seven criteria were chosen as a result of a literature review. The seven chosen, and their corresponding questions to put to rangers, are as follows:

1. **Cost efficiency (‘Is the option affordable?’)** Some adaptation options will be technically possible, but are dismissed because the cost of their implementation is beyond current financial resources. Cost should therefore be assessed, but in the context of non-monetary values (Chambwera et al. 2014).
2. **Goal oriented (‘Does the option meet our goals?’)** Options should be sought and appraised against the overall goals of stakeholders established during the ‘framing’ or scoping step of the adaptation planning process (Noble et al. 2014). As Hinkler (2013) states, the question ‘What are we adapting for?’ (the desired outcome) is as significant as, if not more so, than the question ‘What are we adapting to?’. In this way adaptation focuses on people’s capacity and willingness to respond (Smit and Pilifosova 2003).
3. **Practicality (‘Does the option require skills and capacities available to us?’)** Human resources are fundamental to option implementation (Klein et al. 2014). These include skills, information, leadership and management capacity (Brooks et al. 2011). Considering human resources opens up options that might have been dismissed if finances were the only consideration (Webb and Beh 2013).
4. **Cultural appropriateness (‘Is the option “proper way”?’)** Culture shapes the relationship of society to the environment and is an important determinant of responses to risks (Adger et al. 2014). Options consistent with social norms will be more acceptable to local stakeholders (Alexander et al. 2011; Moser 2006; O’Brien et al. 2007). In an Indigenous context, traditional protocols affect cultural site management and require oversight by Traditional Owners (Walsh and Mitchell 2002).
5. **Co-benefit provision (‘Will the option benefit the community in other ways?’)** Options with co-benefits should be sought out (Noble et al. 2014; Huq and Reid 2004) – they are more likely to be implemented than those with a single benefit (IPCC

2007). In an Indigenous land management context, ‘win-win’ options will complement natural resource management (Djelk Rangers 2014).

6. **Timeliness (‘Can we implement the option in a short time frame?’)** Options that can be implemented in the near to mid-term have advantages over those with long lead times (Klein et al. 2014). The latter face greater uncertainty (Brown et al. 2011) and the danger of immobilising decision-makers and exacerbating psychological, social or institutional barriers (Stafford Smith et al. 2010).
7. **Robustness (‘Will the option work if climate change is worse than expected?’)** Robust, or ‘low regrets’, options satisfy stakeholder goals under different future climate scenarios (Lempert et al. 2013; Willows and Connell 2003). They also have advantages when downscaled climate projections are non-existent, or highly generalised (e.g., Moise et al. 2015), which is often the case for remote locations. For similar reasons, stakeholders should also favour flexible options – those that can be implemented in stages or dismantled easily (Hallegatte 2009; Fankhauser et al. 1999).

In order to rank options using the seven criteria outlined above, a simple scoring system was devised. As per findings by Carmichael et al. (Carmichael, Wilson, Namarnyilk, Nadji, Hunter, et al. 2017), keeping the scoring system simple would make for ease of use. A matrix was constructed with options on one axis and assessment criteria on the other. Each option was given scores for each of the seven criteria in the following way: if rangers answered ‘yes’ to the question corresponding to a criterion, the option earned two points; ‘possibly’ earned one point, and ‘no’ earned zero points. The seven scores for each option were then added up to produce a total score for each option.

Option analysis workshops

The preliminary options list was reviewed, added to and then appraised by rangers at three workshops: one conducted with Kakadu male and female rangers, a second with male Djelk Rangers, and a third with female Djelk Rangers.

Djelk female and male rangers took part in separate workshops reflecting separation that exists in their current work practice. The KNP Ranger workshop was conducted with five rangers (three male, two female). The male Djelk Ranger workshop was conducted with 15 Indigenous rangers and one non-Indigenous ranger coordinator (female). The female Djelk Ranger workshop was conducted with three Indigenous rangers, the total number of female rangers. The female Djelk Rangers had not been involved in the scoping and risk analysis steps of the project, due to their being unavailable at the time research into those steps was conducted. The workshops lasted 61 minutes (KNP Rangers), 58 minutes (male Djelk Rangers) and 72 minutes (female Djelk Rangers). Five one-on-one interviews were also conducted, lasting 30 to 45 minutes each. These were focused on complementing the numerical scoring of options with further Indigenous commentary on options.

Workshop participants and individual interviewees were either self-selected or invited to participate on the basis of their contribution during previous research phases. Participants' knowledge of English was generally good, so a translator was not necessary. Option workshops and interviews were transcribed and organised digitally according to activity and date, using the NVivo software package. Strategies to manage potential biases in data collection included reporting back to participants, and participants reviewing manuscripts and quotes within them presented as verbatim.

Results

The preliminary list of adaptation options for climate change as well as non-climate hazards (see Table 2) was as follows:

- defend the coast (i.e., comprehensively, with sea walls);
- surface-documentation of high risk sites *generally* for a local museum or database;
- relocate cultural sites;
- give sites protective legal designation;
- eradicate feral animals, in particular water buffalo (*Bubalus bubalis*);
- fence sites against feral animals;
- conduct fire management at sites;
- introduce a routine risk assessment and monitoring program by digitising the risk field survey (tested during previous steps in the research) and making it available on rangers' I-Tracker GPS data-collection tablets (NAILSMA 2014);
- establish partnerships with archaeologists and regional stakeholders;
- give training to local stakeholders; and address governance issues.

During the brainstorming exercise, female Djelk Rangers added 'share knowledge' to the option list; male Djelk Rangers flagged a recent proposal made by non-Indigenous enterprises to not eradicate buffalo but, instead, to 'stabilise feral numbers via a harvest' for commercial gain; and KNP Rangers added erect more 'gates on roads – to block vehicles' driven by tourists.

At all three workshops an additional option was proposed by the lead author: developing an Augmented Reality application (as distinct from a Virtual Reality application) to allow 3D models of sites, particularly rock art, to be re-experienced once lost, via an Augmented Reality ocular headset, on their original, non-virtual rock face (where access to the site remains possible).

Option identification	Djelk / Kakadu	Ashmore (2005)	Barclay et al. (1995)	Dawson (2015)	Rockman et al. (2016)	Rowland (1992)	Cassar et al (2005)	Option prioritisation		
								Djelk Men	Djelk Women	KNP Men / Women
Direct intervention options										
1. Do nothing	✓	✓	✓	✓	✓	✓	✓	✘	✘	✘
2. Defend coast – *comprehensively*	✓	✓	✓	✓	✓			✘	✘	✘
3. Defend coast – *less than comprehensively*			✓		✓					
4. Excavate – *exhaustively*		✓	✓	✓	✓					
5. Excavate – *less than exhaustively*			✓		✓					
6. Surface-documentation generally	✓			✓	✓			**2**	**1**	**4**
7. Surface-documentation – 3D modelling and Augmented Reality	✓							**1**	**1**	**2**
8. Relocate cultural site	✓			✓	✓		✓	✘	✘	✘
9. Replicate cultural site							✓			
Options building cultural site resilience										
10. Improve resilience generally		✓			✓		✓			
11. Give sites protective legal designation	✓		✓					**2**	**1**	**1**
12. Modify site structure (no integrity loss)					✓					
13. Eradicate feral animals entirely	✓							**3**	**3**	**6**
14. Stabilise feral numbers via harvest	✓							✘	**NI**	**NI**
15. Fence sites against feral animals	✓							**4**	**2**	**NI**
16. Conduct fire management at sites	✓							**3**	**4**	**6**
17. Erect gates on roads – to block vehicles	✓							**NI**	**NI**	**1**
Options building stakeholders' adaptive capacity										
18. Consult stakeholders generally		✓		✓	✓	✓	✓			
19. Introduce risk analysis system	✓	✓		✓	✓	✓	✓	**1**	**1**	**2**
20. Communicate the vulnerability of sites	✓				✓		✓	**1**	**NI**	**1**
21. Establish partnerships	✓				✓	✓	✓	**1**	**1**	**3**
22. Share knowledge	✓							**NI**	**1**	**NI**
23. Integrate options with local planning		✓					✓			
24. Give training to local stakeholders	✓			✓				**2**	**4**	**1**
25. Address governance issues	✓							**1**	**4**	**5**
26. Build adaptive capacity generally				✓						
Total options identified	17	7	6	9	13	4	9	**Total options prioritised**		
								11	11	11

Table 2. Results for option identification and option prioritisation

Option identification: a tick (✓) indicates that an option was identified by Rangers or archaeological risk literature. *Option 1. Do nothing* was added retrospectively, as from the project's inception, Rangers indicated adaptation a priority need. *Option 20. Communicate sites' vulnerability* was added retrospectively, in light of Rockman et al (2016; published after workshop) considering it an adaptation option.

Option prioritisation: numerals indicate ranger rankings. A cross (✘) indicates an identified option was rejected during screening of a preliminary list of options. 'NI' (Not Identified) indicates that an option identified during the brainstorming exercise by one ranger group was not identified by one or more of the other ranger groups. *Option 20* ranked '1' retrospectively due to instigation/completion of video prior to workshop.

A Djelk Ranger summarised the dilemma in the following way:

> The Djomi museum (local museum in the township of Maningrida) is really good, taking photos and getting information, but in my way, I want to see it 'live'; paintings, right there! (Carmichael, Brockwell, et al. 2017 p n/a: in press)

No application currently exists that allows 3D models of sites, particularly rock art, to be re-experienced once lost, so the application of the Augmented Reality concept in this regard is hypothetical. Open to the idea, workshop participants watched a promotional video, viewable at link: https://www.youtube.com/watch?v=xXy7lbs-D48&sns=em (Microsoft 2016), for the then newly released Microsoft Hololens® Augmented Reality ocular headset. The initial first-pass screening process saw options such as 'defend coast' and 'relocate cultural site' dismissed by all groups as impractical, too costly and culturally inappropriate. As a Djelk Ranger declared:

> Sea walls? Nah! The sea is a really big thing, you can't do anything like that. The sea level is coming up and the floodplain will be filled up, you can't do anything about this.

Buffalo harvesting was also rejected, due to the impacts a maintained herd and capture vehicles would have on natural values and cultural sites.

Of those options identified by *all* ranger groups, appraisal via the assessment criteria resulted in six being ranked by one or more group as a primary priority (i.e., priority '1', see Table 2). These were cultural site surface documentation via 3D photogrammetry for an Augmented Reality app, introduce a risk analysis system, establish partnerships, provide training, give sites protective legal designation, and address governance issues.

A seventh option, 'communicate the vulnerability of sites' was not considered during the construction of the preliminary options list. Rockman et al. (2016), published immediately after the options analysis workshops were conducted, considers communication of threats to cultural sites an adaptation planning option in its own right. In light of Rockman et al's strategic recommendation, and a similar position by Cassar and Pender (2005) under the rubric of 'education', we acknowledge that the early stipulation by rangers (when initially agreeing to take part in this research project) that a documentary video be an additional output of research (in order to raise popular awareness of the vulnerability of cultural sites to climate change and elicit support) constituted identification of this option. Given ranger identification of the option also stipulated its *immediate* implementation, and that the video was largely complete prior to the option workshops, we consider it to have been effectively prioritised at the highest level by rangers, and have therefore retrospectively assigned it to priority level '1' (see Table 2, above).

The following sections present rangers' and community members comments on high-scoring options.

Cultural site documentation – via 3D photogrammetry for Augmented Reality

While coastal protection and relocation were dismissed, new technological approaches to surface-documentation of sites were enthusiastically endorsed. Rangers considered making 3D models of the most vulnerable riverine rock art sites and viewing these, once the original was lost, at their original location (where practical) via an Augmented Reality ocular headset. A KNP Ranger noted that:

> There's no problem with that so long as we have a little bit of help. It could bring everything back to life, we can make a record that will be there forever – that new technology could help.

For both ranger groups, however, cultural protocols, consultation with Traditional Owners and control over imagery would have to be very strictly maintained. Protocols and issues surrounding application of AR will be a topic of future research.

Introduce a risk assessment system

Rangers can conceive of numerous benefits of digitising the risk field survey for their GPS-based field monitoring devices. In addition to mainstreaming the monitoring and prioritisation of cultural sites, digitisation would produce data allowing financially deficient rangers to canvas for more funding and increased managerial support for extended site maintenance. As a KNP Ranger pointed out:

> Rangers have to adapt it [the risk field survey] into the routine conservation checks. It's important to know what you're dealing with and what is important before you go and push other people to help you.

Communicate the vulnerability of cultural sites

From the project's outset, formally communicating the problem of cultural site vulnerability to climate change was flagged as urgent. Rangers felt non-Indigenous Australians were not listening to their repeated warnings about the threat of climate change. Work on the documentary, *Places in Peril. Archaeology in the Anthropocene* (viewable at link https://vimeo.com/203773921) was therefore begun immediately (Carmichael 2017). As one KNP Ranger had explained during initiation of the documentary project:

> Climate change is going to be a big thing throughout Australia. A video is definitely the way to go … It will help people better understand climate change [impacts on cultural sites] as well; a lot more other groups will want to start getting involved.

Partnerships

All groups stressed the value of partnerships, including those with archaeologists, cultural heritage managers, and Indigenous consultative agencies such as the Northern Land Council (NLC). But ultimately partnerships were downgraded by KNP Rangers because they were perceived as all too often lacking financial backing. As one explained:

> Few partners come up with the money for all the stuff to do with sacred site maintenance. You need money. Anyone could become a partner, but once you start mentioning funding, no one wants to put their hand up.

Training

Training was considered vital for using the risk field survey, general rock art recording and maintenance, including vegetation management and insect nest removal, and in following cultural protocols. A KNP Ranger noted that:

> Training meets our goals, and it's in the [Kakadu National Park] Plan of Management, which says that we are supposed to protect rock art. Training needs to include cultural protocols. You can't have people looking at [i.e., working at] the sites that don't know what they're doing.

Give sites protective legal designation

Barclay et al. (Barclay and Fojut 1995) list protection through legal designation as an important coastal protection measure. Rangers independently concurred: listing more sites with the Aboriginal Areas Protection Authority (AAPA), an independent statutory body charged with overseeing the protection of Aboriginal sacred sites on land and sea in the Northern Territory (AAPA 2013), would have additional benefits. As a Djelk Ranger pointed out:

> AAPA needs to come and work with Traditional Owners. It would be really good, I think, if AAPA registered all the sacred sites; that would give us more power to stop mining and stop people coming in looking for oil, gas and the like.

Governance

Djelk and KNP Rangers had different views on governance. For KNP Rangers there was an issue with a lack of consultation around resource provision for maintenance of cultural sites other than those open to tourists. They ranked this issue down, however, because they did not feel confident of achieving results. Ultimately, control was seen to rest with the Australian Government. As a KNP Ranger said:

> How are you going to change the policies? In the 1980s, Kakadu was the place to visit. So we had a lot of money, and a lot of staff to look after a lot of different areas. But today the Park is getting no revenue. At the end of the day, it depends who plays politics best and gets in [i.e., who wins a Federal Election].

Djelk Rangers felt confident about resisting interventions by non-Indigenous administrative staff working for their parent Aboriginal Corporation. Raised as a live issue during the scoping step, by the time of the options analysis workshop it had been resolved by way of non-Indigenous administrative staff changes. As noted by a Djelk Ranger:

> We are working together now, we have solved that problem. Office mob [non-Indigenous administrative staff] have now put it [intervening in Djelk natural resource management planning] on the side. They are focusing more outside of ranger stuff now.

Discussion

This study tested the options analysis step of a proposed Cultural Site Adaptation Guide. It did so by facilitating its use with two Indigenous ranger groups to determine if it could elicit meaningful and comprehensive responses, and whether Indigenous rangers had the organisational capacity to fulfil the requirements of the process. It found the rangers were highly engaged by the approach and that they had the organisational capacity and planning skills to supply detailed and considered responses born of direct observation and insightful appreciation of the climate challenges confronting their cultural sites. In testing a methodology for participatory cultural-site options analysis, our study has identified an unprecedented range of adaptation options. Both the process explored and the resulting options have implications for international efforts to optimise adaptation of cultural sites.

Rangers initiated and considered more options than any one of the other studies considering adaptation of cultural sites cited in Table 2 (Ashmore 2005; Barclay and Fojut 1995; Dawson 2015; Rowland 1992; Cassar and Pender 2005; Rockman et al. 2016). Our study underscored, therefore, the value of locally controlled planning – direct experience of risks proved highly fertile ground for appraising practical, locally appropriate measures. It also underscored the value of Indigenous traditional knowledge and experience (IPCC 2014; Nakashima et al. 2012) to the adaptation of cultural sites, and the extent to which this experience can complement professional cultural site adaptation. Local control might therefore be considered an adaptation option in its own right, one made demonstrably feasible by this study. Our study also underlines the value of collecting options identified informally throughout preceding phases of the adaptation pathway (Burton, Malone, and Huq 2005; UKCIP 2017; Willows and Connell 2003), in other words not siloing the options analysis process.

We have distinguished three classes of option among the list identified by rangers: (1) direct intervention options, such as defending the coast or surface-documentation of sites in the face of inevitable loss; (2) cultural site resilience-building options, such as giving sites legal protection; and (3) adaptive-capacity building options, such as digitising the risk field survey. The following sections discuss these classes.

Direct intervention

There are often clear limits to climate change adaptation (Barnett et al. 2015), and studies of Indigenous stakeholders planning whole-of-community climate change adaptation within the context of sea level rise have reported both important limits as well as cultural barriers (McNamara et al. 2012). Our study, however, documents Indigenous Rangers confronting inevitable loss or damage to cultural values with a high degree of pragmatism and few cultural constraints. Rangers were prepared to bear losses and ameliorate the consequences of loss with surface-documentation, while at the same time exploring new technological aids to this end. Climate change adaptation options that use new technology can potentially benefit disadvantaged populations (Noble et al. 2014; MacLean 2008).

Reilly (1990), an early exponent of Virtual Reality as an archaeological research tool, referred to ‘virtual archaeology’ as the modelling of landscapes, excavations, buildings, and artefacts with computer applications in order to test scientific questions, but also to communicate the past to non-specialists. Digital 3D imagery and visualisation has since become available for many iconic archaeological sites globally (Katz and Tokovinine 2017), for Australian Indigenous cultural sites (e.g., Irving and Hoffman 2014; Bourke 2014), and even for lost sites – for example the Temple of Bel in Palmyra, Syria (Wahbeh, Nebiker, and Fangi 2016). While Virtual Reality provides an immersive experience of a cultural site at an alternative location,

emergent Augmented Reality hardware that supplements reality with 3D imagery might allow Indigenous Traditional Owners to secure threatened traditional cultural *knowledge* but also location-dependent, traditional cultural *practice*. Experiencing a lost cultural site in its original location allows users to maintain their, and a site's, *connection to Country*. Connection to Country is essential to Indigenous cultures – land, language and place are embedded in kinship relations, identity, belief systems, justice codes, spirituality and Indigenous sovereignty, as well as physical, social and emotional wellbeing (Ganesharajah 2009).

While broadly supportive of an Augmented Reality option, rangers expressed some concerns about the implications of producing, regulating access to, and storing a proxy for a lost site. Aside from their identified need for community consultation prior to recording, other issues arise: ensuring culturally sensitive imagery does not find its way, via the internet, into the public domain, where it can be appropriated and altered, and ensuring GPS connected cameras do not reveal site locations (Hennessy 2009); ensuring that the chosen repository allows culturally appropriate equity and ease of access to content (Colley 2015); ensuring a repository does not enter into sharing agreements with other less secure organisations, or that the use of imagery by financially disadvantaged communities for tourism or other income-generating opportunities does not have unintended outcomes (Britz and Lor 2012).

Building cultural site resilience

Building cultural site resilience to climate change is an option not well represented in cultural site climate change adaptation studies. Rangers' holistic understanding of landscape-scale processes conceived of measures such as culling buffalos as a climate change adaptation option. Their insights are consistent with IPCC (2014) findings recognising that invasive species can benefit from climate change, due to a decline in competition from less resilient

native species, and increase landscape-scale vulnerability to climate change because of the environmental degradation they cause (IPCC 2014; Sheppard, Low, and Glaznig 2008).

Well-maintained cultural sites will probably be less vulnerable to climate change, for example sites cleared of vegetation will be less prone to more frequent, intense and extensive fires, or sites that are fenced less vulnerable to impacts from invasive species whose numbers are increased by new conditions brought about by climate change. Adaptation planning that considers both climate and non-climate impacts, such as legal protection or gates to restrict tourist access, represents the 'mainstreaming' of climate adaptation into broader risk management, which increases the likelihood of actual implementation of an adaptation plan (Huq and Reid 2004; Smit and Wandel 2006). A program documenting vulnerable cultural sites is essential in this instance, as Northern Territory legislation (Northern Territory Aboriginal Sacred Sites Act and Northern Territory Heritage Act) already provides legal protection to *known* sites, whereas unrecorded sites remain at risk.

Building local adaptive capacity

Our results highlight the importance of local adaptive capacity. Communicating the vulnerability of cultural sites to climate change was cited as an option by only two studies (Rockman et al. 2016; Cassar and Pender 2005) but seen by rangers as one of the most critical. Indeed, distribution of the resulting documentary film elicited contact from science journalists and entrepreneurs inspired to cover 'the story' or support implementation of options such as 3D modelling of sites and Augmented Reality application development.

Unlike any other cultural site adaptation study, we formally consider governance issues. Rangers working directly for government (KNP Rangers) had low confidence in their ability

to address governance barriers. Wider research stresses that low Indigenous involvement in formal, government decision-making processes regarding resource allocation decreases resilience (Ellemor 2005). Transformational change, or adaptation involving devolved governance or a fundamental shift in power (Pelling 2011; Barnett et al. 2015) might ultimately benefit KNP Rangers. In contrast, Djelk Rangers, operating under the auspices of an Aboriginal Corporation, were able to successfully address issues around planning autonomy.

With the Guide and associated risk field survey, rangers might offer heritage management training and consultation services on a fee-for-service basis, regionally, nationally and even, as flagged during research into the scoping step of the Guide, internationally (Carmichael, Wilson, Namarnyilk, Nadji, Cahill, et al. 2017). Providing market services in relation to customary values fits with Altman's (Altman 2001) hybrid economy model for Indigenous development. Here Indigenous land owners derive economic benefit from three sources: market, state and customary economy.

Ranger prioritisation of partnerships with archaeologists is particularly significant. The risk field survey assesses risk to sites partly via a ranking of *cultural value*. However, rangers recognise that archaeologists might potentially augment the power of assessment results via a complementary *scientific* assessment of significance. Indeed, archaeologists are increasingly recognising the value of significance assessment derived from cultural value (Sutton, Huntley, and Anderson 2013; Brown 2008).

Prompts and generic lists

In light of our identification of three option types, we envisage adding a prompt to the process of option identification. Some generic adaptation option guides (Dazé, Ambrose, and Ehrhart

2009; Hinkel et al. 2013; UKCIP 2017; Willows and Connell 2003) commend specific prompts. We dismissed these prompts as insufficient or incomplete. Our prompt, however, will ask: 'What can we do for sites that are in danger of being lost to climate change?'; 'What can we do to keep sites strong and healthy?'; and 'What can we do to make ourselves more able to make sites strong against climate change?'.

The options identification phase of the process employed here was not able to present rangers with a generic list of options from which to choose. The final form of the options analysis can now do so. The generic list will include options identified by rangers in this study but also those gleaned from academic and managerial studies. During the yet to be explored Step 4 of the Guide, Review, and when data has accumulated from routine risk field survey application, options rejected during this study by Djelk and KNP Rangers may conceivably become tenable to them. For example, some form of coastal protection or relocation – options which have been undertaken by citizen archaeologists in the UK and US (Holtz et al. 2014; Shoredig 2015) – may become favoured options for as yet unconsidered sites.

Conclusion

The multiple insights and outcomes from our study include a repeatable and transferable process with applicability elsewhere in Australia, and with the potential to provide systematic guidance for cultural site climate change responses internationally. The Guide builds an approach that facilitates reflexive learning and continued iteration, with the implication that new, locally specific, adaptation options will continue to be identified. International application of the Guide by local and Indigenous users might see these new additions shared among a global community of cultural site adaptation practitioners.

The development of global strategies to combat climate impacts on cultural heritage sites has stalled since first steps were taken at the beginning of the current millennium (UNESCO 2006). While renewed efforts need to facilitate the adoption of risk *analysis* across global, regional and local scales, the subsequent risk *management* step of options analysis should also be pursued. The fostering of links needs to be developed between those working independently at a local scale in order to share knowledge born of empirical experience.

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Compliance with ethical standards

The study followed standard ethical norms, including obtaining university ethics approval (Australian National University No. 2014-342, Charles Darwin University No. H14022), eliciting informed consent from all study participants, reviewing results with and presenting

results back to communities prior to publication and not divulging the locations of ‘sacred’ sites.

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Chapter 6

- Communicating Indigenous cultural site vulnerability to climate change – *Places in Peril: Archaeology in the Anthropocene*, a video documentary case study

- The video documentary *Places in Peril: Archaeology in the Anthropocene*
  DVD located inside back cover.

Figure 1. Sea level rise and coastal shell middens

A screenshot from *Places in Peril: Archaeology in the Anthropocene*. Betty Ngurrabangurraba discusses the impact of sea level rise and coastal erosion on her traditional lands and shell middens.

Communicating Indigenous cultural site vulnerability to climate change – *Places in Peril: Archaeology in the Anthropocene*, a video documentary case study

Bethune Carmichael[1, 2] *

Abstract Communicating the vulnerability of cultural heritage sites (cultural sites) to the impacts of climate change has been recognised as an important planning option in climate change adaptation. Mass global access to digital media offers the potential for highly effective sharing of information, experiences and research outcomes relating to cultural site adaptation. Production of a video documentary entitled *Places in Peril: Archaeology in the Anthropocene* aimed to undertake such communication. The resulting video fills a gap in the filmic medium: no archaeological documentary film-making focuses on Indigenous cultural site preservation in the face of anthropogenic climate change; and within the emergent sub-genre of film addressing climate change, none focuses on managing the impacts on cultural heritage sites. Production of the documentary addressed the question of how effectively to frame and convey to an international audience the significance of the threat climate change poses to cultural sites so as to generate support for adaptive programmes and further research partnerships and resources. In so doing, it sought to feature analysis of the issue by the custodians of cultural heritage, and allow them to elucidate the site types currently and potentially impacted, plus the nature of those impacts, within the context of scientific research they are undertaking to address the issue. In presenting their analyses, participants were given the opportunity to convey the social and cultural significance of their cultural sites and why they are worthy of conservation. *Places in Peril* investigates the proposition that the issue of climate change impacts on cultural sites is readily and effectively communicable via the digital moving image.

Video documentary as planning option for climate change adaptation

In December 2014, initial meetings were held with Indigenous traditional custodians of cultural sites in remote Arnhem Land, in northern Australia, with the aim of initiating collaborative

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research focusing on Indigenous climate change adaptation planning for cultural sites. At the very first of these meetings a senior custodian declared that the Djelk Rangers, with whom he was a senior ranger, were very disposed to undertaking the research – climate change impacts on cultural sites *were* taking place and were of great concern to him. There was, however, one stipulation: the research must include the making of a video documentary in order to raise broader awareness of the problem. The Djelk senior ranger insisted that if people were only able to *see* the damage being done to riverine rock art sites by more frequent and extreme flooding events, they would be 'shocked' and thereby motivated to lend support. The other interested partners in the research, Kakadu National Park Indigenous rangers (KNP Rangers), concurred.

The US National Parks Service's *Cultural Resources Climate Change Strategy* (Rockman et al. 2016) enumerates a set of seven adaptation option types. The seventh in the set is 'interpret the change', which is defined as:

> '… an action or set of actions that acknowledges and then serves to engage people in the future with the effects of climate change on a [cultural heritage] resource
> (Rockman et al. 2016, p37).

Cassar *et al*. present a similar proposition, this time under the rubric of 'education':

> The public needs educating on the impact of climate change on cultural heritage and on the importance of cultural heritage as a climate change indicator. (Cassar and Pender 2005 p616)

Only after publication of US Parks Service strategy (Rockman et al. 2016), towards the end of the research project, did the author appreciate that the Djelk senior ranger's stipulation had amounted to an insightful, early identification of a climate change adaptation planning option for archaeological sites.

Decolonising the ethnographic film in the Northern Territory, 'reality archaeology' and inconvenient climate truths

The birth of film, at the turn of the 19th century, saw ethnographers stage and construct visual records as part of their anthropological research into exotic cultural practice. Among the earliest were those made in 1901 by Baldwin Spencer, who documented the ritual practices of Aboriginal people in the Northern Territory (Leigh 2017). Ethnographic film making in the Northern Territory has long since moved on, reflecting critiques of film making within a post-colonial or settler state context. Lansing (1989), for example, proposed the 'decolonisation of ethnographic film', arguing that ethnographic documentary making should be structured in terms of user value for its subjects rather than for informational or affective value to others. Plummer discerned a new movement in which documentary film has become a 'critical tool for political change' (Plummer 2001).

McNiven (2017) traces the history of Indigenous film making, beginning in the 1970s, as well as the non-Indigenous filmmakers' facilitation of Indigenous self-representation in film. *Kanyini* (Hogan 2006) exemplifies such critical documentary making within a Northern Territory context: Bob Randall a Yankunytjatjara elder explores the appropriation of Indigenous land, religion and philosophy, and the struggles faced by Aboriginal people in modern Australia, via historical reinterpretation and reappropriation of early ethnographic footage. While the audience is informed, the chief beneficiaries are Indigenous people, who want their challenges to be understood on their terms. Other such approaches from the Northern Territory include *Coniston* (Kelly and Batty 2012), in which Walpiri elders and their descendants explore memories, and offer interpretations of, the massacre of their forebears by mounted police in 1928. At the same time, ethnographic film in the Northern Territory has been able to lay bare the process of ethnographic film production itself, making viewers fully aware

that they are experiencing a social construct. *Waiting for Harry* (McKenzie 1980), shot on Anbarra country in Northern Arnhem Land, is unique in openly revealing to the viewer the Western anthropological research process, as well as the social challenges involved in fulfilling its Indigenous protagonists' wish to record their ritual practice (Loizos 1992).

Archaeological research, too, has an associated tradition of film making. Van Dyke (2006) commends the potential of archaeological filmic research to challenge constructions of archaeological knowledge as well as its potential for the communication of knowledge to a lay public. In the 1950s, archaeological television programming in the United Kingdom and United States came to explore excavations with archaeologists, film editors and animators working together (Morgan 2014). Piccini (1996), for the first time, provided a critique of the construction of ethnicity, in this case Celtic representations, in such archaeological documentaries. In an Australian context, *First Footprints* (Dean 2013) and its accompanying book by archaeologist Scott Cane (2013) engages both archaeologists and the contemporary Indigenous Traditional Owners of sites to scientifically and graphically confront notions of *Terra Nullius*, collaboratively telling the 'epic story of the first Australians'.

Television archaeology has also evolved to encompass a new degree of reflexivity. The advent of 'reality archaeology' via Channel 4's *Time Team* and its various spin-offs, depicts a race against the clock by archaeologists and sociologists to rescue cultural site data before the site's imminent destruction by developers.

A similar race against time to unearth scientific fact in the face of inconvenient truth is emerging in a new filmic sub-genre: the climate change documentary. *Chasing Ice* (Orlowski 2012) sought to graphically depict global warming and enlist support for political action to halt

it. *Chasing Ice* follows the research process being undertaken by a photojournalist as he seeks images as evidence for seasonal changes in Arctic glaciers. The film is as much about the personal journey of its main character as it is about climate change. The 2017 Sundance Film Festival featured *The New Climate,* a program featuring 14 films about environmental change and conservation (Sundance 2016). This program featured Al Gore in *An Inconvenient Sequel: Truth to Power* (Cohen and Shenk 2017*).* Many of the 14 films exposed the impacts of climate change from the perspective of Indigenous, ethnic and disadvantaged minorities.

The following section outlines the motivations for producing *Places in Peril*.

Aims

Making the documentary amounted to an investigation of the practical difficulty of realising a visual documentation of the impacts of climate change on cultural heritage sites. The documentary aimed to convey the gravity of the hazard, but in a way that appealed emotionally to an audience, given the objective of raising consciousness and generating support, yet maintaining credibility in terms of climate change science and formal, archaeological practice. In the latter regard, it aimed to answer and illustrate the questions: 'What evidence is there to suggest that archaeological sites are at risk of being impacted by climate change?' and 'What are the nature of climate change impacts on, or threats to, such sites?', and 'Why is this important?'

Australian archaeologist Michael Rowland was one of the first to consider the implications of climate change for archaeology, noting that one day it would become necessary to 'discuss with Aboriginal owners the potential impact of greenhouse changes on coastal sites' (Rowland 1992 p31). *Places in Peril* aims to undertake and document that conversation. However, the

author, as director, sought to facilitate the emergence of an Indigenous viewpoint on the subject. Aboriginal people initiate the conversation, and inform Western science of the impacts, rather than vice versa.

Methodology

Places in Peril was recorded on an Apple iPad Air II, mounted on a tripod. This 'camera' allowed *in situ* video editing – with the video-editing software application I-Movie within the I-Pad – and thus immediate visualisation of footage by participants during filming. Sound was recorded using a UHF broadcasting microphone connected to the iPad, which synchronised voice and video. The use of a hand-held microphone allowed the participants to emulate an active 'reporter', rather than be represented as passive interviewees. The participants were not posed formal questions, but spoke spontaneously with only basic prompting. As well, all the Australian sites were selected by rangers. Where a sub-title was later added under Indigenous language dialogue – such as in the final scenes – the 'translations' were provided by the original speaker himself on reviewing the footage (and so may not be a literal translation of what was actually said). The documentary was assembled by the author (as director) before a final edit by a professional video editor.

Results

Places in Peril is viewable at https://vimeo.com/203773921. It consists of three distinct segments filmed in: (1) Kakadu National Park (KNP), Northern Territory; (2) Orkney Islands and Fife, Scotland; and (3) the Djelk Indigenous Protected Area, Northern Territory. Selection of the Indigenous locations resulted from rangers in those locations initiating the project; the Scottish site selection arose from the author's participation in the 2015 European Archaeological Association Annual Conference, which had a plenary session on public

archaeology and climate change. After the conference, Tom Dawson, University of St Andrews, conducted a field trip to cultural sites vulnerable to climate change impacts in Fife. The Orkney Island scene was filmed on a later, independent excursion by the author.

A number of scenes from *Places in Peril* feature Indigenous rangers providing important evidence for climate change impacts, or potential impacts, on cultural sites. In the first segment (at 2.10 minutes), KNP Indigenous Ranger Fred Hunter describes outer perimeter erosion from extreme flooding at a very large, 50 m × 50 m, deflated earth midden located on a slight rise within the South Alligator River floodplain north of Munmalary. It was located very close to a channel, along which new colonisation by mangroves was taking place. Mangrove encroachment in freshwater areas is evidence of saltwater intrusion (Winn et al. 2006). While footage of the exposed human skeletal remains of two individuals was taken, this was not used in the film for cultural reasons.

Also in the first segment (at 4.46 minutes), KNP Indigenous Ranger Sean Nadji describes flood threats to floodplain-fringing rock art near to and at a low elevation above a floodplain abutting a creek inflow south of Ubirr, a major rock art complex in the north of the Park. A large log, which is most likely flood debris, can be seen stranded on a rock outcrop at a height less than 2 m below an adjacent rock art painting.

In the third segment (at 18 minutes), Djelk ranger Ivan Namarnyilk presents a site with white-ochre paintings of kangaroos in x-ray style on the Cadell River, inland and to the extreme south of the Djelk Indigenous Protected Area. The art is almost entirely faded below a distinct line horizontally dissecting it. The location of the paintings on a rock face inaccessible to buffalos confirms that the line dissecting the paintings did not represent the height limit of feral-animal

rubbing. Flood debris caught on an adjacent elevated rock outcrop at the same level as the art work confirmed that the dissecting line resulted from an extreme flood event or events.

In segments one and two, Indigenous rangers can be seen with clip boards holding the prototype Risk Field Survey (i.e., at 20.30 minutes), developed and tested during the collaborative research process (Carmichael, Wilson, Namarnyilk, Nadji, Brockwell, et al. 2017).

Cultural sites in Scotland are also explored, giving the film international context and relevance. In the second segment, Historic Scotland officer Aiden Morrison presents graphic evidence of erosion at Skara Brae, Orkney Island, Scotland (at 9 minutes). The impact on the World Heritage listed site, however, has been mitigated by a coastal defence.

Places in Peril also visually illustrates the value placed on cultural sites by their custodians, in terms of their importance to self or group identity. In the third segment (at 15.30 minutes), Djelk Ranger Greg Wilson, whose animist Aboriginal cosmology is vital to his understanding of the world and his place in it, speaks of ever-present Ancestors, calling out to them and asking for their permission to visit the site. The local appreciation of ancient sites' living social significance is no less the case on the other side of the world, where Pictish carvings in Fife, Scotland, are guarded by local custodians Michael McFarlane and Dr Susan Hampstead under the auspices of the Save the Wemyss Ancient Caves Society (at 11 minutes). The caves represent a point of local, community connection to the Picts, the prehistoric inhabitants of Scotland.

Discussion & Conclusion

Places in Peril combines ethnography and archaeology, but in a manner that 'decolonises' what were once the investigative tools of a coloniser. *Places in Peril* features Indigenous people as researchers. With its focus on Indigenous cultural heritage, the documentary confirms the Intergovernmental Panel on Climate Change's (IPCC) proposition that Indigenous people's traditional knowledge of, and relationship with, the natural environment can provide important insights into climate change trends and impacts, and thus also into what constitutes an optimal climate change adaptation response (IPCC 2014).

At the same time this documentary sees Indigenous people active in an important new sub-genre in film-making, one that engages with the global issue of climate change and makes the argument for action. Indeed, Indigenous rangers took a world view from the project's start. Communications, they said, should aim to situate what is on the face of it a local issue within an international context in order to build bridges with others around the world experiencing the same challenge (Carmichael, Wilson, Namarnyilk, Nadji, Cahill, et al. 2017). The importance of a global approach is affirmed by Erlandson (2012) who states that climate change threatens to destroy hundreds of thousands of archaeological sites along *all* of Earth's coasts.

The economic and political disadvantage Indigenous people face increases their vulnerability to climate change impacts (Altman and Jordan 2008). Some have suggested that this disadvantage means Indigenous peoples will be less inclined, or able, to prioritise and undertake adaptation planning: they have more pressing day-to-day problems (Petheram et al. 2010) such as health, housing, employment and structural racism. *Places in Peril*, in contrast, confirms the view of Adger et al. (2013): when material cultural values are made a subject within climate change adaptation planning, and planning is mediated by social values, the

outcomes are likely to be improved. Effective adaptation planning is made more likely if it involves local insight, control, motivation and commitment.

Places in Peril constitutes an ethnographic exploration of the social impact of climate change on Indigenous and local custodians, yet the film's aims were determined by Indigenous initiators of the project. It supports the proposition that the issue of climate change impacts on Indigenous cultural sites is readily and effectively communicable via the digital moving image.

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Chapter 7

Conclusion

Figure 1. Extreme flooding impact at a riverine rock art site (II).

During field work in 2015, Djelk Ranger Ivan Namarnyilk tests the Risk Field Survey at a Cadell River site several kilometres downstream from that shown in Chapter 4 (Figure 1A). Flood debris (foreground) is less than 1m below a red ochre painting of a kangaroo (upper right).

Introduction

The collection of papers, presented as chapters within this thesis, form a coherent body of research that proposes and then investigates the effectiveness of a procedural guide (the Guide) to assist Indigenous cultural-site custodians, or local-community-based custodians in general, to manage climate change impacts on cultural sites (Appendix 1. presents the completed first three steps of the Guide together). In doing so, it documents the organisational capacity of Indigenous custodians to put each component of the Guide into operation. The use of two case studies and methods germane to a Participatory Action Research (PAR) methodology means that the assessment of the Guide is rigorous, robust, and scientifically repeatable. In the process of constructing and testing the Guide, the thesis identifies various factors that impede adaptation planning for cultural sites, as well as the means by which these barriers can be surmounted. Furthermore, it highlights the great potential Indigenous rangers have for autonomous conservation and maintenance of internationally significant cultural resources. In this way, the research makes a distinct and original contribution to our knowledge and understanding of an optimal response to climate change impacts on cultural sites. It also establishes a valuable adaptation pathway for Indigenous communities to engage in a general adaptation planning process they themselves own and control.

While previous research considers Indigenous people's perceptions of climate change (Bird et al. 2013) or the role of Indigenous traditional knowledge in climate change adaptation (Nakashima et al. 2012), this research is unique in considering Indigenous perceptions of climate change in relation to cultural sites. Previous research (Petheram et al. 2010) argued that climate change adaptation is not a primary concern for Indigenous people, given they already confront a wide range of major challenges to the general welfare of their communities. This

thesis found, however, that when it comes to cultural sites, Indigenous people feel very strongly that climate change adaptation is a priority need.

Research to date has developed methodologies for risk *analysis* of climate change impacts on cultural sites (Daire et al. 2012; Dawson 2015; Daly 2014; Bickler, Clough, and Macready 2013). However, none is expressly aimed at overall risk *management* of climate change impacts on cultural sites, that is none explores a *process* for scoping or for the options-analysis component of such management. This is because this previous research is geared towards developing the risk analysis component of an otherwise top-down management process applied by heritage professionals, or a middle path process that involves community stakeholders but after substantial planning and prioritisation has been undertaken by heritage professionals. Though they might ask professionals to review their prioritisation results and augment them, Indigenous rangers remain in control of the planning process.

No previous research has investigated processes to support control over the management of climate impacts on cultural sites by stakeholders without professional heritage experience. This thesis argues that developing a procedural guide for local stakeholders managing impacts on cultural sites is important because of:

(a) a stall in UNESCO initiatives, and an absence of IPCC heritage initiatives aimed at coordinating and guiding international actions to manage the issue (UNESCO 2006);
(b) the special relationship Indigenous people have with cultural sites, which are vital to their identity, wellbeing and cultural traditions (Australia ICOMOS 2013);
(c) the importance of Indigenous control in planning processes in general (Walsh and Mitchell 2002);

(d) the value of community controlled adaptation planning (Jones and Preston 2011); and,

(e) the limited access remote Indigenous communities have to cultural heritage services and resources (Tacon and Marshall 2014).

The Guide developed and tested here requires users to consider:

a) hazard zones, aims, methodology, barriers, resources, leadership and ownership of output;
b) non-climate threats alongside climate threats, in order that assessment be mainstreamed into core business;
c) exposure and sensitivity to hazards;
d) cultural site significance;
e) building the adaptive capacity of site managers;
f) building the resilience of sites; and
g) a variety of direct intervention actions.

No previous research has brought these fundamental elements together in one integrated methodological approach. In particular, the fact that non-climate as well as climate threats are considered, makes the Guide applicable outside a strictly climate change adaptation context. The Guide has the potential for wide application in terms of general cultural site conservation.

Proposing a guide necessitated its subsequent testing. Given the final Guide will constitute a form of PAR in its own right, using PAR in testing and refining it was a complementary, highly compatible approach. The Guide was tested but also modified by those testing it, through workshops, semi-structured interviews, and observations of field activities, particularly during

the risk assessment step, so that it produced practical outcomes tailored to the articulated and observed adaptation needs of users.

Discussions on Country facilitated the development of place-specific strategies (instead of having to think of all the issues away from the field). Small group discussions with Indigenous workers and managers allowed practitioners to 'negotiate' answers more readily among themselves. Semi-structured interviews allowed for a more natural flow of inquiry. The application of these multiple methods of inquiry among the same group of participants allowed for triangulation of the results while also providing a more holistic reality (Bryman 2008).

The overall aims of the research – to develop the Scoping, Risk analysis and Options analysis steps of an effective Cultural Sites Adaptation Guide – have been achieved. Rangers recognised the potential management implications of this research in enthusiastically engaging with its Scoping phase. Incremental realisation of outcomes saw them subsequently progress first to the Risk analysis and thereafter, on the basis of further outcomes, to the Options analysis step. The integrated nature of the Guide's steps hinders progression through the process without successfully completing previous steps. Rangers now have great interest in pursuing the final phases of the Guide: Step 4: Plan/implement; and Step 5: Review. In April 2017, Djelk Rangers travelled to Canberra and met with the author and the Research Services Unit from the College of Asia Pacific, Australian National University, to plan an Australian Research Council Linkage Project that aims, primarily, to explore the final steps of the Guide, subsequently test the Guide in an international context (e.g., the Pacific), digitise the Risk Field Survey, and develop 3D photogrammetry workflows for rangers. Further detail is provided in the section Future Work, below.

Key findings and contribution to knowledge

This study contributes to academic knowledge relating to:

(a) cultural site climate change adaptation, and

(b) Indigenous climate change adaptive capacity.

Improvements in institutional management, organisational practices or use of technology may lead to an increase in adaptive capacity (Smit and Pilifosova 2003; Folke et al. 2010). The methodology designed and tested here for institutional management of climate change risks by Indigenous rangers was able to elicit detailed and extensive responses from rangers, who produced a large data set pertaining to risk and options analysis, and a formal adaptation plan. Assisted by the methodology's first three steps – Scoping, Risk analysis and Options analysis – ranger outputs demonstrate a high degree of adaptive capacity.

The study contributes to knowledge of Indigenous rangers' cultural site adaptive capacity by way of the following findings:

1. two Indigenous ranger groups in northern Australia have substantive perceptions of climate change impacts on cultural sites, and these are broadly consistent with climate change projections made for their region by the CSIRO; two ranger groups in central Australia had no such perceptions, most likely due to the absence of sea level rise as a threat and central Australia's extreme natural climate variability;
2. Indigenous rangers with perceptions of climate change impacts on cultural sites express a priority need for a planning methodology to assist them manage the impacts of climate change on cultural heritage sites and were willing to engage in the development of a bespoke method;

3. The use of a Participatory Action Research approach, involving rangers as co-researchers in developing the methodology, led to significant modification of a proposed methodology. This was particularly the case with the Risk analysis step, which found a base model too generic and unworkable, and led to a revamping of values and the addition of five new variables as well as a significantly modified system for assessing cultural value;
4. The Indigenous rangers that engaged with the planning methodology were able to reach a considered consensus on the nature of climate change threats posed to cultural sites. Rangers concluded that (a) climate change is increasing the risk of more frequent, extensive and faster-moving riverine flood events, which in turn impact inland and floodplain-fringing rock art and floodplain-fringing shell and earth middens, (b) climate change is increasing the threat of sea level rise, and more frequent, extensive and faster-moving storm surge events, which in turn impact coastal middens and floodplain-fringing shell and earth middens, (c) climate change is exacerbating numbers of invasive species, which in turn increase risks to middens and rock art, and (d) climate change is exacerbating the frequency and extent of severe fire events, which in turn increases risks to middens and rock art.
5. The Indigenous rangers that engaged with the planning methodology were able to nominate and reach a consensus on appropriate goals for cultural site climate change adaptation. Those goals chosen were broad, and reflected the cultural responsibilities of Traditional Owners and custodians;
6. The Indigenous rangers that engaged with the planning methodology were able to, from a set of proposed approaches, nominate and reach a consensus on a risk analysis method for cultural site climate change adaptation. They regarded an *in situ*, field-based approach, as opposed to GIS methodology, to be culturally appropriate;

7. The Indigenous rangers that engaged with the planning methodology were able to nominate and reach a consensus on barriers and resource shortfalls that might impede climate change adaptation. These included the availability of data, finances, training and governance issues. However, a wide set of skills and traditional knowledge was identified as being available. Barriers and resource shortages were not deemed insurmountable or too onerous in terms of achieving project goals;
8. The Indigenous rangers that engaged with the planning methodology were able to nominate individuals able to take leadership roles in climate change risk analysis;
9. The Indigenous rangers that engaged with the planning methodology argued that published findings from research they participate in should cite them as co-authors;
10. The Indigenous rangers that engaged with the planning methodology were found to have unique climate change adaptation risk analysis needs including adopting an approach that is: (a) amenable to bottom-up planning, (b) able to incorporate non-climate change impacts on sites, (c) not dependent on climate change projection data, (d) not based on remote GIS analysis, (e) able to provide a monitoring function and interface with an existing ranger digital data collection platform (I-Tracker), (f) able to assess risk but also assess significance, and (h) able to conduct adaptation planning in a culturally appropriate way;
11. The Indigenous rangers that engaged with the planning methodology were able to assign a management priority to a set of cultural sites. Over 120 cultural sites, consisting of 25 rock art sites and 101 middens, were prioritised. These management priorities combined assessment values for (a) the risk of loss or damage from human, climate change, biological and natural weathering hazards to cultural sites, with (b) the relative cultural value (significance) of sites;

12. The Indigenous rangers that engaged with the planning methodology were able to identify and appraise an exceptionally large range of climate change adaptation options. The actions prioritised were diverse and involved: direct adaptive interventions at threatened cultural sites; augmenting Indigenous ranger groups' cultural site management capacity (adaptive capacity); and increasing the climate resilience of cultural sites. Rangers prioritised (a) communicating the gravity of the climate change threat to cultural sites via a video documentary, (b) developing research partnerships with universities and archaeologists, (c) digitalising a Risk Field Survey, (d) developing a 3D modelling workflow and an Augmented Reality application to document sites most at risk, (e) addressing governance issues (f) training provision, (g) increasing legal protections to sites, (h) creating safe storage for 3D models of sites, (i) culling invasive species, and (j) conducting fire management at sites.

Effectiveness of the planning methodology

The value of the planning methodology's individual steps and components was assessed using a technique first outlined by Weiss (1995) and later incorporated into a goal-orientated action research method called 'Theory of Change' (Taplin, Collins, and Colby 2013). Using this technique, underlying assumptions or 'theories' inherent in the tool were stated from the outset, along with their expression in academic studies. The theories were linked to proposed corresponding outcomes, or outcome indicators, in an assessment model. As rangers progressed through the tool's steps, achievement of outcomes allowed the validation, negation or modification of initial assumptions, and of the guide itself. Where the propositions in the validation model were largely or partly confirmed, subsequent phases were then tested by the assessment model.

Further discussion of the results from the Scoping, Risk analysis and Options analysis steps of the methodology are now presented.

Scoping

This research finds that experienced Australian Indigenous rangers in two coastal case study areas perceive climate change to be impacting cultural heritage sites. Rangers were able to identify site types impacted as being shell and earth middens, rock art, Dreaming sites, ceremony and burial sites.

The main climate change impacts perceived are coastal and floodplain erosion and inundation derived from sea level rise and extreme storm surge. However, riverine erosion and inundation derived from more frequent and extensive extreme precipitation events was also perceived. The vulnerability of riverine cultural sites to climate change impacts is a further unique finding of the research.

Rangers 'perceived' the impacts of extreme weather events as climate change impacts. These perceptions may have been influenced by popular representations of climate change in the media, by ranger attendance at climate change symposiums over the years, or by the presence of climate change research in their domains. However, these perceptions are also consistent with documented trends in sea level rise for northern Australia, current issues with vegetation death from saltwater intrusion into low lying freshwater flood plains, and climate change projections. Very significant sea level rise has been observed in the monsoonal north of Australia since the 1960s. Furthermore, there is a 'high confidence' in future sea level rise and extended extreme sea level rise events (i.e. extreme storm surges), in more extreme precipitation events (i.e. riparian inland flooding), and 'moderate' confidence in more intense

cyclones (CSIRO and Bureau of Meteorology 2015). This consistency between ranger perceptions and regional scale climate change projections suggests a useful role for heritage monitoring by rangers as a means of ascertaining trends in climate change at a local level.

The current cultural site management practices and policies that guide rangers in the case studies are currently not adequate to manage climate change impacts on cultural sites. The Rangers, however, were able to reach a consensus on planning goals and on a preferred methodology to achieve those goals. The preferred methodology is to assess risks to sites *in situ*, but simultaneously to address governance issues and build adaptive capacity. Governance issues, experienced at the local level, were different in each case study: the Djelk Rangers experienced interference from non-Indigenous community administration officers in their planning processes, while KNP rangers lacked control over resource allocation to cultural site management. The Djelk Rangers' dissatisfaction with non-Indigenous interference in a consultatively planned buffalo cull ultimately led to the departure of the administrator involved (Altman 2016). In contrast, the KNP Rangers felt they did not have the power to intervene in the decision-making process and were disillusioned with joint management. The governance barriers faced by the KNP Rangers were therefore more significant than those of the Djelk Rangers, because of KNP Ranger dependence on outside resourcing, with the implication that a ranger group working under the auspices of an Aboriginal corporation (Bawinanga Aboriginal Corporation) is better equipped to undertake climate change adaptation than is one ultimately controlled by an Australian Government department. In terms of resource availability, the KNP Rangers felt allocation to site maintenance was diverted to the demands of tourism but that an adaptation planning process might reveal the dangers facing sites and thereby persuade the Park to revisit its priorities. In contrast, the Djelk Rangers felt their biggest

resource deficit was data. In both case studies, leaders emerged who proved willing and able to take a proactive role in the research process and help address these concerns.

Risk analysis

The testing of the Risk Field Survey gave rise to multiple findings. The Survey was able to allocate a management priority to 126 sites (1001 middens and 25 rock art sites) on the basis of a combined assessment of three factors: exposure to threats, sensitivity to threats, and cultural significance (consequence). During testing by rangers the Risk Field Survey was modified to produce a system able to rank sites as either a 'high', 'very high', 'medium', 'low' or a 'very low' management priority.

The base model (Daire et al. 2012) did not distinguish between site types. The Risk Field Survey devised here, however, differentiated between middens and rock art, using different values to assess factors such as the sensitivity of the substrate to exposure variables. Because of this, results for middens and for rock art can be directly compared. Middens were generally assessed as being more at risk than rock art sites. In terms of relative risk (exposure / sensitivity) 48 percent of rock art sites were at high risk of loss or damage, while 90 percent of middens were at high risk of loss or damage. Results also show, however, that rock art sites are generally more valued than midden sites. In terms of cultural value, 84 percent of rock art sites were assessed as class 3 significance, while only 3 percent of middens were assessed as class 3 significance.

The results for the assignment of management priority ratings reflect significantly the additional value assessment. Around 40 percent of rock art sites were given a 'very high'

management priority, while 3 percent of middens were given a ‘very high’ management priority. This underscores the importance of including an assessment of cultural value.

Assessment of site significance in a transparent fashion was something lacking prior to this research, though studies do acknowledge its importance (Dawson 2015; Daly 2014; Bickler, Clough, and Macready 2013). Dawson makes a scientific assessment on the basis of such factors as ‘rarity’, ‘period’, ‘condition’, ‘group value’ and ‘potential’ (Dawson 2013 p. 80). He does not, however, make the criteria explicit, conducts the assessment as a heritage professional and does so within the context of a remote GIS-based evaluation.

Assessing significance on the basis of Indigenous cultural site value required a novel approach. As Brown (2008) stated, there was formerly no rigorous methodology for assessment of Indigenous social value:

> If Aboriginal heritage items are to be managed pre-eminently for their Indigenous heritage values then methodologies to assess (and also identify and manage for) social and spiritual values are required (Brown 2008, p24).

Absence of significance assessment is one of the detractions of the base model developed by Daire *et al* (2012). Without including consideration of value, conservation or adaptation efforts might focus on sites for which Indigenous social or cultural consequence is less important. As a result, precious Indigenous resources might be misdirected. The model developed here, however, *is* able to target those middens that *do* have significant cultural value.

From a scientific or archaeological perspective, the use of cultural values might be seen as a major flaw in the Risk Field Survey: middens might hold values appreciated by archaeologists

but not Indigenous custodians. However, rangers are clear that they want to maintain relations with archaeologists and give them the opportunity to review their Indigenous value assessments and augment them with archaeological assessment if need be.

There is another consideration. As stated in Chapter 3, absolute notions of scientific significance were abandoned in the post war period in favour of determining which sites best represent a range of archaeological variation (Briuer and Mathers 1996). Assessing the significance of Australian Indigenous sites, Bowdler considered a site's 'representativeness' and ability to 'answer timely and specific research questions' (Bowdler 1981 p.1). In one of our case studies (see below), research has been prolific, but in the other, no comprehensive survey for each site type has been undertaken to date. This is likely to be the case in many Indigenous contexts internationally. Although the relativistic approach acknowledges that significance is mutable and dynamic, it still sees significance residing in the physical fabric of the place, rather than something given to a place by those who value it (Little, Mathers, and Darvill 2005).

The study restricted itself to assessment of middens and rock art sites despite rangers also identifying threats to Dreaming, ceremony and burial sites. These broader categories, often inclusive of midden or rock art sites, were usually landscape-scale features such as entire hills or broad ecological areas such as whole forests comprising particular species.

Options analysis

The testing of the options analysis phase found rangers were able to identify a very comprehensive list of options and successfully appraise them. The final rankings encompassed three categories of response: direct intervention actions; adaptive capacity building measures;

and site resilience building measures. No other single study has brought together as many possible options for site intervention, adaptive capacity and resilience building as those identified by the rangers, albeit ranger-identified options were particular to local conditions. The results constitute the first systematic options analysis for cultural site adaptation. The results also constitute a preliminary cultural site adaptation plan. Appendix 3. Presents the Djelk Ranger preliminary cultural site adaptation plan.

Limitations of the research

The Guide, however, had a number of limitations and constraints, which included:

1. not being based on climate change data, but on ranger perceptions of climate change;
2. being devised without reference to any site monitoring data;
3. not being able to be used if sites are secret and if traditional owners do not grant permission for ranger access;
4. being restricted to two site types, namely rock art and middens, and not being applicable to landscape-scale cultural sites such as whole hills or extensive forest tracts;
5. having a focus on coastal sites;
6. not testing the methodology outside the particular bioregion of the case study areas;
7. having less than optimal female ranger input;
8. not undertaking a calibration of the Risk Field Survey during the Scoping step; and
9. the absence from the significance assessment of aesthetic and scientific values.

The following sections address these issues:

Climate projections at the local scale

This research confronts the issue of adaptation planning conducted without downscaled, local climate change projections. Its approach is influenced by the Intergovernmental Panel on Climate Change's (IPCC 2014) recommendations to, despite uncertainty, engage in adaptation. As a proxy for detailed climate change projections, rangers planned adaptation on the basis of their observations of current extreme weather events. While their observations of impacts on cultural sites were consistent with broad climate change projections for monsoonal northern Australia, they were, pointedly, 'perceptions' of climate change impacts rather than demonstrable proof of climate change. As downscaled, localised projections become available in the future, a means of incorporating these into the process will be sought.

Absence of monitoring data

The planning process was undertaken despite the non-existence of monitoring data on impacts. For this reason, the Risk Field Survey is designed to also be a monitoring tool. Once data is collected, it will be incorporated into future adaptation planning cycles. Data review will be an important element in subsequent steps.

Cultural protocols

The research demonstrated that cultural protocols are not generally a barrier to adaptation planning for cultural sites. Precautions such as providing the opportunity for planning in which men and women certain kinship relations are separated is not difficult to arrange. In terms of sacred sites with restricted access, consultation must be conducted with Traditional Owners and caretakers at every stage of the planning process. It is inevitable that assessing, recording and storing data will not be permitted for some sites. The type of site excluded, however, is likely to be landscape scale sites, such as sacred forests, billabongs, springs or ceremony areas.

Rock art and middens are significantly less likely to be ‘dangerous’ or secret places. A study of the Implementation step might investigate a change in the amenity of traditional custodians to allow assessment of secret sites, and methods to maintain privacy. Provision of training that allows traditional custodians to undertake the assessment themselves may overcome the issue.

Risk Field Survey is site-type specific

The Risk Field Survey is geared to specific cultural site types rather than being generic in its application. The study restricted itself to assessment of middens and rock art sites because the broader categories of Dreaming, ceremony and burial sites were – if not actual midden or rock art sites with Dreaming, burial or ceremonial associations – landscape-scale features such as entire hills or broad ecological areas such as whole forests comprising particular species. Designing a tool specifically geared for to middens and rock art was a decision made on the basis of these having been the only non-landscape scale site types nominated by rangers as under threat. The base model (Daire et al. 2012) was designed for a European context containing a highly diverse range of site types, but the base model was found to be too difficult to use on account of that generality. Future testing of the tool may encounter other site types, such as historic buildings, in which case further site-specific assessment additions will have to be devised and tested.

A focus on coastal sites

The research was largely focussed on coastal sites. While over 100 coastal sites were investigated, only 25 inland sites were assessed. In investigating those inland sites, which were exclusively rock art sites adjacent to rivers, the study was able to add important knowledge to the field: riverine sites were confirmed to be vulnerable to extreme precipitation events and extreme flooding derived from elevated daily, as opposed to total, rainfall. Elevated daily

rainfall is nominated as a climate change threat for the region by the CSIRO (CSIRO and Bureau of Meteorology 2015).

For riverine sites, an option of ameliorating the threat of flooding by way of clearing debris from rivers or diverting the course of rivers was not identified as an option by rangers. This is likely because of the extreme inaccessibility of remote and rugged territory and the major resources diversion would require, let alone the cultural appropriateness of such works.

Application of the methodology outside the case study areas

Mainstreaming climate change risk analysis into broader risk analysis makes practical action significantly more likely (Huq and Reid 2004; Smit and Wandel 2006). The field survey approach is unique in that it includes exposure and sensitivity to additional non-climate threats, avoiding a scenario in which a site rated as a low climate change priority is lost to another threat not considered. It also means that the field survey can be used in regions of great natural climate variation, however, where there may be few observable, direct climate change impacts. Given the Guide is more than a tool for climate change adaptation, where perceived or recorded climate change impacts are negligible, its use for general conservation is still highly relevant. This is a secondary advantage of taking a mainstreaming approach to climate change adaptation of cultural sites. The current study included two case studies in coastal areas but did not, however, have the resources to include a third, inland case study.

Female ranger involvement

The involvement of female rangers was limited. During the Options phase, Djelk women became available to engage with the identification and appraisal of adaptation measures. Their input was insightful, especially so given they had not been involved in Scoping and Risk

analysis steps. Of note, they emphasised the importance of knowledge sharing. Future research will aim for greater gender balance.

Calibration of the Risk Field Survey during the Scoping step

The Risk Field Survey had not been constructed at the time of the Scoping phase. If it had been, an additional scoping element might have considered the calibration of the survey. For example, it might have been weighted to emphasise particular concerns or vulnerabilities experienced by a ranger group. This might involve giving less weight to feral animal impacts where feral animals are being successfully culled, or less weight to tourism impacts where tourism is not a feature of the local economy. Such a weighting process would not be difficult, in principle, but further tests of the Scoping step are needed to understand how Indigenous participants would undertake the task.

Significance assessment

The significance assessment considered neither aesthetic significance nor scientific significance, in response to ranger preferences. The International Council on Monuments and Sites (ICOMOS) in Australia defines 'cultural significance' in terms of 'aesthetic, historic, scientific, social or spiritual value' (Australia ICOMOS 2013). 'Social' is defined in terms of 'group' or 'community identity'. There is, however, little in the way of detailed guidance in assessing site cultural significance beyond this. During the scoping phase, rangers and Traditional Owners discussed why cultural sites were important to them, without reference to the five ICOMOS categories. The explanations provided, however, were broadly in keeping with three of the five ICOMOS indicators of cultural significance. Notably, no aesthetic or scientific explanations of value were provided. It is conceivable that other users could deem these factors equally important. This might especially be so where the users are non-Indigenous

or where cultural traditions have been lost. There is, however, flexibility within the Guide to incorporate such additions.

Future work

Future research will be concerned with the Guide's fourth and fifth steps, Plan/implementation and Review.

Writing formal adaptation plans

The process of turning ranked options into a formal plan will involve broad community consultation and endorsement. It is envisaged that rangers will be responsible for this process, which has the potential to raise issues previously not considered. The process will be planned and documented; lessons learnt and the resulting protocols for the process will be negotiated and inserted into the final version of the Guide.

The Implementation and Review steps were not investigated. Assessment of the Implementation of the Cultural Site Adaptation Plan, drawn up by the rangers, would require an analysis spanning some years, and the Review step can only take place after the Implementation step. It is proposed the final two steps be the subject of further research.

Implementation

Implementing plans will involve research into the role and nature of partnerships with organisations that include: the Aboriginal Areas Protection Authority; ranger coordinating bodies, such as the Northern Australia Indigenous Land and Sea Management Alliance; neighbouring ranger groups, such as Warddeken Rangers; cultural heritage managers; and Indigenous cultural IT development companies, such as Indigital Pty Ltd.

Mainstreaming the Risk Field Survey into ranger workflows will involve creating a digital version for I-Tracker, the GPS-controlled data tablet (usable in remote areas where mobile connections are not available) used in the field by rangers across the Northern Territory to monitor weed, feral and fire management. I-Trackers are connected daily to ranger databases to upload information gathered in the field and provide visualisation of management progress via digital, real-time mapping. It is envisaged that collected cultural site data will be uploaded in order to create real-time maps displaying prioritised cultural sites. Research will explore the practicality of this process as well as the implications for cultural protocols. It will also explore how to filter data specific to various threats, given the Risk Field Survey collects data on a range of non-climate as well as climate threats. Further research will also focus on incorporating other site types into the Risk Field Survey, such as Dreaming and historic sites, and on how their unique features can be reflected in the Risk Field Survey's parameters.

During the Options analysis step, rangers prioritised digital 3D documentation of high-risk sites for use on monitors but also with Virtual and Augmented Reality applications. There are often clear limits to climate change adaptation (Barnett et al. 2015), and studies of Indigenous stakeholders planning whole-of-community climate change adaptation within the context of sea level rise have reported both important limits as well as cultural barriers (McNamara et al. 2012). Our study, however, documents Indigenous Rangers confronting inevitable loss or damage to cultural values with a high degree of pragmatism and few cultural constraints. Rangers were prepared to bear losses and ameliorate the consequences of loss with surface-documentation, while at the same time exploring new technological aids to this end. Climate change adaptation options that use new technology can potentially benefit disadvantaged populations (Noble et al. 2014; MacLean 2008).

Reilly (1990), an early exponent of Virtual Reality as an archaeological research tool, referred to 'virtual archaeology' as the modelling of landscapes, excavations, buildings, and artefacts with computer applications in order to test scientific questions, but also to communicate the past to non-specialists. Digital 3D imagery and visualisation has since become available for many iconic archaeological sites globally (Katz and Tokovinine 2017), for Australian Indigenous cultural sites (e.g., Irving and Hoffman 2014; Bourke 2014), and even for lost sites – for example the Temple of Bel in Palmyra, Syria (Wahbeh, Nebiker, and Fangi 2016). While Virtual Reality provides an immersive experience of a cultural site at an alternative location, emergent Augmented Reality hardware that supplements reality with 3D imagery might allow Indigenous Traditional Owners to secure threatened traditional cultural *knowledge* but also location-dependent, traditional cultural *practice*. Experiencing a lost cultural site in its original location allows users to maintain their, and a site's, *connection to Country*. Connection to Country is essential to Indigenous cultures – land, language and place are embedded in kinship relations, identity, belief systems, justice codes, spirituality and Indigenous sovereignty, as well as physical, social and emotional wellbeing (Ganesharajah 2009).

Unfortunately cultural protocols and resources did not allow experimentation with this approach. Future research will explore 3D photogrammetry workflows appropriate for rangers, as well as the development of an Augmented Reality application for ocular headsets such as Microsoft's Hololens, which could potentially allow the visualisation of lost sites within their former, non-virtual location.

Future research will also focus on barriers to incorporating more female rangers' input into the management and monitoring of cultural site climate impacts. It will also investigate how best to use the Guide in a context in which threats to a single site are being addressed. Investigations

will be undertaken into an additional scoping step element that allows rangers to calibrate the Risk Field Survey in line with the threat types and levels unique to the area in which it is to be used.

It is anticipated that the Guide will allow rangers to develop a whole new skill set. Training courses will be developed in the use of the Risk Field Survey as well as in general cultural site management. Training courses will be developed for delivery by rangers to other rangers. A Certificate in Sacred Site Maintenance might be developed as a module in an overarching Certificate 4 in Indigenous Natural Resource Management.

Review

Further research will also investigate the nature, content and structure of the Review step to be incorporated into the Guide. In particular, investigations might focus on the use of data gathered by way of the Risk Field Survey in the Review process, how that data will be presented and who will be party to it. A broad community consultation process might be undertaken, in which rangers present data gathered to date to various outstations and to different language groups in order to record their feedback. This might also allow further or extensive perceptions of impacts of climate change on cultural sites to be gathered and possibly the inclusion of new cultural site types. It might allow a more comprehensive identification of adaptive measures and might include new criteria in the options appraisal process. The inclusion of landscape-scale sites might also be considered, and the kind of variables and values needed to allow their inclusion in the Risk Field Survey. An important focus will be on the period between each Review process. The period might be every two, five or even ten years. Feedback on this important issue from a variety of custodians will be useful.

Broader research into Indigenous wellbeing

Further research might also consider the potential for multiple co-benefits to arise through the application of the Guide and regular use of the Risk Field Survey by rangers and custodians and other Indigenous community members. In particular, research might investigate the Guide's potential to re-establish the connection between Indigenous people and their cultural sites, where this has been diminished or lost. Research might consider the Guide's role in returning to and carrying out activities on Country, and thereby providing a way to counter feelings of disempowerment and despondency. Activities that re-engage Aboriginal people with Country might serve to build cultural resilience in the face of multiple economic, environmental and social challenges, so benefiting their physical and psychosocial health and wellbeing.

Conclusions

Indigenous management of cultural heritage site adaptation is important given the Indigenous origins, continued custodianship, cosmological importance of, and remote locations of many cultural sites. However, Indigenous knowledge and empirical understanding of challenges to cultural sites makes it an imperative. While this research focused on an Australian setting, these findings may well be relevant to Indigenous groups undertaking cultural site adaptation elsewhere. In Alaska for example, municipal government agencies have heritage responsibilities, but cannot address the issue alone. Avenues for community participation are being developed to support local custodians in protecting their cultural heritage sites (Jensen 2017). Support for climate change adaptation strategies that involve ownership and control by Indigenous stakeholders (i.e., bottom-up planning) needs to be incorporated into contemporary climate change policy.

Work in the field of Indigenous community adaptation is in its infancy and there remains a need for practical and accessible adaptation planning pathways for Indigenous peoples. While this study will support Indigenous custodians to identify and appraise adaptation options, it also has the potential to provide experience of adaptation planning that can be used in whole-of-community projects.

The multiple insights and outcomes from this research include a repeatable and transferable process. Results critically highlight that practical and rigorous approaches can be taken to climate adaptation of cultural heritage sites, even if financial resources are constrained.

The development of strategies at an international level, as well as at national and regional levels to combat climate impacts on local and world heritage assets have made little progress since interventions at the beginning of the millennium by the UN and UNESCO. Renewed efforts need to facilitate not only risk analysis but also options analysis, across global, regional and local scales, and create links between those working independently at a local scale in order to share knowledge born of empirical experience. Future reports of the IPCC and programs of the United Nations Framework Convention on Climate Change need to increase the inclusion of archaeological considerations and research.

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Appendix 1

The Cultural Site Adaptation Guide

The Cultural Site Adaptation Guide

Step 1. The Scoping workshop

Scoping questions / issues for consideration by stakeholders	
1	**Problem analysis – Is there a climate change problem for cultural heritage sites?** • Is there a climate change problem for sites? • If so, where is it happening? What kinds of sites are being affected? How are they being affected? • How are sites currently being looked after? How often are sites visited? How often is maintenance done? Often enough? Health of sites? What gets in the way of conducting site maintenance? • Is what's being done now enough to make sites strong against climate change?
2	**Aims, goals and objectives – What do you want for and feel about sites?** • Why are sites important to you? What do you want for sites and for the next generation? • What are the goals of this project?
3	**Methodology – How will we make sites strong against climate change?** • Do you know of other projects looking at sites and climate change? What have these projects achieved? If not, facilitator describes France-NZ-UK-Belgian risk analysis for heritage sites. • What do people think of this? Instead we could: o Not focus on sites, but talk about how to make ranger job descriptions more inclusive of climate change adaptation duties? o Not focus on sites or job descriptions, but talk about how to make Park or Aboriginal Corporation natural resource management policies more inclusive of climate change adaptation considerations? • Could the chosen approach fit in with current work? • What cultural protocols should be considered? • Would this benefit for the community? Could this be bad for the community • How will we know when what we do is working or checks-out with sites? In other words, that sites on maps are where the map says they are or sites we think are in big danger on a map seem so on the ground (i.e., develop monitoring and evaluation strategy?). • What's our time frame? • Do we need a communication plan?

4	**Stocktaking of resources – What do we have that will help?** • What physical resources do you have? • What people / skill resources do you have? • What money resources do you have? • What maps do you have: For sites? For places where climate change is happening? • What is in the Park/ranger database? • Can the facilitator access it to build up a map of sites?
5	**Barriers – What might get in the way?** • What difficulties might you face? What are your strengths and weaknesses? • Does the Park/ranger group support the project? • Might the management plan prevent us from undertaking the project?
6	**Leadership and roles – Getting the full team together** • Who inside the ranger group might also be on the project team? Who else has special authority? • Who else needs to be involved and why? Who outside the ranger group in the Park or Indigenous Protected Area (IPA)? Who outside the Park or IPA? • Who will do what? • How will we record what is said and decided?
7	**Ownership – How will knowledge be protected?** Who will have ownership of any outcomes, such as an adaptation plan or documented traditional knowledge?

Step 2. The Risk Field Survey

A – EXPOSURE				
Exposure variables		**Value options**		
		Numerical score for each option		
		1	*0.6*	*0.2*
Human impacts	**A1. Infrastructures**	township <4km	outstation <4km	neither <4km
	A2. Activities	tourism <4km	hunt/gather <4km	neither <4km
	A3. Traffic/frequency of passage	graded road <4km	track <4km	neither <4km
Climate change impacts	**A4. Distance *from* tidal edge/river**	<100 paces	100 to 400 paces	>400 paces
	A5. Distance *above* tidal edge/river	below 2 paces	2 to 6 paces	above 6 paces
	A6. Geomorphological risk a) gorge (rock art) b) channel (floodplain midden) c) river mouth (coastal midden)	 narrow gorge <100 paces <100 paces	 wide gorge 100 to 400 paces 100 to 400 paces	 none >400 paces >400 paces
Bio-impact	**A7. Feral animal and plant impacts**	strong	some	none
	A8. Native flora/fauna erosion	strong	some	none
	A9. Fire hazard	strong	some	none
Natural weathering	**A10. Natural weathering** a) fading (rock art) b) deflation (midden)	 strong completely flat	 some minor elevation	 none steep sided
Score for Exposure = A1+A2+A3+A4+A5+A6+A7+A8+A9+A10				
B – SENSITIVITY				
Resistance	**B1. Remains' resistance** a) ochre type (rock art) b) structure (midden)	 red solid	 yellow soft	 black/white/wax scattered
	B2. Substrate's resistance a) rock hardness (rock art) b) soil type (midden)	 hard clay	 soft soil	 crumbling sand
Protection	**B3. Natural protection** a) rock overhang (rock art) b) tree consolidation (midden)	 deep rock shelter strong	 some overhang some	 no overhang none
	B4. Built protection (fence)	well maintained	unmaintained	none
	B5. Legal protection (a) on Indigenous-owned land, (b) listed under heritage legislation	both (a) and (b)	either (a) or (b), but not both	neither (a) nor (b)
Score for Sensitivity = B1+B2+B3+B4+B5				
LIKELIHOOD OF LOSS / DAMAGE = Subtract score for Sensitivity from score for Exposure				

C – CULTURAL VALUE			
	Value type	**Questions for Traditional Owners / Caretakers about midden and rock art sites**	**Cultural value class**
C-1	**Group-identity value**	**No questions:** This is the default class for all sites	**One**
C-2	**Historical value**	**Does the midden or rock art site contain or have:** 1. A name, either traditional or modern? 2. Tools (or tool impacts, such as grind holes), which show us how old people lived on Country? 3. Pictures that show us how old people looked, hunted, gathered, fought, their tools, and what they noticed about white fellas? 4. Pictures good for showing us how to paint things?	**Two**
C-3	**Traditional cosmological value**	**Does the midden or rock art site have:** 1. A Dreaming story? 2. A burial (bones) in it or nearby? 3. A ceremony site at it or nearby? 4. Secret or dangerous knowledge? 5. Pictures showing spirits, or half-animal, half-people beings, or sacred animals, or a ceremony?	**Three**

Matrix for calculating the management priority of cultural sites

		MANAGEMENT PRIORITY		
LIKELIHOOD OF LOSS OR DAMAGE	**> 2**	medium	high	very high
	1-2	low	medium	high
	< 1	very low	low	medium
		CLASS 1	**CLASS 2**	**CLASS 3**
		CULTURAL VALUE CLASS		

Step 3. The Options analysis workshop

1. Identifying options

1.1 Use options suggested during Scoping and Risk analysis steps.

1.2 Use a generic list of options.

1.3 Use free brainstorming.

1.4 Use the following prompts to elicit responses:

a) options that directly intervene at sites;

b) options to build adaptive capacity of stakeholders;

c) options to build site resilience.

2. Appraising options

2.1 Conduct a first-pass option screening.

2.2 Use the following assessment criteria to rank options in a matrix:

Criteria	**Question put to stakeholders**
1. Cost efficiency	'Is the option affordable?'
2. Goal orientation	'Does the option meet our goals?'
3. Practicality	'Does option require available skills & capacities?'
4. Cultural appropriateness	'Is the option "proper way"?'
5. Co-benefit provision	'Will option benefit the community in other ways?'
6. Timeliness	'Can we implement option in a short time frame?'
7. Robustness	'Will option work if CC is worse than expected?'

2.3 Use the following scoring system in the matrix for answers to the questions put to stakeholders:

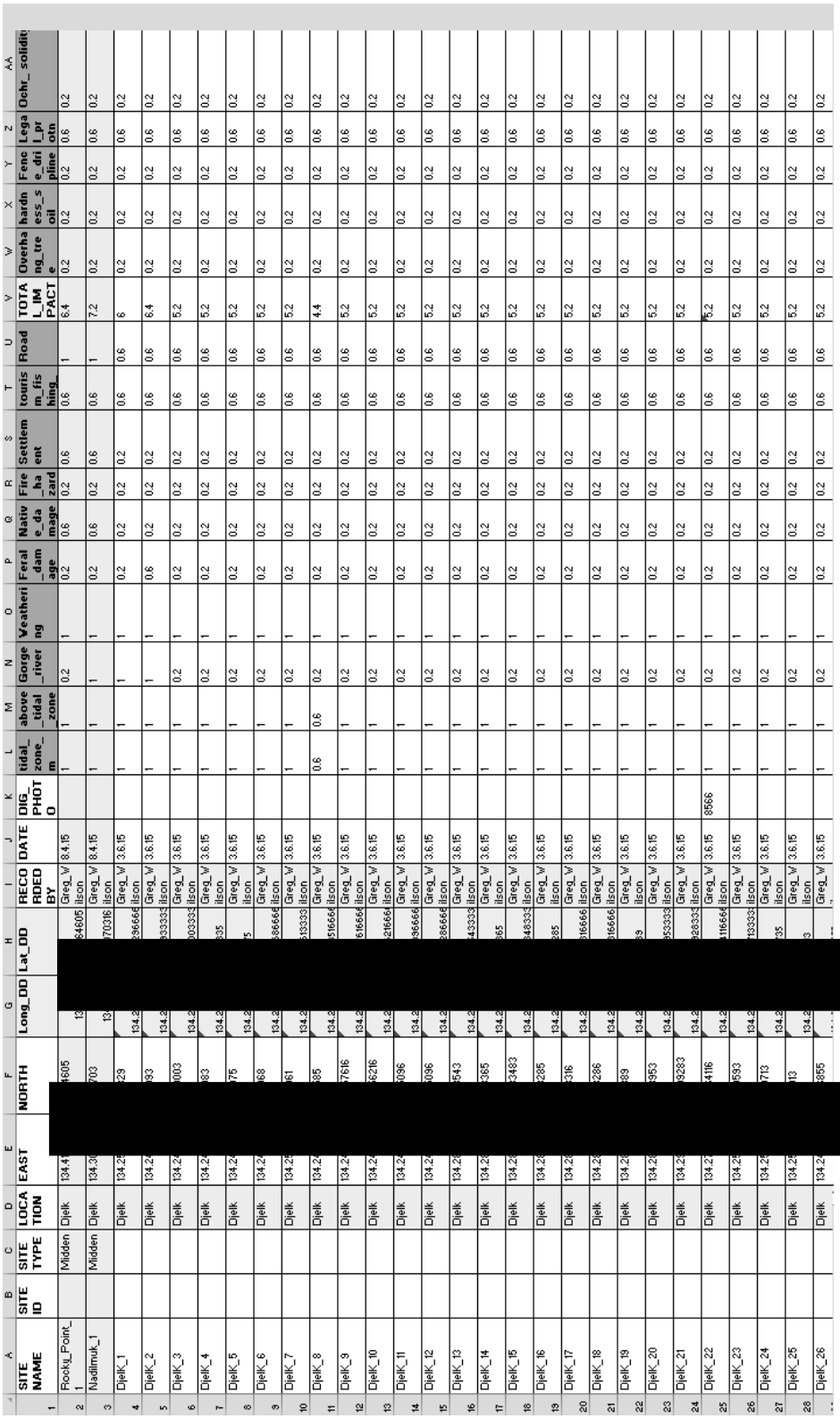
'Yes' = 2pts. 'Possibly' = 1pt. 'No' = 0pts.

Appendix 2

Risk Field Survey results for Djelk IPA coastal middens

Example of attribute table used in ArcGIS to map data collected with the Risk Field Survey

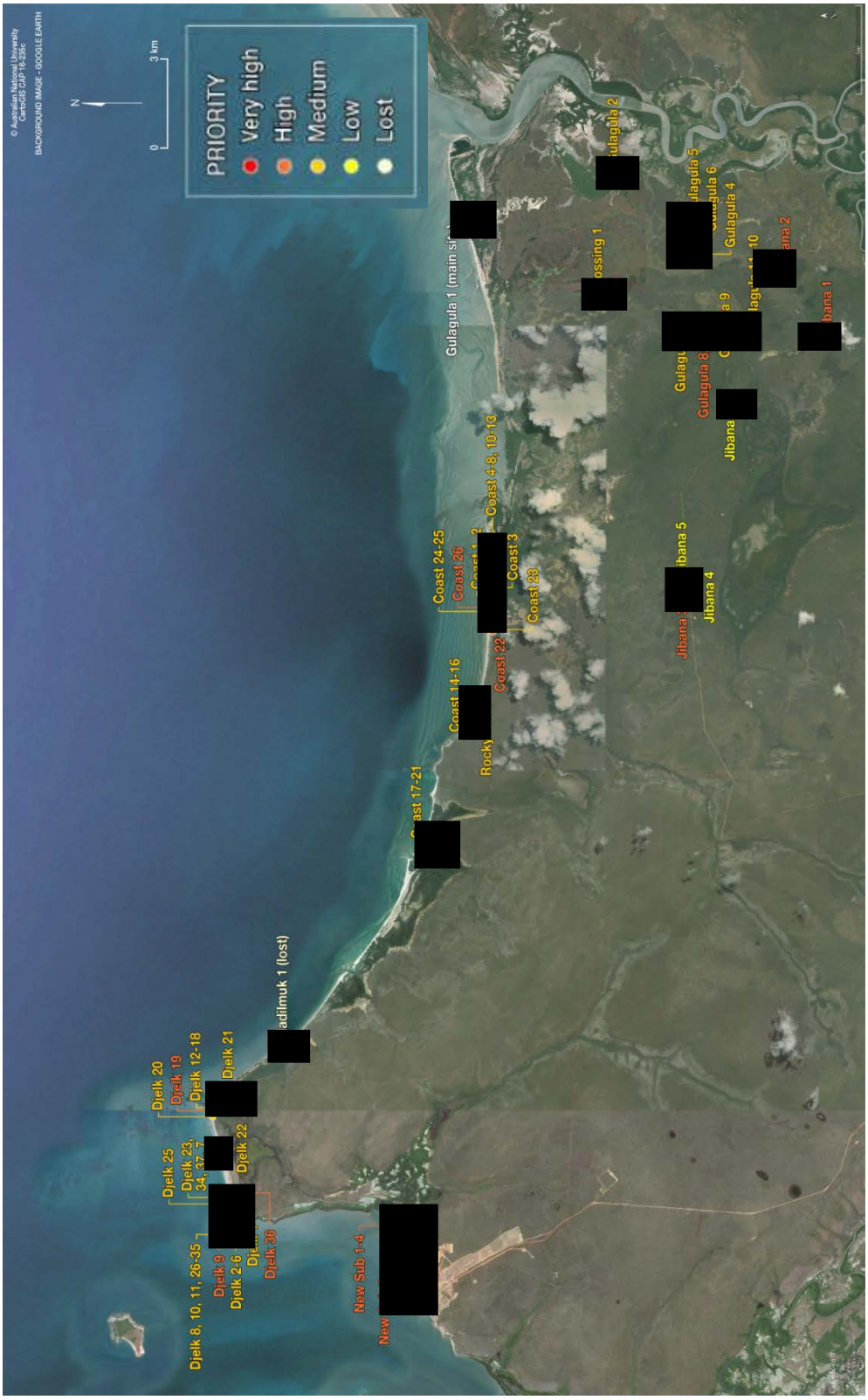
Coordinates have been redacted to hide site locations.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	SITE NAME	SITE ID	SITE TYPE	LOCATION	EAST	NORTH	Long_DD	Lat_DD	RECORDED BY	DATE	DIG_PHOTO	tidal_zone_m	above_tidal_zone	Gorge_river	Weathering	Feral_damage	Native_damage	Fire_hazard	Settlement	tourism_fishing_	Road	TOTAL_IMPACT	Overhang_tree	hardness_soil	Fence_driline	Legal_proin	Ochr_solidit
2	Rocky_Point_1		Midden	Djelk	134.41	4605	13		Greg_W ilson	8.4.15		1	1	0.2	1	0.2	0.6	0.2	0.6	0.6	1	6.4	0.2	0.2	0.2	0.6	0.2
3	Nadilimuk_1		Midden	Djelk	134.30	703	13		Greg_W ilson	8.4.15		1	1	1	1	0.2	0.6	0.2	0.6	0.6	1	7.2	0.2	0.2	0.2	0.6	0.2
4	DjelK_1			Djelk	134.25	29	134.2		Greg_W ilson	3.6.15		1	1	1	1	0.2	0.2	0.2	0.2	0.6	0.6	6	0.2	0.2	0.2	0.6	0.2
5	DjelK_2			Djelk	134.25	93	134.2		Greg_W ilson	3.6.15		1	1	1	1	0.6	0.2	0.2	0.2	0.6	0.6	6.4	0.2	0.2	0.2	0.6	0.2
6	DjelK_3			Djelk	134.24	003	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
7	DjelK_4			Djelk	134.24	83	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
8	DjelK_5			Djelk	134.24	75	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
9	DjelK_6			Djelk	134.24	68	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
10	DjelK_7			Djelk	134.25	61	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
11	DjelK_8			Djelk	134.24	85	134.2		Greg_W ilson	3.6.15		0.6	0.6	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	4.4	0.2	0.2	0.2	0.6	0.2
12	DjelK_9			Djelk	134.24	7516	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
13	DjelK_10			Djelk	134.24	6216	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
14	DjelK_11			Djelk	134.24	096	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
15	DjelK_12			Djelk	134.24	096	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
16	DjelK_13			Djelk	134.25	543	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
17	DjelK_14			Djelk	134.25	365	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
18	DjelK_15			Djelk	134.25	3483	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
19	DjelK_16			Djelk	134.25	285	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
20	DjelK_17			Djelk	134.25	316	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
21	DjelK_18			Djelk	134.25	266	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
22	DjelK_19			Djelk	134.25	89	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
23	DjelK_20			Djelk	134.25	953	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
24	DjelK_21			Djelk	134.25	9283	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
25	DjelK_22			Djelk	134.25	4116	134.2		Greg_W ilson	3.6.15	8566	1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
26	DjelK_23			Djelk	134.25	693	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
27	DjelK_24			Djelk	134.25	713	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
28	DjelK_25			Djelk	134.25	13	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2
29	DjelK_26			Djelk	134.24	3855	134.2		Greg_W ilson	3.6.15		1	1	0.2	1	0.2	0.2	0.2	0.2	0.6	0.6	5.2	0.2	0.2	0.2	0.6	0.2

Example of map produced in ArcGIS from data collected with the Risk Field Survey

Djelk coastal middens: site symbols have been redacted to hide locations.



Appendix 3

Djelk Ranger preliminary cultural site adaptation plan

Djelk Ranger preliminary cultural site adaptation plan

Action	Description	Status
Communicate the problem	Make a video highlighting climate-change threats to sites	Complete
Develop partnerships	Help, and get help from others, with similar problems. Get funding and share skills with other affected groups; form partnerships with NAILSMA and archaeologists.	Part of proposed Australian Research Council Linkage project
Digitise the Risk Field Survey	Make an I-Tracker, digital version of the Risk Field Survey that is easy to use and practical.	Part of proposed Australian Research Council Linkage project
Develop a 3D modelling workflow and Augmented Reality app	Develop new ways to document cultural sites most at risk: make 3D models for Virtual/Augmented Reality; develop workflows so rangers can make 3D models.	Part of proposed Australian Research Council Linkage project
Address governance issues	Make sure Bawinanga Aboriginal Corporation and Djelk Rangers are able to work harmoniously together.	Ongoing
Provide training	Provide two kinds of training: in using the Risk Field Survey; and in 3D modelling	Part of proposed Australian Research Council Linkage project
Increase legal protections	Work with the Aboriginal Areas Protection Authority to list more sites; put up more sacred site signs.	Ongoing
Create safe storage for 3D models	Put the 3D models in a private and secure database that allows ease of access.	Part of proposed Australian Research Council Linkage project
Cull buffalos	Cull buffalos to reduce their impacts on cultural sites.	Ongoing
Conduct fire management	Ensure current fire management is not damaging sites.	Ongoing

Appendix 4

Australian Indigenous rangers managing the impacts of climate change on cultural heritage sites

Permission to submit article for PhD examination
Article title: Australian Indigenous rangers managing the impacts of climate change on cultural heritage sites.

Authors: Bethune Carmichael, Sally Brockwell, Greg Wilson, Ivan Namarnyilk, Sean Nadji, Jaqueline Cahill, Deanne Bird

Publication: Chapter 17 in peer-reviewed monograph: *Public Archaeology and Climate Change.* (Eds T Dawson, C Nimmura, E Lopez-Romero and M-Y Daire). Oxbow Books: Oxford, UK

Status: Peer reviewed, corrected, accepted for publication, proofed and currently in press.

Bethune Carmichael Conceptualised the Cultural Site Adaptation Guide (the Guide) and Risk Field Survey; wrote the paper, collected and conducted all analysis of data; facilitated all workshops and testing of the Risk Field Survey.

Signed .....

Sally Brockwell Provided archaeological and editorial guidance and input into the development of the paper.

Signed .....C.J. Brockwell.....

Greg Wilson Participated in the testing of the Scoping, Risk analysis and Options analysis steps of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Guide and Risk Field Survey.

Signed .....Greg Wilson.....

Ivan Namarnyilk Participated in the testing of the Scoping, Risk analysis and Options analysis steps of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Guide and Risk Field Survey.

Signed .....Ivan Namarnyilk

Sean Nadji Participated in the testing of the Scoping, Risk analysis and Options analysis steps of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Guide and Risk Field Survey.

Signed .....

Jaqueline Cahill Participated in the testing of the Scoping and Options analysis steps of the Guide; provided cultutal site guidence and knowledge; and contributed to the conceptual refinement of the Guide.

Signed .....

Deanne Bird Contributed to the conceptual refinement of the Guide.

Signed .....

Chapter 17

Australian Indigenous rangers managing the impacts of climate change on cultural heritage sites

Bethune Carmichael, Greg Wilson, Ivan Namarnyilk, Sean Nadji, Jacqueline Cahill, Sally Brockwell and Deanne Bird

With contributions by Victor Rostron, Patricia Gibson, Jonathan Nadji, Jeffrey Lee, Fred Hunter, Jimmy Marimowa, Natasha Nadji and Kadeem May

Abstract

Over 100 Australian Indigenous ranger groups manage a significant proportion of Australia's natural and cultural resources. Two Indigenous ranger groups in Australia's monsoonal far north are concerned about a perceived escalation of impacts on cultural heritage sites arising from climate change, variation and extremes. A preliminary version of a tool to assist them in managing these impacts was synthesised from other community-based climate adaptation tools. It contained phases for scoping, risk analysis and options analysis. In the testing and further development of the tool, rangers identified risks to shell mounds and middens (remains of shellfish meals that have accumulated over time), earth mounds (mounds of earth that contain cultural material) and rock art (paintings and engravings found in caves and open sites) caused by more frequent and extreme sea level rise events, and inland river flooding events. They set goals, considered barriers and assessed the availability of appropriate resources. During the tools risk analysis phase, rangers sought to prioritise sites with the greatest exposure and sensitivity to not only the identified climate impacts but also a range of other threats such as fire and feral animals. While the risk analysis phase used a modified field survey approach, it sought to complement the original model with a cultural-value assessment methodology that would allow further prioritisation on the basis of site significance. To date, over 100 sites have been assessed with the tool and allocated one of five possible management priorities. In considering adaptive options, rangers confronted limits to climate change adaptation for the prioritised heritage sites. For sites most in peril from climate extremes, digital documentation was chosen over salvage or physical protection. However, rangers were concerned that confinement of sites to a database would undermine their ongoing use of them in traditional cultural practice. They therefore considered the possibility of combining photogrammetry-derived 3-D models with augmented-reality applications to re-experience lost sites in their original non-virtual locations. Validation of ranger group organisational capacity to use the climate change planning tool bodes well for its use by other Indigenous ranger groups.

Introduction

In 2015, 108 Australian Indigenous ranger groups managed 70 Indigenous Protected Areas (IPAs) covering some 63 million ha of land (Pew Charitable Trusts 2015). (Indigenous landowners nominate their estates as IPAs, which are subsequently recognised as part of the National Reserve System and attract government resourcing.) A significant number of Indigenous rangers are also employed in Australia's national and state parks. Ranger work involves addressing a host of environmental issues, such

as wildfires, weeds and feral animals, but also managing tourism operations, quarantine services, and monitoring and reporting illegal commercial fishing. Indigenous Protected Areas and national parks contain an extensive range of cultural heritage sites also managed by rangers (Department of Environment 2013). Importantly, these sites are vital to ongoing traditional cultural practice.

A limited number of studies have investigated the impacts of climate change on Indigenous communities in Australia and elsewhere. Indigenous communities experience great social and economic disadvantage and various studies document heightened vulnerability because of poor service delivery and a lack of political participation (Ford *et al.* 2006; Altman and Jordan 2008; Green 2009). In this context, some scholars have concluded that while Indigenous Australians are worried about ecological change, it is a peripheral concern for a dispossessed people struggling with poverty and social dislocation (Petheram *et al.* 2010). Notwithstanding this, Australian studies are increasingly engaging local Indigenous stakeholders in discussions around climate change impacts and adaptation needs (*e.g.* Bird *et al.* 2013; Leonard *et al.* 2013) and have successfully elicited participation in the writing of formal adaptation plans (Memmott *et al.* 2013; Nursey-Bray *et al.* 2013). McIntyre-Tamwoy *et al.* (2013) found that many of the concerns Indigenous people had about climate change were related to cultural values, places and landscapes, and concluded that there remains an urgent need for processes and systems to be developed to promote knowledge sharing and action in this regard.

In considering climate change impacts on Indigenous cultural heritage sites, we focus on the potential role and capacity of Indigenous ranger groups. Ranger groups not only have responsibilities for cultural heritage sites, but they also represent a positive step towards addressing some of the issues underlying Indigenous disadvantage. The benefits of ranger programmes to Indigenous people are many, well-documented and promoted by Indigenous communities and representative bodies. Rangers earn wages in remote locations where unemployment is high; become community role models; engage in work that is meaningful to them; and are highly motivated because the work underpins cultural maintenance (DPMC 2015). Ranger groups address Indigenous poverty and increase health and wellbeing (WalterTurnbull 2010).

The project described here was originally motivated by the idea of developing a decision tool to guide rangers in addressing climate change impacts on cultural sites. While a growing literature on climate change adaptation offers many insights and principles, there tends to be something of a gap between this theoretical work and practice on the ground. For this reason many decision tools have been developed to aid governments, organisations, businesses and communities which undertake adaptive action. They are particularly useful for supporting local level organisations conducting participatory or bottom-up planning for climate change. While frameworks for cultural heritage risk assessment are now emerging (*e.g.* Bickler *et al.* 2013; Daly 2014), none are expressly aimed at non-professionals or a bottom-up planning context.

Stakeholder-led or bottom-up planning is routinely characterised as fundamental to climate change adaptation (Dessai and Hulme 2004; Wilby and Dessai 2010; Raiser 2014). Studies already cited echo the same point (Bird *et al.* 2013; Green *et al.* 2012; Nursey-Bray *et al.* 2013; Memmott *et al.* 2013; McIntyre-Tamwoy *et al.* 2013; Leonard *et al.* 2013). The Intergovernmental Panel on Climate Change (IPCC 2014, 87) notes, too, that climate change adaptation planning benefits from combining western science and traditional Indigenous knowledge.

Rangers are also a good fit in this regard. Bottom-up participatory planning is fundamental to their work. Indigenous Protected Areas involve rangers in rigorous, facilitated natural resource management planning each year, which involves extensive consultation with the Traditional Owners of given lands. (The Aboriginal Land Rights Act [1976] describes 'traditional Aboriginal owners' as local descent groups with primary spiritual responsibility for sites and land.) Indeed, the majority of rangers are themselves Traditional Owners (Djelk Rangers 2014). The same is true of Indigenous rangers in national parks, where joint management by Traditional Owners and the Australian Government takes place (Kakadu Board 2014).

Before developing a decision tool geared to support Indigenous site management of climate change impacts, we needed to establish whether or not rangers believed climate change to be an issue for cultural heritage sites, and if so, whether addressing the issue with a tool was a priority need for them. To this end three diverse ranger groups in Arnhem Land in the Northern Territory were approached. In the two more mature groups, senior rangers expressed very strong views as to the impact of climate change on cultural sites, and they welcomed the opportunity to undertake a project aimed at developing and testing a tool to address these impacts (Carmichael 2015).

Senior rangers, some with up to 30 years' experience, were adamant that sea level rise and sea level rise extreme events such as storm surges were increasingly impacting coastal shell middens, that salt water intrusion combined with extreme precipitation was increasingly inundating floodplain-fringing rock art and earth mounds, and that inland riparian rock art was being washed away by more frequent and higher floods. Senior rangers from both of these groups explicitly stated that addressing these impacts was a priority need for their groups.

These perceptions may have been influenced by popular representations of climate change in the media, by ranger attendance at climate change symposiums over the years,

Table 17.1. Climate projections for the monsoonal north (Moise et al. *2015)*

Climate change aspect	*Projection*
Average temperatures will continue to increase in all seasons	Very high confidence
Numbers of hot days and warm spells will increase	Very high confidence
Total rainfall changes are possible but unclear	Unknown
Intensity of extreme rainfall events will increase	High confidence
Mean sea level will continue to rise	Very high confidence
Height of extreme sea-level events (storm surge) will increase	Very high confidence
Tropical cyclones will be fewer but more intense	Medium confidence
Natural variability in the climate system can act to either mask or enhance any long-term human induced trend, particularly in the next 20 years and for rainfall	Unknown

or by the presence of climate change research in their domains. However, these perceptions are also consistent with documented trends in sea level rise for northern Australia, current issues with vegetation death from saltwater intrusion into low lying freshwater flood plains, and climate change projections. Very significant sea level rise has been observed in the monsoonal north of Australia since the 1960s. Furthermore, there is a 'high confidence' in future sea level rise and extended extreme sea level rise events (*i.e.* extreme storm surges), in more extreme precipitation events (*i.e.* riparian inland flooding), and 'moderate' confidence in more intense cyclones (Table 17.1).

The aim of the project described in this paper was to propose and then test a preliminary decision tool. Testing by rangers would shed light on its usefulness – or otherwise – and inform its further development. The preliminary model was synthesised from generic climate change adaptation decision tools on the one hand, and recent attempts by heritage managers internationally to develop methods to address the issue on the other. This synthesis was further modified in light of findings from Indigenous adaptation studies, as well as the particular needs of Indigenous rangers. The tool encompasses five distinct phases:

1. *Scoping*: Rangers design their project.
2. *Cultural heritage risk analysis*: Rangers determine and prioritise sites most at risk.
3. *Cultural heritage options analysis*: Rangers prioritise adaptation options for sites.
4. *Document and implement*: Rangers write and execute a plan.
5. *Monitor and review*: Rangers assess progress and update their plan.

For this chapter we will explore the development of the scoping, risk analysis and options analysis phases alone.

The rangers

The two ranger groups engaged in the project are from Kakadu National Park (KNP), and the Djelk Indigenous Protected Area (Djelk IPA), both in Arnhem Land, Northern Territory, Australia. The climate is tropical with a short but intense wet season followed by a longer rainless dry season.

Kakadu National Park is centred on the Alligator Rivers region (Fig. 17.1) and is World Heritage listed. The Park's cultural values include a record of habitation stretching back 50,000 years, exceptional rock art, and the living knowledge of Aboriginal Traditional Owners. Indigenous rangers from Kakadu National Park (Kakadu Rangers) are a cohort that constitute roughly one third of Park rangers. The Park is managed by Parks Australia in conjunction with Traditional Owners through a board of management, which has a majority of Indigenous members. Final management decisions must be ratified by Parks Australia.

The Djelk IPA is centred on the Blyth and Cadell rivers (Fig. 17.1) and contains comparable cultural values to those of Kakadu National Park. Djelk Rangers employs an entirely Indigenous ranger staff, and operates under the auspices of the Bawinanga Aboriginal Corporation (BAC), which is directed by a wholly Indigenous executive committee.

The scoping phase of the tool

The scoping phase of the tool consists of seven elements:

1. Analysing the problem
2. Setting goals
3. Selecting a methodology
4. Conducting a stocktake of resources
5. Conducting a stocktake of barriers or obstacles to action
6. Considering leadership
7. Considering ownership

The seven elements contain a further extensive list of questions designed to help rangers consider each element as thoroughly as possible. Here we consider the responses of both groups to each of the scoping phase's seven elements. The preliminary results of the study are presented here. A more comprehensive discussion of the results is presented in Carmichael *et al.* (2017).

Analysing the problem

In this phase, rangers considered the types of site currently being impacted by climate change, the nature of the impacts and the areas on their estates where these impacts were being felt. Whether the rangers' perceptions are of climate 'change', climate 'variation' or climate 'extremes' is less important than the need to protect sites from the resulting impacts. This paper takes the view, recommended by the IPCC (2014, 31), that because it may not be possible to

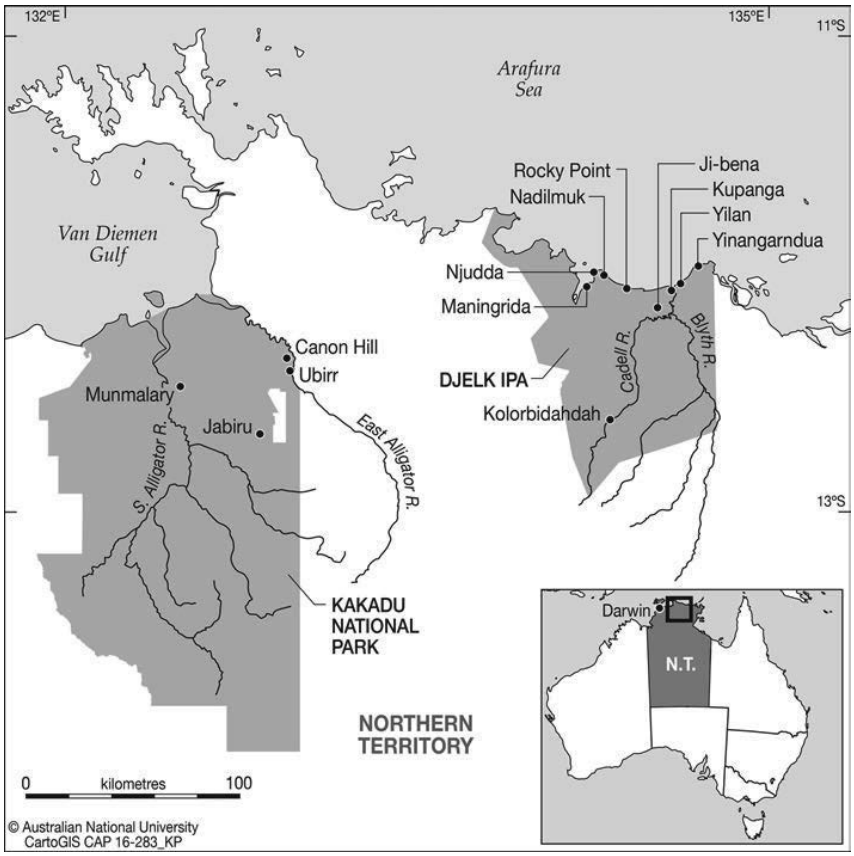


Figure 17.1. Map of case study areas.

differentiate climate change from climate variation and extremes, 'a first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate'. Ranger perceptions of 'climate change' were nonetheless consistent with previously published climate change projections made by Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) and the Australian Bureau of Meteorology (BoM) for the monsoonal north (CSIRO and BoM 2015; Moise *et al.* 2015), the region taking in their territories (Table 17.1).

Extreme wetland flooding

Kakadu National Park Rangers report unprecedented flooding of the East Alligator River area in recent decades. The onset of the monsoonal wet season has become less predictable and when rain does come it is extreme, with wetland impacts accentuated even further when the rain coincides with a high tide. One ranger says:

> We're getting heavier rain: used to be more spread out; but now we're getting it all at once. Then we get that water rising really quickly … when you get the king tides, and you get a big rain on top, there's nowhere for that water to get out, so it just backs all up onto the floodplains. … That's when these sites are going underwater.

In 2006, there were two extreme flood events, one associated with Cyclone Monica and another unrelated to a tropical cyclone. Rock art in the Canon Hill area and the area around Ubirr was impacted by flooding (Fig. 17.1). Rangers were able to explore the Canon Hill area by boat at the time and witnessed what were for them unprecedented water levels. During the following dry season, they observed resulting damage and watermarks at rock art sites. One ranger says:

> It's not normal. It's getting worse. The old people, our ancestors, would not have put it [burial sites and rock art] there if it was going to go under water.

Rangers also expressed concerns for stone artefact scatters, earth mounds and shell middens on the South Alligator River floodplains. One ranger sums up:

> Climate change is really huge! A lot of people talking about it. Things might change, site might have gone … where's all the things, tools and everything? Nobody, nothing ... I break

> down ... I see that long history there from our ancestors, and it's hard. I don't want to see it gone.

Extreme coastal flooding

According to Djelk Rangers, the IPA has changed dramatically over their lives but sea level rise is particularly pronounced. Rangers relate childhood memories of low tides being significantly lower than today. One ranger notes:

> I can tell you about when I was young. Everything was there, but now it's changed. The tide has changed; the weather has changed. When I was a boy, the low tide used to go right out. Now it goes out about halfway.

One ranger explains this as the result of:

> Pollution … sea level is up, because of those icebergs melting.

Rangers reported observing the wholesale loss of shell middens after Cyclone Nathan on 23 March 2015. Djelk Rangers identify the entire coast of the IPA as a hazard zone for shell middens, earth mounds, sacred billabongs, sacred trees and ceremonial grounds. Areas around the Blyth River entrance (near Kupanga), Rocky Point, Maningrida and east of Njudda (Fig. 17.1) are highlighted as particularly vulnerable for shell middens. Earth mounds in the Jibena floodplain area are also said to be vulnerable. These nominations are based on observations of vegetation loss over time, changes in tidal extents, channel expansion and erosion, wholesale loss of sites to receding beaches and saltwater intrusion into sites that previously contained freshwater exclusively.

Extreme inland flooding

Djelk Rangers are also observing unprecedented riparian flooding in escarpment country away from the coast. Rivers are increasingly flooding outstations, and evacuation by helicopter is becoming a more regular occurrence. Djelk Rangers report more erosion and the formation of new creeks and channels. They identify the upper Cadell River (Fig. 17.1) as a climate change hazard zone, specifying six rock art sites they perceive as impacted by unprecedented flooding (Fig. 17.2). This is pointedly described as not being the result of an overall increase in rainfall but of more extreme rainfall events. One ranger observes:

> Not more rain, but bigger floods!

In one instance the total obliteration of rock art was observed by way of dry season visits over a period of several years. One ranger explains:

> One year we went to the Cadell, right on the IPA border, for ceremony; there were really old paintings there; on a second visit the paintings were damaged; on a third visit they were gone; water marks were there … when we are on country we record things with our mind.

Rangers also have concerns for unspecified ceremony grounds, burial and Dreaming sites (during the Dreaming, ancestor spirits created the world then changed into trees, the stars, rocks, watering holes or other land forms). These concerns are held on the basis of observations of damage to and loss of sites resulting from flooding and associated algal growth on rock art.

Setting goals

Establishing goals for protection of sites from the start is important to ensure all participants have a shared understanding of the project and what its outcomes should be. There was no disagreement here: Djelk and Kakadu Rangers hope the project will be able to keep their sites 'healthy', 'safe' and 'strong'. One Djelk ranger echoes the feelings of his colleagues in stating:

> We want them to be safe! Safe! To be safe!

Asking rangers 'why are sites important?' was a unifying experience for both groups. Their identities as Aboriginal people are bound up with their sites. One ranger says:

> They're in our blood, all those sacred sites … our body and spirit.

Responses are often heartfelt when their loss is contemplated:

> That damage makes me cry inside … I ask myself, 'What am I going to do?'

Often it is the impacts on cherished culture that represent the greatest motivation for climate change adaptation (Adger *et al.* 2012).

Selecting a methodology

The tool does not take it as a given that a biophysical risk analysis is the ideal approach to take. It is presented as one among three options, which also include organisational capacity building and individual ranger capacity building. Both ranger groups were initially adamant, however, that a biophysical risk analysis was the most appropriate approach. Djelk and Kakadu Rangers favoured the prioritisation of sites according to (a) proximity to hazard, (b) sensitivity to hazard and (c) significance. One Kakadu Ranger concludes:

> That's the good one: risk analysis … for future generations; [Traditional Owners] can pass that information on to … kids.

Focusing on capacity building alone is rejected.

> We couldn't just stop worrying about the sites … we have to look after those sites, it's what the old people say needs to happen.

Figure 17.2. Ranger Ivan Namarnyilk uses the field survey to conduct a risk analysis of flood damaged rock art. Stranded flood debris is evident on a rock outcrop level with the painting. Upper Cadell River, Djelk IPA.

Later in the Kakadu Ranger workshop, however, when rangers discussed barriers to adaptation, they raised issues around not spending enough time maintaining sites. As a result, they revised their decision on methodology, opting for a mixed approach encompassing both risk analysis and organisational policy change. They insisted that a resulting adaptation plan should not shy away from 'the problems' they have with the Park's provision of resources for site maintenance. Similarly, Djelk Rangers were ultimately concerned to modify BAC policies as well as conduct a risk analysis, in order that perceived governance issues be resolved.

The scoping phase's 'selecting a methodology' element contains a particularly long list of further discussion points. These points aim to ensure the selected methodology fits in with current work practices; is culturally appropriate; benefits the community as a whole; and can have its effectiveness scrutinised. Discussion points also explore the need for a communication plan as well as an appropriate time frame for the method's application.

Among the responses to these questions, it is important to mention here that risk analysis is seen to be culturally appropriate only insofar as consultation with Traditional Owners and *djunkai* (traditional custodians) takes place throughout its application. The method should be flexible enough that Traditional Owners are able to require that sensitive sacred sites not be entered onto maps if needs be. For this reason, this article cannot reproduce the mapping outputs generated during the testing of the risk analysis phase.

Conducting a stocktake of resources

For Djelk Rangers, data is an issue: apart from Brandl (1988) and Meehan (1982), no extensive formal surveys of rock art and other archaeological sites have been conducted in the Djelk IPA. While around 130 sites are scheduled for maintenance, these are potentially a fraction of sites in the IPA. Conducting a risk assessment might ultimately serve to populate a database, albeit one adhering

to strict administrative protocols negotiated with Traditional Owners. Certainly, the skills and resources needed to obtain data are available.

For Kakadu Rangers, decades of scientific recording in the Park have produced a vast data set of rock art and other archaeological sites (*e.g.* Gillespie 1983; Jones 1985). More resources, however, are needed in order to extend site maintenance significantly. Indeed, a climate change adaptation project might be a catalyst for this, insofar as it alerts authorities to the climate threats facing the World Heritage listed Park.

Conducting a stocktake of barriers

Governance barriers potentially exist. Some Kakadu National Park Traditional Owners favour a wholesale change to Park governance, proposing Aboriginal Corporations manage ranger groups rather than Parks Australia. Djelk, however, have some issues with this very model, alluding to the potential for planning and consultation outcomes to be circumvented by a corporation's non-Indigenous administrative officers. Such barriers, however, were not judged to be insurmountable for the climate change adaptation project.

Considering leadership

An adaptation project might fail without individuals motivated to take on leadership roles. There is no shortage of leadership within Kakadu and Djelk ranger groups. However, the need for consultation suggests a leadership that is shared, more communal and consensual. This notion of leadership lends itself well to the tool's bottom-up approach.

Considering ownership

Studies of Indigenous community adaptation emphasise the need for formal legal agreements ensuring Indigenous control over research outputs (Leonard *et al.* 2013). This draws only a neutral response from Djelk and Kakadu rangers, because all research on their lands takes place only after research permits are issued by the Northern Land Council (which represents Indigenous landholders) and Kakadu National Park. If the tool is used in a context lacking such overseeing authorities this issue may be more pressing. On the other hand, it is important to rangers that research outputs formally recognise their contribution.

The cultural heritage risk analysis phase

The initial construction of a risk analysis phase considered lessons from (1) climate change adaptation literature; (2) archaeological climate change risk assessment studies; and (3) the particular needs of rangers. The preliminary results of the study are presented here. A more comprehensive discussion of the results is presented in Carmichael *et al.* (2017).

Lessons from climate change adaptation literature

Climate change adaptation studies emphasise many key considerations. The value of stakeholder participation, using local experience of current extremes as a starting point for climate change adaptation, and using Indigenous knowledge have all been mentioned above. Another important principle is mainstreaming. To increase the likelihood of adoption by an organisation, a climate change risk analysis needs to be combined with the management of other risks to the system, not just those related to climate (Huq and Reid 2004; Smit and Wandel 2006, 285). In assessing risk, it is also important to consider either the consequence or the sensitivity of the system to the given impact under consideration (Füssel 2007). Finally, in the face of uncertainty and a lack of fine scale climate change data, establishing a monitoring programme should be an early initiative of those wishing to adapt (Rowland *et al.* 2014).

A synthesis of existing approaches to archaeological risk assessment

Archaeological risk assessment methods to date have largely relied on desktop, GIS-based analysis of the probability of site exposure to a hazard, based on a range of geospatial data and/or climate change projections (Westley *et al.* 2011; Johnson *et al.* 2015; Reeder-Myers *et al.* 2015). The threat considered was typically sea level rise but has also included forest desiccation and wind damage (Dupont and Van Eetvelde 2013). While the GIS approach has mainly considered probability of exposure, the consequence of exposure has also been factored in (Bickler *et al.* 2013).

Other approaches have sought to incorporate stakeholder consultation. Dawson's (2015) GIS-based analysis was reviewed and amended by local stakeholders. Daly's (2014) non-GIS approach combined secondary research and climate change projections with local stakeholder interviews.

Many of these approaches are, however, dependent on a high degree of technological or archaeological expertise. Our approach therefore seeks to extend Marie-Yvane Daire *et al.*'s (2012) field survey approach to risk assessment because it can be conducted by non-specialists rather than expert professional heritage managers. The survey is based on the *in situ* recording of data on a range of exposure and sensitivity variables and resembles a questionnaire. Furthermore, the survey differs from the above approaches in that threats other than climate change are also included. The survey produces a risk score for each site. Finally, the collection of largely quantitative data on the ground means that the survey can act as a monitoring system; future re-assessment can deduce areas of change or otherwise.

What is missing from the field survey, however, is further prioritisation based on significance or cultural heritage value. Other methods note the value of significance assessment

(Bickler *et al.* 2013; Daly 2014), and Dawson (2013, 78) incorporates a significance assessment into prioritisation based on criteria of 'rarity', 'period', 'condition', 'group value' and 'potential'.

Including significance assessment in a field survey approach is challenging. Collecting data relevant to Dawson's (2013) criteria requires skills not available to rangers. Bowdler (1984), assessing significance in Australian archaeology, considered a site's ability to 'answer timely and specific research questions' and its 'representativeness'. In the Djelk IPA no comprehensive survey of each site type has been undertaken to date. This makes reference to 'representativeness' and 'timely and specific research questions' difficult.

Our solution is for rangers to ask Traditional Owners (if they themselves are not the Traditional Owner for the site) to determine significance according to their values, and then later consider inviting archaeologists to contribute their perspectives to the results. The approach adheres to a major concern highlighted by ICOMOS (2013, article 12): that conservation of a place should be based on 'a consideration of cultural significance' and 'the participation of people for whom the place has significant associations and meanings'.

As noted, rangers who are all Traditional Owners were asked during the scoping phase why cultural sites are important. The rangers provided explanations broadly in line with ICOMOS indicators of significance. Their explanations of significance pertain to: social identity value (*e.g.* 'Sites are who I am'); historic value (*e.g.* 'The stories [in rock paintings] are about how we lived off the land, and some of them may point to how we still need to care for the land'); or spiritual value (*e.g.* 'We have to look after those Dreaming sites and the stories that go with them, or the country will die') (Carmichael *et al.* 2017). Accordingly, the questions developed for the significance assessment tool record the significance of sites in terms of social identity value, historic value, and spiritual value. Importantly, the resulting schema (Table 17.2) assumes *all sites* are significant from the outset: social identity value is taken as a given for all archaeological sites, and is the default position.

Exposure and sensitivity variables

Rangers using the tool are prompted to record values for (1) exposure variables for sites and (2) sensitivity variables. Each variable has a set of alternative value options from which rangers are required to choose, and each value has a corresponding numerical score. Likelihood of loss or damage is determined by subtracting the total score for sensitivity from the total score for exposure, in the manner pioneered by Daire *et al.* (2012). After multiple iterations based on ranger trial and error, the field survey risk assessment tool's likelihood of loss or damage element requires rangers to choose values for the following exposure and sensitivity variables.

Exposure variables

Direct human induced impacts: recorded by selecting a value option for the proximity of (a) road types, (b) settlement types and (c) activities.

Climate change impacts: recorded by selecting a value option for (a) proximity to the edge of the tidal zone or centre of a river; and (b) vertical distance above tidal zone or river in recognition of slope variance in sea shore and river banks in the study areas. Rangers' observation of impacted sites also led to the inclusion of a variable gauging (c) proximity to geomorphological hazards. This requires rangers to record if the rock art site is in a gorge (where a bottleneck effect can accentuate flooding); the proximity of a floodplain midden to a channel (where water moves at greater speed); or the proximity of a coastal midden to a river mouth (where salt water flooding can be accentuated by fresh water flooding).

Large-scale biological impacts: recorded by selecting a value option for (a) the degree of damage done by feral animals such as pigs and buffalos. Rangers felt strongly that the tool should account separately for biological threat types with greatly differing impact magnitude. The impacts of feral animals, such as buffalos and pigs, are a highly destructive problem in both study areas (Meehan *et al*. 1985; Jambrecina 2010; Saafield 2014), and are therefore distinguished from those of birds and insects. Rangers also wanted the threat of (b) vegetation conflagration, also highly destructive to rock

Table 17.2. Assessing Indigenous significance

Value type	*Questions for traditional custodians*	*Significance*
Social-identity Value Site connects us with ancestors and country.	**No questions:** Social-identity Value is a given for all middens and rock art sites.	Class one
Historical Value Site shows us how ancestors lived.	**Does the site have, or contain:** A traditional or modern name; tools; depictions of hunting and gathering; paintings that inform current painting practice?	Class two
Spiritual Value Site shows us ancestors' ideas about the world.	**Does the site have:** An associated religious story; a burial; a ceremony site; depictions of spiritual themes or practice?	Class three

art (Lambert and Welsh 2011), to have a dedicated variable based on the degree of vegetation build up at the site.

'Erosion' impacts: recorded by selecting a value option for (a) rain and wind damage (degree of fading in rock art and degree of deflation for a midden); and (b) values for the mechanical impacts of native flora and fauna.

Sensitivity variables

Built and legal protection: recorded by selecting a value option for (a) the degree of legal protection pertaining to the site; and (b) whether or not a midden or rock art site has a fence or a rock art site has had a protective silicon dripline installed (for the history of this measure, see Gillespie 1983).

'Weathering' sensitivity: recorded by selecting a value option for (a) the nature of the substrate (rock hardness for rock art, and soil type for a midden – i.e. clay, soil or sand); (b) the nature of the remains (ochre type for rock art, and structure characteristics for middens); and (c) natural protection (the degree of rock shelter overhang for rock art, and the degree of protective tree-root consolidation for middens – rangers observe that middens with trees growing in them are usually the most intact).

Preliminary results

Combining assessments of likelihood of loss or damage *and* significance for each site allows for site risk to be expressed in a classic risk matrix, giving rise to five possible management priorities: 'very low', 'low', 'medium', 'high' or 'very high'.

As an example (Table 17.3), rangers assessing a site near a creek in the Canon Hill area of Kakadu National Park gave it a 'high' management priority. Firstly, its risk rating is 2.2, or 'high', because of: close proximity to a creek, and only moderate height above it; moderate weathering; high fire-hazard proximity; and very close proximity to a settlement.

Table 17.3. Management priority assessment for an unnamed site in the Cannon Hill area of Kakadu National Park. The management priority was assessed as 'high' due to a 'high' risk score, and a Class 2 significance rating.

		Management priority		
Likelihood of loss or damage	High	***medium***	***high*** ✓	***very high***
	Medium	***low***	***medium***	***high***
	Low	***very low***	***low***	***medium***
		Class 1	Class 2	Class 3
		Consequence (Significance)		

These factors are offset to some degree by: a good rock-shelter overhang; hard rock; and red, more durable, ochre. Secondly it is assessed as being in Significance Class Two, due to paintings depicting traditional hunting and gathering. 'High' likelihood of loss or damage and Significance Class Two converge on a 'high' management priority in the tool's management priority matrix.

Across the two case studies, of over 100 sites so far assessed by rangers approximately 10% were rated as being a 'very high' management priority and 19% a 'high' priority. These preliminary results are a very small fraction of total sites needing assessment within each ranger group's domain. The majority of the shell middens assessed have been formally recorded for the first time.

The cultural heritage options analysis phase

Throughout the testing of the preceding phases of the tool, both ranger groups continually identified adaptation options for sites. These were collected and presented back to rangers for analysis at options workshops and in individual discussions. An additional option, concerned with developing an augmented reality application, was proposed by the lead author. The adaptation options nominated were concerned with either capacity building or delivering adaptation actions directly to sites.

Rangers reviewed each option against seven criteria adapted from generic adaptation planning tools (*e.g.* UKCIP 2013):

1. *Is it 'proper way'?* Will our old people think it is culturally appropriate?
2. *Will it help Aboriginal people in other ways?* Does it meet other community goals?
3. *Could it be done quickly?* How soon could it be started and completed?
4. *Is it easy to do?* Or is it too complicated and requires unavailable skills?
5. *How costly is it?* Is it too expensive?
6. *Will it meet our goals of 'safe', 'strong' and 'healthy' sites?* Or will it lead to other counter-productive problems?
7. *Is it flexible?* Will it still work if climate change happens more quickly or is worse than expected?

There is unanimity around the benefits of digitising the risk assessment field survey for use in GPS-based field monitoring devices, such as I-Tracker (NAILSMA 2014), which are used by rangers to collect management data. Doing so would make the survey integral to heritage maintenance programmes.

Attitudes to other options sometimes reflect the differing circumstances of each group. For example, Kakadu rangers are concerned with introducing more gates across roads to keep tourists away from sites, while for Djelk a low tourist presence means this is not a priority. Buffalo culling is not of primary importance to Kakadu Rangers given buffalo

numbers were drastically reduced by a major cull in the 1990s (Petty *et al.* 2007). Numbers are, however, increasing again and pigs are a major issue.

In terms of salvage, moving shell middens or earth mounds and rock art is dismissed as impractical, too costly and culturally inappropriate by both groups. Building flood barriers is generally considered in similar terms, though some feel an earthen bank with consolidating vegetation to protect floodplain sites could be engineered in a culturally appropriate way. As risk assessment progresses, barriers might conceivably be revisited as a viable option for the cream of 'very high' priority sites in amenable locations. In Kakadu, a simple earthen 'causeway' was built in the 1970s to ameliorate saltwater intrusion at Canon Hill, and before falling into disrepair it reportedly had some success (Thiele 1987, 28).

Salvage ultimately comes down to cultural data salvage; that is ensuring sites most in peril are fully documented for posterity. Photogrammetry-based three-dimensional (3D) modelling techniques are surprisingly inexpensive and have been used to record vulnerable coastal heritage (López-Romero *et al.* 2014) and remote Indigenous rock art (Bourke 2014). For Kakadu Rangers, storing such documentation in a museum is more appealing than in a database with its attendant problems of access and privacy, though Djelk do not preference one over the other.

A central plank in the national rock art strategy proposed by Taçon and Marshall (2014, 7) is to develop 'new database systems, innovative ways of using 3D and other new technology'. They propose that 3D records could be used for detailed recording and to provide virtual access to sites via museums and online, and conceive of virtual reality 'walk-throughs'. Virtual reality (VR) technologies have been applied in the cultural heritage field for decades, and heritage professionals have set out guidelines for enhancing their applicability and usability (Luchia *et al.* 2010).

However, the concept of cultural data salvage of imperilled sites for posterity's sake causes great despondency among rangers, and even virtual reality applications may not attend to the particular needs of Indigenous custodians. Significant sites continue to be used in cultural practice and are important for the 'learning on country' undertaken with young people. Digital salvage might allow the maintenance of cultural identity, but it could not facilitate perpetuation of a way of life. Indigenous people see sites as connected to the land, and want to interact with them in their original spatial reality. As one Djelk Ranger says:

> The Djomi Museum [local museum in Maningrida] is really good, taking photos and getting information, but in my way I want to see it 'live'; paintings, right there.

In the spirit of Taçon and Marshall's (2014) call for innovative ways of using 3D and other new technology, we conceive their use in augmented reality applications. An augmented reality (AR) device overlays a virtual world on the real one. In this sense, it is unlike virtual reality, which entirely replaces the external world with a virtual one. Instead, AR embellishes the real world.

AR ocular headsets, such as those now produced by Microsoft, might conceivably allow observers *in situ* to experience a 3D model of a lost rock painting superimposed on its original, non-virtual rock face. For rock art already damaged, the image capture used to generate the 3D model might conceivably incorporate 'DStretch' enhancement (Harman 2016). When rangers were shown promotional video for the Microsoft ocular headset (Microsoft 2016), their response was one of intrigue and excitement. Assessing an unproven technological solution against the seven assessment criteria was pure speculation. However, while the functionality of the imagined concept is unknown, AR would almost certainly pose a more realistic option than moving sites or building sea walls.

Discussion and conclusion

In the 1990s, archaeologist Michael Rowland (1992; 1996; 1999) proposed that Indigenous cultural heritage was in peril from climate change and sea level rise, and noted that a necessary priority would be to, 'discuss with Aboriginal owners the potential impact of greenhouse changes on coastal sites' (Rowland 1992, 31). We document Aboriginal owners' openness to such discussions. Their closeness to, and deep understanding of, their natural environment directly informs them of significant impacts now affecting cultural heritage.

Rowland (2010) argued that climate change was one of among many critical impacts on cultural heritage, and he and others (Rowland 2008; Rowland and Ulm 2012; Rowland *et al.* 2014) focussed in particular on the issue of monitoring of impacts on sites to determine the real impact of climate change on cultural heritage. Assessing risk with a field survey approach fulfils the dual purpose of both risk assessment and monitoring. Its inclusion of non-climatic threats allows for an integrated approach and therefore greater likelihood of adoption.

Given the right tools, planning autonomy and adequate resources, Indigenous ranger groups have the organisational capacity to confront the issues related to climate change and its impact on cultural heritage. In fact, few other organisations are as well equipped to do so. Their local presence and traditional knowledge, the highly consultative nature of their planning and leadership styles, their willingness to combine their insights with western science, and above all their deep affinity with and care for their cultural heritage will potentially place Indigenous rangers at the forefront of cultural heritage adaptation efforts worldwide.

The risk analysis methodology described here constitutes an ongoing monitoring programme that will, over time,

build a body of data supporting informed adaptation actions. Heritage sites are highly valued in terms of Indigenous cultural identity. Their destruction represents the loss of places vital to Indigenous people's historical understanding of themselves as well as their understanding of the world and their place in it. Incorporating these values into risk assessment allows prioritisation on the basis of the magnitude of consequence, making for a risk assessment that recognises sites as 'living' cultural entities.

Indigenous rangers are embracing innovative technical solutions in their management of serious environmental problems. GPS-based field monitoring devices allow them to collect data vital to fire and weed management. Rangers hope to digitise and incorporate the risk assessment field survey tested here into these devices. This is an important next step that would allow the mainstreaming of climate change adaptation into rangers' daily work practice.

Rangers welcome other potential technological solutions as well. Traditionally, Aboriginal artists undertook rock art repainting as works faded. The use of augmented reality devices might one day constitute 'digital rock art repainting'. Rangers are interested in investigating further the potential of VR and the glimmer of hope it offers for overcoming the enormous challenge of salvaging sites prioritised as the most in peril.

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