Mapping cultural ecosystem services with rainforest aboriginal peoples: Integrating biocultural diversity, governance and social variation

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ABSTRACT

Cultural ecosystem services (CES) include the aesthetic, artistic, educational, spiritual and/or scientific values of ecosystems and have been described as 'intangible' and complex, reflecting diverse people-nature interactions that are embedded in dynamic linked social-ecological systems. CES have proved difficult to value, therefore mapping CES has largely concentrated on more tangible aspects, such as tourism and recreation—presenting the risk that highly significant cultural relationships, such as those between Indigenous peoples and their traditional land, will be rendered invisible in ecosystem assessments. We present our results from co-research with a group of 'Rainforest Aboriginal peoples' from the Wet Tropics, Australia that illustrates a method to address this gap through mapping their perceptions of the health of Indigenous CES. We found that categories associated with biocultural diversity and governance matched their perceptions better than the usual framework that recognizes aesthetic, spiritual and other categories. Co-produced maps presented demonstrate spatial patterns of CES that are related primarily to variations in social attributes (such as adherence to cultural protocols), rather than the ecological attributes (such as biodiversity patterns). Further application of these concepts of biocultural diversity governance, and variation in social attributes when mapping CES, particularly in partnerships with Indigenous peoples is recommended.

1. Introduction

Cultural ecosystem services are an essential, yet under-researched, sub-set of the ecosystem services that are derived from landscapes (Satz et al., 2013). The benefits of these services are often tied to place reflecting the values held by different groups for a particular landscape, and were first described as being related to the "aesthetic, artistic, educational, spiritual and/or scientific values of ecosystems" (Costanza et al., 1997:254). Until recent times, mapping and assessment of cultural ecosystem services have been limited by a number of conceptual barriers. Definitions and typologies of cultural ecosystem services are diverse and lack consistency particularly in the economic literature, where they are described as being 'intangible', 'subjective', 'non-use' and 'non-material' benefits obtained from ecosystems and difficult to quantify (Chan et al., 2012a, 2012b; Millennium Ecosystem Assessment, 2003; Plieninger et al., 2013). As a result, the assessment and mapping of cultural ecosystem services has been largely limited to

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those services that have more tangible benefits and can be marketed as a commodity, such as tourism (Grêt-Regamey et al., 2008; Anderson et al., 2009) and recreational activities (Willemen et al., 2008). These methodological limitations lead to a risk that highly significant intangible cultural connections and services, such as those between Indigenous peoples' and their traditional land, will be rendered invisible in national and global ecosystem assessments with consequential threats to their maintenance (Turner et al., 2008). In this paper, we present a method to map Indigenous cultural ecosystem services, developed through co-research with Rainforest Aboriginal peoples in Australia's humid tropical forests, a globally significant site for biodiversity.

The term Indigenous is highly contested in the academic literature, although Indigenous peoples through the United Nations have argued that no formal universal definition is needed. Use of the term "Indigenous" in this article is guided by Martinez Cobo's (1982) working definition that "Indigenous communities, peoples and nations are those which, having an historical continuity with pre-invasion and pre-colonial societies that developed on their territories, consider themselves distinct from other sectors of the societies now prevailing on those territories, or parts of them". The phrase "Australian Indigenous peoples" refers to hundreds of distinct language and cultural groups with historical links and continuity with different parts of the Australian continent and the Torres Straits (Horton, 1994). We use the specific term Rainforest Aboriginal peoples throughout this paper to refer collectively to the groups of Australian Indigenous peoples, including families, clans, tribal and language groups, whose traditional lands lie within the humid tropical forests region in Far North Queensland, Australia (Fig. 1). The term "Traditional Owners" refers to the people or groups as individuals.

Rainforest Aboriginal peoples in Australia's humid tropical forests have actively and collectively asserted their right to manage their traditional estates according to their culture, (lore, protocol, customary processes) since the 1980s (RAPA, 2013). Each of the Traditional Owner groups has a complex cultural system of customary laws and kinship which together determine important life events such as marriage, subsistence and management practices such as hunting, gathering and vegetation burning (Zurba et al., 2012; Hill et al., 2004). The recognition of the global significance of their traditional lands through the listing of the Wet Tropics World Heritage *only* for its *natural values* has long been contested by Rainforest Aboriginal peoples who seek recognition of the global significance of their Indigenous cultural values (WTRA, 2005). In December 2012, the national listing of the Indigenous Values of the Wet Tropics World Heritage Area under the *Environment Protection and Biodiversity Conservation Act* (*Commonwealth*) 1999) gave impetus to the ultimate goal of world heritage listing. Rainforest Aboriginal peoples' aspirations towards protection, maintenance, interpretation and promotion of the cultural values of their traditional country underpins the relevance of understanding methods for mapping Indigenous cultural ecosystem services in this study.

Poe et al.'s, 2014 recent review of the literature highlighted numerous risks posed by omitting cultural services, or rendering certain cultural ecosystem services invisible, in assessment processes: creating or reproducing social inequalities; diminishing community resilience; stripping away important management processes (e.g. customary tenure, social norms, and knowledge systems); and reducing trust between collaborative management partners. On the other hand, their review identified many potential benefits of appropriate assessments of cultural services including: increasing buy-in between groups; reducing conflict and costs associated with negotiation of management options; and yielding better alternatives that address concerns of those most affected by environmental and institutional changes. However, better methods for assessing cultural ecosystem services are needed to manage risks and realize benefits.

Several teams are making progress with improved cultural ecosystem services methods including: Satz et al. (2013) who focus on addressing interconnected benefits, incommensurability, plurality of values and unit of analysis; Chan et al. (2012a, 2012b) on separating values, benefits and services within a value-centred framework addressing linkages through an influence diagram to inform decision-making; and others that have used surveys and interviews to map socio-culturally important sites (Klain and Chan 2012) and link these with biologically-important sites and identify "social-ecological" hotspots (Alessa et al. 2008) or apply socio-cultural ranks of value/threat to categories of ecosystem services (Raymond et al., 2009). While approaches have extended and advanced the methodological toolkit, further innovations are needed to take account of the dynamic processes, relationships, and practices that constitute "culture" (Poe et al., 2014).

As UNESCO (2002) explains, culture is "… the set of distinctive, spiritual, material, intellectual and emotional features of society or a social group, and … it encompasses, in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs". As a consequence, appropriate categories for cultural services need to be defined by the members of the community whose cultural values are being assessed rather than by experts (Chan et al., 2012b; Satterfield et al., 2013; Poe et al., 2014). Poe et al. (2014) clearly argue the need for equitable, meaningful participatory approaches that facilitate communities to determine both the appropriate categories for cultural ecosystem services assessments', and the means for measuring them. Our study addresses this gap in scientific knowledge through a participatory process that recognises culture and cultural ecosystem services as constituting dynamic processes, relationships and practices.

Zander et al. (2013) describes how Australian Indigenous peoples view their relationships with the environment in terms of cultural obligations rather than cultural services (Zander et al. 2013). Rainforest Aboriginal peoples, like Indigenous peoples throughout Australia, use the term "country" as shorthand for their many deep connections and cultural responses to both "sea country" and "land country". As Debra Bird Rose (1996, p. 7) explains, people: "speak to country, sing to country, visit country, worry about country, feel sorry for country, and long for country … country knows, hears, smells, takes notice, takes care, is sorry or happy". This Australian context of deep interconnections between the social and ecological "components" of a linked social-ecological systems provides a fertile space for joint efforts to develop an innovative way of mapping cultural ecosystem services.

In this paper we present a collaborative mapping method for Indigenous cultural ecosystem services developed with Rainforest Aboriginal peoples in the terrestrial parts of Australia's humid tropical forest region—referred to as "wet tropics country" (Fig. 1). We introduce the categories for Indigenous cultural ecosystem systems derived through co-research and present maps of their perceived health of these through ratings based on mutually generated indicators. We also present qualitative data that helps explains the reasons behind the ratings. In the discussion, we link these co-produced categories and indicators to biocultural diversity and the governance of ecosystem services. We conclude with a discussion of implications of our methods for future mapping of cultural ecosystem services.

2. Material and methods

2.1. Study areas

The co-research was conducted in tropical north-east Queensland, Australia, which extends from Cooktown (15°S, 145°E) to
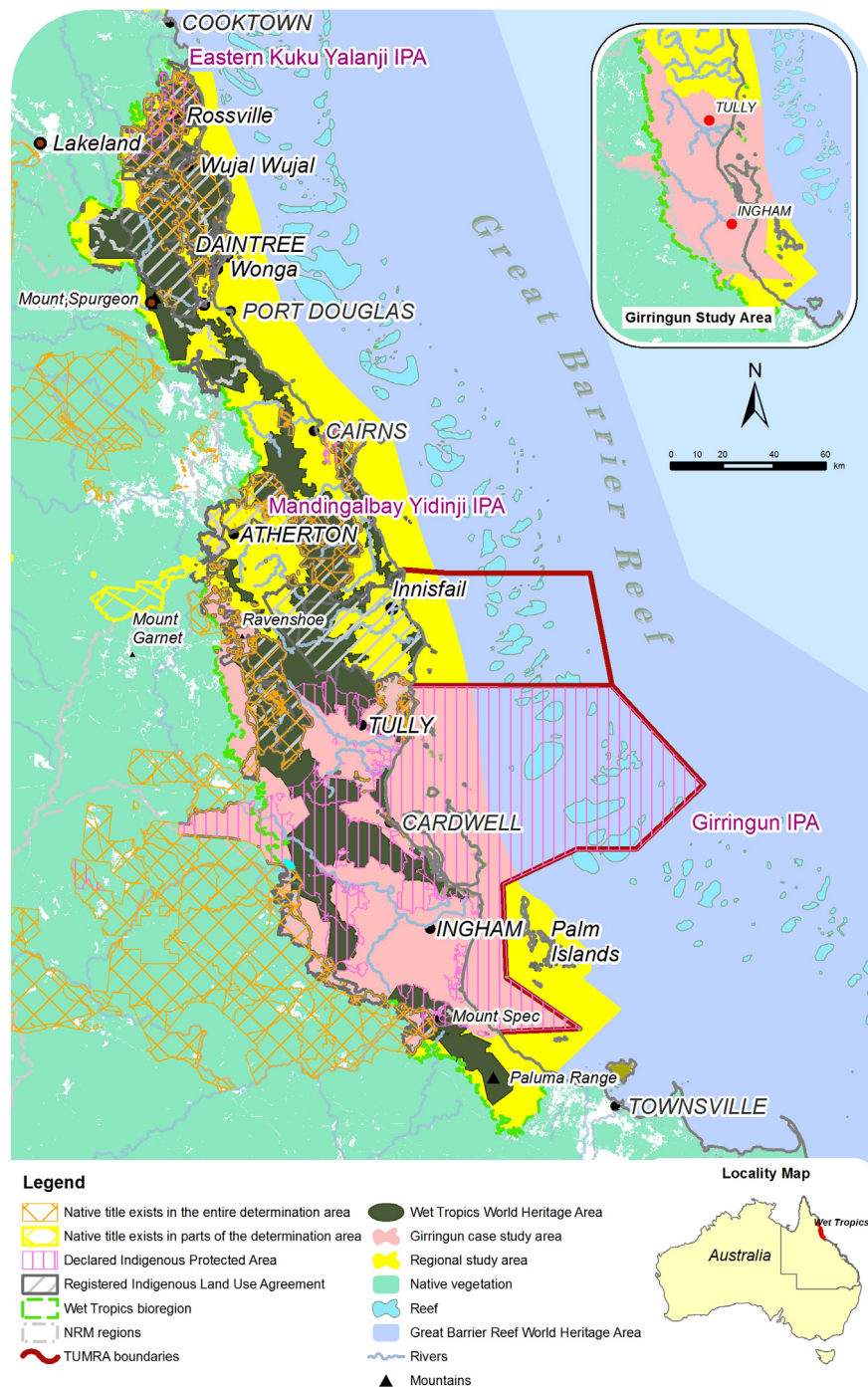
Fig. 1. Location of Wet Tropics regional and sub-regional (Girringun) case study areas in Queensland, Australia. Recognised native title determinations, Indigenous Land Use Agreements (ILUAs), the Wet Tropics World Heritage Area, Great Barrier Reef World Heritage Area, Traditional Use of Marine Resources Agreement (TUMRA) areas, Indigenous Protected Areas, Natural Resource Management (NRM) regions, Great Barrier Reef and Wet Tropics World Heritage Areas, and native vegetation are also shown.

Townsville in the south (19°S, 147°E), and encompasses the "Wet Tropics Bioregion" which covers 28,448km² (Queensland Government Natural Resources, 2004; Fig. 1). The Wet Tropics bioregion is characterized by its tropical climate, spectacular scenery, Indigenous cultural values, economic productivity and globally significant biodiversity that was recognized through natural values protection of some 9027 km² within the Wet Tropics World Heritage Area in 1988.

Mapping within this region was conducted through a regional-scale case study with Rainforest Aboriginal peoples, and a sub-regional case study with Girringun Aboriginal Corporation. The regional case study boundary includes the intersection between the wet tropics bioregion and the customary lands of the twenty tribal groups of Rainforest Aboriginal peoples in the region. These customary lands include freehold and leased farmlands, generally owned by non-indigenous landholders, and some small towns. It has an areal extent of 28,448.3 km², which stretches from *Kalkajaka* (Black Mountain) near Cooktown in the north, west to Mt Garnet, and south to Paluma (Fig. 1). This region is home to 20,000 Rainforest Aboriginal people, 120 clans within 8 language family groups, 70 legal entities including Registered Native Title Prescribed Body Corporates and registered Cultural Heritage Bodies, 2 Aboriginal Councils and 20 tribal groups: *Northern:* Eastern Kuku Yalanji, Western Yalanji, *Central*: Djabugay, Gunggandji, Mamu,

Mbabaram, Muluridji, NgadjonJii, Yidinji and Yirrganydj, and *Southern:* Bandjin, Djiru, Girramay, Gugu-Badhun, Gulnay, Jirrbal, Nwaigi, Warrgamay, Warungu and Wulugurukaba (RAPA, 2013).

Within the Wet Tropics bioregion, a smaller sub-regional case study area was undertaken encompassing nine tribal groups and traditional estates of the Bandjin, Djiru, Nywaigi, Girramay, Gulnay, and Warrgamay coastal groups, and the Gugu Badhun, Jirrbal, and Warungnu inland groups (Zurba, 2010). These groups come together under the banner of Girringun Aboriginal Corporation (GAC) and are located between Paluma and Mission Beach in the southern third of the Wet Tropics bioregion (see inset map in Fig. 1). The Girringun sub-regional case study has a total area of 25,078 km^2.

Recognition of Rainforest Aboriginal peoples' rights by the Australian nation-state have gradually increased through a variety of instruments including:

- Indigenous Land Use Agreements under the *Native Title Act* 1993 (a binding agreement entered into between native title claimants and the other land managers of the land);
- Indigenous Protected Areas (a voluntary agreement between Traditional Owners and the Australian government to promote biodiversity and cultural resource conservation on Indigenous-owned land);
- The establishment of Indigenous Land and Sea Ranger programs;
- The granting of Aboriginal freehold tenure;
- The signing of a Wet Tropics Rainforest Aboriginal Agreement; and
- Other arrangements as detailed further in Maclean et al. (2012, 2013) (Table 1).

2.2. Participatory co-research methods

The research in this study used a participatory co-research approach (Cullen-Unsworth et al., 2010; Maclean and Cullen, 2009). Co-research is a transdisciplinary approach that involves scientists and practitioners working together throughout the whole research cycle, from the common setting of research goals, development of methods, analysis of results through to co-delivery of policy-relevant findings and new contributions to social science theory (Tress et al., 2005). Our co-research was developed through a five stage/phase process:

(i) Mutual interest identification;
(ii) co-research agreements with relevant organizations;
(iii) co-produced categories and indicators;
(iv) participatory evaluation through multi-scalar community-driven processes; and
(v) collaborative analysis, interpretation, report-writing and theory-building (Fig. 2).

Phase one—(mutual interest identification), occurred over two years, through a scoping study (Hill et al., 2011b) and subsequent development into a project that was funded by the Tropical Ecosystem Hub of the National Environment Research Programme from July 2011 to December 2014 (see http://www.nerptropical.edu.au/project/indigenous-peoples-and-protected-areas).

Phase two—(co-research agreements) were negotiated with relevant Rainforest Aboriginal peoples' networks and organizations. The co-research design meets the Guidelines for Ethical Research in Australian Indigenous Studies (AIATSIS, 2012) and operated under a Ethics Approval from the CSIRO Ethics Committee. Community, government and non-government partner provided letters of commitment outlining the mutually agreed-upon process to engage with Rainforest Aboriginal peoples in the management of biodiversity. This co-research team has met sixteen times since its inception meeting in May 2012.

In phase three, a document and institutional analysis was undertaken to interrogate the context, together with collection of spatial data to support mapping, and a review of theoretically-driven sets of categories in the scientific literature (Maclean et al., 2012). A set of categories and indicators were developed by the co-research team and refined through participatory workshops (Hill et al., 2012b; Hill et al., 2013b).

In phase four, the participatory processes to undertake the mapping at multiple scales were developed and delivered together with the relevant Rainforest Aboriginal peoples' organizations. Two scales are reported here; further work is continuing at a finer scale. Girringun Aboriginal Corporation discussed the approach at their Annual General Meeting and decided to conduct their evaluation through hosting a workshop of appropriate members at Cardwell Community Hall on 23 November 2013. The invitees were selected by Girringun as those appropriate to provide an informed perspective from their Traditional Owner groups; sixteen people attended and contributed to the evaluation. The Rainforest Aboriginal Peoples' Alliance decided to conduct their evaluation as part of the 'Warrama: for Rainforest Country, Kin and Culture' held at Genazzano Retreat 28 November-1st December 2013, which brought together invitees across the region to focus

Table 1
Number and type of agreements in the regional case study region and the percentage of entire region (For dataset sources used see Appendix A).

Agreement type (as at December 2013)	Number in case study region	% of region	Gazettal area (km^2)
Native title exists in the entire determination area	18		11,734.9
Native title exists in parts of the entire determination area	1		317.5
	Sub-total	13	12,052.4
Indigenous Land Use Agreement—registered[b]	97		68,325.0
Indigenous Land Use Agreement—in notification	1		1.5
	Sub-total	73	68,326.0
Indigenous Protected Areas (IPA)[a]			
• Manadingalbay Yidinji	3		97.4
• Eastern Kuku Yalanji			2760.1
• Girringun			12,600.0
	Sub-total	14%	15,457.5
	TOTAL	**100%**	**95,835.9**

[a] An Indigenous Protected Area (IPA) is an area of Indigenous-owned land or sea where traditional Indigenous owners have entered into an agreement with the Australian Government to promote biodiversity and cultural resource conservation—see http://www.environment.gov.au/indigenous/ipa/index.html
[b] Determinations see Native Title website http://www.nntt.gov.au/Pages/default.aspx for further details and any further additions.

1. Mutual interest identification

Developing a co-research project around a cultural ecosystem services challenge of mutual interest to science and the communities associated with the social-ecological system. Stakeholder analysis to identify the appropriate organisations including rights-holders and stake-holders with responsibility and accountability for ecosystem management.

2. Co-research agreements with relevant organisations

Negotiating research collaboration agreements and letters of commitment with relevant community organisations . Agreements ensure processes that meet standards for ethical engagement with Indigenous peoples, including issues such as prior informed consent , benefit-sharing and protection of intellectual and cultural property rights. Establish a co-research team between scientists and relevant organisations.

3. Context analysis, co-produced categories & indicators

Context analysis of documentary , institutional and spatial data. Co-producing a participatory framework of categories and indicators that reflect the dynamic complexity of culture as experienced by the relevant communities, refined by theoretically-based approaches from the scientific literature. Reviewing and revising the categories through participatory workshops.

4. Participatory evaluation through multi-scalar community-driven processes

Undertaking a participatory evaluation using the co-produced categories and indicators through processes developed with relevant Rainforest Aboriginal community organisations. Attendees, interviewees, protocols and processes of the workshops determined and driven by these organisations in accordance with their particular cultural protocols.

5. Collaborative analysis, interpretation, report-writing and theory-building

Analysis of the results from the participatory workshop together with other data previously collected. Review and revision by participants of the resultant maps and of the qualitative data interpretation by the science members of the co-research team; finalisation of reports on the participatory evaluations, and theory-buildng in this manuscript, through co-authorship by the co-research team.

Fig. 2. Phases in the co-research method.

on strategic issues and priorities. Twenty-four people at this workshop contributed to the evaluation. In the fifth and final phase, the science members of the co-research team conducted initial data and spatial analysis.

Qualitative data were imported into QSR International's N-Vivo 10 software for coding and analysis to identify common topics. Quantitative and spatial data were analysed using Microsoft Office 2010 Excel and ESRI's ArcGIS v10.2. Convergent triangulation between quantitative, qualitative and documentary analysis was used to test validity (Creswell and Miller, 2000). Review and finalisation of reports on the participatory evaluations, and theory-building in this manuscript, occurred through co-authorship by the co-research team.

2.3. Categories, indicators and decision rules used to map cultural ecosystem services

The categories to underpin our interpretation of cultural ecosystem services were developed in phase 3 of the co-research through iterative participatory and literature review processes which are described elsewhere (Maclean et al., 2012). This resulted in two primary categories (each with a number of sub-categories, hereafter referred to as themes): (I) *Rainforest Aboriginal people keeping strong* (6 themes) and; (II) *Keeping engagement with non-Aboriginal people strong* (7 themes). The former recognizes that the effective engagement of

Indigenous culture, knowledge and values for co-governance requires that Rainforest Aboriginal people are thriving and able to keep their knowledge systems alive. The latter (*Keeping engagement with non-Aboriginal people strong*) recognises that co-governance arrangements cannot provide the means for effective *engagement* of Indigenous knowledge unless engagement mechanisms with non-Aboriginal counterparts are thriving and strong (see Australian Government, 2012). The themes under each of these two categories reflect the Indigenous rights holders' perceptions and expectations, including the distinct Indigenous knowledge systems and values of Rainforest Aboriginal people. Indicators and decision rules for the themes were similarly developed through iterative participatory and literature review processes in phase 3 that are described in detail elsewhere (Hill et al., 2013b). In order to enquire into the cultural values, benefits and services being delivered, three types of components were identified for each theme (Stankovitch, 2008 p. 88) (Tables 2 and 3).

2.4. Health rating of themes according to components

A coloured traffic light system was developed to assess the 'health' rating of the different themes, according to these three components: structures, processes and results for each of the two themes (a) Rainforest Aboriginal People keeping strong, and (b) Keeping engagement strong (see Table 4).

Table 2
Indicators and themes used for cultural ecosystem services mapping.

Category and definition Indicators	1. Rainforest Aboriginal people keeping strong Themes	2. Keeping engagement strong (with non-Aboriginal people) Themes
1. *Structures*: governance of cultural ecosystem services indicator	1.1 Culture 1.2 Kin 1.3 Country 1.4 Indigenous leadership & governance 1.5 Capacity 1.6 Rainforest Aboriginal People' (RAP) strategic vision & intent Average overall rating for structures	1.1 Principles 1.2 Relationships 1.3 Mechanisms 1.4 Protocols 1.5 Regimes for joint management 1.6 Power 1.7 Issues resolution Average overall rating
2. *Processes*: governance of cultural ecosystem services indicator	2.1 Culture 2.2 Kin 2.3 Country 2.4 Indigenous leadership & governance 2.5 Capacity 2.6 RAP strategic vision & intent Average overall rating for processes	2.1 Principles 2.2 Relationships 2.3 Mechanisms 2.4 Protocols 2.5 Regimes for joint management 2.6 Power 2.7 Issues resolution Average overall rating
3. *Results*: delivery of cultural ecosystem services indicator	3.1 Culture 3.2 Kin 3.3 Country 3.4 Indigenous leadership & governance 3.5 Capacity 3.6 RAP strategic vision Average overall rating for results	3.1 Principles 3.2 Relationships 3.3 Mechanisms 3.4 Protocols 3.5 Regimes for joint management 3.6 Power 3.7 Issues resolution Average overall rating

Table 3
Indicators used to evaluate themes (shown in Table 2) by workshop participants (adapted from: Stankovitch 2008).

Indicator	Explanation
Structures: governance of cultural ecosystem services indicator	● Setting things up—both Rainforest Aboriginal people and government/others—including: 　○ Starting organisations; 　○ getting the constitutions in place for organisations; 　○ progressing Native Title recognition; 　○ making agreements (e.g. Indigenous Land Use Agreements); 　○ making new laws or rules; and 　○ agreeing on protocols.
Processes: governance of cultural ecosystem services indicator	● Doing things—both Rainforest Aboriginal people and government/others—including: 　○ making plans; 　○ getting people to meetings; 　○ starting projects; 　○ getting Indigenous Ranger Groups out 'caring for country'; 　○ exercising native title rights (hunting, lighting fires); 　○ finding ways to sort out arguments; 　○ teaching language; 　○ finding partners and working together with partners; 　○ finding ways to sort out arguments; and 　○ progress mutual interest.
Results: delivery of cultural ecosystem services indicator	● Things actually being delivered—both Rainforest Aboriginal people and government/others—including: 　○ Rainforest Aboriginal people knowing their language and culture; 　○ government people showing respect for Rainforest Aboriginal People law/lore; 　○ good relationships being in place; 　○ protocols being followed; and 　○ the country getting healthier.

Small groups at the workshops were asked to give a numerical rating (1–5) to the 'health' (see Table 3) of the structures, processes and results associated with each theme, and to discuss the reasons for that rating.

2.5. Mapping approach

All the quantitative data (health ratings) were entered into a Microsoft Excel spreadsheet. The health ratings were mapped

Table 4
Decision rules for rating health of indicators.

Health rating	Decision rule – health of indicator
5 Excellent	This indicator is excellent and continuing as is will keep it in excellent health.
4 Very good	This indicator is very healthy and does not need to be too much different to be done to keep it healthy
3 Good	This indicator is healthy and may need something more or different to be done to keep it healthy
2 Little bit sick	This indicator is a little bit sick and needs work to be done to make to healthy. If no work is done it will get worse.
1 Very sick	This indicator is very sick and if no work is done to make it better it may never be healthy again.

using ESRI's ArcGIS 10.2 using the same colour health rating system outlined previously in Table 4. Maps of individual themes were created and shown as smaller inset maps for each theme according to the three cultural ecosystem services indicators: structures, processes and results (Table 3). These maps were completed for both the regional and sub-regional case study areas. Overlaying the two regions allows comparison between health ratings for themes as rated at each workshop.

3. Results

3.1. Structures: governance of cultural ecosystem services

Structures are one component of the governance of cultural ecosystem services. Both Rainforest Aboriginal peoples' (RAP) regional and Girringun sub-regional evaluations rated the structures for the *Rainforest Aboriginal Peoples Keeping Strong* (RAPKS) category overall as healthier (mean 3.9 and 3.4 respectively) than those for the *Keeping Engagement Strong* (KES) category (mean 2.3 and 2.7 respectively) (Figs. 3 and 4). Detailed analysis of the reasons behind each of the health ratings shown in the maps can be found in Hill et al. (2013b); we highlight here only some of the key aspects.

The cultural and spiritual foundation was identified as the primary source of structural strength in both case studies:

We have that cultural foundation. Culture and spirituality is our way (Girringun sub-regional workshop).
Our mob manage through our ancestors by being linked into, by law, on the spiritual level… The principles of the law (RAP regional workshop).

Indigenous governance and leadership was rated as "very good" across the region, reflecting the recognition of its basis in customary law, but also of the Indigenous organisations that enable carriage of this leadership in the contemporary context. Cultural art, craft and language programs run by these organisations provide effective structures for culture, as do informal family and clan-based structures:

For example, kinship, we are always looking after our families. That's a thing that's been passed through many tribal groups, that we look after each other (RAP regional workshop).

The poorer health ratings for structures for "Keeping Engagement Strong" in both case-studies reflects the inequitable basis of native title, leading to poor Indigenous Land Use Agreements (ILUAs) and highly constrained tenure outcomes:

Once you get native title (even then it's just a right to negotiate), under the threat of compulsory acquisition: if industry wants the land for something, if you can't come out with some sort of agreement, ILUA, whatever, their legal people threaten "if you don't agree we'll ask the State for a compulsory acquisition". So it puts us on the back foot, right is given and taken away at the same time. Any industry can actually do that, it goes back to the institutionalised racism in the system (RAP regional workshop).

Indigenous Protected Areas (IPA) and Rangers were identified as providing a means for developing and implementing a strategic vision and offering a more effective pathway towards adaptive governance than through native title:

IPA is what gives us the structure for strategic vision, IPA is 'the what', comes—together in putting our vision, Rangers is 'the how'… ILUAs put us in a competition with the State, negotiating to reach an agreement…. In an IPA we have something that can be adapted, it evolves. With an ILUA, it depends on the strength of the negotiation (Girringun sub-regional workshop).

Other factors that contributed to positive health ratings for structures included "excellent" relationships among diverse partners, mutual respect, and established protocols. In contrast, factors that contributed to poor health ratings for structures were related to poor support for Prescribed Body Corporates,[1] lack of support for economic relationships to be developed, and the lack of coordination and clear mandates between government agencies. Structures for governing key decisions on-country were viewed as preventing rather than facilitating application of Indigenous knowledge and practices:

For fire management, we went through and did all the certificates under their mainstream law. Elders would say to us "burn now". But government say "we have a plan" "we are going to burn on these dates"… We say things like, "we haven't had a good season of fruit, so we should burn now". If we want our regular food

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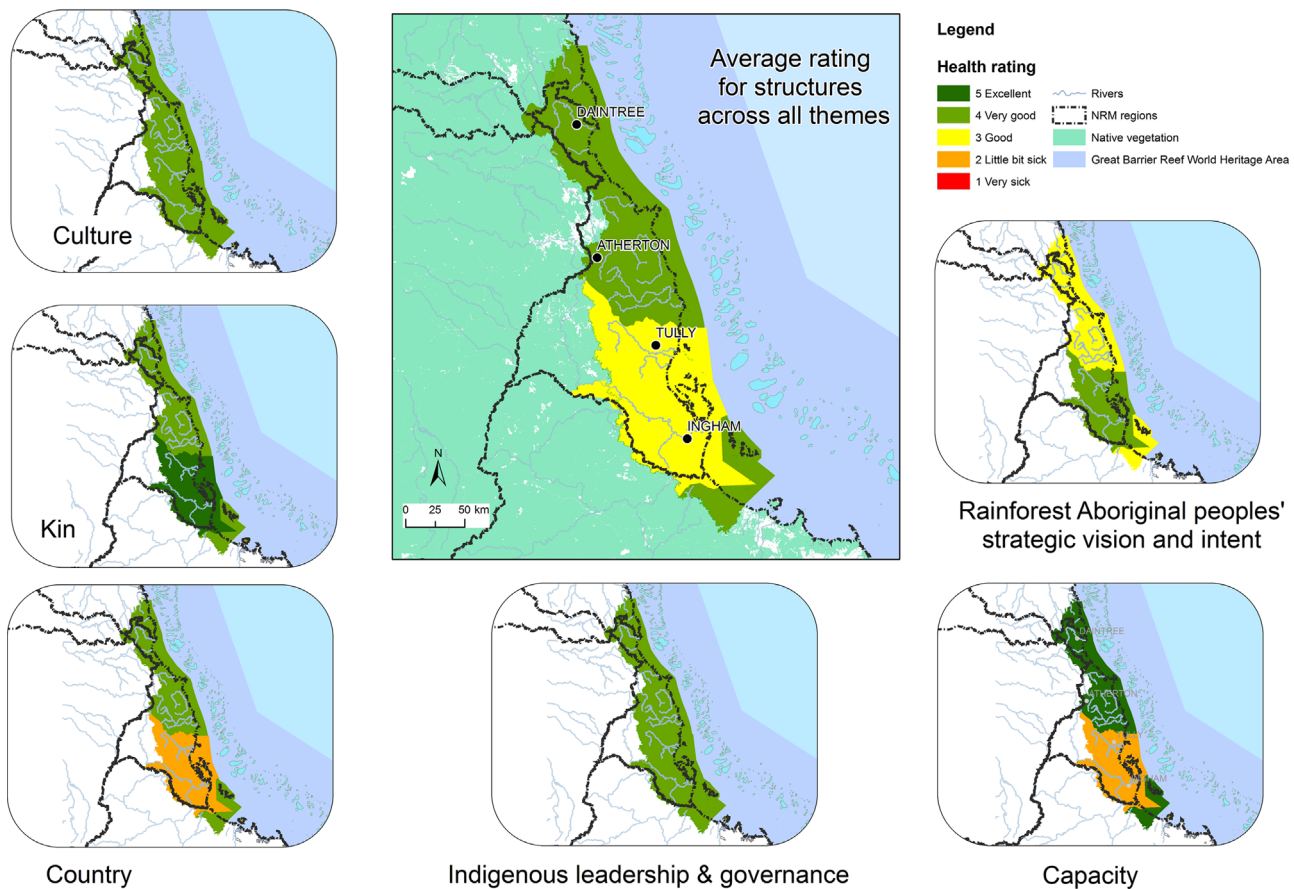[1] Organizations required under legislation to hold native title

Fig. 3. Regional evaluation of health of structures for Rainforest Aboriginal Peoples Keeping Strong in Wet Tropics country (with Girringun sub-regional evaluation shown in their part). *Note*: where there is no change in colour, this indicates that both the sub-regional and regional case study rated the theme the same value (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

source we have to burn at the season… There's a clash between scientist and Traditional Owner (TO) burning. And that ILUA stops us doing our traditional burning, [as it] *says 'burning only for weeds' (Girringun sub-regional workshop).*

3.2. Processes: governance of cultural ecosystem services

Processes also form a component of the governance of cultural ecosystem services. Both Rainforest Aboriginal peoples' (RAP) regional and Girringun sub-regional evaluations rated the processes for the *Rainforest Aboriginal Peoples Keeping Strong* (RAPKS) category overall as healthier (mean 3.1 and 3.2 respectively) than those for the *Keeping Engagement Strong* (KES) category (mean 2.5 and 2.3 respectively)(Figs. 5 and 6). Detailed analysis of the reasons behind each of the health ratings shown in the maps can be found in Hill et al. (2013b); we highlight here only some of the key aspects.

Processes for *Indigenous governance and leadership* were identified as a key strength in both regional and Girringun sub-regional case studies, with health ratings of "very good" and "excellent" respectively. Taking on leadership roles, based on Indigenous culture and customary institutions, allows Rainforest Aboriginal peoples to claim self-determination in a manner that is consist with their concept of "first nation" status, despite (and without seeking permission of) the overarching colonial nation-state (Fig. 5):

Blackfella leadership business is about going and meeting with people. [There are] so many ingredients in it. You have to be able to manage people, and you have to be able to do that well… Our

leadership is very much underpinned by our cultural values. It's the leadership that can get it right. What we are talking about is contemporary sovereignty. If you act as if it's there, you achieve it. If you go and ask for it, people will say "no" (Girringun sub-regional workshop).

Processes that enable young people to step into leadership roles, and to be mentored by senior elders were also key strengths. Again, the spiritual basis of processes were emphasised, processes that enable spiritual visions to provide the foundation of actions. Poorer health ratings reflected challenges like keeping harmony between groups and fostering collaboration; and the confusion and conflicts caused by the experiences of the 'stolen generation[2].

Strengths identified in the health ratings for the processes in Keeping Engagement Strong with non-Aboriginal people (Fig. 6) included a substantial number of tools for engagement including: Memoranda of Understanding (MOU), partnerships, native title, Prescribed Body Corporates, strategic plans, board meetings and others (see Hill et al., 2013b). Issue resolution was viewed as in "very good" health in the regional case study area because of particular long-standing government project officers and staff with whom people had developed personal relationships of trust. In other cases, the constant churn of government staff, policies and

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[2] The policy of forcible removal of children from Indigenous Australians to other groups for the purpose of raising them separately from and ignorant of their culture and people (Source: Human Rights and Equal Opportunity Commission, 1997).
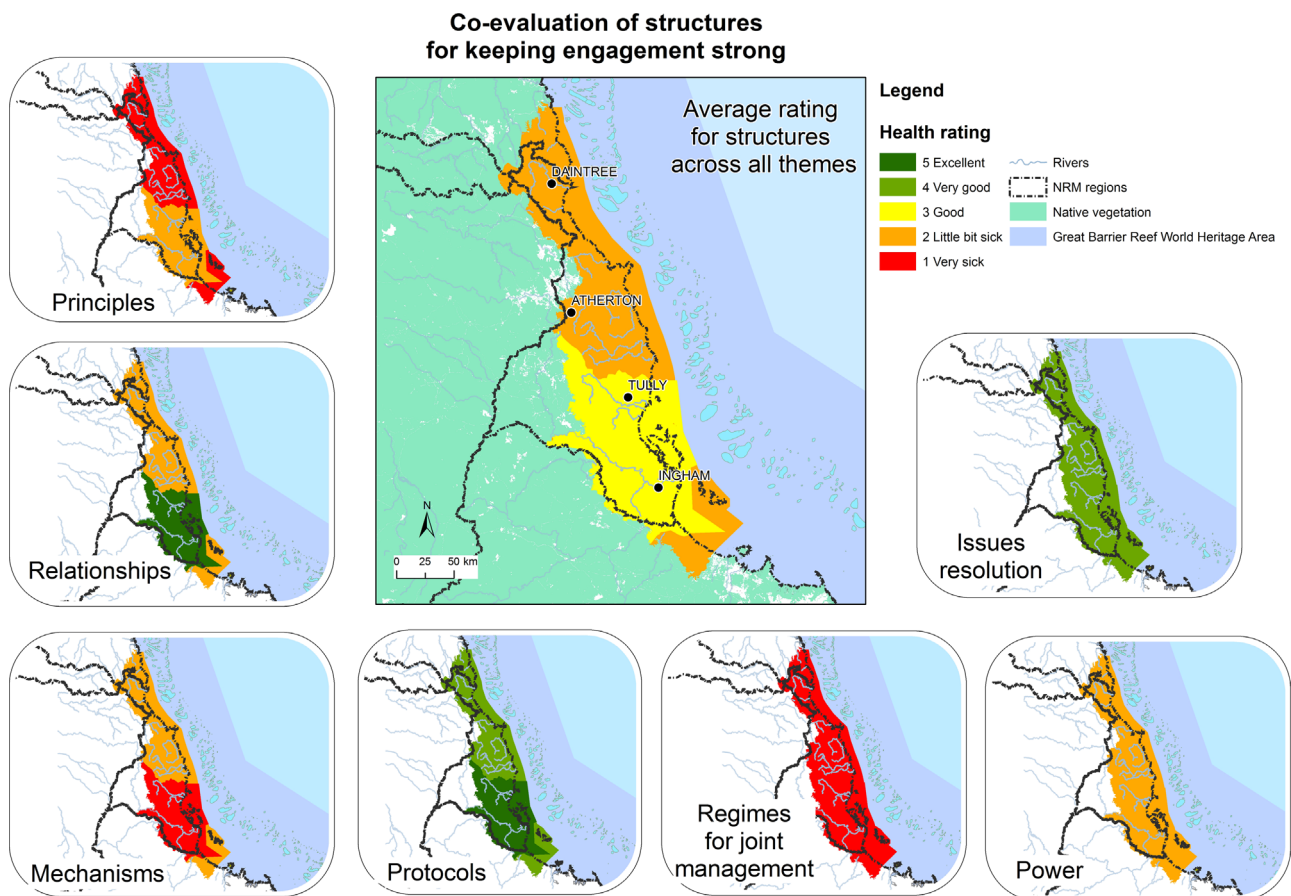
Fig. 4. Regional evaluation of health of structures for Keeping Engagement Strong in wet tropics country (with Girringun sub-regional evaluation shown in their part). *Note*: where there is no change in colour, this indicates that both the sub-regional and regional case study rated the theme the same value.

programs were noted as a contributor to poor health. Both case studies identified the need for brokering organisations to provide effective linkages with these agencies and for business development.

Native title *processes* were again highlighted as in conflict with the Indigenous cultural norms and expectations:

Native title is disempowering. When the court came here to give our determination, the court says "no photos, no singing out with happiness". The Judge walks in, sits up there, going through papers, reading out all the conditions on our native title. Who the hell is this bloke? It upset me. That's not his to give. That's ours, it's always been ours. What we are doing here is our own sovereignty. Not some bloke that comes from Brisbane to tell us what our country is (Girringun sub-regional workshop).

Nevertheless, people recognised improvements in processes over time:

The (engagement) processes used to be very very sick but we have managed to break down their stereotypes. In early days we did a lot of communication work with people about having native title co-exist. [We told them that] "we're not taking anything off you, we just want to be able to check our sites" (Girringun sub-regional workshop).

3.3. Results: delivery of cultural ecosystem services

The *Results* indicator represented the delivery of cultural ecosystem services. This is a part of the analysis that is more familiar with the western perspective on ecosystem services. Both Rainforest Aboriginal peoples' (RAP) regional and Girringun sub-

regional evaluations rated the results for the *Rainforest Aboriginal Peoples Keeping Strong* (RAPKS) category as healthier overall (mean 3.3 and 3.0 respectively) than those for the *Keeping Engagement Strong* (KES) category (mean 2.7 and 2.8 respectively) (Figs. 7 and 8). Detailed analysis of the reasons behind each of the health ratings can be found in Hill et al. (2013b).

The topics discussed in both regional and sub-regional workshops to explain the reasons for health ratings for results align more closely with the biocultural diversity categories, than with the unique categories and themes developed for this study. Positive health ratings were associated with improvements across all categories. Key environmental improvements included: water quality, removal of exotic species and habitat restoration (including post-cyclone[3]) assured delivery of cultural ecosystem services, including relationships with key species:

I walked around the front and there was about 16 dugongs, just near, probably from here to that building - playing, they were just dancing in the water. Sea grass has come back (RAP regional workshop).

Many results for cultural renewal, site protection, celebration, and promotion were recognised. Social relations were noted as a key result area:

Results come through mutual understanding. Build a sort of trust, not really proper trust, I wouldn't go that far, but trust within certain bounds. It's a culture, environment, feeling that you build.

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[3] Severe Tropical Cyclone Yasi made landfall near Mission Beach (18°S, 146°E) north of Townsville on 3 February 2011. It is described as one of the most powerful cyclones to have affected Queensland since records commenced (Bryan et al., 2010).
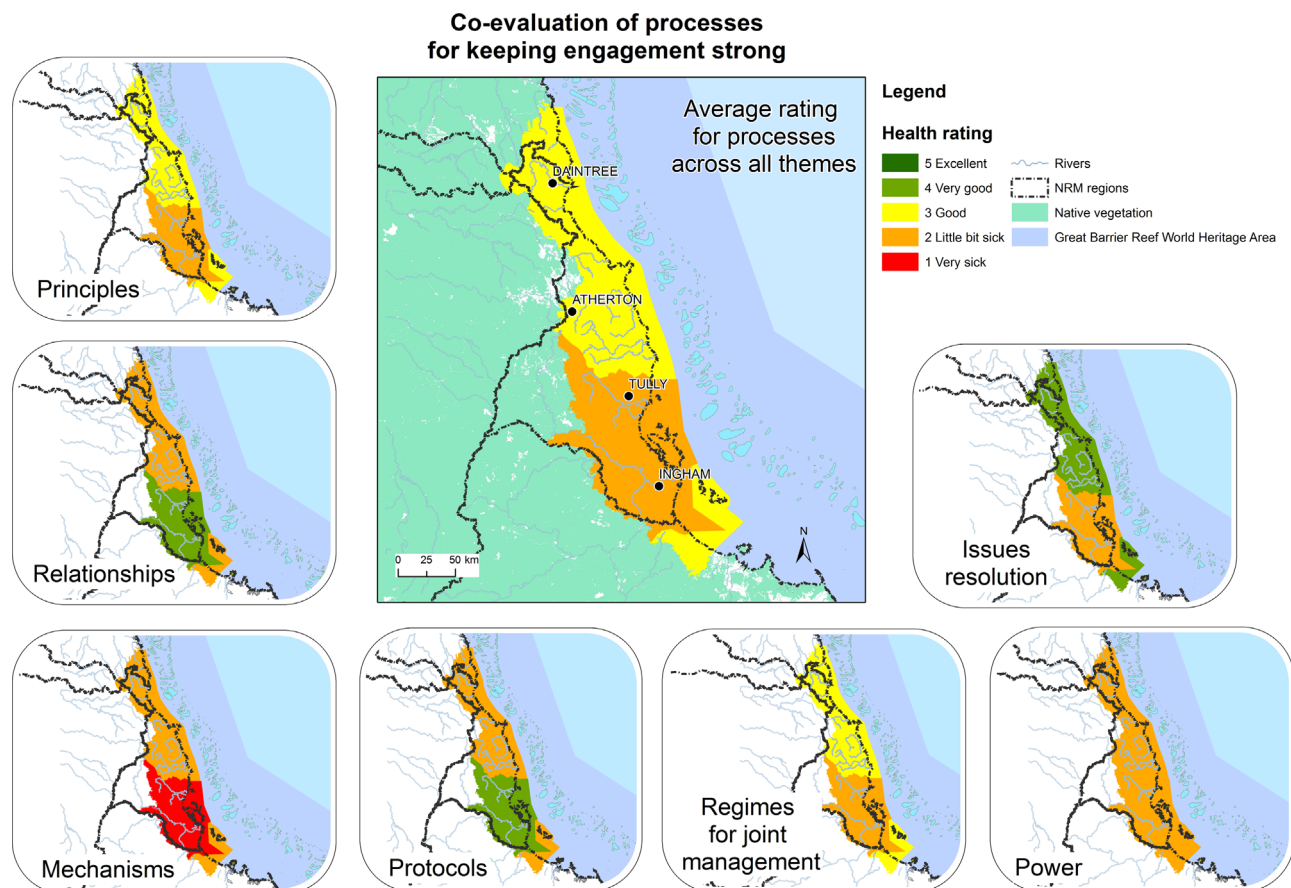
Fig. 5. Regional evaluation of health of processes for Rainforest Aboriginal Peoples keeping strong in Wet Tropics country (with Girringun sub-regional evaluation shown in their part). *Note:* where there is no change in colour, this indicates that both the sub-regional and regional case study rated the theme the same value. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

An understanding between you and me, as good as an agreement (RAP regional workshop).

Delivery of multiple cultural ecosystem services are being mediated through key organisations:

We've got the arts in one section, the rangers, we've got a biodiversity project, a great big nursery. They've gone on country and got seeds, come back, germinate, they've been re-vegetating 2000/3000 plants in a few weeks… We sent out flyers last week actually all around Cardwell and we've had people just flocking in buying trays and trays of plants (RAP regional workshop).

Improved access to country is enabling re-connections to place, sites, and multiple cultural services:

Walking tracks…are all culture, it's part of our culture… really old highway just followed our Aboriginal walking tracks… south of Cardwell, used to be a goat's track but our rangers have widened it, gone through and cleaned it, we can walk our country again… walking the trails (RAP regional workshop).

While this is recognised as strengthening delivery of cultural ecosystem services, other factors are weakening it:

We're losing the old knowledge, while Aboriginal management is getting better recognized, [it's] not good enough, not quick enough, not enough to make a big difference (Girringun sub-regional workshop).

Overall, poor health ratings for results were associated with a lack of progress in economic and political relations and with legal-

institutional instruments. Peoples' access to land has not yet delivered the cultural ecosystem services they had expected:

People don't have a fridge, don't have a proper home, but they own a $3 million cattle station.[4]How do we capitalise on that asset, and bridge the gap, to get equitable social-economic benefits? We own this cattle station but our kids can't read (Girringun sub-regional workshop).

We've been talking and talking and talking. I think over the years when people have been talking and talking we've lost a lot of our elders. Still today we're still talking about what they're talking about, and no action (RAP regional workshop).

Nevertheless, many value the gains that have been made, and have suggested that "increasing cross-cultural confidence" is a way of expressing the improvements overall.

4. Discussion

The themes identified through a co-research process do not easily map to the usual categories for cultural ecosystem services,

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[4] The Mungalla Station was acquired by the Nywaigi Aboriginal Land Corporation (the prescribed body that operates on behalf of the Nywaigi traditional owners for that area of land), in 1999/2000 with financial assistance from the Indigenous Land Corporation (an Australia Government statutory authority established in 1995, administered under the *Aboriginal and Torres Strait Islander Act, 2005*) Australian Bureau of Meteorology, 2014. *Severe Tropical Cyclone Yasi. http://www. bom.gov.au/cyclone/history/yasi.shtml (accessed 24.03./14) [online].* Available from: http://www.bom.gov.au/cyclone/history/yasi.shtml (Accessed 24.03.14).
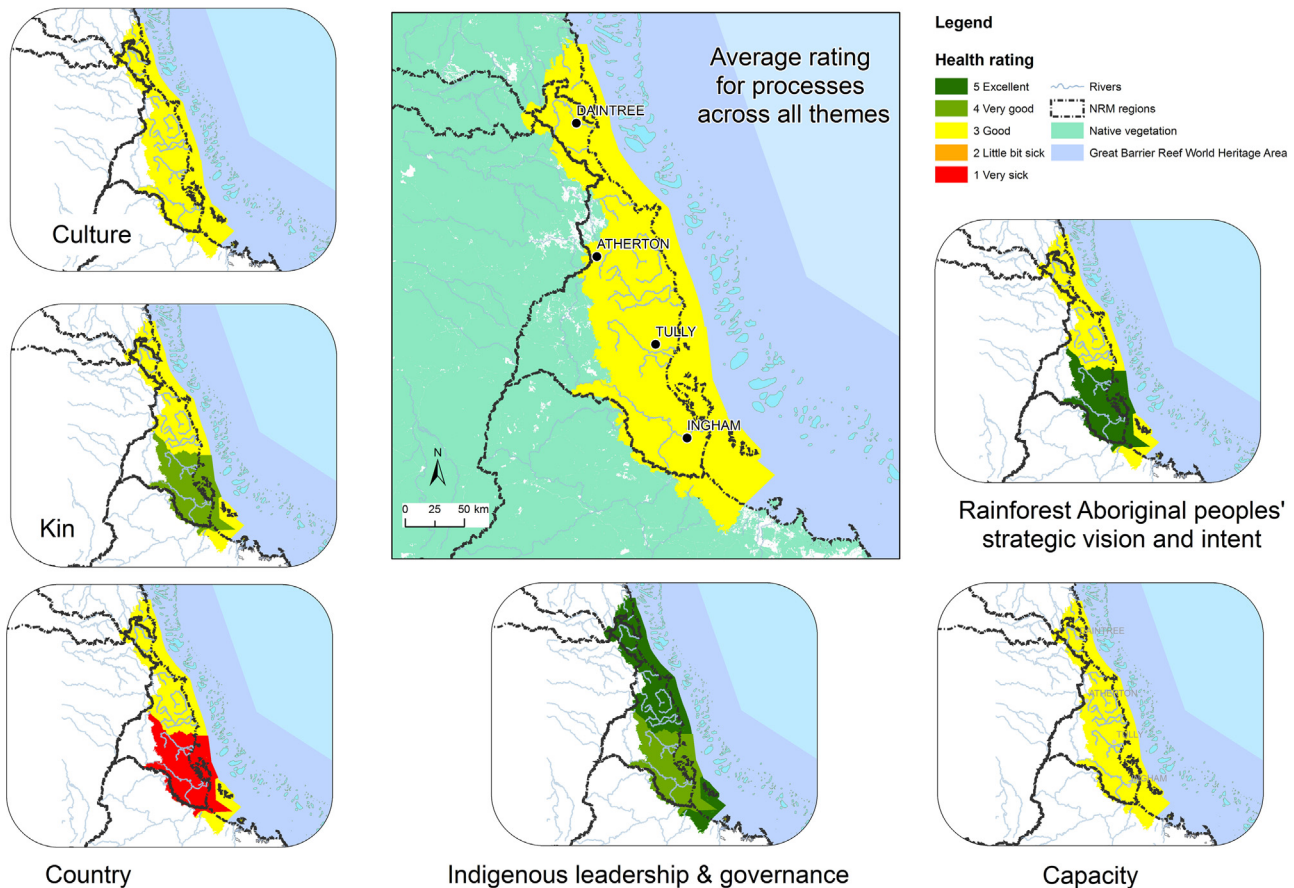
Fig. 6. Regional evaluation of health of processes for Keeping Engagement Strong in wet tropics country (with Girringun sub-regional evaluation shown in their part). *Note*: where there is no change in colour, this indicates that both the sub-regional and regional case study rated the theme the same value.

originally developed for the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005). Eleven categories of cultural services were recognised: cultural diversity; spiritual and religious values; knowledge systems; educational values; inspiration; aesthetic values; social relations; sense of place; cultural heritage values; recreation and ecotourism. These categories, with the addition "bequest, intrinsic and existence values" have underpinned most cultural ecosystem services studies to date—but do not fit easily with the categories identified here.

Our categories are more consistent with categories of interlinkages in biocultural diversity developed by Persic and Martin (2008) (Table 5). This congruence with the concept of "biocultural diversity" reflects Rainforest Aboriginal peoples' perspective that culture and nature are not separate, but interlinked. Previous research with Rainforest Aboriginal peoples (Hill et al., 2011a, 2013b) identified that these biocultural diversity categories of *interlinkages* (Persic and Martin, 2008) encompass Rainforest Aboriginal peoples' understanding of their cultural values in wet tropics country (Hill et al., 2011a). "Biocultural diversity" is defined as the total variety exhibited by the world's natural and cultural systems (Gorenflo et al., 2012). The term denotes three key concepts: (1) the diversity of life includes human cultures and languages; (2) biodiversity and cultural diversity share common links; and (3) these links have developed over time through mutual adaptation and possibly co-evolution. Biocultural diversity recognizes that the humans and non-human species are integral to shaping and maintaining biodiversity and associated ecosystem services—and exclusion of these may result in degradation of these

values (Loh and Harmon, 2005). The categories of ecosystem services developed through this co-research can be readily mapped to Persic and Martin's (2008) categories of interlinkages in biocultural diversity (Table 6).

For Australian Indigenous peoples, the concept of culture is also inextricably linked to the governance of their traditional country and is an expression of rights—for example, the ability to engage in a particular cultural relationship with an animal as a "totem" depends on factors such as membership of a land-holding group, gender, cultural seniority and other governance-related factors (Hill et al., 2012a).

The integration of concepts of linked social-ecological systems into the field of biodiversity and ecosystem science has led to recognition that governance is a critical—arguably the *most* critical—factor in mediating the delivery of ecosystem services (Hill et al., 2013a; Paavola et al. 2009). Governance is recognized as "…the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens and other stakeholders have their say" (Graham et al., 2003). Governance systems will therefore largely determine which cultural ecosystem services are delivered from an area of nature—by selecting which particular stakeholders' perceptions and expectations are recognized.

However, governance of social-ecological systems is multi-actor, multi-scalar and polycentric, and its effectiveness in mediating biodiversity and ecosystem service outcomes is strongly linked to the quality of collaboration (Hill et al., 2010; Ostrom and Cox, 2010). Co-governance concepts, for example, bring together
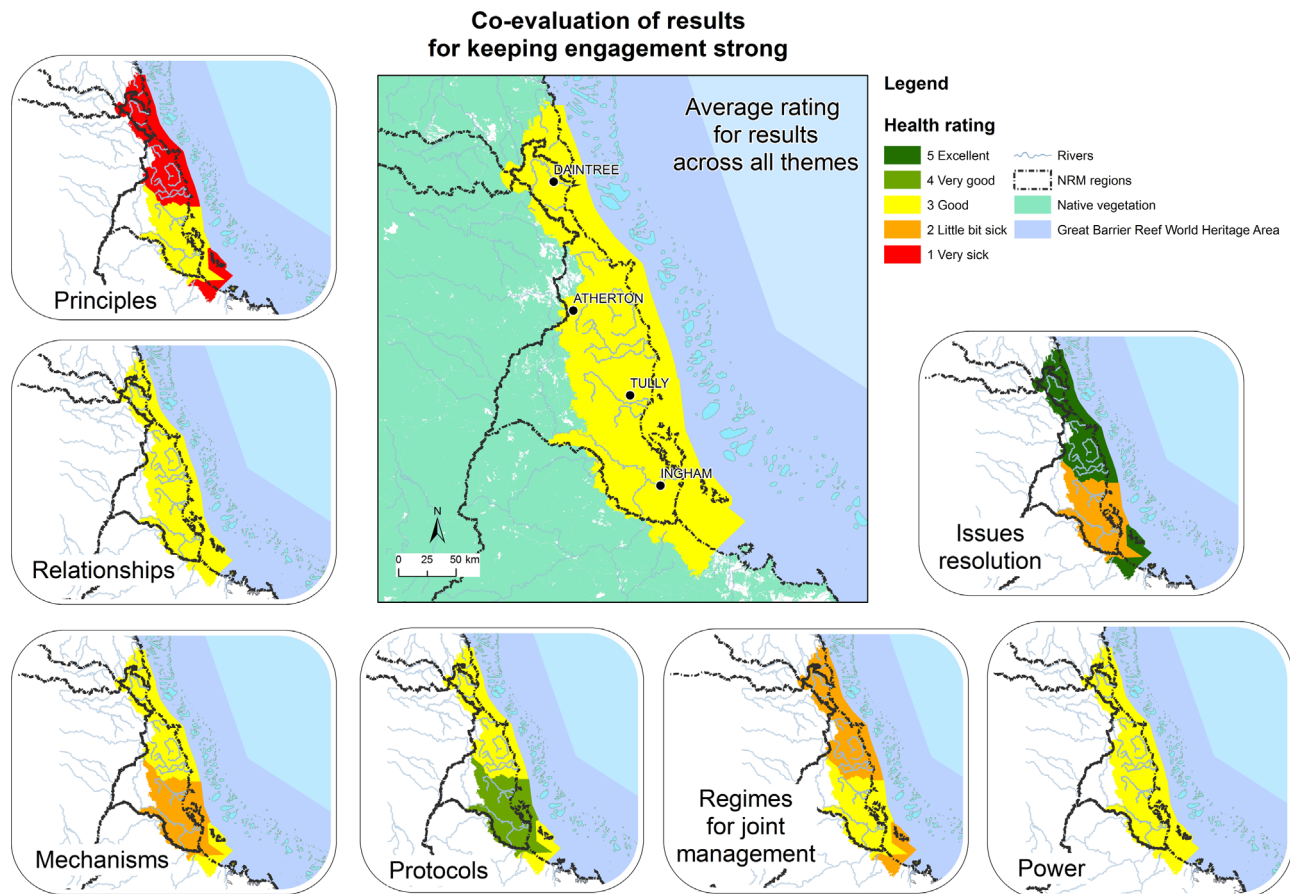
Fig. 7. Regional evaluation of health of processes for Rainforest Aboriginal Peoples keeping strong in wet tropics country (with Girringun sub-regional evaluation shown in their part). *Note*: where there is no change in colour, this indicates that both the sub-regional and regional case study rated the theme the same value.

elements of sharing power, decision-making and actions, with trust and capacity building, and cost sharing (Carlsson and Berkes, 2005; Zurba et al., 2012). Several of the categories developed through this co-research resonate with these concepts of governance: power; relationship; protocols and regimes. Mapping exercises can be powerful tools for grasping the socio-cultural realities of communities, regions, landscapes, seascapes and ecosystems (Ryan, 2011). Traditionally cartographic representations have focused on the spatial variation of the "ecological" component of the linked social-ecological system as the basis of stakeholders' preferences leading to identification of cultural services and social-ecological "hotspots" (Bryan et al., 2010; Alessa et al., 2008). Our co-research demonstrates that variation in cultural ecosystem services is also linked to variations in the "social" component (e.g. individual, family, clan or tribal group) of the linked social-ecological system. Variations in the cultural ecosystem services are largely a result of variations in the social-ecological *interlinkages* which are mediated by social and governance factors – not just the physical attributes of the landscape. Mapping of this biocultural dimension is important to encompass Indigenous cultural perspectives.

5. Conclusion

The participatory co-research methods used in this study enabled Indigenous peoples and their partners to drive categorisation and measurement of cultural ecosystem services, producing outcomes that reflect their rightsholders' perceptions. As predicted by Daniel et al. (2012), we encountered multiple conceptual and technical challenges to represent and model the complex socio-ecological relationships that define and constrain cultural ecosystem services.

We identify that the concept of "biocultural diversity" provides the necessary categories to translate our stakeholder-derived cultural ecosystem services categories into a more generic, transferable model. Nevertheless, these interlinkages are not well understood—correlations between natural and cultural diversity could result from co-evolution, asymmetric causation, or other factors affecting both simultaneously. Further insight into these interlinkages and the biocultural diversity produced through the culturally embedded practices of associated communities is required to enable full integration into ecosystem service approaches.

We further identify that measures of governance are necessary to address Rainforest Aboriginal peoples' concepts of ecosystem services. Governance is another concept that is poorly theorized and explored in the domain of ecosystem services. We developed our methods by drawing on the governance evaluation approaches and frameworks presented in the recent IUCN Best Practice Guidelines (Hill et al., 2012a). However, diagnostic tools for interrogating co-governance of ecosystem services are yet to be included in these guidelines, and are generally poorly developed in the literature. Again, further insight into governance of ecosystem services will aid future refinement and application of governance diagnosis.

Technical challenges in our co-research approach included that of addressing literacy and language barriers within both the co-research team and the participatory workshops. While many Indigenous peoples lack access to education and scientific

Co-evaluation of results
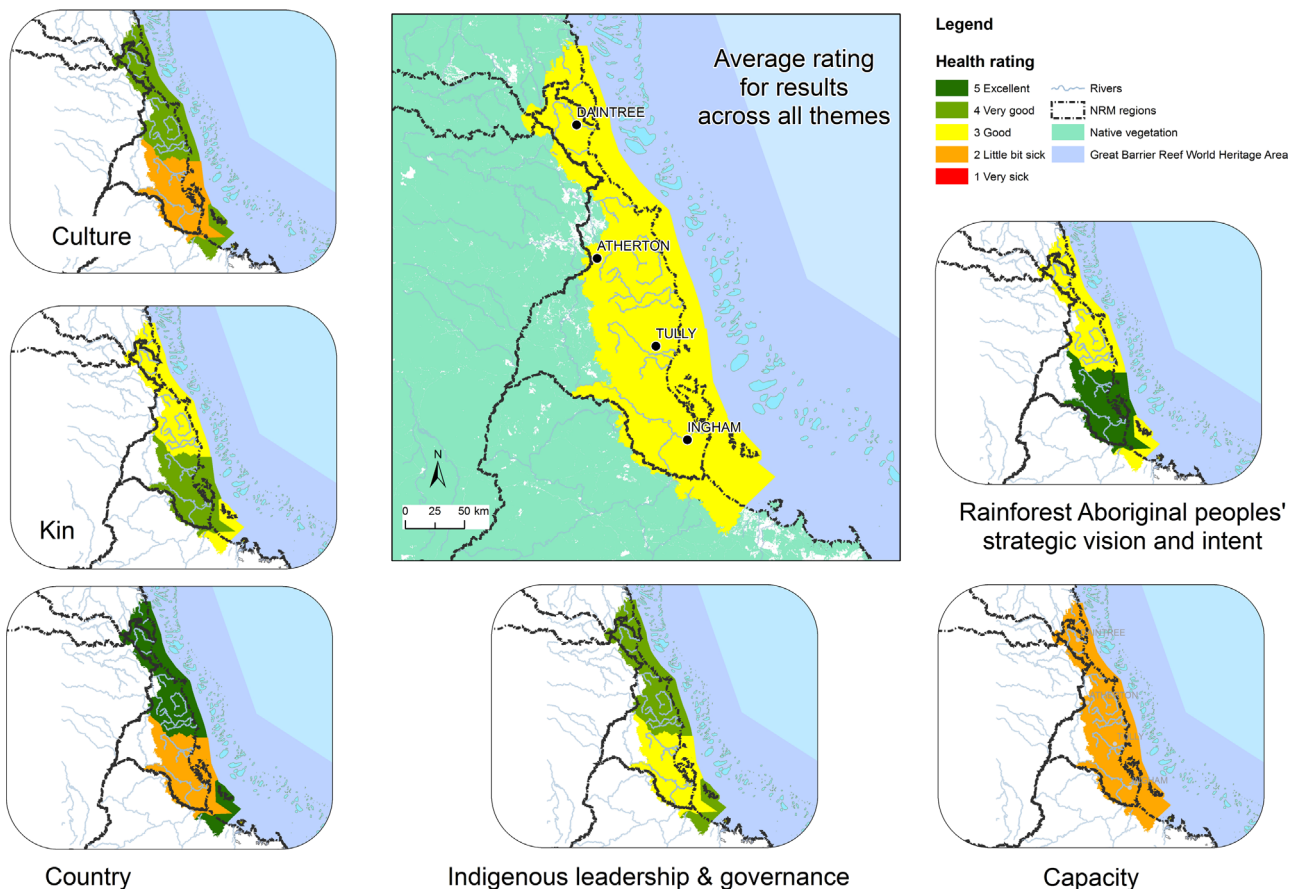## for Rainforest Aboriginal peoples keeping strong

Fig. 8. Regional evaluation of health of results for Keeping Engagement Strong in wet tropics country (with Girringun sub-regional evaluation shown in their part). *Note*: where there is no change in colour, this indicates that both the sub-regional and regional case study rated the theme the same value.

knowledge, most non-Indigenous participants lack access to Indigenous knowledge and world views, particularly the spiritual aspects. This highlights the deep epistemological divide and challenges in enabling the concept of ecosystem services to move beyond its origin in western culture and utilitarian assumptions (Daniel et al. 2012). Our approach of defining indicators of health in accordance with the Aboriginal English usage e.g. "little bit sick", and by using mixed quantitative and qualitative methods for measurement, has proven effective.

Our research challenges previous arguments that cultural services can be managed through focus on how social values attach to biophysical attributes leading to variations in the intensity, richness and diversity of their provision (Alessa et al., 2008; Bryan et al., 2010). Rather than being distributed according to features of the landscape, we found that the spatial distribution of cultural services follow specific patterns in terms of social, political, and economic relationships and is subject to legal and institutional instruments, knowledge and technologies that mediate provision. We expand the concept of cultural services to encompass more of the aspects that Plieninger et al. (2013) argues are pivotal and challenging to integrate [and remind the readers what Plienger et al. says are pivotal and challenging to integrate].

Our co-research confirms many of the findings from Poe et al.'s, 2014 recent review and provides an actual example of cultural ecosystems services mapped using and expanding on Poe et al.'s (2014) five categories: cultural meanings, values, and identities; knowledge and practice; governance and access; livelihoods; and biophysical environments. Our co-research resulted in the

development of meaningful local indicators, which were then used to give a health rating to the 13 components of the two themes: *"Rainforest Aboriginal Peoples Keeping Strong"* and *"Keeping Engagement Strong"* by workshop participants. These health rating were then displayed spatially enabling visualization of the health ratings using a simple traffic light colour system. Using this approach both Indigenous people and relevant stakeholders are able to visualize areas shaded "red" (such as processes for the "Country" theme for Girringun people—Fig. 5) denoting "the indicator is very sick and if no work is done to make it better it may never be healthy again". Whereas areas shaded "dark green" (e.g. for structures in place for Rainforest Aboriginal peoples keeping strong theme—"Kin" for Girringun people—Fig. 3) denote "the indicator is excellent and continuing as is will keep it in excellent health".

The ongoing co-research project of which this cultural ecosystem service mapping is a part, aims to produce policy-relevant findings about how to better manage Indigenous cultural values. Substantial further work is planned before that aim will be realized. However, this paper provides methods that respond to two of the questions for the special issue: How to address social and economic values in ecosystem service maps? and, How to create and use ecosystem service maps based on participatory mapping and stakeholder engagement (supported with biophysical modelling and quantification)?

Our methods have engaged a more sophisticated view of social-ecological linkages that underpin cultural ecosystem services, greater recognition of deeper held values, and greater awareness of the consequences of human actions with the environment. We

Table 5
Categories of interdependence between biological and cultural diversity as defined by Persic and Martin (2008) related to Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) cultural services (shown in brackets, as in Table 1)—1. Cultural diversity, 2. Spiritual and religious values, 3. Knowledge systems, 4. Educational values, 5. Inspiration, 6. Aesthetic values, 7. Social relations, 8. Sense of place, 9. Recreation, 10. Ecotourism and the themes derived and mapped from the research reported in this paper.

Categories of interdependence between biological and cultural diversity	MEA cultural services	Our mapped themes
1. Language and linguistic diversity		Culture
● Language (e.g. terms, concepts and categories relating to nature)	Cultural diversity (1)	Culture
● Linguistic diversity (the relation to biological diversity)		Culture
2. Material culture		Culture
● Material culture (e.g. objects created from and/or representing biodiversity, including those reflecting spiritual and religious beliefs ad aspirations, and the arts)	Cultural diversity (1)	Culture
3. Knowledge and technology		Capacity
● Technology and techniques related to natural resources	Knowledge systems (3)	Capacity
● Traditional and local knowledge about natural resources, ecological relationships	Educational values (4)	Culture
● Transmission of knowledge between generations		Culture
● Mechanisms for traditional knowledge revitalization		Capacity
● Mechanisms for the adoption of new knowledge		Capacity
4. Modes of subsistence		Country
● Natural resource livelihoods	Cultural heritage values (1)	Country
● Land/sea use and management		Country
● Plant/animal domestication and selective breeding		Country
● Supplementing economies through sustainable harvesting		Country
5. Economic relations		Mechanisms
● Economic relations through partnerships based on natural resources	Recreation (9)	Mechanisms
● Management of common property resources	Ecotourism (10)	Principles (self-determination)
6. Social relations		Kin, relationships, issue resolution
● Attachment to place	Social relations (7)	Kin
● Social relations with natural resources	Sense of place (8)	Kin
● Gender relations with natural resources		Kin
● Political relations with natural resources		Power, protocols
● Legal-institutional e.g. customary law regarding resource use, acces		Regimes
7. Belief systems		Culture
● Rites and rituals	Spiritual and religious values (2)	Culture
● Sacred sites (landscapes)	Inspiration (5)	Culture
● Mythology, worldview, cosmology	Aesthetic values (6)	Culture
● Identity with the natural world, e.g. totems		Culture

Table 6
Explanation of themes within the two categories of Indigenous biocultural ecosystem services and relation to Millennium Ecosystem Assessment (2005) cultural services (shown in brackets, as in Table 1)—1. Cultural diversity, 2. Spiritual and religious values, 3. Knowledge systems, 4. Educational values, 5. Inspiration, 6. Aesthetic values, 7. Social relations, 8. Sense of place, 9. Recreation, 10. Ecotourism.

1. Keeping Rainforest Aboriginal people strong requires attention to six themes			2. Keeping engagement strong requires attention to seven themes		
Theme	Explanation	Biocultural ES (interlinkages)	Theme	Explanation	Biocultural ES (interlinkages)
Culture	Rainforest Aboriginal peoples' worldviews, lore, law, language, dreaming and ways of knowing, doing and being.	Language (1) Material culture (3) Belief systems (2)	**Principles**	Provide fluid movement for self-determined levels of involvement in the shared space, which allows for each Traditional Owner group's distinct trajectory, and for difference across scales (local, sub-regional, regional).	Legal– institutional (6)
Kin	Internal Traditional Owner relationships, networks and connections.	Social relations (7)	**Relationships**	Good relationships enable (rather than constrain for contain) Indigenous roles, which requires a flexible approach.	Social relations (6)
Country	Traditional knowledge and practices, including story places, fire management, totems, hunting, fishing and collecting plants and animals, making a living from country.	Modes of subsistence (4)	**Protocols**	For a range of engagement processes.	Legal-institutional (6)
Indigenous leadership and governance	Strong grass-roots organisations and institutions supporting Traditional Owner groups, language family groups, and sub-regional and regional alliances; co-management between Traditional Owner groups that share boundaries, intra- and inter-group issues resolution and interests progression.	Political relations (6)	**Regimes for joint management**	Clearly defined government role established through legislation and policy.	Legal-institutional (6)
Capacity	Individual, family, clan, tribal group, language family group and organizational skills, expertise, knowledges, and resourcing including financial.	Knowledge and technology (3)	**Mechanisms**	Strategic and practical plans and documents; roundtable of stakeholders who follow up with actions.	Economic relations (through partnership) (5)

Table 6 (*continued*)

1. Keeping Rainforest Aboriginal people strong requires attention to six themes			2. Keeping engagement strong requires attention to seven themes		
Theme	Explanation	Biocultural ES (interlinkages)	Theme	Explanation	Biocultural ES (interlinkages)
1. Keeping Rainforest Aboriginal people strong requires attention to six themes			**2. Keeping engagement strong requires attention to seven themes**		
Theme	**Explanation**	**Biocultural ES (interlinkages)**	**Theme**	**Explanation**	**Biocultural ES (interlinkages)**
Rainforest Aboriginal peoples' shared strategic vision and intent	This is the pivot-point of co-governance, as the tribal autonomy and sovereignty that TOs have over an area of country provides the mandate to "act on the front foot" and engage the multiple non-Indigenous mainstream organizations. Institutional fragmentation is such that there is no equivalent government organization with a similar mandate.	Social relations (6)	**Power**	Right to exercise native title, "big-stick" Common law rights Free, prior and informed consent	Political relations (6)
			Issues resolution	Mechanisms for sorting out issues and collaborating on shared interests between Indigenous and non-Indigenous organisations and people.	Political relations (6)

have moved beyond mapping leading to the identification of cultural services "social hotspots", and, consequently, identification of critical focal areas for cultural services management (Kirchhoff, 2012). Our mapping also leads to the further identification of social systems "hotspots" as critical focal areas for cultural services management, which can then be incorporated into policy-relevant findings from our research. We recommend that the application of these concepts of biocultural diversity governance, and variation in social attributes when mapping cultural ecosystem services, (particularly in partnerships with Indigenous peoples) be taken into consideration. These methods will be of particular use to land management agencies and researchers, both government and non-government, who are aiming to understand and improve management of Indigenous and other cultural services from ecosystems. We look forward to future evaluations of their general effectiveness for mapping, modelling and visualising ecosystem services.

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