

Drone technology and Indigenous Australians: A scan of current uses



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Citation

Worden, S. & Holcombe, S. (2025). *Drone technology and Indigenous Australians: A scan of current uses*. Centre for Social Responsibility in Mining, The University of Queensland: Brisbane.

Acknowledgements

Thanks to Kamila Svobodova (CSRSM) for providing peer review of this report.

Cover image

Mataranka Springs, NT. Photo taken by Sarah Holcombe.

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1. Introduction

Indigenous peoples around the world are increasingly using drones in diverse ways, from protection and preservation of traditional lands to participatory mapping and countermapping, supporting existing knowledge practices for land stewardship, filmmaking and storytelling. In Australia, some thematic drone research has been undertaken on topics such as data protocols and individual land stewardship cases, but very little work has examined how Indigenous peoples and organisations are using drones more broadly and the diversity of applications.

This report presents the findings from a 12-month research project that investigated Indigenous drone use in Australia, aiming to better understand Indigenous peoples' perspectives on and experiences with using this technology. The project was commissioned by Director UQ Drone Research Platform, Associate Professor Steve Micklethwaite, and undertaken by the Centre for Social Responsibility in Mining (CSRM).

The Sustainable Minerals Institute is establishing a national, common-use platform for researchers to access a comprehensive suite of drones that have sophisticated remote sensing capabilities. This research is part of that work. Funded by AuScope and the Federal Government's National Collaboration Research Infrastructure Strategy, the platform is part of a broader collaboration with the European Union-funded m4mining consortium.

The overall objective of this project is to examine Indigenous drone use, predominantly in Australia. The specific aims are to:

1. Determine the types of Indigenous organisations using drones and the range of current drone applications
2. Identify the extent of Indigenous drone use agreements that address privacy, data protection, ethical risks and cultural safety and, where publicly available, collect examples of such agreements and protocols
3. Identify opportunities for drone pilot training and data sharing between the UQ Drone Collaboration Research Platform and Indigenous groups
4. Present high-level guidance for researchers on the ethics of drone use on or near Indigenous lands, including when a human research ethics application may be required
5. Make recommendations for future research.

The report has seven sections. Section 2 provides a high-level literature review. It identifies how Indigenous peoples globally are using drones, provides an overview of scholarship on Indigenous data sovereignty and links the concept to its potential drone application. This section addresses aims 1 and 2. Section 3 presents our research methods. Section 4 describes the research findings, articulating the key themes from the interviews and document analysis. The themes are: land use monitoring and land management; drones as a sky-camera; cultural mapping; drone photography for advocacy; drones for Indigenous storytelling; training and accreditation; land tenure issues; data capture, processing and storage; Indigenous data sovereignty and governance; and protocols and policies. Like Section 2, Section 4 addresses aims 1 and 2. Section 5 summarises drone use limitations identified by one of the research participants while Section 6 discusses participant views on potential future drone use. The discussion and conclusion are presented in Section 7, which addresses all the research aims.

2. Methods

As two non-Indigenous researchers undertaking an office-based project on Indigenous Australians' use of drones, it was essential that we interviewed Indigenous people from Indigenous organisations and businesses. As Table 1 outlines, five of the nine organisations we engaged with are Indigenous entities and four of the participants are Indigenous. We sought to ensure regional diversity of our research participants. This included engaging with organisations and businesses across five jurisdictions, plus a national organisation. This qualitative approach was used to generate primary (original) data in addition to using data obtained from secondary sources. The project was undertaken in five stages.

Stage 1: Kick off meeting and scoping discussions

The research team met face-to-face with Steve Micklethwaite, Reilly Williamson (BRC¹ Chief Remote Pilot) and Craig Jarvis (BRC Principal Research Technician) to scope the project and identify potential research participants. Further scoping interviews were conducted with Williamson and Jarvis. The project team then developed a written scope of work to guide the research.

In Stage 1, the project team also submitted a human research ethics application to a UQ human research ethics committee. The application included a comprehensive description of the project, a three-page participant information sheet and consent form. Ethics clearance was granted on 2 May 2025 (no. 2025/HE0001148).

Stage 2: Literature review

A literature review was undertaken to explore how Indigenous peoples and organisations around the world are using drones, based on a scan of academic and grey literature. Key academic literature on Indigenous data sovereignty and governance was reviewed to inform our analysis of protocols being used in Australia to manage drone use.

Stage 3: Semi-structured interviews

Following UQ ethics clearance, the information sheet and a consent form were emailed to potential participants with a request to participate in the research. We offered an honorarium to self-employed participants. Follow-up emails and calls were made to some people if they had not responded of their own volition.

Informed consent was obtained from all participants prior to the interviews being conducted. We shared drafts of the report with the interviewees to check their quotes and relevant content.

Interviews were conducted by Holcombe and Worden with nine participants from across six jurisdictions. Eight interviews were conducted online via Zoom and one was face-to-face. One interview was with two participants. Interviews ranged from 60 to 90 minutes in duration. With participant consent, the interviews were recorded then transcribed using Zoom's AI function. The transcriptions were reviewed for accuracy. Table 1 provides an overview of research participants, their organisations and the jurisdictions in which they are located. Figure 1 is a map showing where they are based and where some of their work is located.

¹ BRC is the WH Bryan Mining Geology Research Centre at the Sustainable Minerals Institute.

Table 1: Overview of research participants.

Participant	Title	Organisation	Organisation type	Jurisdiction
Participant 1	N/A	Central Land Council	Indigenous organisation	NT
Paddy O’Leary	Founding Director	Country Needs People	NGO	National
Participant 2	N/A	Department of Transport and Major Infrastructure	Government	WA
Andrew Bassford	Chief Commercial Officer	Nallawilli Bunjil	Indigenous business	NSW
Paul Mead	Co-founder	She Maps & GeoNadir	Private business	Qld
Andrew Dowding	Co-founder and Managing Director	Winyama	Indigenous business	WA
Chris Warrior	Owner	Wiru Drone Solutions	Indigenous business	Vic
Helen Tait	CEO	GMYPBCAC	Indigenous organisation	Qld
Stirling Ludwick	Junior Ranger Team Leader	GMYPBCAC	Indigenous organisation	Qld
Reilly Williamson*	Chief Remote Pilot	WH Bryan Mining Geology Research Centre	University	Qld
Craig Jarvis*	Principal Research Technician	WH Bryan Mining Geology Research Centre	University	Qld

* Scoping discussions

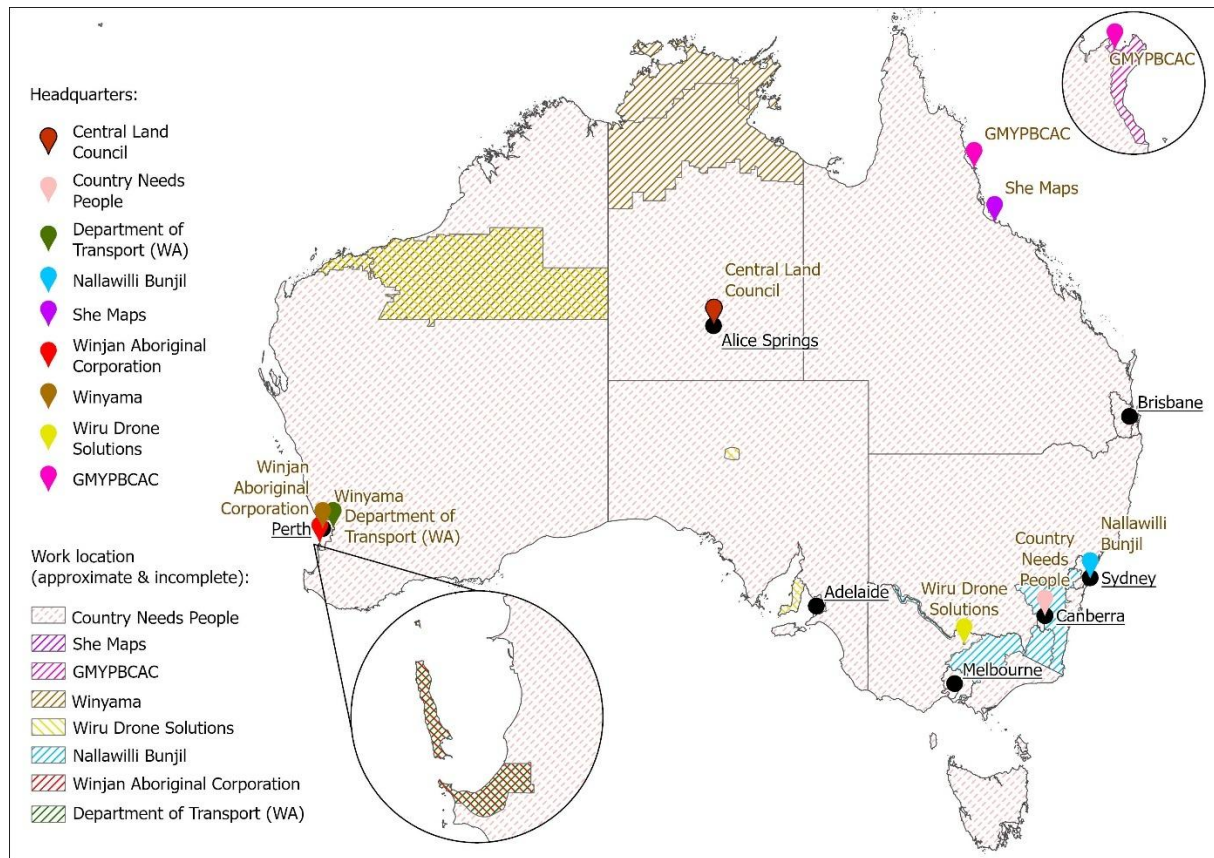


Figure 1: Geographic spread of where research participants are based and some of their work locations (Kamila Svobodova, CSRM).

Stage 4: Document analysis

Select documents – such as research reports, mainstream and social media posts, relevant websites and academic literature – were collected for analysis to triangulate findings from the primary data.

Stage 5: Analysis and write-up

Thematic analysis was used to evaluate data collected in Stage 3 and Stage 4 of the project. Categories, patterns and themes in the interview transcripts and documents were identified inductively.

To distinguish primary and secondary data, participant voices (captured from the semi-structured interviews) are presented using their first name and surname in the first instance, then surname in subsequent instances. Participants who preferred anonymity are identified as Participant 1 and Participant 2. Draft text in which participants were directly quoted was emailed back to them for approval. In some cases, participants edited their comments. Authors of secondary sources are cited using the author date method.

Four case vignettes were developed to provide context on how some Indigenous groups are using drones. These are presented in text boxes to distinguish them from the body of the report.

3. Literature review

The literature review provides a foundation from which to explore the research objectives presented in Section 2. Two inter-related topics are examined. Section 3.1 provides an overview of how Indigenous peoples and organisations around the world are using drones, based on a scan of academic and grey literature. Section 3.2 summarises conceptualisations of Indigenous data sovereignty and Indigenous data governance from the academic literature.

3.1 How Indigenous peoples are using drones

The drone uses most frequently discussed in the academic and grey literature reviewed are conservation (particularly monitoring of deforestation/illegal logging), flora and fauna monitoring, and mapping of Indigenous lands. The most common geographies examined were Latin America, Australia and North America, potentially reflecting greater use of drones in these jurisdictions. We discuss these key themes below:

Assertion of jurisdictional and territorial rights

A strong theme to emerge in articles on Indigenous drone use in Latin America and Asia, in particular, was the assertion of jurisdiction and territorial rights (Cifuentes, 2023; Sauls et al., 2023; Naufal et al., 2022; Radjawali and Pye, 2017). This included the subthemes of:

- Protection and preservation of traditional lands (Cool Earth, 2024; Sauls et al., 2023; CENFENG, 2021; Smith, 2017)
- Participatory mapping and countermapping (Naufal et al., 2022; Yonas, 2022; Paneque-Galvez et al., 2017; Radjawali et al., 2017)
- Training of Indigenous peoples in drone operation, related technological skills and building capability of leaders (Cool Earth, 2024; Cifuentes, 2023; CENFENG, 2022; Yonas, 2022; CENFENG, 2021; Paneque-Gálvez et al., 2017), while,
- Partnerships with non-government organisations (NGOs), donor agencies, research institutions and universities underpin much of the drone use and training highlighted in the literature.

Strengthening autonomy and protecting territory

Sauls et al. (2023, p. 24) find that Indigenous communities in areas of high ecological and cultural diversity in the Amazon Basin are using drones to “advance their own territorial, political and socio-ecological goals.” Cifuentes (2023, p. 1) concurs, stating that the use of drones is seen as a way to strengthen autonomy and build capabilities of leaders: “Through forest monitoring programs, Indigenous leaders and organizations imagine and enact territorial defence, or a politics founded on integral territorial ontologies.” Smith (2017) notes that in Latin America, laws that limit external activities on Indigenous land are not well enforced. Indigenous groups are using drones to collect data to provide the government with evidence that laws are being broken.

Radjawali et al. (2017) report that drone mapping in Kalimantan, Indonesia, has bolstered the legal and political claims of NGOs and Dayak communities about the boundaries of traditional territories. Villages and overlapping concessions are being formally mapped using drones to reclaim Dayak customary forest rights. Radjawali and Pye (2017) note that drones have helped to reduce the cost of countermapping – as the practice of a local group recording, preserving and fostering their enviro-cultural assets on their own terms (see also Byne, 2008). While Yonas (2022) finds drones to be an efficient method of mapping hard-to-reach areas. Yonas (2022, p. 1) also states that creating accurate and culturally sensitive maps gives Indigenous communities respect from governments and connects them to their

traditions: “While there is a long history of erasure within Indigenous lands, mapping legitimizes their claims in the eyes of surrounding governments. This is particularly important when it comes to the preservation of this land, as well as the livelihoods of the Indigenous peoples who inhabit it.”

Partnerships and cross-scalar allies

NGOs are working with Indigenous groups in Latin America to protect the Amazon rainforest and undertake territorial mapping and monitoring. In their analysis of five territorial mapping and monitoring projects in Peru, Guyana and Panama, Paneque-Galvez et al. (2017, p. 15) find that “cross-scalar allies” are integral to the funding and delivery of drone workshops and capability building. They contend that the partnerships “have the potential to play a key role in empowering disempowered Indigenous communities toward achieving greater levels of territorial protection and justice”. In Vale do Javari, Brazil – home to 26 different Indigenous peoples – a territorial monitoring project is training members of these groups in the use of drones, maps, computers for georeferencing and radio equipment to monitor criminal activities in the region. Tracking information from drones arrives more quickly than from satellite data, an alternative data source which often arrives too late for communities to deal proactively with emerging issues. The three-day training program is organised by the Brazilian NGO, Kanindé Ethno-Environmental Defence Association, and funded by WWF (CENFENG, 2021).

In the Amazon rainforest, straddling Brazil and Peru, a partnership between Conservation International and the Yawanawá and Ashaninka peoples has delivered a territorial monitoring and management system to map agro-extractivist production, collect demographic and local biodiversity data and alert the team about changes in soil use. The system uses software, an online digital platform, geospatial analyses, and customised mobile phone applications in native languages, optimising techno-scientific knowledge and traditional knowledge (CENFENG, 2023).

Naufal et al. (2022) caution that the use of ultra-high resolution drone imagery does not automatically deliver participatory mapping processes, nor improve the quality of data and uses of information. Radjwali and Pye (2017) observe that while drones create potential for more inclusive use of technology, there is a political dimension at play in respect to who controls the technology and to what end. This issue is further discussed in Section 3.2.

Drones for solving complex environmental management issues

In Australia, Robinson et al. (2022) find that Indigenous rangers are using digital technology and data analytical tools to support their existing knowledge practices to solve complex environmental management issues. In the Kimberley region of Western Australia (WA), for example, the Nyikina Mangala Rangers are trialling thermal imaging drones to track the endangered black-footed rock-wallaby. This project is a partnership between Walalakoo Aboriginal Corporation, Charles Darwin University and World Wide Fund for Nature – Australia (Woolley, 2022). In the Northern Territory (NT), the Tiwi Rangers (Tiwi Islands) and Yugual Mangi Rangers (Ngukurr, Roper Gulf region) have been learning how to use drones and artificial intelligence systems to help find and remove ghost nets and debris from the territory’s beaches. Ghost nets are collections of rubbish, predominantly plastic bottles and bags, tin cans and fishing lines, that become tangled in discarded commercial fishing nets (Ellis, 2025).

In Kakadu National Park (NT), a multi-actor collaboration co-designed and tested protocols to navigate the use of drones at Jarrangbarnmi, an important biocultural landscape in Jawoyn Country (Macdonald et al., 2021). The collaboration, which speaks to the cross-scalar allies discussed above, includes Jawoyn Traditional Owners, Northern Land Council, North Australian Indigenous Land and Sea Management Alliance, CSIRO, Charles Darwin University, University of Western Australia, Northern Australian Environmental Resources and Kakadu National Park.

In this multi-partner context, Macdonald et al. (2021, p. 300) report that the protocols “provide a way for Indigenous cultural responsibilities for knowledge sharing and stewardship of country to guide and authorise the co-design and application of technological innovations, which are increasingly being used to produce new knowledge to adaptively co-manage Indigenous people’s lands and seas”.

The issue of protocols to manage drone use in this context is part of the broader issue of Indigenous data sovereignty.

3.2 Indigenous data sovereignty and drone use

There is a significant body of academic literature, including from Australian scholars, that explores Indigenous data sovereignty and governance. For our purposes, reflecting on why this ‘movement’ emerged and how it can be understood in this context is useful. First, what is Indigenous data and data sovereignty?

Indigenous data are defined by Rainie et al. (2017, p. 1) as “any facts, knowledge, or information about the nation and about its citizens, lands, resources, programs, and communities. Information, ranging from demographic profiles to education attainment rates, maps of sacred lands, songs, and social media activities are all data”.

Indigenous data sovereignty and governance are related but distinct concepts. The Maïam nayri Wingara Indigenous Data Sovereignty Collective, founded in 2018, developed a communique in collaboration with the Australian Indigenous Governance Institute, which describes Indigenous data sovereignty as:

a global movement concerned with the right of Indigenous peoples to govern the creation, collection, ownership and application of their data. Indigenous Data Sovereignty in Australia is derived from Aboriginal and Torres Strait Islander peoples inherent right to govern our peoples, Country (including lands, waters and sky) and resources as outlined in the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), for which Australia has declared its support (2018, p. 1).

The communique authors describe Indigenous data governance as: “the right of Indigenous peoples to autonomously decide what, how and why Indigenous Data are collected, accessed and used”. It includes individual and collective rights to data access and privacy (Reyes-Garcia et al., 2022). Data governance ensures that data on or about Indigenous peoples reflects their priorities, values, cultures, worldviews and diversity. In other words, governance enacts the rights asserted through data sovereignty. Carroll et al. (2022) contend that Indigenous data governance also provides a method of addressing deeper historical issues resulting from colonisation.

One of the key themes addressed in the literature is the lack of consent from Indigenous peoples for their data to be collected (Robinson et al., 2021; Lovett et al., 2019; Kukutai and Taylor, 2016). So, regaining control over ‘data’ – broadly understood – is crucial. Likewise, constraints on Indigenous peoples’ access to their data and the cost of that access (Snipp, 2016; Yap and Yu, 2016) are issues. Data sovereignty and data storage are topics that several Indigenous businesses have begun to address in the services that they offer to organisations engaging with drone technology (see Figure 2).

Data governance also includes the development of protocols that support the co-design of data collection methods (Macdonald et al., 2021) and data management capability building (Robinson et al., 2021; Davis, 2016; Yap and Yu, 2016). However, as we explore in Sections 4.8, the development of drone use protocols in Australia is not standardised nor consistent.

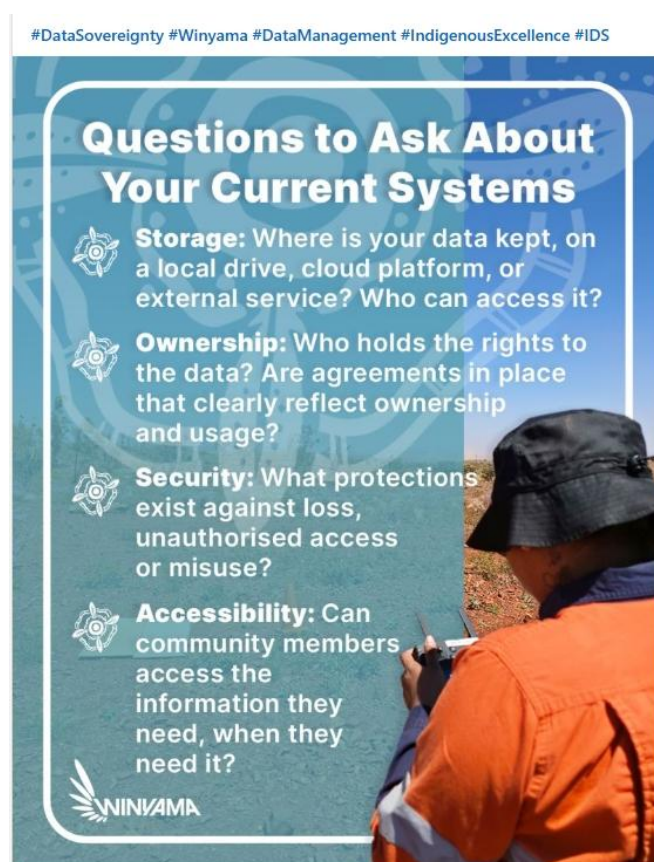


Figure 2: Data governance questions posted by Winyama on LinkedIn, 2025.

4. Findings

4.1 The core uses for drones: Indigenous ranger work

Indigenous rangers are the predominant users of drones in Australia, with the technology providing the ability to meet contemporary land management demands, including for biosecurity, across the increasingly vast formally recognised Indigenous estate.

The Indigenous estate comprises more than 55% of the Australian land mass (see Figure 3). The estate includes inalienable freehold title under the *Aboriginal Land Rights Act (1976) NT* and exclusive and non-exclusive determined native title lands, under the *Native Title Act 1993*. These formal legal rights provide opportunity for Indigenous groups to gain funding and other support for their land management practices under the Commonwealth Indigenous Protected Areas (IPA) scheme, as part of the national reserve system. This IPA scheme has been operating since 1997 and there is now a network of 93 IPAs (with another 28 under consultation as we write), incorporating 106 million hectares of land (see map, Appendix A). The scheme has been very successful in supporting the work of rangers from Indigenous communities “to combine traditional ecological knowledge with contemporary management tools to manage their land and sea Country, leverage partnerships with conservation and commercial organisations and provide employment, education and training opportunities for [Indigenous] people” (NIAA, 2025).

Paddy O’Leary, Founding Director of Country Needs People, an independent not-for-profit committed to championing Indigenous land and sea management across Australia, says drone use among Indigenous groups is common. He says given the vastness and remoteness of most of this

estate it is not surprising that drones have emerged as a useful tool to support land management and Indigenous land access. He adds that they are also fun to use. Joyce et al. (2020, p. 1) find that drones have democratised remote sensing data because Indigenous peoples can capture their own data rather than relying on expensive aerial survey companies. For many of them, drones have provided a powerful enabler for accessing areas that are topographically challenging, such as the extensive Arnhem Land Plateau in the Northern Territory, vast areas of remote coastline across Australia and wetlands and forests in northern Australia. As O'Leary states, "my understanding is that [the IPAs are] the biggest run Indigenous conservationist state in the world [...] and the biggest interconnected set of protected areas in the world".

All IPAs have associated Indigenous ranger groups. There are also other ranger groups established to manage areas of Aboriginal land in the Northern Territory and nationally in some determined areas of granted native title lands. There are now more than 129 Indigenous ranger groups across Australia (Country Needs People, n.d.). More than 1,900 Indigenous rangers are employed through government programs. The Commonwealth Government has committed to fund 1000 new ranger positions over the next four years to support the long-term sustainability of the program (Commonwealth Government, 2024). A broad public understanding is that rangers are performing eco-system services for the nation, protecting biodiversity, supporting biosecurity and conservation activities. From the rangers' perspective, they are engaging in a livelihood that enables them to maintain their responsibilities to care for Country, now and into the future (Putnis et al, 2021).² There is a significant literature on the many socio-cultural benefits of ranger work not only for rangers themselves, but for their families and communities (Mackie and Meacham, 2016; Jones et al., 2018).

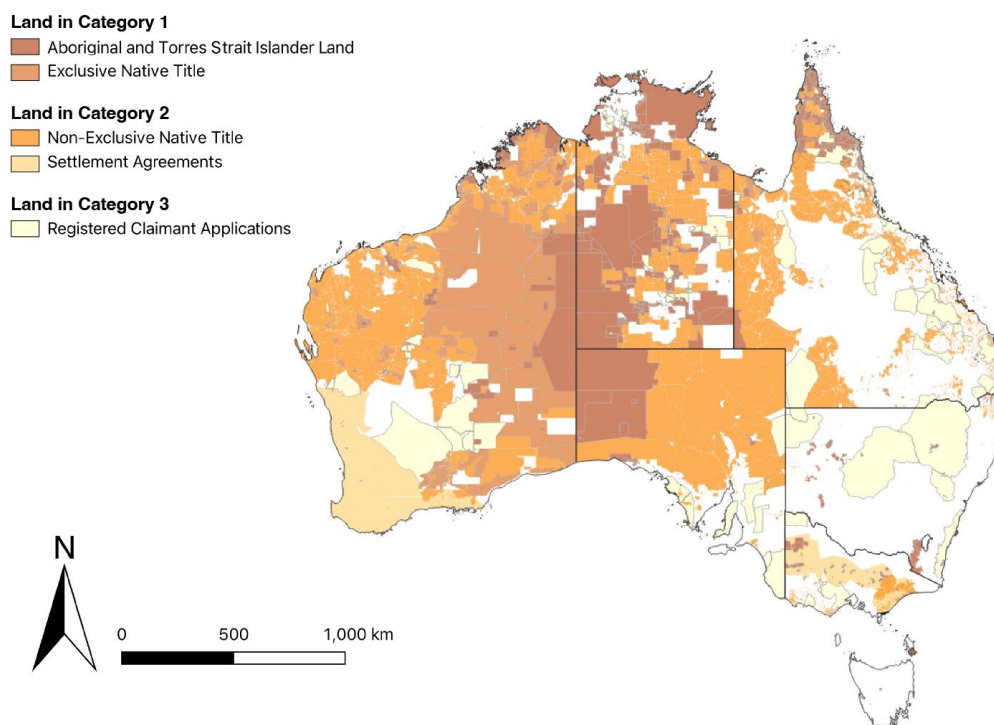


Figure 3: Categories of land held by Aboriginal and Torres Strait Islander peoples in Australia (John Burton, CSRM), 2023.

² Our focus in this report is on the systematic use of drones by Indigenous peoples. Of course, there will be individuals who are Indigenous who are using drones with similar intent to non-Indigenous people, such as for fun. This is not the focus of our research.

As a result of this vast estate, the potential of using drones for land management is also vast. However, the take-up of drones is not uniform across Indigenous Australian organisations. Some organisations are more amenable to adopting this technology than others. For instance, within the land management unit of the Central Land Council (NT), drone use is very limited, as Participant 1 outlined:

We do own a couple of drones...we're a large bureaucracy so we had to write a SOP (Standard Operating Procedure) for their use, [some staff] did the...quick CASA accreditation online...Basically they [drones] didn't get used... and we have such a staff turnover in in remote locations, in certain positions that it's really hard to follow through a project for any more than 18 months to two years. And that corporate knowledge applies very much to drones; maintenance...being the biggest issue. Drone gets broken. No worries, bring it back, put it in the cupboard, and it doesn't get touched again. No one bothers to take it to a repair or replace it.

Participant 1 added that other barriers include the cost and team readiness. Nevertheless, CLC Rangers (the corporation has a separate ranger unit) are beginning to dip their toes into the potential uses of drone technology. During the annual 2025 ranger camp at Ross River (near Alice Springs), the rangers were split into gender groups to learn to fly drones and undertake accredited training (Central Land Council, 2025).

At the other end of the spectrum of drone uptake are the Gunggandji-Mandingalbay Yidinji (GMY) Land and Sea Rangers, based near Cairns, who routinely use drones for a diverse range of land and sea management activities (see case vignette 3, p. 27).

In the following sections we drill down into some of the more widespread uses of drones in Australia, beginning with the use of drones in land management including land use monitoring and asset management; fire management and carbon programs; cultural mapping and cultural heritage protection; videography and taking landscape level images for advocacy. We then discuss the growing network of Indigenous expertise in drone training and application. The final topics addressed in our findings are data capture, processing and storage; Indigenous data sovereignty and governance; and drone protocols and policies.

4.2 Land use monitoring and land management

Both the literature and the interviews indicate that drones are especially valued when the ranger groups are operating in terrain that is difficult to access (not suitable for 4x4 vehicles), where the work is repetitive (e.g. walking transects for invasive species surveys) and where large areas require surveying. Of course, all three conditions can occur in some contexts. For instance, in Kakadu National Park (NT) the Mirarr (Bininj) Traditional Owners and rangers, supported by CSIRO and the joint management process for the park, have co-developed and trialled an Indigenous-led Healthy Country AI model. This place-based model enables the collaborators to monitor indicators they established to determine the health of the Country in the Nardab floodplain, a place of significance for one of the clan groups:

At Nardab [...] the Indigenous-led Healthy Country AI model enable[s] us to monitor Country indicators by rapidly surveying large areas and interpret drone-collected footage to show important changes to the ecosystem following on-ground management interventions. The Healthy Country AI model converts large volumes of data (thousands of high-resolution photos) into metrics – in this case, magpie goose numbers and spread of [the invasive species] para grass – to demonstrate how Bininj-identified country indicators are changing following management interventions. (Robinson et al., 2021, p. 11).

As part of the adaptive co-management of the national park, the drones were used to collect aerial photos to monitor changes to Country over time. In this case, the use of drones is part of a suite of technologies, including camera traps and sensors. The drone protocols this group of Bininj and Mungguy co-developed are discussed in Section 4.8.4.

In far north Queensland, drones are also being used in tandem with other technologies by the Gunggandji-Mandingalbay Yidinji (GMY) Land and Sea Rangers. To optimise data collection opportunities, they schedule activities throughout the year, ensuring that drone surveys are conducted at the same time as other data collection methods, such as seagrass mapping, coral surveys and isotope surveys. The corporation has strong collaborations with university marine scientists, government agencies, local government training and community organisations. “We work with a series of scientists, marine biologists etc to be able to assist with managing and protecting natural and cultural values within the GMY country,” says GMY Prescribed Body Corporate Aboriginal Corporation CEO Helen Tait.

Andrew Dowding (Winyama) says that the labour and time intensive work of walking transacts is being replaced with drone data acquisition flights:

Over the top for weeds and asset management, such as fence lines and tracks. The drone then captures the whole thing automatically. Then the high-resolution imagery is used to mark out the areas where the weeds are, so that you know where to go to when you're doing your treatments. In the same kind of vein, like reconnaissance for certain jobs like fencing, [...] people will send the drone and create the ortho mosaic and then come back into the office to plan out the route for the fence and do a bit of an analysis on the terrain. This form of asset management, where you're looking at large areas of fencing or mapping areas where you might need to do some maintenance. And I think those are helping the ranger coordinators to input drone data directly into their workflows. Likewise, hydrological monitoring, where rangers are monitoring issues such as algal bloom in waterways.

Drones are also being used to map cultural burning outcomes. Chris Warrior (Wiru Drones Solutions) says data acquisition flights are conducted prior to and after burning to capture changes in vegetation coverage and analysed using photogrammetry modelling. He finds this method of mapping to be less invasive than walking Country.

The use of drones by ranger groups to monitor changes in terrain due to climate change impacts, such as coastal erosion due to sea level rise and powerful storms, is also emerging as a significant tool. The following case vignette highlights a collaborative program engaging the Winjan Aboriginal Corporation.

CASE VIGNETTE 1: State-wide beach monitoring program

Aboriginal rangers in Western Australia (WA) are assisting in using drones to monitor erosion and inundation (flooding from the sea) hazards along a stretch of coast from Rockingham to Busselton as part of a collaborative trial program.

The drone capture team consists of rangers, elders and staff from the Winjan Aboriginal Corporation (representing the Bindjareb Noongar community), the Department of Transport and Major Infrastructure, the Peron-Naturaliste Partnership (which manages the stretch of coastline for the local government), the local government authorities and Main Roads WA, which provided program guidance and access to its chief remote pilot. The aim of the beach monitoring program is to bring together staff from the five groups to collaborate in delivering monitoring outcomes. Funding is provided by the federal government's Disaster Resilience Fund and a Coastal Adaptation and Protection grant from the state government.

The beach monitoring program is building on a 2022 Department of Transport study that identified 23 local government areas (LGAs) across the state that are at risk of inundation over the next 25 years. The study used baseline digital elevation model (DEM) data. In the beach monitoring program, rangers are working as part of the project team in the capture of high-resolution DEM and aerial imagery to track how the coastal terrain and built environment are changing due to the impacts of cyclones and storm surges. Data is captured annually after winter and summer and at selected sites before and after single major storm events. More than 33 sites have already been captured. An online portal was created to enable data visualisation and analysis. Data captured is publicly available using this app: [Drone Beach Capture Program Web App](#). Department of Transport staff undertook data processing, including the data visualisation and analysis.

As part of the program, the training supplier Aviassist trained five rangers who received remote pilot accreditation, with one ranger obtaining the CASA certified remote pilot licence (RePL). The rangers have also been trained to undertake the set up and the survey of the beach control points and quality control check points using Trimble GPS equipment, manage the base station and to act as spotters to keep people off the capture site until the survey has been completed.

To resource the monitoring program, two drone kits were purchased, comprising two DJI Matrice 350 RTK drones with high-resolution cameras, GPS equipment, drone imagery processing software and ancillary equipment.

The first of the ongoing capture program was successfully completed in May 2025 with high praise for the endeavours and task dedication of the Winjan rangers. The program has been recognised through the prestigious WA Coastal Awards for Excellence, receiving a Special Commendation in the Education, Engagement, Science and Research category.



Lift off for the drone capture team. Photo credit: WA Department of Transport and Major Infrastructure.



Surveying the photo control for use in aerial triangulation. Photo credit: WA Department of Transport and Major Infrastructure.

Rangers are also using drones to monitor water quality and asset management. Andrew Dowding says hydrological monitoring is becoming increasingly common:

Recently we were out doing some drone training for the Noongar (WA) guys, and they got a phone call from Department of Water saying that they were told there was an algal bloom in the waterway, and they knew that we were out in the area [...] and so they asked if we could [...] at least [take] photos [...] to create an area to monitor. And they did that and sent that on the day to the Department of Water to monitor an algal bloom.

The other [common area of drone use] that we've been seeing in terms of the where ranger groups are interested in is [...] asset management [...] monitoring tracks and doing track management and track maintenance.

Dowding adds that in remote areas where human (and potentially other) activity requires monitoring – but there is not the people power – the new technology of a 'drone in a box' is an ideal means to keep an eye on unwarranted or illegal activity:

(The) drones are sitting out in the bush, self-powered by solar, and they are triggered by some form of alert [...] either someone's moved into a place or a sensor has indicated that something's wrong. And the drone unfolds from the box and flies an automated flight perimeter, taking photos and sending pictures back to [...] the home base [...] And then, once it has completed its pre-arranged flight path [...] it returns to its box and charges and waits for the next alert.

Dowding says that such automated monitoring enabled an Aboriginal corporation to address environmental destruction from motorbikes and 4x4 wheel drive enthusiasts along a riverbed it is managing.

4.3 Sky-camera

4.3.1 Cultural mapping

Drones can and do play a role in Indigenous cultural mapping for some groups. In general terms, this mapping practice incorporates both intangible (e.g. language, sacred places) and tangible (e.g. burials, archaeological sites) cultural assets, materials, norms and values. Cultural mapping is a means to transform the intangible and invisible into a medium that can be applied to heritage management and protection, education and intercultural dialogue. At a fundamental level it involves the recording of Indigenous place names and, as a result, it can be understood as ‘countermapping’ – by providing the pre-existing layer of cultural meaning on colonially altered landscapes and the maps produced to record them (Holcombe, 2023; see also, Strang, 2010 and Crawhall, 2007).

To understand the possibilities and limitations of drone use in this context, it’s necessary to reflect on the widely used concept of ‘Country’ and thus what it is that drones would be providing viewing access of and recording data for. ‘Country’ is an Aboriginal English concept that embodies the complex social and spiritual connection that reflects the relational quality of Indigenous peoples to their territories. As part of human relationality, Country is kin and sentient (Rose, 1996; Bawaka Country, 2016). Though the religious term ‘animism’ and its sister term of ‘totemism’ are not widely in use today, they apply in this context, recalling that animism derives from the Latin *anima*, ‘breath, spirit, life’. It’s the belief that objects, places and creatures all possess a distinct spiritual essence.³

In this multilayered intercultural context, protocols for data use and management are especially important and it could be argued that *any* drone use over Country is a form of cultural mapping. Indeed, this is recognised in some protocols, which we discuss in Section 4.8. These protocols also recognise that the layers of data are understood or read differently by different participants depending on their age, gender, affiliations and cultural seniority for specific places.

In 2019, Winyama was able to purchase its first drone. Dowding explains that at one of its earliest projects in the Pilbara region, the team realised that “drones were actually a mapping tool rather than only a video camera in the sky”.

In cultural mapping projects, drones have enabled non-ambulatory elders to have access to Country, via a screen. Rangers can fly drones over land, river systems or culturally sensitive areas then re-play the footage and engage with elders when they return to their corporation. Viewing this footage can then provide the opportunity to recall and discuss places that they may not have been able to access (Participant 2; see, also, ABC News 2018).

Drones have been used to identify and map burial sites on Country. Chris Warrior shares an example of a project he was involved with in Victoria. His starting point was stories told by elders of past burial practices in a particular location. He then used light detection and ranging (LiDAR)

³ For instance, under the *Native Title Act 1994* – a successful claim entails that the Indigenous claimants have maintained (quote) “an active spiritual potency” in connection to country. While under the *Aboriginal Land Rights Act 1976* in the Northern Territory, the language of attachment and connection is “primary spiritual responsibility”.

technology⁴ to help identify the sites. He describes this approach as traditional knowledges meeting modern technology:

Our people have been buried there for a very long time, and LiDAR is a good way to look at the landscape, especially with dense vegetation. LiDAR will penetrate that vegetation. It'll create this awesome digital elevation model and we can look at the landscape. And when you look at everything around, you see this really abnormal mound.

Warrior explains despite looking like natural terrain, the mound was a burial site: "We had cars driving through the site. [...] People were just driving over this hill, thinking it was just a hill, but it was an actual burial site." He notes the discovery refuted claims by current landholders that the land was devoid of Aboriginal cultural heritage artefacts.

Though there is a role for drones in some contexts of cultural mapping – such as enabling visibility for those who can't access places and providing a different perspective – Andrew Dowding says they are not commonly used in this context:

"We were kind of hoping [that] because we do all the cultural mapping [...] people would want to take stock and record every site, but [...] we're not seeing a lot [of] that [...] unless there is some danger to the site or some perceived management need.

Dowding suggests that a reason for this relates to who is operating the drones – the ranger groups who are focused on their work programs week-to-week. Prescribed bodies corporate, on the other hand, are more interested in holding the data related to a place or sacred site. This observation correlates with Holcombe's (2023) findings that the systematic practice of cultural mapping is not widespread in Australia. Site surveys and work area clearances are conducted by representative organisations' anthropologists and archaeologists who rarely use drones. Furthermore, cultural mapping is not common within these organisations as they don't have the resources to undertake it in any systematic way – as much of the site survey work is reactive to proponents' applications. However, this is not to say that the interest and potential is not there.

Case vignette 2 provides an overview of the Indigenous business – Winyama from the perspective of its founding director Andrew Dowding. The vignette provides insights into the recent history of drone use uptake and the emerging range of drone applications, including cultural mapping.

⁴ LiDAR is a remote sensing technology that uses light to measure distances and create detailed 3D maps of the environment.

CASE VIGNETTE 2: Winyama uses drones to provide an eagle eye view of Country

Winyama was established in 2018 with Andrew Dowding as the sole trader consulting for Aboriginal corporations in relation to cultural mapping. He soon realised that global information systems (GIS) had to be a significant part of the work and partnered with a GIS company - NGIS - to “grow this capability for myself. And I quickly became really aware that the Aboriginal corporations that I was working with needed to speak a kind of mapping language as well and understand the systems and software that I had been introduced to in my discussions with the larger mapping company – NGIS [natural global information systems].” Dowding and the managing director from NGIS then formed a new company with Dowding owning the 51% share. He was initially using their resources a lot, but today (2025) Winyama has 14 staff, the majority being Indigenous.

Winyama is a Ngarluma word for the Sea Eagle, which reflects Dowding’s Ngarluma coastal Country, in the Pilbara region. The name also represents an eagle looking down on the land. Over the years they have concentrated mainly on geospatial mapping: mapping software and mapping services. Dowding explained that “it was probably a personal interest in drones. And then the discovery really early, maybe 2019, that drones were actually a mapping tool rather than a than only a video camera in the sky.” So Dowding created an ad hoc arm of Winyama that had an interest in how Aboriginal organisations could use drones. And so, at that time it wasn’t thought of as a service line with products, as he elaborates:

We just knew these would be really useful tools, if people understood the mapping component of a drone. The first drone that we bought was with a Pilbara Aboriginal Corporation we were doing a cultural mapping project with. As the project was with some really senior elders from the Pilbara it was the project’s logic that thought that it should get a drone to give a bit of a higher perspective on the landscapes that we were recording with them. It wasn’t until we had the drone that we actually explored the kind of mapping use case. So initially, it was about just a higher reach of a video and a capture of sites using video.

This first drone cost \$15,000, which Dowding states “was a really expensive piece of equipment for us. The same drone today is worth probably \$2,000, with a much higher set of capabilities than the early drones, which were just really great video cameras.” Likewise, in that short period of time the price point has come down. In these early days Winyama was experimental. And it was because they were working with groups in the Pilbara that they could afford drones. They were early adopters, whereas, he says that “you just couldn’t sell a drone into a project down in remote New South Wales, Barkinji country or something, because the guys didn’t have the mining cash and the wealth behind them”.

So, the use of drones started for Winyama in the Pilbara in 2020. With this particular Aboriginal corporation, it won a lottery West grant (WA government grants for not-for-profits) for a project that was to increase the capability of Indigenous rangers in the Pilbara, in the “digital” space. The pilot project allowed them to explore what that meant for Indigenous rangers. They asked Winyama to draw up a program, within which they included drone capability as an important component of ranger work. And that’s where they built their first program for how to train rangers to work with drones: how to unbox a drone; how to understand the licensing arrangements; how to fly them in terms of practical flying. But then the next level collecting mapping data with it and building the data pipeline for ortho mosaics, which were initially the first use cases for mapping.

In the Pilbara pilot project Winyama developed a “roadmap” for 15 ranger groups in the region. Dowding explains that:

It was very difficult to tell you the truth, that was quite hard. We found that every ranger group wanted to get every single person – every ranger – a drone pilot's license, which is not a great way to look at Drone use. They were very enthusiastic! Every time we talked about data they would glaze over. And you do need to talk about data. All we'd have to do is say "drone" and people would be switched on. It was definitely a lure for other parts of the program.

They found that a ranger program only needs one or two drone people inside its organization. And, that in fact, half of the people were scared to unbox the drone, while the other half of them just wanted to zoom around and do stuff. As Dowding states:

They don't see it as work. They didn't see it initially as a workflow inside of their program. They thought it was fun, and so it was quite a culture shift to try and find who the pilots would be and then I think the second part that we explored was that sometimes we scared people off with the risk component when you do a RePL [Remote Pilots Licence].

Today Winyama works nationally, though they are based in Perth. They offer a suite of services, including cultural mapping; geospatial capability assessments; GIS support; data strategies and Indigenous data governance; field data capture support and ranger program guidance; data analysis and 3D visualisation; mapping, drone and field data collection training; and data backcapture.⁵

4.3.2 Drone photography for advocacy

Country Needs People routinely uses drones to capture imagery of Country and people to support its advocacy work. O'Leary explains this approach:

One of the things we do is [...] we remind people how incredible these places are, how beautiful they are, how great the people are that work there. And part of that is by getting extremely good imagery, not just average, but really good, and then making that available to the group we're working with. [And], also, under agreement with them, using it to advance the benefits of the entire sector.

The [drone photographers] that we regularly contract [...] will use it for aerial shots, shots of Country that you can't get from ground perspective. Sometimes shots of people in Country [...] Video could be stills... People need a subjective attachment... an emotional pull. Logic does not move people.

I think it's the biggest run Indigenous conservationist state in the world... and the biggest interconnected set of protected areas in the world. Australia is globally leading on this stuff, and a lot of that, frankly, has come, not solely obviously, we're built on other people's work, but from our advocacy when right from the start, people said, you will not get any more money for this. You have to go to other non-government funds. Since then, we've got 1.8 billion dollars into the sector that wouldn't necessarily be there. [...] So, this stuff [drone photography] is critical.

So, the drone as 'sky camera' provides the technology to make remote areas of Australia accessible, so that the vast and often inaccessible environmental beauty can be appreciated by all.

⁵ <https://www.winyama.com.au/>

4.3.3 Drones for visual storytelling

The use of drones can enable storytelling on a grand scale, as the technology can capture the landscape as sweeping and awe-inspiring. When paired with lighting, drone technology can create storytelling on a spiritual or mythical level.

The award-winning Indigenous videographer Tyson Mowarin, a Ngarluma man based in Roebourne, Western Australia, routinely utilises drones in his films. He owns and operates a media production company, Weerianna Street Media. Mowarin's documentary 'Connection to Country' provides "a drone's eye view of the spectacular Pilbara country of Western Australia" (Daley, 2017).⁶ As the opener to the film explains, "I wanna tell you a story about why this country means so much to us blackfellas and why it should mean something to you, too".

Frey (2018) observes that the use of drones in Indigenous cinematography is widespread. Her 2018 PhD thesis analyses Indigenous filmmaking to explore "how these films transmit Indigenous peoples' ways of knowing and relating to the environment, while reaching both Indigenous and non-Indigenous audiences". In some cases, filmmaking includes the use of drones. In her thesis, Frey shares the following observations of Mowarin's documentary:

The first images are a panoramic view of Murujuga (Burrup Peninsula) in the Pilbara region [...] these panoramic views do not function as panoptical images of the environment, where nature is portrayed as an object, through differentiation and distance: on the contrary, they establish a connection between filmmaker and place. This is especially the case here because the place is well known to the filmmaker, who understands its history and has the authority to speak about it. Aerial images of the land and waterscape made by drones are followed by a voice-over of an elder Aboriginal woman speaking in Ngarluma. The voice-over represents the spirit of land: "Can you hear that sound? That's my winds carrying my story. My story touches everyone, everything, completely. This is my story, but it is your story too". Again, the documentary discourse endorses a sense of belonging that wants to include the wider audience [...] In the next scene, the film's director, Tyson Mowarin, is showed setting up his drone. This shot sets the style of the documentary as ranging from the participatory to the performative (Frey, 2018, p. 138).

Mowarin was not interviewed for our drone research. Report coauthor, Holcombe, however, is familiar with his use of drones in videography as the pair collaborated on the short film 'Waanyi Voices: Century Mine'. In this film, a drone was also used in the opening sequence to introduce the regional landscape (Mowarin and Holcombe, 2022).

Drones have also been used in documentaries about the use of drones in conservation and cultural projects, such as the film about the Ngururrpa Rangers (Balgo, WA).⁷ As the lead narrator Clifford Sunfly, a young Ngururrpa man, explains, "Our elders were using their minds to map out country, nowadays we have the drone to map out country". This film documents a trip to the Yagga outstation in WA where the rangers are developing their drone operation skills. It is explained as a big step forward for the Ngururrpa Rangers who are now planning to use a drone to map out landscapes and support their work looking after threatened species. This film, created by Sunfly in collaboration with the Ngururrpa Rangers and the Indigenous Desert Alliance, was inspired to show how rangers are using drones to map country the right way:

Operating drones out on country has been really important and has become very popular these past few years because it lets rangers see country like they've

⁶ See <https://colourboxstudio.com/creating-on-country-with-tyson-mowarin/>

⁷ See [Ngurra Yulpararra](#)

never seen before, it's very useful and also very helpful to our elders (Indigenous Desert Alliance, 2023).

Also in the desert, the Anangu Traditional Owners of the Uluru Kata Tjuta national park partnered with the Voyagers Ayers Rock Resort to develop the permanent Wintjiri Wiru drone and light show at Uluru. This show uses synchronised drone swarms to tell ancient creation stories or Tjukurrpa. Traditional knowledge is blended with drone technology:

Wintjiri Wiru, meaning 'beautiful view out to the horizon' in the local Pitjantjatjara language, is a breathtaking cultural storytelling experience that brings to life a chapter of the ancestral Mala story through choreographed drones, lasers and projections that illuminate the night sky. A story passed on for thousands of generations, now passes to you. (Voyages Indigenous Tourism Australia, 2025)

The light show was developed through extensive consultation with elders and community members to ensure the technology is used appropriately to convey stories and cultural wisdom. As the Voyager website elaborates, "A group of 10 senior Anangu from Kaltukatjara and Mutitjulu, have taken great care to tell their story in the right way."



*Figure 4: The Wintjiri Wiru drone and light show at Uluru, showing huge devil dog called Kurpany.
© The Ayers Rock Resort, The Mala Story | Ayers Rock Resort*

4.4 Drone training and accreditation

In Australia, drone operators require Civil Aviation Safety Authority (CASA) training and accreditation to fly drones that weigh more than 2kg.⁸ There are three pathways available. They are:

1. Remote piloted aircraft (RPA) operator accreditation
2. Remote pilot licence (RePL) and
3. Remote operator's certificate (ReOC) (see Table 2 for further details).

Table 2: Current drone training and accreditation options

	Step 1	Step 2	Step 3
Result	Accreditation	Licence	Certificate
Training name	RPA Operator Accreditation	Remote Pilot Licence (RePL)	Remote Operator's Certificate (ReOC)
Training duration	1 day	5 days	1 day
When required	• For participants who want to fly for business or part of their job • The drone weighs no more than 2kg OR more than 2kg but no more than 25kg if only flown over their own land	• For participants who want to become a remote pilot for an individual or business that holds a remotely piloted aircraft operator's certificate (ReOC) • Fly a drone or remotely piloted aircraft that weighs more than 2kg but less than 25kg	• For participants who want to fly remote piloted aircraft commercially • If individuals or businesses want to hire remote pilot licence holders

(Adapted from Eaton in Schultz and Barnett, 2024).

While the success rate for accreditation is very high among Indigenous candidates, when it comes to obtaining a RePL, the success rate is much lower. Research participants attributed the lower rate to the length of the CASA training program (five days) and the western approach to content delivery. Chris Warrior has observed participants in the classroom:

When people are sitting in the course, you can see deer in the highlights. If you keep going, bang, bang, bang [when delivering the content] and not stopping and reading the room, people just get lower and lower in their seats. Then they don't ask any questions and by the second day, they're mentally checked out. By the time they sit the exam, they're already daunted and they don't remember half the subjects.

⁸ For recreational purposes, accreditation is generally not required to fly a drone that weighs less than 250g but operators must follow CASA's standard operating conditions.

Warrior notes that when participants failed the exam, they lose confidence in their ability to learn. To address this issue, Indigenous organisations are undertaking pre-training programs that prepare candidates for the CASA training in more culturally safe environments.

Warrior's own experience was that:

When I did the course, they gave me a book about that thick [illustrates thickness]. I was sitting in the class, and I was like, what on earth is this? It was ridiculous. It was a shock, because I just wanted to fly a drone. I honestly thought, oh, we'll just do a couple of things. You look at where to fly, do the risk assessment, and I was like the flight assessment also, I'm good to go. I said I can fly a drone, just watch me, and I'll pass it. But the reality of the five days of training and a big book, to realise what's required to sit an exam at the end. It's over 28 subjects of aviation from flight planning to airspace, meteorology, units of measurements, aerodynamics, propellers, principle of orientation, battery limitations, roam of the earth, nautical charts, and also true north of a magnetic compass, airspace charts and aeronautical publications, remote part of aircraft systems, aerodynamics and operations.

Paul Mead, co-founder of the social enterprise organisation, She Maps, and drone data analytics platform, GeoNadir, notes that a licence is not needed to operate drones under 2kg – which is what the majority of Indigenous rangers are operating: “So long as you're going to fly with what's called the standard operating conditions – so don't fly within 30m of people not involved in the operation, don't fly at night, and other conditions, [...] – and for most people, that's fine”.

Like Warrior, Mead acknowledges that the RePL course is challenging for Indigenous participants. He described it as “a horrible course”.

It is two days of theory followed by a multi-choice exam and then some practical flying. It is hard for me to get through that course, let alone someone with low literacy. And we have found so many rangers have been told you need to go [...] off and do a remote pilot license course; that'll teach you everything you need to know. And they turn up to these providers that take \$2,500 off them, teach them in a way that doesn't meet their needs and then they come back and they fail the exam.

And so, we have gone and taught so many rangers who say, Yeah, I've got my remote pilot's license, or I've done that course, and they know [very little] because it's all theoretical or tick a box [...].

This course is a huge industry problem, but it is magnified massively when it comes to Indigenous ranger groups. It's a real problem. And it is something that I absolutely hate, and I will continue to tell everyone that. Often, we have people that teach this who are not educators; they are trainers. And there is a big difference between an educator and a trainer when it comes to understanding how to work with people who have English as a second or third language, or have low literacy levels; [...] someone who teaches and someone who delivers [...] content, but not checking for learning or understanding along the way. The course is not competency based largely, and the rangers are competent, but often fail due to the way the course is delivered. And that's the problem we have.

Wiru Drones Solutions is an Indigenous business that focuses on providing culturally safe drones training. The story behind the business is presented in the following case vignette, drawing from an interview with Warrior.

CASE VIGNETTE 3: 100% Indigenous-owned drone business

Wiru Drone Solutions, a 100% Aboriginal-owned business, is using drones and other visual media to provide commercial, creative and community solutions for clients, including land management, cultural mapping and enabling communities to use technology to care for Country. The business is owned and operated by Chris Warrior, a Kokatha/Yunkunytjatjara man, based in Shepparton, Victoria, on Yorta Yorta Woka (Country).

Warrior works with rangers and Indigenous organisations across Australia. A chief remote pilot, he holds a remote pilot's licence, remote operator's certificate and a Graduate Diploma of Natural and Cultural Resource Management from Deakin University. He founded Wiru Drone Solutions in 2022, and, in 2023, he was awarded the Australian Association for Uncrewed Systems (AAUS) Diversity & Inclusion. Training the next generation of Indigenous drone pilots is a key component of his work.

Warrior had worked in mining for 13 years. He was first introduced to drones in the 2010s when his mining surveyor friend showed him a large drone which was being used to map underground roadways and quantify minerals mined over each 12-hour shift. Although it took a while to come to fruition, Warrior was already thinking about using drones, photogrammetry and LiDAR to map cultural heritage.

A decade later, Warrior learned of a funding opportunity to train Indigenous Australians as drone pilots. He completed the training and obtained a drone licence in 2021. In his cohort of 12, only two passed the CASA exam. He said the training was challenging and he was fortunate that he was able to debrief with his sister, who had a private pilot's licence.

Warrior said he found the CASA training more challenging than completing his graduate diploma because it was five full days of theory and required that he sit in a classroom from 8.30am to 4.30pm every day. He said while the theory components were difficult to tackle, they provided foundational knowledge for drone operation.

After obtaining his licence, Warrior built up flight hours with a mentor group and gained commercial experience around Melbourne assessing WorkCover claims on building sites using drones for data capture. He then decided to launch his own business. Wiru in Warrior's language, Yaku Jara, means good or beautiful [drone] solutions. He focuses on using photogrammetry to map Country:

So, it's cultural mapping [and] working with ranger groups. I just got back last week from WA. So, I was on Banjama Country, up on the Yandi mine with BHP. We're teaching ranger groups how to fly drones safely and how to use photogrammetry to capture Country and use those 3D model maps to look at survey sites for capturing cultural heritage sites. If they're looking at erosion or flood plans in their Country, how do they manage that? Also, cultural burns. My clientele is a lot of aboriginal corporations, ranger groups and land management



Chris Warrior flies his drone on Country.
Photo credit: Wiru Drone Solutions

mob. This weekend I'm driving back to South Australia to Coober Pedy and we're working with a land management board for an IPA area, so Indigenous protected area, and we're teaching [mob] how to use drones to map Country as another tool. So, it's a lot of cultural mapping with drones.

Warrior collaborates with other training organisations, such as Winyama and Aviassist. He draws on his own RePL training experience to provide a culturally safe learning environment.

4.4.1 Increasing access to and diversity in drone training

Chris Warrior, who works with Winyama and Aviassist, has developed a three-day training course that Indigenous rangers can complete prior to undertaking CASA training. It usually runs Wednesdays to Fridays, giving participants time to “decompress” over the weekend before they start the CASA training the following week. The pretraining combines practical exercises with classroom work, plenty of breaks, and includes “translation” of technical aviation terms and theories into concepts that resonate with the rangers. Warrior compares, for example, Bernoulli’s principle – which helps explain how lift is generated on drone wings – to the lift of a boomerang.

When we run the three days, we make sure every day we go for a fly. I'm not hovering over them, and it gets them to get the jitters out the way when they know how it flies. Get them to have a fly, and then we take the shame factors away. If you haven't flown a drone and the first time, you're taking it out in front of instructor, you'll get shame. We're teaching ranger groups to get them mentally prepared. We go through the terminology. We go through risk assessments. We talk about flight planning, BTC charts and the reason on why you need CTAF (common traffic advisory frequency). So, you need a radio and AROC (aeronautical radio operator certificate). How do you listen to aircraft taking off to near an airport? What direction?

Warrior emphasises that it is important that CASA trainers have experience working with Indigenous groups and that they understand the cultural and language barriers. Pretraining and the use of culturally competent trainers has boosted the pass rate.

She Maps promotes diversity in STEM education through the use of drones and geospatial technologies, aiming to engage students through interactive, hands-on experiences, while sister company, GeoNadir, has a focus on making drone mapping technology accessible to a broad range of users. Paul Mead says they focus on an inclusive approach to bringing drone use into the classrooms and communities. Indigenous rangers are one of the diverse groups that they seek to work with:

Drones are captivating teaching tools that spark curiosity and engagement among students of all backgrounds and ages. Their hands-on nature encourages active participation, making STEM more accessible—even for those who may not typically gravitate toward technology. By piloting drones and applying real-world problem-solving, students gain confidence and a fresh perspective on STEM, seeing it as creative, dynamic, and relevant to their future. This interactive approach breaks down barriers, inspiring a more diverse range of learners to explore and embrace STEM with enthusiasm (She Maps, 2025).

Mead states that She Maps is keen to increase the diversity of the geospatial workforce: “We use micro drones, so little 67 gram drones that fly indoors that you can code. We use that as our hook to engage. So, we say it's not about the drone. The drone is just the tool to enable us to have some stem concepts and conversations spark some interest”.

CASE VIGNETTE 4: GMY Rangers care for Country

Near Yarrabah, south-east of Cairns, the Gunggandji-Mandingalbay Yidinji (GMY) Land and Sea Rangers are using drones and western science alongside traditional knowledge to care for Country.

The rangers primarily work in the Wet Tropics World Heritage Area and adjacent sea country within the Great Barrier Reef World Heritage Area. They are using a Mavic 3 Enterprise drone to help them undertake a range of activities, including:

- monitoring and controlling weeds and feral animals and revegetating riverbanks
- monitoring and protecting turtle nests, monitoring crocodile presence along beaches and tributaries, and monitoring turtle, dugong and manta rays
- conducting intertidal seagrass surveys and seagrass and coral reef monitoring
- monitoring climate impacts, including erosion.

Helen Tait, CEO of the GMY Prescribed Body Corporate Aboriginal Corporation (GMYPBCAC), said the corporation had established a ranger program four years ago.

“Since then, we’ve been developing, employing and recruiting local Gunggandji and Mandingalbay Yidinji men and women and training them in ranger roles and to help them develop their skills to care for Country by using traditional knowledge as well as modern technology techniques, such as drones,” she said.

GMYPBCAC received a federal government grant to fund the purchase of the drone and the associated training through the Department of Infrastructure Transport Regional Development Communication Sports and the Arts’ First Nations Drone Policy Project. All GMY rangers have obtained drone operator accreditation from CASA.

Junior Ranger Team Leader Stirling Ludwick said drones enabled the rangers to collect important data relating to the health of Country.

“We make videos, do surveys, pre- and post-cyclone surveys of erosion, reef surveys, turtles, dugongs, crocodiles and all that. It’s a pretty handy tool with the technologies,” he said.

Training is a priority for the GMYPBCAC. In 2024 its intensive training and development program was recognised by the Australian Training Awards when the corporation won the Small Employer of the Year.

Helen said peer-on-peer training was an important part of the program. Several rangers had been identified as having peer training skills and were given more in-depth training as part of their development.

Stirling Ludwick is one of the GMY rangers’ peer trainers. He said he was happy to share his knowledge with the other rangers and that learning was a step-by-step process.

“I feel good about [...] showing my peers. When I look back from then and think, oh we’ll see it was easier than it looked last time,” he said.



GMY Rangers peer-to-peer drone training with trainee rangers (left to right) Stirling Ludwick, Malachai Ambrym-Cedric and Ngulun Yeatman. Photo Credit: GMYPPBC



GMY Rangers flying a drone at Buddabadoo (left to right) Stirling Ludwick, Brody Gray and Justin Keyes. Photo Credit: Annette Ruzicka Photography and Country Needs People.

4.5 Drones and native title lands

As the map (Figure 3) on page 12 illustrates, the vast majority of the Indigenous estate is determined native title lands. As of 2024 this accounted for approximately 40% of the land mass. However, because native title is not a 'property right', but rather a bundle of rights – it is weaker than forms of land tenure, such as pastoral leases or freehold lands. For instance, non-exclusive native title includes the right to negotiate over mining, visit or potentially live on the area, hunt, fish, gather food and teach law and custom on Country. The impact on these limited rights on drone use was raised by Andrew Dowding who discussed the challenges for rangers who are seeking to use drones on their native title lands, which can include extensive IPAs. Dowding indicated that native title tenure is not a classification that CASA understands or therefore recognises. He indicates that this can include exclusive native title:

That's a level of tenure, which is exclusionary to others. And yet CASA is not really acknowledging that so essentially...If you're a farmer who owns freehold land, and you're flying a drone you don't need any form of license to do that. You can fly under the exclusionary category. There's a certain weight limit that you can fly under, but essentially the same drone. A ranger could not fly over their exclusive native title area. And so, I just think there's an emerging interesting space around Indigenous drone use and tenure...the license restriction for an Indigenous person who's working at a ranger group to fly for their rangers. They need a professional licence to do that, and that's a \$4,000 investment. Plus, the cost of the drone and then they still don't have the what's you know the ReOC – which is the commercial license. They only have the RePL, which is a remote pilot license. And so, there's a I think, quite a hypocrisy about the fact that it's the tenure class that some of these Indigenous rangers have access to is kind of is not really beneficial to the drone industry in their area.

Indigenous rangers working on Aboriginal Land in the NT would not face this issue – as that is freehold land. However, this is an exception. As Figure 3 indicates, most of the Indigenous estate in Australia is native title. However, this issue of the potential challenges that native title as a

limited legal right across much of Australia presents for native title holders is an area that has been little researched.⁹

4.6 Data capture, processing and storage

There have been significant advancements in technology used to capture land management data with drones, from traditional and multispectral photogrammetry to light detection and ranging (LiDAR).¹⁰ Chief Commercial Officer of the Nallawilli Bunjil (part of the Nullawilli Group), Andrew Bassford, says given the size of data being collected by drones, one of the challenges is managing and storage of it.¹¹ Nullawilli Bunjil has moved to Microsoft Fabric, a comprehensive cloud-based analytics platform designed to unify data management and analytics processes. Bassford explains that geospatial platforms enable users to overlay multiple layers of data such as weather, river systems, LiDAR and multispectral photogrammetry. He says Nallawilli Bunjil is collaborating with CSIRO to develop machine learning models:

We see the opportunity in land management [...] to really map biodiversity at levels that have never been mapped before. We can incorporate satellite information, but satellites get down to about 30m pixels, so 30m by 30m. With high-spectral, [it's] 1cm, which is just unheard of, [and] the amount of information you can capture within that. So, we've got the technology pathway.

There are a range of drone data processing models being used by Indigenous organisations, where the level of their direct input varies. These models include:

1. Set up and control of the site survey location
2. Set up and data capture
3. Set up, data capture and upload
4. Set up, data capture, upload and analysis
5. External data storage.

In the WA beach monitoring program (case vignette 1), rangers from the Winjam Aboriginal Corporation predominantly used model 1. The rangers undertook the set up and survey of the beach control points, quality control check points using GPS equipment, managed the base station and acted as spotters to keep people off the capture site until the survey had been completed. Department of Transport and Major Infrastructure staff undertook data processing, including the data visualisation and analysis.

⁹ There are staff in the “Uncrewed Systems Capability” at The Department of Climate Change, Energy, The Environment and Water” (Commonwealth), who we are keen to interview for the article that are told have more information about this issue.

¹⁰ Photogrammetry uses overlapping images to create 3D digital models. It captures high-resolution imagery, is cost-effective and provides a visual record from which data can be reprocessed. Key constraints are that it is dependent on light and weather, is limited by line of sight (i.e. it cannot penetrate dense vegetation) and its complex processing requires significant computer power and skilled personnel. Multispectral photogrammetry enhances traditional photogrammetry by capturing images across multiple (8 to 11) spectral bands. This enables monitoring of environmental conditions, including early detection of issues. Its disadvantages include the need for special sensors, processing complexity and lower spatial resolution compared with standard cameras at the same altitude. LiDAR uses laser pulses to measure distances and produces very accurate 3D point clouds and terrain models. It can map ground surfaces beneath forest canopies and dense foliage. Its disadvantages are that it is expensive and has heavy data storage and processing demands. Some organisations, such as The University of Queensland, CSIRO, Geoscience Australia and Nallawilli Bunjil, have invested in hyperspectral (400 bands) remote sensing to enhance data capture (Bassford, 2025).

¹¹ This business was founded in 2009 by Roderick McLeod, a Senior Elder of the Jaithmathang Nation, and is being led by CEO Scott Allen, a descendant of the Awabakal Worimi Nations.

Paul Mead describes geospatial drone mapping data as ‘big data’. It is hard to process and the systems that are needed to use to analyse the data are becoming increasingly complex:

From a drone mapping data perspective, at GeoNadir we're aiming to be that gold standard of interoperability, of intuitive use combined with data sovereignty, and easy to implement data security as well. [...] I don't think that there are many [organisations with the] ability to manage big data on [their] own servers, computers, all of that. That's often beyond the organisational structure of many organisations, not just Indigenous rangers. So, unless you have GIS data analysts, data warehouses or servers and high-performance computers, you're probably not doing it to a level that enables best use of the data you are collecting.

Participant 1 from the CLC stated that the processing and storage of drone data is about management:

[...] it's managing the people, not the system. Yeah. you can have the best system in the world that people still have to work with it. And this, yeah, this applies to very much to drone footage. [...] there's also the mapping data that comes out of the drone. But that's just that's just mapping data that could be record from a helicopter or draw lines on a map in GIS. So that's no [big] deal. And that's it with the spatial geospatial services to mapping team. But yeah, photography of sacred sites, etc, would probably should sit with Anthro [Anthropology section], but most of it would sit with land management. Because we're the people that take the take that footage.

4.7 Indigenous data sovereignty and governance

Data capture, processing and storage have implications for Indigenous data sovereignty and governance. In this section we summarise the principles that underpin Indigenous data sovereignty. In Section 4.8 we link these concepts to drone protocols and policies.

Contemporary concepts of Indigenous data sovereignty emerged in the 1990s from the groundbreaking work of Canadian First Nations communities who were responding to poor data practices and exclusion (Lovett et al., 2019). They were frustrated by non-Indigenous data users speaking with authority about the health of First Nations peoples (Walter and Suina, 2019). The communities developed a new data model known as **OCAP®**, which establishes collective:

- Ownership of data
- Control over how data are collected, used and disclosed
- Access to data about them
- Possession of this data (Lovett et al., 2019).

Since the OCAP® model was first published, its principles have been adapted and used by Indigenous peoples across Canada (Lovett et al., 2019) and around the world (Walker et al., 2020). Walter and Suina (2015) report that data sovereignty networks have been established to support this work. In Australia, the **Maia n nayri Wingara Indigenous Data Sovereignty Collective** is working to change practices in relation to Aboriginal and Torres Strait Islander peoples' data. The United States Indigenous Data Sovereignty Network provides research information and policy advocacy to safeguard the data rights and interests of Native American, Hawaiian and Alaskan peoples. In Aotearoa New Zealand, the Te Mana Raraunga Indigenous Data Sovereignty Network aims to advance Māori aspirations for collective and individual wellbeing by asserting Māori data rights and interests and ensuring Māori data can be protected (Walter and Suina, 2019).

Collectively, the advocacy of Indigenous peoples' data rights and interests is known as the Indigenous data sovereignty movement.

4.7.1 CARE principles

Robinson et al. (2021) state that the open data movement calls for data sharing to abide by the FAIR principles¹² but as Walter et al. (2020) contend, these principles do not mention nor address the concerns Indigenous peoples have about how their data are collected, used and reused. Robinson et al. (2021) assert that data-sharing is problematic for Indigenous peoples because the data can reflect insights from different knowledge systems with diverse knowledge sharing protocols. They argue that without Indigenous data governance, misrepresentation and decontextualised analysis can lead to harm to the people to whom the data belong. To encourage the open data movement to consider people and purpose in their practice, the International Indigenous Data Sovereignty Interest Group of the Research Data Alliance developed the **CARE principles** (collective benefit, authority to control, responsibility, ethics) at a workshop in 2018 (GIDA, n.d.). Robinson et al. (2021, p. 161) present their understanding of the CARE principles:

Collective benefits: Benefits to Indigenous people are key to data analysis purpose, practice and translation.

Authority to control: Indigenous authority to control access and analysis in accordance with Indigenous values and collective interests.

Responsibility: Those working with Indigenous data have a responsibility to share how those data are used to support Indigenous People's self-determination and collective benefit.

Ethics: Commit to minimise harm and maximise benefits to Indigenous peoples throughout data collection, integration and analysis and translation practices (Robinson et al., 2021, p. 161).

Walter et al. (2020) state that the CARE principles aim to complement rather than displace the FAIR principles, as the more mainstream approach.

4.8 Drone protocols and policies

4.8.1 Applying the Indigenous data sovereignty concept to drone use

Because Indigenous groups using this technology have unique data access and management needs there has been a focus on developing systems to ensure Indigenous data sovereignty and associated protocols. Data sovereignty is being considered in government policy through collaborative initiatives such as the First Nations Drone Policy Directions Group, established through the federal government's First Nations Drone Policy Design Project (see Section 4.8.3 for further details of the project). The group's participants said the way data was stored and by whom had major implications in achieving data sovereignty. They were concerned by the complex use policies of third-party data storage companies and wanted a focus on how data storage (move to earlier) could benefit Indigenous communities (Relative Creative, 2024).

An outcomes summary report published from the project listed the following seven important data storage considerations:

1. Data storage options should be designed by (or co-designed with) the community for the community

¹² FAIR principles were developed by a consortium of scientists and organisations and published in 2016. They were developed to improve the findability, accessibility, interoperability and reusability of data (Walter et al., 2020).

2. There is a preference for data to be stored on Country but the implications of this need further consideration
3. Government support for different types of storage (online, cloud, offline)
4. Appropriate cultural access to data is an important and continued consideration that relates to how data is stored
5. Proposals for a safe and cultural data keeping place for mob to use
6. Facilitation of the repatriation of data
7. What a Commonwealth data repository might look like (Relative Creative, 2024, p. 15).

Data sovereignty is also front of mind for some drone training organisations in their work with Indigenous rangers. Trainers are asking questions about where data will be stored, who will have access to it and what access permission protocols exist. Wiru Drone Solutions vets data storage organisations and Warrior says he ensures access to client data is restricted to the data owners:

We actually have agreements where Wiru Drone Solutions will be capturing photogrammetry data. Data must be handed back to the corporation up to seven- or 14-days post capture. No-one has access to this data. If you need to post data, share data, you must get permission from this Indigenous group by email. And that's how they're slowly mitigating and providing fail safes on who has access to data.

At Nallawilli Bunjil, Bassford says Microsoft Fabric offers an opportunity for data from multiple Indigenous organisations to be securely stored and processed and for sensitive parts of the capture area, such as burial grounds, to be omitted. Nallawilli Bunjil is working with Microsoft and CSIRO to advance this capability.

As cultural mapping entails recording places of significance, which can include secret or sacred sites, this is an area of drone use that will also require protocols. Chris Warrior, for example, speaks about the need to train male and female pilots to enable men's and women's sacred sites to be mapped. In his training work with ranger groups, he explains that being in command of a drone controller, which often has a touchscreen display, is akin to physically being onsite. When discussing women's sites, he says:

It's not for men's eyes to see. Men pilots look after men's sites. Women pilots look after women's sites and then the cultural protocol describes how you go about doing that. Say, if you're just a non-Indigenous mining group coming from Melbourne, and you got to go map something in regional Victoria, you gotta make sure you're gonna talk to the right TO [Traditional Owner] group. You'd be guided by the TO group about what can be mapped and what can't be mapped. 'We're not taking any cool photos in this direction, because there's a men's site or something in that area.' Our job is making sure they have a cultural liaison with them at all times, so making sure they're not flying where they're not supposed to be going; they're not taking photos where they're not supposed to be; and also, when they go back to Melbourne, no photos are to be posted on Facebook. That's part of the agreement before they come there.

4.8.2 Ensuring data sovereignty

Not all Indigenous organisations are finding data sovereignty a challenge. Gunggandji-Mandingalbay Yidinji Prescribed Body Corporate Aboriginal Corporation ('GMY'), for example, has had no difficulty maintaining data sovereignty using the GeoNadir online drone data sharing platform as rangers are able to control access to their data. "The data belongs to GMY. Even with

the GeoNadir website, you can choose when you create a licence, whether you want your data to be publicly available, and the ranger team chose not to share their data, so everything they are collecting stays within the organisation,” GMY CEO Helen Tait said.

GMY has forged a collaboration with Associate Professor Karen Joyce at James Cook University (JCU), who is also a co-founder of GeoNadir. Joyce provided GMY rangers with basic drone training and data collection skills. While she initially undertook training with the rangers, they’re now doing their own analysis. “The rangers want to use the data captured to establish a long-term monitoring program to document flora and fauna, and changes to their country from the impacts of climate change. This data will be used to guide restoration programs and management activities moving forward,” Helen Tait said.

GeoNadir was founded by Joyce and Paul Mead (also cofounders of She Maps). The organisation’s scientists and developers use GeoAI to support data-driven decision making. “We are building tools that combine the precision of drones, the scale of satellites, and the intelligence of AI to revolutionize environmental and ecosystem analysis. Our platform will use drones to provide ground-truthing data, satellites for global coverage, and a natural-language AI interface to make it all happen” GeoNadir states (GeoNadir, 2025).

This local control of the process and the associated data is a fundamental principle. Participant 1 from the CLC notes that who is managing the drone is important:

Yeah [...] if the right people are leading the drone flight and planning, it's implicit that the right people are doing it... And that's why the Kardiya [Warlpiri term for non-Indigenous staff] get a bit more stressed about it without having that knowledge. But out on Country everyone knows what they're what they're able to do.

4.8.3 First Nations Drone Policy Design Project

Indigenous Australians have been contributing to policy design through the federal Department of Infrastructure, Transport, Regional Development, Communication, Sport and the Arts’ First Nations Drone Policy Design Project. The project was funded in 2023-24 under the APS Capability Reinvestment Fund “to uplift cultural competency in technology policy design, focusing on drone policy” (DITRDCA, 2025). The department established a First Nations Drone Policy Directions Group to enable Indigenous individuals and organisations to share their experience and expertise, capture their perspectives on drone policy and support Closing the Gap targets. The group ran until 30 June 2024 (DITRDCA, 2025).

The group explored training and data themes, such as working together, cultural responsiveness, sovereignty and technology, and values, during three online conversations in April 2024. An outcomes summary report was produced from the conversations. It noted that participants reiterated the need for policy or protocols to be responsive to place and local (Country-based) protocols.

It was also evident that ethics need to sit behind any rules, procedures or processes. The ethical use of data is crucial, and there is potential that considerations should be made in regard to policy [that] could ensure appropriate use of the data. Broadly, data sovereignty is viewed as a significant topic, not just impacting new data but data already stored. There is a bigger question at play here in relation to the government’s role in establishing, supporting and maintaining the data sovereignty of First Nations peoples. This question goes beyond the drone industry (Relative Creative, 2024, p. 15).

The group then developed eight policy design recommendations at a workshop in Gimuy (Cairns)-Yarrabah, Queensland, in June 2024. The recommendations related to:

1. Simplification of regulations
2. Recognition of Sky Country
3. Support for culturally responsive training and training providers
4. Funding that supports self-determined projects
5. Supporting greater community understanding of new technologies to increase capacity for decision-making
6. Opportunities for education, employment and economic outcomes
7. Continued partnerships are further case studies will be important
8. Cultural authority on emerging technologies.

Project outcomes and resources are available [here](#).

4.8.4 Drones to support the monitoring of healthy Country indicators in Kakadu

Drones are being used as part of a suite of technologies by two Traditional Owner groups – Bininj and Mungguy – in Kakadu National Park to support the monitoring of a set of 5 indicators that have been developed to manage Country. This particular project has been supported by CSIRO (Robinson et al 2021) and the North Australian Environmental Resources (NESP) hub with Bininj and Mungguy ran from 2019 to 2021. Note that the term Munggay refers to the customary landowners in the southern part of Kakadu National Park, while Bininj are in the north. The Traditional Owner-driven project identified three ecological zones (stone Country, floodplains and woodlands) as pilot sites that they then monitored for change using the indicators they developed (NESP n.d).

This project used aerial drones, sensor cameras and other forms of artificial intelligence (AI). The use of these technologies was Indigenous-led to ensure the co-design and use of digital technologies that enable data collection and analytical efforts from which they developed the Healthy Country AI model. This model governed by Traditional Owners, reflects the priority areas of Traditional Owners and rangers, responds to the seasonal aspects of their stewardship of their estates and supports on-ground adaptive co-management efforts. (Robinson et al., 2021).

The Healthy Country AI model was constructed with several layers of privacy, as some of the sites where the drones collect data are sacred to Traditional Owners and imagery and data from those sites need to be protected. The Healthy Country AI model converts large volumes of data (thousands of high-resolution photos) into metrics – in this case, magpie goose numbers and spread of para grass – to demonstrate how Bininj-identified country indicators are changing following management interventions. The Bininj-Mungguy Indicators project was developed to also show how and why these indicators can be used as decision triggers to guide adaptive joint management in decision-making for Kakadu National Park.

Traditional Owners at the two sites that were being monitored (Nardab and Jarranbanmi) raised their concerns regarding drone use. These concerns included that the user might ‘see’ restricted sacred sites, including gendered sites, and that sensitive information might be recorded in an open-access database. Other concerns were that Traditional Owners might be removed from decision-making processes on Country. As the Robinson et al (2021: 12) report highlighted in their review of an on-Country workshop at Jarranbanmi:

It’s alright that you bring that technology, but you need to make sure you bring TOs [Traditional Owners] with you when you’re setting it up so they’re still on Country, learning and listening to Country. – Wurrkbarbar Traditional Owner, Jarranbanmi, 25/06/2019

The collaboration between the researchers and Traditional Owners co-designed protocols to ensure drones and the data collected responded to privacy, data ownership and protection, and ethical risks identified from drone use and surveillance. These protocols included the need to:

1. Empower Indigenous governance for Country to decide when technology should be used and how it can benefit *Bininj/Mungguy*
2. Respect kin-Country relationships to guide where, when and what technology can help Traditional Owners and rangers to see and hear, when they are on Country and when they are not
3. Enable training opportunities so Traditional Owners and rangers can use this technology, especially their young people.

As Robinson et al. (2021, p. 12) state, “these protocols provided a way for Indigenous people to guide and authorise the introduction of new technologies that are used to produce new knowledge needed to adaptively co-manage Indigenous people’s lands”.

This is an example of when partnerships and cross-scalar allies are integral to the funding and delivery of caring for Country projects and where partnerships have played a key role in empowering Indigenous communities toward achieving greater levels of on-Country management of invasive species.

Figure 5 illustrates a drone use application in the project designed to empower Indigenous land managers rapidly survey large areas and interpret drone-collected footage to show important changes to the ecosystem following on-ground management interventions.

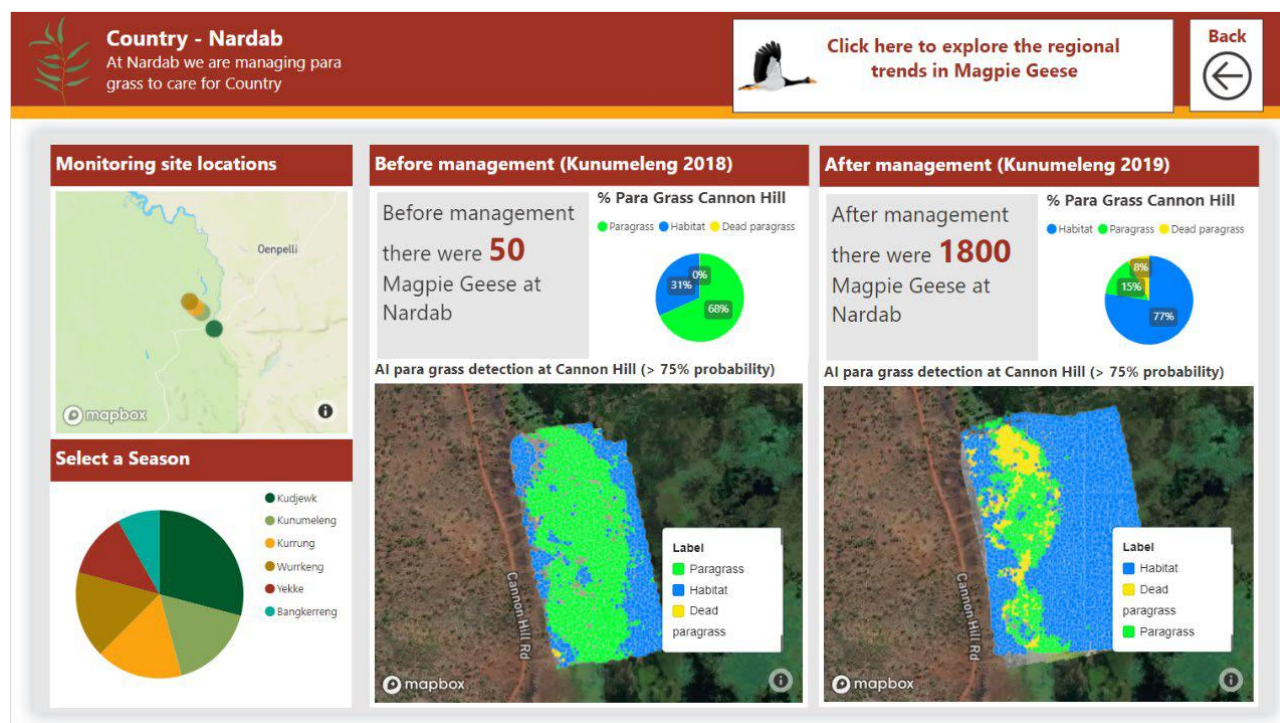


Figure 5: The Healthy Country AI model. Source Robinson et al. (2021, p. 11)

4.9 The “use of drones is not an end in itself”

Not all Indigenous organisations in our research sample have embraced drone technology; for example, the Central Land Council. Participant 1 explains that drones are a tool and his organisation has yet to find an application for the tool. In other words, “using drones is not an end in itself”:

The original idea was to use it, to find sacred sites remotely to get [access to sites]. So, for cultural mapping [...] Yeah. So all people who are mobile enough that they couldn't walk to a site but could get within a few 100 metres of it [...] they could sit in the car and fly the drone in and identify spots within the site using the camera, and I've had a few people come back from the field and say, Oh, we did this, and so where's the evidence of it? Did you record anything? [they replied] No, but it was fun. And so, we didn't get any corporate knowledge or ongoing benefit to TOs [Traditional Owners] from Land council by doing that exercise. And it's also a fairly specific activity that the drone is identified as the solution before you know that you need a solution.

So in some instances, a TO might be willing to walk to that site, but an enthusiastic land management person will say, ‘Oh, you don't have to walk to the site you can sit here in the car and watch it on the camera’, which probably is, you know, diminishes people's access to country. So, in that way the drones are more of a solution looking for a problem.

Participant 1 also discussed how, in these remote desert areas, helicopters are the dominant technology for land management, including feral animal control or weed surveys. Though he did suggest that some of those problems could be solved with drones, at this stage the drone capability isn't there for their specific needs: as it's not yet possible to go out and map vast areas or travel long distances beyond line of sight. This is because of the scale of the desert, which makes solving these logistical issues not straightforward.

4.10 Potential future uses

The potential scope of future drone applications was raised by several participants. For instance, Participant 1 says future potential uses include **carbon abatement projects and fire management** in carbon farming:

The big value proposition I can see at the moment is with carbon projects. And so where there's a financial imperative to burn as cheaply as possible. And if you, if you could save [on a] \$50,000 helicopter bill four times a year by using a \$200,000 drone that only costs you, you know, staff time and some maintenance to run that...then that's a really good use for a drone [...]. And you have to report that fuel and emissions usage when you calculate your carbon credit...that's what I'm hanging out for is for carbon projects in fairly simple terrain, as in not too mountainous where you can send a drone with a good range like a I don't know a 40 kilometre range, or something beyond line of sight, with a pre-programmed run to drop incendiaries at pre-program points, and then fly home.

There's now [...] incendiary machines made for a specific type of drone. There's a bunch of people in town [Alice Springs] at fire and rescue who have the qualification to fly these things out of line of sight and that will be a very, very useful tool for fire management. We're talking about a \$200,000 drone with a \$100,000 incendiary machine.

Another emerging use raised by participants is the potential use of hydrogen-fuelled drones to **transport medicine and other medical supplies** to remote Aboriginal communities. Speaking about a pilot project involving desert communities, Dowding (Winyama) acknowledges the potential is there for the 'public good' but raises a number of questions that need to be addressed:

Where is the flight path? And does it intersect with areas that Aboriginal people may be sensitive about? Those questions stumped the drone group because they were like, well, we're in airspace. So, what are we interacting with here? [...] well, you are doing scanning, and your cameras are working as the drone's flying over, and all the landscape is being captured as you're flying. And so that's what the [Indigenous] group is concerned about, right like a view from above. And because the drone is so low to the ground. It's not like an aircraft in airspace. It's you know, it's at a high could be at 100 metres. But the camera [is always on].

Other questions [I] had were: How high is the cruising altitude? And then how does the drone approach when it comes to the community? How low is it? So those are the things we're currently waiting [...] to [...] map out because that's ... I think the issue of concern that the community has: Drones are overhead. What are they doing? And there's no [...] protocol at the moment.

Likewise, the use of drones for **cultural mapping** seems nascent at this stage, according to Dowding. It is rarely anthropologists using the technology, but usually rangers and other land management staff who may coincidentally be recording sacred sites/sites of spiritual significance as they undertake their core activities. As a result, they do not have the knowledge management systems in place to ensure effective knowledge governance of this drone data. Shifting this ad hoc pattern will require the establishment of an integrated approach to working across these different units / departments in land councils and other organisations, such as prescribed body corporates (PBCs) who operate in this field.

5. Discussion

Anyone familiar with Indigenous art from Central Australia (NT) and the Kimberley (WA) can see an alignment with the contemporary use of drones – as looking down from above – and the landscape scale movement across the land that is embodied in so much of this art. Though it may be 'fun' to fly drones, and this in itself is a great hook to engaging with any new technology, the 'sky camera' also suits an Indigenous sensibility. This cultural insight takes a landscape level approach to land stewardship and caring for Country. As places and sites are interconnected rather than isolated units, drones provide an opportunity to view the Country as a more complete, large-scale domain – i.e. an estate wide level – and this aligns with cultural norms. Nevertheless, it is critical to ensure that this new knowledge economy of drone data is effectively managed and controlled in local cultural terms.

In the book *Decolonising the Digital: Technology as Cultural Practice*, the authors argue that "technology is not a neutral instrument, but the application of a particular culturally-specific set of knowledge[s] to solve a (perceived) problem. Technology is a cultural practice" (Harle et al., 2018). The authors argue for the importance of 'decolonising the digital' which, in broad terms, describes a process of disentanglement from colonial power, seeking independence and self-governance: "creating and consciously using various strategies to liberate oneself from, or adapt to, or survive in oppressive conditions" (Harle et al., 2018, p. 10). As they discuss, decolonising is an ongoing process.

Decades earlier, the anthropologist Eric Michaels, working with the Warlpiri in central Australia, wrote the book *For a Cultural Future: Francis Jupurrurla Makes TV at Yuendumu* that documented

the development of Aboriginal television broadcasting in Yuendumu, (NT), through the work of Francis Jupurrurla and the Warlpiri Media Association. He explored how Warlpiri strategically adapted western media technologies like video and satellite television to serve their own cultural interests and created a distinct media practice that coexisted with traditional forms. This cultural future is based on an agenda for cultural maintenance that not only assumes some privileged authority for traditional modes of cultural production but also argues that the political survival of Indigenous people is dependent upon their capacity to continue reproducing these forms (Michaels, 1987).

Such a creative engagement has carried over to the new technology of drones, as Clifford Sunfly (Ngururrpa Rangers) talked about his groups elders now having the drone to map out country, instead of using their minds (Indigenous Desert Alliance, 2023).

Our research shows that Indigenous organisations in Australia are engaging with drone technology to take a landscape level approach to land stewardship and caring for Country, to democratise scientific data collection and for cultural purposes – extending traditional modes of cultural production. In making use of this technology, Indigenous peoples are also challenging the regulatory requirements for drone licensing and training, establishing their own culturally safe processes. Importantly, such culturally informed processes are locally driven and reflect the Indigenous polity and customary governance structures. As a result, though high level principles are useful and have been developed (i.e. by CSIRO, 2022 and the CARE principles), it is at the local level where specific protocols are appropriately established.

5.1 Conclusions

In this section we return to the project aims outlined in Section 2.

We found that there is a wide variety of **Indigenous organisations using drones**, including ranger groups, PBCs, land councils and Indigenous-owned businesses. We note, however, that across Australia there is considerable diversity of uptake among organisations. Not all groups have embraced drone technology. For some groups, drones are an essential part of their monitoring toolkit and are used frequently, for example, by the GMY rangers. Other groups, such as the Indigenous land management group within the CLC (central Australia), have not found drones to be an essential or particularly useful tool yet.

We did not identify significant drone use in Australia that supported the assertion of jurisdiction and territorial rights, protection and preservation of traditional lands or countermapping as is common in Latin America and Indonesia. Like elsewhere in the world, Indigenous peoples and organisations in Australia are undertaking participatory mapping, training and forging partnerships with NGOs, research institutions and universities.

The drone applications used by these groups is extensive and varied, incorporating land use monitoring and land management, cultural mapping, photography for advocacy, filmmaking and cultural light shows. This observation tells us that Indigenous peoples see drones as an opportunity and we expect the range of applications to continue to grow.

As Macdonald et al. (2021, p. 303) indicate, “drones have the capacity to produce increasingly accurate and precise wildlife and habitat monitoring data, allowing for more informed and proactive environmental management. Additionally, drones can produce accurate and replicable data at larger scales than on-ground assessments [...] and] their application for environmental management is profound”.

Due to their reliance and connection with natural resources, “Indigenous peoples [...] are often the first to feel the impacts of environmental crises such as deforestation and droughts. Consequently, films about Indigenous sustainability display stories of resilience and survival

that allow for the renegotiation of global and local meanings of natural resources” (Frey, 2018, p. ii).

Agreements and protocols for drone use are starting to emerge, although we have not found many examples of agreement content in the public arena. Often Indigenous peoples operate drones on their own land, so the protocols that are developed in this context are specific – to the group and to the drone use context.

The CSIRO has undertaken concerted collaborative work with several groups in the NT over the past decade and as a result they have developed a short guide on the “Responsible use of drones and other digital technologies on Indigenous owned and managed Country” (CSIRO, 2022). The co-designed rules mandate that:

- Traditional Owners must be on Country when drones are used
- Traditional Owners map the area the drone can fly to ensure knowledge and sites are protected and access rules are respected
- Young Indigenous people to drive the technology so that they learn and benefit from the process.

These rules for technology use on Country and the ensuing protocols that emerged from this collaborative work ensured that the introduction of new technologies to Country was:

- transparent
- purpose oriented
- responsive to context
- provided benefit
- centred the user in the design.

We expect protocols for data storage to become more prominent in the future given that storage options are mostly external to Indigenous organisations capturing drone data. However, importantly, no set of protocols nor single agreement is applicable Australia wide. As the Indigenous polity is diverse and territorially based, each Indigenous group (however defined) will require its own set of protocols, though there may be shared or transferable principles.

In relation to the objective of **identifying opportunities for drone pilot training and data sharing** between the UQ Drone Collaboration Research Platform and Indigenous groups, this would require further discussion with the UQ team as to its capacity to engage. Our project has connected with several Indigenous groups who actively partner with universities and NGOs to scale up their work, so there are opportunities to engage with these groups. However, the UQ team needs to determine its own interests and the funding possibilities that would support engagement and the establishment of subsequent partnerships.

The collaborative social enterprises, SheMaps and GeoNadir (Paul Mead and Karen Joyce), illustrate an empowering partnership model with several Indigenous organisations. We recommend that the UQ drone team reaches out to Mead and Joyce for guidance and to identify potential for shared projects.

It is an expensive and time-consuming option for Indigenous groups to come to UQ to use the platform. They often have already established relationships with training providers, such as with GeoNadir and Indigenous companies profiled in the report (Winyama and Wiru Drones Solutions). In addition, data capture tends to be related to the Indigenous group’s Country, so it is unlikely they would want to share their data with UQ, given concerns about data sovereignty and governance.

Present high-level ethics guidance for researchers: Researchers should be informed about the impetus for the Indigenous data sovereignty and governance movement and follow the CARE principles (see Section 4.7.1) and the CSIRO Responsible use of Drones principles (2022) in designing drone use projects that intersect with the interests of Indigenous rights holders. Developing relationships with Indigenous peoples and organisations who are custodians of the land of interest is not just about adding another set of stakeholders to the project. It is also about another set of knowledge practices providing additional, in some cases alternative, insights into drone use.

In areas on the Indigenous estate where the Traditional Owners or native title holders are managing the technology and using it for their own purposes, the development of local protocols is far more straightforward than other contexts.

5.2 Recommendations for future research

We note a potential gap in human research ethics requirements when commissioned projects are understood as consultancy rather than research and in situations where researchers' interface with Indigenous rights and interest holders is incidental or indirect. The university's ethics process does not account for these circumstances and work is required to address this gap.

In addition, this project did not include a scan of drone use across all states and territories within Australia. Future research should extend the geographic spread of investigation, particularly in New South Wales and South Australia. There is also scope for case study research and comparative studies of Indigenous peoples' drone use in Australia.

Future research could investigate drone use in community and on Country, exploring topics such as:

- Drone use as a cultural practice. Gaining insights into the creative and adaptive ways in which drone technology is being harnessed by Indigenous rights and interest holders is only possible by on the ground engagement. We know that there are cultural norms and practices – such as gender relations – that need to be managed both in relation to site-specific places, as well as in work-based interactions.
- Engagement with this technology on Country will provide insights into this intercultural sphere and the ways in which drone use is pushing the boundaries of Indigenous knowledge governance and the implications for knowledge management practices.
- Spiritual dimensions of drone use, including an exploration of the concept of 'sky country'.
- How drones are acting as a tool for local empowerment and conversely contexts where this is not the case, where drone-use may be encroaching on Indigenous rights and interests.
- The challenges and barriers that operating drones on native title lands poses for Indigenous rangers and other land managers seeking to conduct land management, and the associated issues of training requirements.

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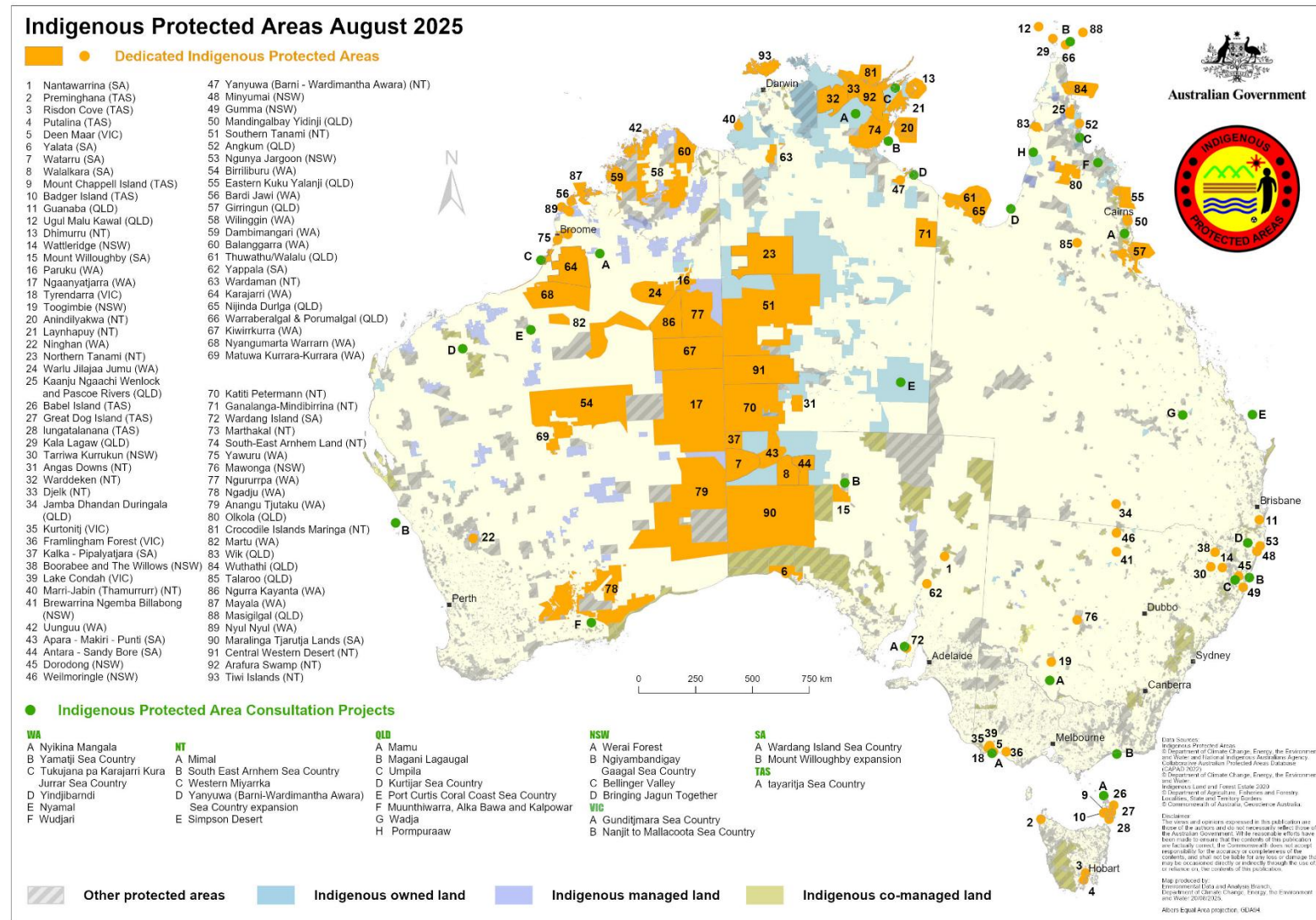
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Appendix A: Indigenous Protected Areas map



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