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ORIGINAL ARTICLE

Challenges of diverse knowledge systems in landscape analysis of the Murray–Darling Basin, Australia

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Abstract Geographic information systems are a means to develop a common framework for the integration of a range of perspectives into natural resources management decisions. The incorporation of these perspectives presents more than a technical challenge—diverse knowledge systems make demands on the structure of geodatabases, the ways in which data are collected, held and interrogated, and the choices around which types of knowledge can and should be incorporated. Here, we investigate these questions in the context of Indigenous Yorta Yorta knowledge contributions to the management of a sensitive region of the Murray–Darling Basin in Australia. Management of the Barmah-Millewa region and its natural resources is governed by a wide array of sometimes inconsistent policies with differing regulatory frameworks and management foci. We find that (1) appropriate collection, management and database design protocols require substantive intellectual property protections and (2) once in place, spatial analysis can support management decisions without revealing sensitive information. Importantly, these protocols support the effective and respectful participation of the Yorta Yorta community in management of this ecologically, economically and culturally important region.

Keywords Indigenous knowledge · Sustainability · Land management · Murray–Darling Basin · Geographic information system

Introduction

> ..I am concerned that so many so unprepared are setting out boldly to make land-use maps. There are few kinds of research which carry with them such tremendous social responsibility and which are so thoroughly difficult to perform effectively. Karl E. Francis (quoted in Tobias 2009, p 1)

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The use of geographic information systems (GIS) for geospatial analysis is becoming a powerful and ubiquitous technology in support of evidence-based land management decisions (Gallo and Goodchild 2012). The legibility of a complex landscape is enhanced by the assignment of features, resources, facilities and services in a searchable, geolocated database. In relation to Indigenous knowledge, however, GIS has been critiqued for its limited potential because it de-emphasizes or ignores concepts that cannot be geolocated, that change with time or circumstance or that are held by a limited number of individuals. Because of this, the risk of misrepresentation of Indigenous knowledge is not insignificant even when community participation is secured (Tobias 2009; Veland et al. 2014). Further, maps generated by GIS are often widely used and assumed to be accurate even when the underlying data are incomplete or otherwise flawed. Chambers et al. (2004), however, suggest that geospatial technologies can be developed that are true to Indigenous ontologies and serve current community goals, a process we have termed "seeing with both eyes" (Western and Indigenous) or *Nhawul Bultjubul Ma*. This is a process that includes protections through intellectual property rights (Lynch and Hammer 2013) and concepts of affinity and context (Laituri 2002; Crawhall 2004), and is informed by principles articulated by UNESCO (Crawhall 2004).

The Yorta Yorta people consider the Murray River, *Dhungala*, as their life source and spirit. Yorta Yorta Traditional Tribal Lands span over 30,000 years of active use and include an area of significant international ecological value. The region has been extensively colonized in the last two centuries (Fig. 1). In colonial times, the Murray River has suffered considerable damage from water diversions for agriculture, channel re-routing and dredging, the introduction of non-native flora and fauna, and other stressors (Grafton et al. 2012). The ability of the Yorta Yorta community to respond to these rapid changes to protect and manage culturally important plants, animals and places, and share the wisdom they have gained through generations of managing the land, has been curtailed by their limited access to the contested management processes in the Murray–Darling River Basin.

To enhance Yorta Yorta participation in forest and water management through supporting their knowledge system, an approach was co-developed with the Yorta Yorta Elders Council. The strategy chosen was to create a geographical information system (GIS) framework incorporating both Yorta Yorta knowledge and landscape level biophysical, climatic and demographic data. This choice of approach immediately raises the question: Are Western geospatial technologies compatible with Indigenous epistemologies (Barber and Jackson 2015)? Deeply rooted in these epistemologies rest the concepts of ubiquity of relatedness, significance of non-empirical experience, responsibility of the caretaker and the value of ambiguity (Fox 1995; Rundstrom 1995; Alessa et al. 2010). An example in the Yorta Yorta context is useful: Wilcock (2013) has noted that the creation stories of the emu (*Bigarumdja*) and the turtle (*Bayadherra*) provide a cultural orientation to "caring for Country." This orientation highlights Yorta Yorta knowledge that the ecological basis for environmental water allocations, which at present can be crudely summarized as "trees, fish and birds," can be better informed through understanding the health of *Bayadherra* and *Bigarumdja* on country. And indeed, a baseline study of the three freshwater turtle species that inhabit the Barmah-Millewa has elucidated and quantified linkages between turtle population health and environmental stressors such as boat traffic, drought and food availability, with downstream impacts on other species (Howard et al. 2013).

In this paper, we describe a methodology to address the challenges of respectfully integrating Indigenous knowledges into a geodatabase that can be used actively for land management decisions. This methodology contains three key elements. The first of these, protection of Indigenous knowledge, is the most critical element of this methodology. This includes procedural, legal and technical aspects as will be described. The second is a protocol for the collection of Yorta Yorta knowledge, building on the cultural land use and occupancy approach of Tobias (2009). As part of this process, Yorta Yorta youth were trained in cultural data collection techniques, in order to interview their Elders to record confidential geolocated knowledge. As a result, information was collected that could not be revealed to non-Yorta Yorta researchers. A co-benefit of this approach is that the process supports inter-generational knowledge sharing. The third component is the construction of a geodatabase that integrates Yorta Yorta knowledge with conventional data about the climate, hydrology, demography and biodiversity of Yorta Yorta country. A co-benefit of this phase is the construction of a database that collects all available conventional data for Yorta Yorta country into a single resource for the first time.

This paper details the development of the database and the accompanying collection and protection protocols. A prototype of analysis approaches used to yield insight for co-management of water and forest resources by the Yorta Yorta and Government agencies is provided to demonstrate how such a methodology can be implemented.

Case study region: the Barmah-Millewa

The Barmah-Millewa is located in the Murray–Darling Basin, which drains approximately one-seventh of the Australian land mass ($\sim$1 million km^2). Though the

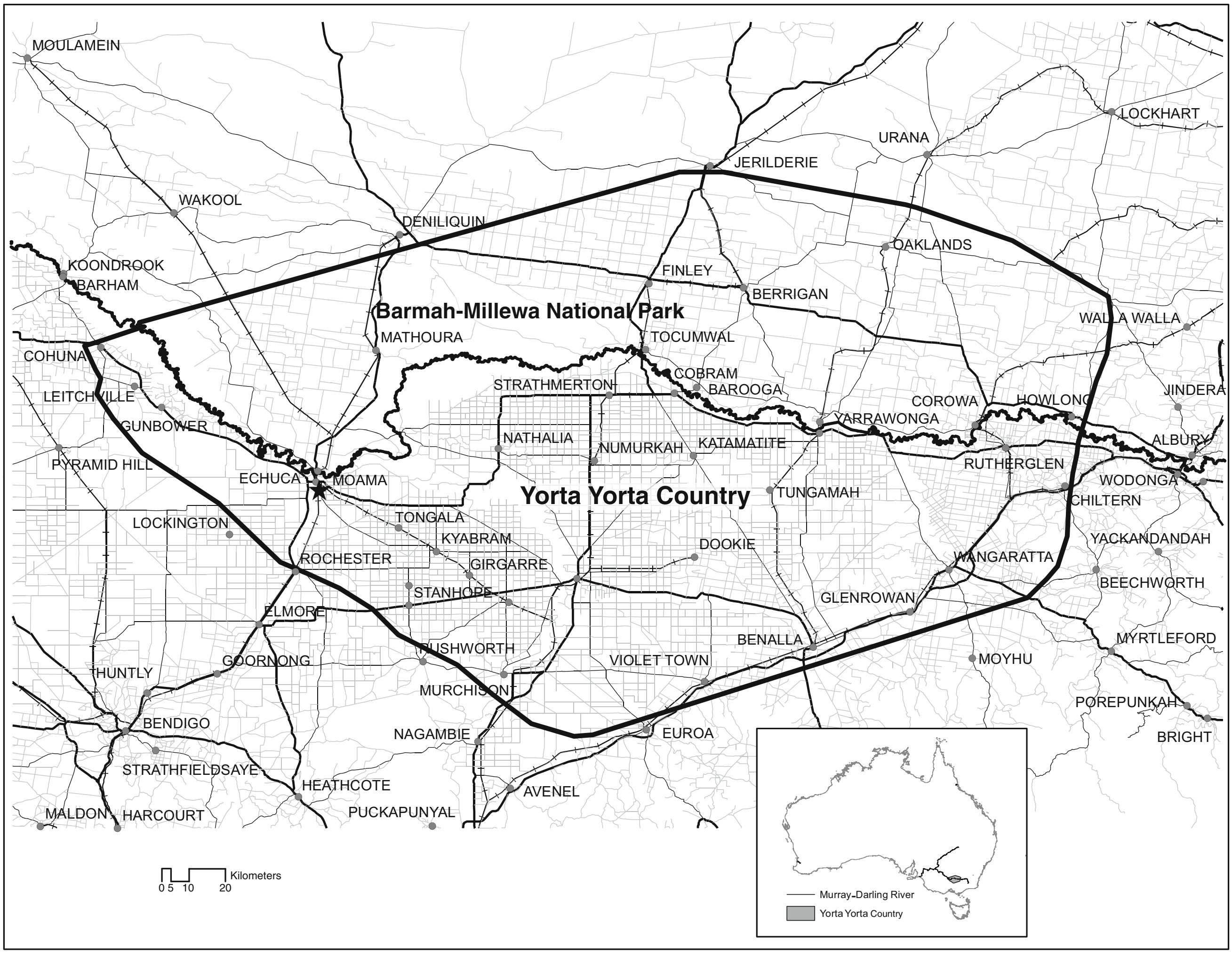

Fig. 1 Yorta Yorta country and the Barmah-Millewa Forest in Australia. This region lies along the Murray River branch of the Murray–Darling Basin. Yorta Yorta country is defined by the Elders as the boundary shown which has a precision no wider than 2.5 km. The region supports substantial infrastructure and settlement both within and outside Yorta Yorta boundaries

Murray–Darling Basin is supported by little direct rainfall (~500 mm per year), it supports 40% of Australia's gross value of agricultural production (AU$19 billion in 2010–2011, ABS 2013). The Barmah–Millewa, in the heart of Yorta Yorta Traditional Tribal Lands, is home to the largest river red gum forest (*Eucalyptus camaldulensis*) in Australia. Spanning the states of New South Wales and Victoria, the region covers 66,000 ha of forest, grassland and wetland (Fig. 2), supporting a richly biodiverse native flora and fauna. It is a significant breeding and nursery site for waterbirds, frogs, turtles and crayfish. At least 37 threatened plant species (including 4 endemic species), 10 endangered waterbirds, 3 threatened mammal species and the endangered trout cod (*Maccullochella macquariensis*) are found in the Barmah-Millewa (Robinson 1998; McKinnon 1993; Leslie 2001). This ecological uniqueness arises in part from a geologic formation called the Barmah Choke, with a channel capacity of 8000 Ml/day, which constricts flows of the Murray River and leads to frequent small flooding events in the broad floodplain immediately upstream, and supports a distinctive wetland environment that is characterized by changes in micro-topography (Stone 2006). Because of this geography, the Barmah-Millewa serves an important filtration function for downstream water users.

Water diversions for agriculture and hydroelectricity, channel re-routing and changes to seasonal river flow regimes, in-stream wood removal, cattle grazing, commercial firewood collection and the introduction of invasive species, among others, have all caused significant change to the environment of the Barmah-Millewa. This damage has been compounded by the Millennium Drought (1997–2009, with a sustained average 12% rainfall deficit) followed by the 2010–2011 floods (Fig. 3a). This sequence of events was reflected in severe rainfall deficits in the Barmah-Millewa for an even longer period (1994–2009),

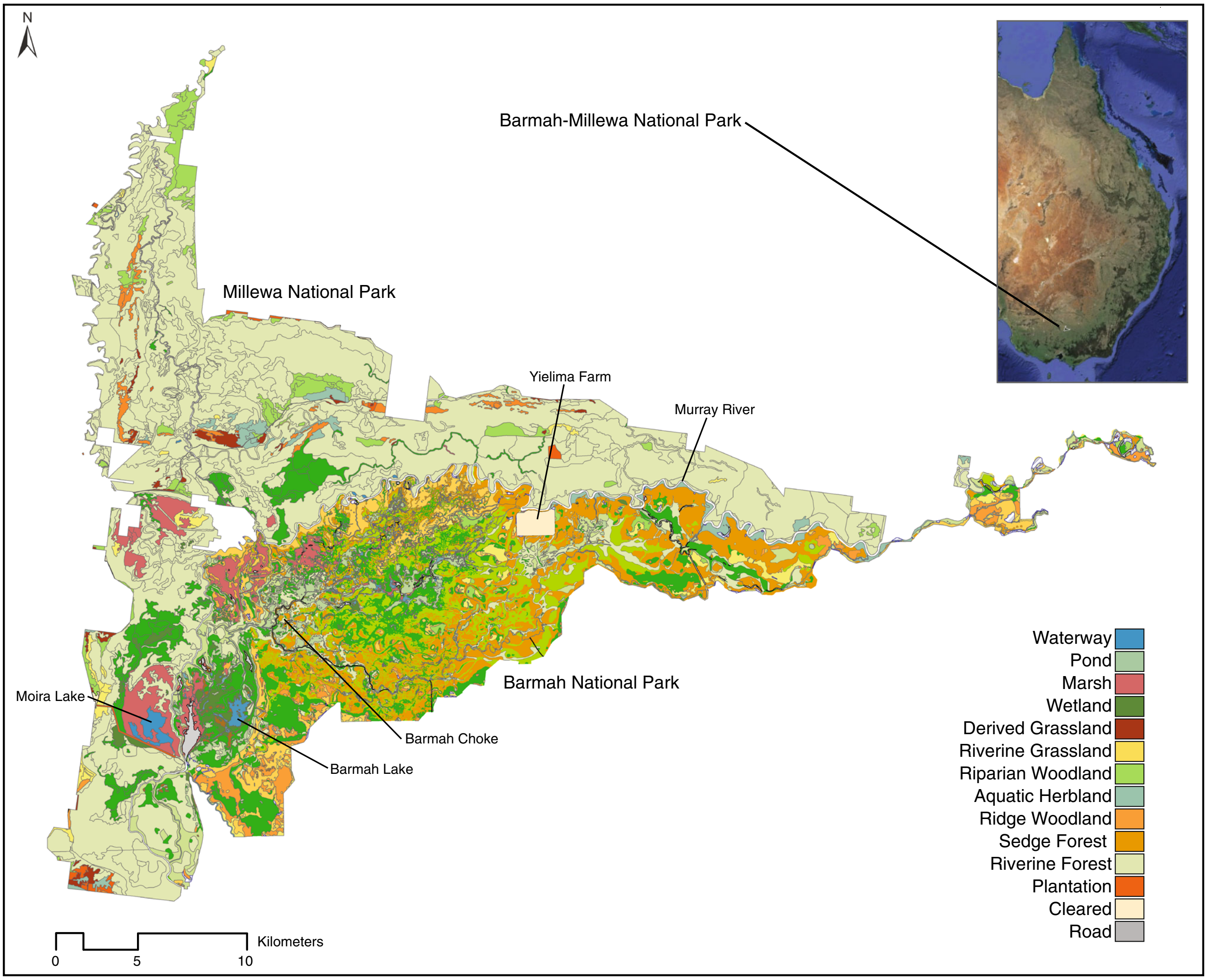

Fig. 2 Vegetation classifications for the Barmah-Millewa Forest, based on disparate data sets. While vegetation categories can be synchronized with appropriate ecological insights, the difference in scale of polygon between the two datasets cannot be resolved without additional data collection

which resulted in very low streamflows followed by "blackwater" (hypoxic) events and aquatic fauna kills that affected native species disproportionately in the Barmah-Millewa (Fig. 3b; King et al. 2012).

Land and water management in the Basin involves a complex range of stakeholders and agencies acting over large and sometimes overlapping jurisdictions. The Barmah-Millewa region includes a Living Murray Icon Site, one of six sites chosen along the Murray River for their high ecological, economic and cultural value by the Murray–Darling Basin Authority. It is also designated as a wetland of international significance under the Ramsar Convention and is a National Park. Several Federal government departments and agencies have oversight of different aspects within the region, including the Murray–Darling Basin Authority (MDBA). The MDBA is a government agency that reports to the Federal Minister with oversight of the water portfolio, as determined by the Water Act of 2007 (which is currently under review). The Water Act established a new position, the Commonwealth Environmental Water Holder, to manage, protect and restore the environmental assets of the Murray–Darling Basin. As of April 2014, the Commonwealth Environmental Water holdings were just over 1.7 million Ml of registered entitlements. Another requirement of the Act was the development of a coordinated approach to water management, which resulted in the Murray–Darling Basin Plan that commenced a seven-year implementation process in 2012. While the plan is adaptive in nature, it contains no provisions to include or assess non-quantifiable information. The independent body that is responsible for auditing the Plan, the National Water Commission, was disbanded

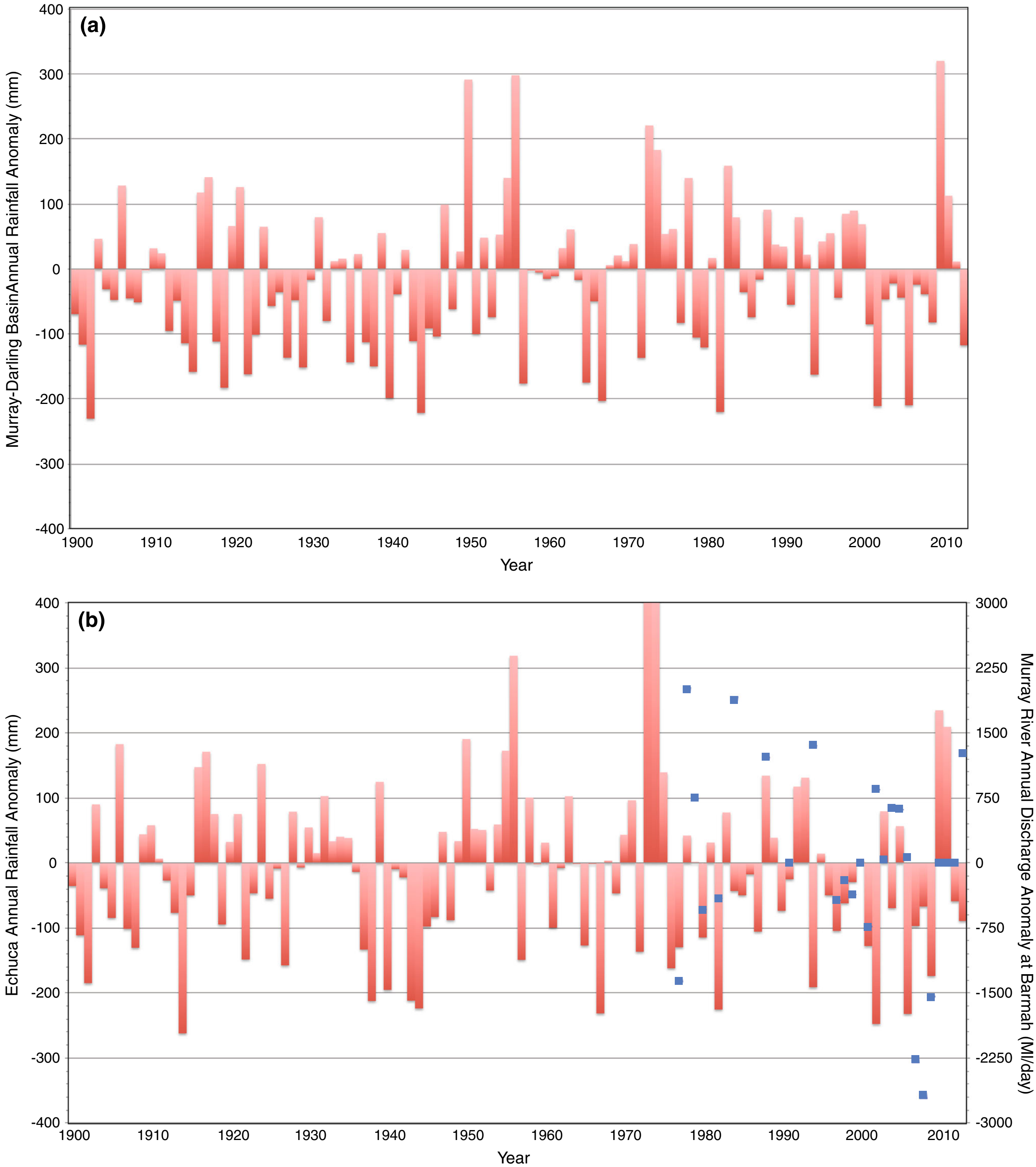

Fig. 3 **a** Annual rainfall anomaly (*red bars*) compared to the 1961–1990 long-term mean of the entire Murray–Darling Basin, from 1900 to 2013. **b** Annual rainfall anomaly (*red bars*) compared to the 1961–1990 long-term mean at Echuca, from 1900 to 2013. Annual discharge anomaly (*blue boxes*) for the Murray River at Barmah, compared to the 1976–2013 long-term mean, from 1976 to 2013 (color figure online)

in 2014 following a change of government. These functions have not been replaced by an alternative agency.

Because the Barmah-Millewa spans two states, two sets of state government departments—including Water, Environmental Protection, Primary Industries, Planning and Communities—and state agencies—such as Parks Management, Aboriginal Affairs and Essential Services Commissions—are involved. Layered on top of these are several Catchment Management Authorities, research providers, local interest groups such as Landcare Australia groups, regional partnerships, First Nations organizations, task forces and industry associations. The Yorta Yorta cooperative management agreement of 2004 with the Victorian State Government requires the "active and resourced involvement of the Yorta Yorta people in decisions about the management" of the Barmah Forest. Cooperative management agreements with the New South Wales (NSW) or Federal government are yet to be negotiated. But joint management in Barmah, as in Kakadu, Mutawintji and Mungo National Parks, is characterized by under-resourcing, a lack of understanding the contributions Indigenous knowledge can make, and a lack of adequate time for deliberations. In particular, identifying the existence of data critical for co-management input, securing the right to use this data even in a restricted fashion and obtaining the data itself remain complex and difficult processes.

Methodology

Knowledge protection protocol

The decisive feature of this methodology is the protection of knowledge from access by those not approved by the Elders Council, and the associated confidence provided that knowledge would not be inappropriately shared or misappropriated for gain, as had occurred in the past (e.g., the case of medicinal plant *Centipeda cunninghamii*, Williams 2014, see below). In the international context, protection for Indigenous knowledge is a relatively recent development. For example, it was only in 1989 that the United Nations Food and Agriculture Organization resolved that national sovereignty was a deciding factor in the ownership of plant genetic resources, which provided a measure of support for Indigenous people to manage resources on their land (Hammer et al. 2013). But it was not until the Convention on Biological Diversity (1992) and the World Trade Organization (WTO) Trade Related Intellectual Property Rights Agreement (TRIPS Agreement, 1994) that a new global standard on knowledge protection was available. Once Australia jointed the WTO in 1995, the TRIPS Agreement could serve as a foundation for Yorta Yorta knowledge protection.

As a result of the TRIPS Agreement requirements, Australia continues the process of assessing and amending domestic legal and regulatory regimes that influence intellectual property protections, such as patent law and copyright. These regimes provide guidance for collaboration between the Yorta Yorta and researchers, government agencies and departments, and representatives of private industry. However, these protections are limited by the costs in time and money of challenging existing patents and trademarks of previously misappropriated knowledge. For example, "Old Man Weed" (*Centipeda cunninghamii)* is sold under trade-marked brands such as Petyan Skin Balm, Youth-Derm Ultra Healing Cream and Pure&Green Organics, despite the fact that an administrative decision by the Australian Patent Office (APO 25 *Frank D'Amelio and Graeme A. Close v Australian All Natural Pty Ltd* 2003) found that the patent specification explicitly acknowledged traditional medicinal knowledge. Indeed, a US Patent was granted in 2002 (US20020044977 A1) using similar language to the same individuals. Further, these protection regimes do not lend themselves easily to the protection of traditional ecological knowledge that serves to enhance the sustainable use of water (such as the importance of appropriately placed eucalypt snags as turtle nurseries.)

While most authoritative sources of international domestic law afford the Yorta Yorta little explicit protection, there has been an increasingly widespread conceptual acknowledgement of the importance of benefit-sharing with Indigenous groups. Accordingly, a potentially workable alternative is the eventual mainstreaming of certain forms of reciprocity into legally binding contracts which set out agreements between outside actors and the Yorta Yorta (Bierer et al. 2006). In addition to articulating expectations for financial remuneration, legal agreements might additionally reference certain moral and relational benefits, such as formal recognition or attribution of the role of the Yorta Yorta in publications. Within the confines of adherence to cultural practices, this might support partnerships that build trust and productive, continuing relationships with the Yorta Yorta.

With these critical issues in mind, a knowledge protection protocol was implemented with the following principles:

- All researchers working in connection with the database development in any capacity are to sign a confidentiality agreement with the Yorta Yorta Nation Aboriginal Corporation;
- Yorta Yorta Council of Elders is to be approached for approval and consent at all stages of planning, design and development;
- The ownership and copyright of cultural data entered into the database is held in perpetuity by the Yorta Yorta person from whom it was collected; and
- Yorta Yorta Council of Elders has the right to determine the contents of the database, the rights of access to the database and the ways in which the data and information are to be accessed, presented and delivered.

Most importantly, the rights of the Yorta Yorta people to keep secret and sacred their cultural knowledge are respected.

Knowledge collection protocol

This project is a product of several years of collaboration between the Yorta Yorta, environmental scientists and legal scholars. Out of this collaborative process, a clear need emerged to find ways to facilitate Yorta Yorta voices to be heard in discussions with natural resource managers, policymakers and the community, and to build capacity within the Yorta Yorta community to better communicate culturally significant practices in ways that non-Indigenous land managers could understand. The solution developed in partnership with the Yorta Yorta was the creation of a GIS containing both Yorta Yorta knowledge and more conventional knowledge. The use of a GIS database was selected because it met a primary requirement of the Yorta Yorta—that of having a place where their knowledge could be stored with appropriate levels of security. With this requirement met, a GIS also provides a way of integrating different types of data in ways that can highlight important features of the system to support sustainable and inclusive management decisions.

The principles for the data collection were determined through consultation with the Yorta Yorta Elders Council, who emphasized maintaining the traditional method of transferring knowledge across generations, by walking and talking on country. This method complements and extends earlier efforts of developing a "map biography", in which Elders are interviewed by a third party while sitting with a map of country and indicating key locations on the map (Tobias 2009). Project researchers trained youth volunteers in interview techniques, voice recording, and Global Positioning System (GPS) logging. With the Elders Council, a protocol was developed in which volunteers would accompany Elders to places of cultural significance in the Barmah-Millewa, record knowledge associated with these places using field notes, voice recordings, photography and GPS tracks. The volunteers were trained to upload all of the data to the database, keyed to the participating Elder, and applied the appropriate password protection. A training manual was developed by Yorta Yorta researchers, so that Yorta Yorta collaborators could continue to implement the protocol over wider regions and at times convenient to the Elders and volunteers.

Geographic information system development

One of the key aims of this project was to integrate Yorta Yorta knowledge with conventional information in a way that would allow the Yorta Yorta to develop new ways of understanding and articulating their needs and insights about the Barmah-Millewa area, as input to policy and management processes affecting the region. Data were collected from many different sources, including the Victorian Departments of Sustainability and Environment and Primary Industries; the NSW Land and Property Department and the NSW Office of Environment and Heritage; the Goulburn-Broken, North Central and Murray Catchment Management Authorities; the Murray–Darling Basin Authority; the Australian Bureau of Meteorology; the Australian Bureau of Statistics and the Arthur Rylah Institute for Environmental Research. Assembling all of this data and exploring it with simple GIS data layering tools provided significant initial insight about Yorta Yorta country for the research team. However, the process of dataset collection, while time consuming, provides only the first step in the process. The next phase was to conduct a rigorous quality control process. For example, several datasets were obtained that described vegetation cover in the Barmah (Victoria) and Millewa (New South Wales) sections of the National Park. For each of these datasets, the vegetation categories and mapping protocols were different, resulting in varied vegetation types at different scales of resolution. By comparing the datasets to each other, to Landsat imagery, and to global datasets, a consistent vegetation map for the Barmah-Millewa was developed. The approach gave priority of distribution to Landsat imagery and priority of vegetation classification to the Barmah map. The Barmah map was selected based on advice from the Barmah-Millewa Forest Icon Site Technical Advisory Group. Limited ground-truth field observations are made during the Knowledge Collection phase of the program. Issues of resolution differences remain to be addressed (Fig. 2). The ultimate goal was to provide coverage of the entire Yorta Yorta country. To this end, the data was compiled into a single geodatabase to enable the development of maps that included both National Park vegetation and land use categories in the surrounding settled and farmed regions. The cultural land use and occupancy data that had been collected in the past using the map biography method (Tobias 2009) and those that were collected as a part of the new protocols based on in-field youth interviews were also incorporated into the geodatabase.

Prototype enquiry: landscape features and traditional use

One of the datasets acquired in this process is the light detection and ranging (LiDAR) digital elevation data acquired by the Murray–Darling Basin Commission in 2001. LiDAR data were available for most of the cultural land use and occupancy data locations. The analysis area included all of the cultural data points across the Barmah-Millewa region and extended to Echuca and Deniliquin (Fig. 1). These data were used to conduct a multivariate statistical analysis of cultural uses as they relate to identifiable landscape features, in order to explore relationships between Yorta Yorta use and occupancy of the landscape and features of the topography. For example, even the low elevations of floodplain ridge tops might provide appropriate locations for burial grounds. Banks of small water features such as *billabongs* (oxbow lakes) may be useful locations for birthing sites. Since this cultural data is secret, it cannot be shown here, but the relationships so determined will serve as a tool to guide land use decision making to retain and enhance long-standing cultural values. Such a process was used in this prototype to make an assessment of appropriate access restrictions to an 18 km^2 feature known as "Kow Swamp" located just west of the Barmah-Millewa core study region (see, for example, Thorne and Macumber 1972). Kow Swamp had been developed as a permanent water body for irrigation storage, but traditionally, this area filled only when the Murray River was in flood. However, current management practices are exposing burial grounds to erosion by cattle grazing and water flow.

Topographical position indices (TPI, Guisan et al. 1999) were calculated for each pixel over the whole database as the difference between pixel elevation and the mean elevation of the surrounding neighborhood. Two radii were used to describe TPI for a small (100-m radius) and large (1-km radius) neighborhoods. The LiDAR data were also used to derive new representations of stream location and extent. These data provided a more accurate representation of the true locations of water features than did the existing vector stream coverage in the geodatabase. To quantify the elevation of the floodplain surface relative to river stage, river and stream stage data were extrapolated across the entire floodplain; the difference in elevation from the bare-earth LiDAR Digital Elevation Model was calculated, yielding a map of floodplain elevation relative to river stage.

Multivariate classification was conducted for the 69 unique cultural land use points used in this analysis—these points were buffered by 50 m and used to perform the initial supervised classification. The 69 units were grouped into eight distinct classes for the final analysis based on clustering of the individual units. A class probability analysis was conducted to identify the probability of each pixel on the landscape to support the cultural uses included in each group.

Although eight distinct groups were identified, the majority (98%) of cultural uses clustered within two of the groups. Group One was characterized as having a low TPI for both the small and large neighborhood, a low relative elevation to the stream channel, and was located close to rivers and streams (Table 1). Cultural uses within this grouping included permanent and overnight camps, fishing sites, hunting sites associated with aquatic species and other cultural activities most associated with water. Group Two was characterized by areas of relatively higher ground and further distance from streams. Cultural uses associated with this grouping included permanent residences, upland wildlife hunting and plant uses, burial sites and other uses more associated with drier areas.

Results from this pilot analysis confirmed some of the connections we would expect to see between landscape features and cultural uses. A detailed analysis of the Kow Swamp site in the LiDAR data revealed predictive capability for Group Two locations within the swamp, where elevations were locally higher. That is, analysis of relationships between cultural and scientific data in one location highlighted sensitive sites for consideration in another, un-surveyed location. This finding was used to support the Yorta Yorta claim to protect particular locations in Kow Swamp from the impacts of environmental flow releases—effectively, releases were to be spread over time to prevent surges of high water. Future work will be benefited by better geolocation of cultural activities and coding from recorded interviews in order to provide a more robust analysis, as will the refinement of data sets describing current and potential vegetation and landcover, and a more robust analysis of floodplain inundation.

Discussion

This project aimed to understand how the deep knowledge of country of the Yorta Yorta people could complement and enhance state-of-the-art environmental science to strengthen the participation and influence of the Yorta Yorta in national and regional water management processes. At the outset of the project, it was decided in a collaboration between researchers and Yorta Yorta elders that the main tool through which this would be carried out was a GIS database. Although data were often disparate and difficult to obtain, the resulting database has succeeded in assembling, in a common framework, a comprehensive array of climate, hydrology, biodiversity, administrative, imagery, socioeconomic and cultural data. Lack of coherent information accessible to all greatly hinders the ability to make sound management decisions regarding management of natural resources within a region. Hence, even without any Indigenous information, a GIS database of the type developed here is a valuable tool as a basis for sound decision making. The main difficulties encountered in the process of collecting the data were (1) tracking down who

Table 1 Values for cultural sites (50-m buffer)

Class ID	% Of sites	Mean distance from water (m)	Mean TPI_{100} (m)	Mean TPI_{1000} (m)	Mean relative elevation (m)
1	59.0	154	−0.13	−0.48	1.34
2	39.0	982	0.04	0.29	3.47
3	1.5	1565	0.57	3.39	9.73
4	0.3	1185	0.00	0.16	1.29
5	0.04	422	−0.01	−0.22	0.74
6	0.08	400	−0.04	−0.32	4.29
7	0.04	440	0.01	−0.45	0.06
8	0.03	7	−0.42	−1.97	1.06

held the various datasets, particularly across state boundaries, and getting in contact with (and getting responses from) the right people; (2) obtaining permission to use the data and to show it to other stakeholders; and (3) dealing with non-uniform data (e.g., for vegetation) across agencies or state boundaries.

The most significant development in the project was the methodology developed to allow the sustainable and protected collection and archive of Yorta Yorta cultural knowledge. The process of having the Yorta Yorta youth collect the Indigenous knowledge facilitated transfer of knowledge from one generation to another and raised community awareness and knowledge of this valuable part of Yorta Yorta country. It also energized the Yorta Yorta youth to take an interest in their history and culture, as well as in the environmental challenges facing their community. Increased sharing of knowledge and capacity was developed within the community. The existence of unique and useful understanding was explicitly acknowledged as a revelation by staff at the Victorian Department of Sustainability and the Environment (G. Marin, pers. comm.) Thus, this process supported participation in a specific co-management negotiation associated with Kow Swamp. This process revealed the particular power of an approach that uses statistical relationships in a closely studied area to highlight and inform discussions around areas that have not been so surveyed, while maintaining critical intellectual property protections. Negotiations conducted on a confident and transparent footing are more likely to lead to outcomes valued by all parties (Tobias 2009).

GIS can provide a common language between Indigenous and Western knowledge systems through which to communicate interventions to support sustainable and inclusive land and water management. Limitations in the capacity of geospatial technologies to represent lived contexts are significant in any context, since the software requires knowledge to be compartmentalized based on the chosen *ontology* (theory on the nature of being), and since their content can only be an expression of the values and perspectives held by the persons who created the database (Veland et al. 2014). The particular attention to relatedness and non-empirical experience in Indigenous contexts (Fox 1995; Rundstrom 1995; Rose 2004; Alessa et al. 2010) is therefore transferable to non-Indigenous contexts. Being cognisant of the relationships that sustain particular GIS ontologies permit treating the database as an expression of living engagement, through which relational processes between people, water, land and ecosystems can be studied and interpreted through Indigenous and non-Indigenous eyes. The possibility of retracing such relationships to pre-colonization, by performing multivariate statistical analysis of the relationships between topography, cultural sites, hydrology and ecology, is a particularly promising development permitted by geospatial technologies in Indigenous contexts.

This research project has been an enormous learning process, both for the research team and the Yorta Yorta. Prior to the research project beginning, there had been a two-year period where both parties simply talked together about issues, each learning to see things from the others perspective and building trust. In the process developed here, the community is left with increased administrative and technical capacity, as well as an enhanced awareness of connection to country. Young and old shared experiences and knowledge, in the process developing a heightened understanding of the quest for Native Title and a desire to get involved in making changes.

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