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Evolving nature-based solutions for Australia's Indigenous estate in 2024 – opportunities and challenges

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ABSTRACT

Globally, there is growing interest and potential for investment in Nature-based Solutions (NbS) to protect, manage or restore ecosystems through incentive schemes including Payment for Ecosystem Services (PES), Nature Repair, Carbon Markets, Common Asset Trusts. Collectively, these NbS markets establish interchangeable mechanisms to help address biodiversity and climate crises, as well as socio-economic issues concerning many Indigenous Peoples and Local Communities (IPLCs). IPLCs manage and/or own almost 32% of the world's land area through customary and community-based tenure arrangements. Since 2000 several PES schemes have been implemented in Australia. These schemes have been overwhelmingly implemented as public-good expenditure, with governments providing ~90% of total funding. Indigenous people have either the legal right to run or veto a carbon market or nature repair project over 57% of the Australian land mass, increasing to 63% in savanna and 85% in desert regions. Here we critically assess opportunities and challenges for Australia's Indigenous estate associated with existing and emerging NbS market approaches, especially the Commonwealth's current Savanna Fire Management (SFM) and Human Induced Regeneration methods, evolving Integrated Farm & Land Management (IFLM) and Blue Carbon methods, and proposed Nature Repair (NR) market. To date, Indigenous NbS interests have focused especially on SFM across northern Australia, with prospective opportunities especially for IFLM and NR markets. Most available schemes focus on remediation of degraded lands and seas, ignoring cost-effective investment opportunities to maintain habitats and ecosystems in less-degraded condition. Government-supported Common Asset Trusts can provide effective models for governance of stewardship schemes relevant to on-going care for relatively intact ecosystems. In Discussion we summarise key methodological, institutional, and policy opportunities and challenges for constructive Indigenous engagement with developing NbS markets. Our purpose is to provide an Indigenous land and sea management context to inform development of rapidly evolving NbS markets in Australia.

Keywords: Aboriginal and Torres Strait Islander peoples, Australia, carbon markets, common asset trusts, Indigenous, nature repair, nature-based solutions, payments for environmental services, stewardship.

Introduction

With recent growing interest and potential investment in nature-based solutions (NbS), a local, regional and global level understanding of emerging nature-based opportunities to deliver required biodiversity and climate change outcomes is essential. NbS are viewed as feasible alternatives in private and public sectors including State governments, corporations, conservation organisations, and others (IPBES 2019, 2022; UNEP (United Nations Environment Programme) 2023). The need for NbS to transform from current GDP (gross domestic product)-based to sustainable economies is highlighted by international organisations including the United Nations Intergovernmental Panel on Climate Change

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(IPCC 2022), UN-led Millennium Assessment program (2000–2005; 2005), and recently the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES 2019, 2022), World Economic Forum WE (2020) and eminent scholars across the globe. NbS are seen as a key strategy in this context. The recent 'Finance for Nature' report by the UNEP (United Nations Environment Programme) (2023) advises that a USD540 billion investment in NbS is required by 2030 to address the current crisis of biodiversity, climate change and land degradation, nearly tripling the present investment of USD200 billion per year. NbS offer diverse, sustainable, and unique opportunities, with multiple environmental and socio-economic outcomes, critical for sustainable economic development – often a focus for State governments (Bears 2020).

The International Union for Conservation of Nature (IUCN) defines NbS as the actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits (IUCN 2020). NbS involve a range of approaches – from the restoration and protection of habitats and ecosystems to land and water resource management, disaster risk reduction, and developing green infrastructure – that address both societal and environmental needs (Bears 2020; IUCN 2020). NbS are based on the notion that when ecosystems are healthy and well-managed, they provide essential benefits and services to people. To support NbS activities, Payment for Ecosystem Services (PES) – typically perceived as a pathway to exchange resources among natural resource users (beneficiaries) and managers (providers) – provide a mechanism to address biodiversity and climate crises as well as socio-economic issues concerning many Indigenous Peoples and Local Communities (IPLCs), if appropriately developed and implemented (Grima *et al.* 2016; TNC 2020; Badola *et al.* 2021; Costanza *et al.* 2021; Sangha *et al.* 2024).

Globally, IPLCs manage and/or own almost 32% of the global land area through customary and community-based tenure arrangements (WWF *et al.* 2021; Rights and Resources Initiative 2023). There is growing recognition that IPLCs' managed lands/resources typically are managed sustainably (Sangha 2020; Dawson *et al.* 2021; WWF *et al.* 2021; IPBES 2019, 2022).

In Australia, the momentum has been growing rapidly in recent years to realise emerging NbS opportunities. The success of the existing *Carbon Farming Act 2011 (Cth)* (CoA 2011) in establishing a carbon market has initiated the potential of nature-based economies for wider benefits. The *Nature Repair Act 2023* was passed by the Australian Government in December 2023 to create a national framework for establishing a voluntary national biodiversity market (CoA 2023*a*). Under this Act, proponents will be able to register biodiversity projects with a Regulator responsible for the approval of the project under a given methodology. This work is being managed by the Australian Department of Climate Change, Environment and Water (DCCEEW), and methodologies are expected to be ready for the market before the end of 2024. However, it is important to note that Indigenous perspectives on managing their lands can differ significantly from that of mainstream land managers (Sangha and Russell-Smith 2017; Russell-Smith and Sangha 2019; Russell-Smith *et al.* 2019); a deeper understanding and integration of Indigenous perspectives in these emerging economic frameworks and methods is thus essential.

For applying NbS-PES in Australia, we follow the comprehensive definition by Muradian *et al.* (2010), which regards PES as a mechanism to help transfer resources between social actors, with the aim of creating incentives to align individual and/or collective land use decisions with social interests in the management of natural resources – contrasted with the common perception that sees PES as a market mechanism. We postulate PES as a 'system' for delivering effective NbS to address environmental crises as well as socio-economic issues (following Costanza *et al.* 2021), while encompassing diverse values, outcomes, actors and their needs and aspirations (refer Sangha *et al.* 2024).

In Australia, since 2000 several PES-like schemes have been implemented mainly by government, with more than 90% funding from public sources (Sangha *et al.* 2024). These schemes include private land conservation for protecting threatened species and habitats through Conservation Agreements, Water Buyback in the Murray–Darling Basin, Reef Credits, and Carbon Farming. In particular, the Carbon Farming Initiative (under the *Carbon Farming Act 2011*), recently known as the Emissions Reduction Fund and currently the Australian Carbon Credit Unit (ACCU) Scheme, with initial funds of AUD2.5 billion in 2012 and an additional AUD2 billion in 2019, has proven popular; it involves >35 approved methods such as savanna fire management, landfill, and land-based activities (Russell-Smith *et al.* 2013, 2015; Grafton and Wheeler 2018; Baumber *et al.* 2019; Edwards *et al.* 2021). Of the available Carbon Farming methods, the Savanna Fire Management (SFM) method has been particularly successful for Indigenous land managers in northern Australia, where they manage 34 projects, covering nearly 24 M ha, and abate 1.2 M tonnes of greenhouse gas emissions per year while delivering a regional economy of >AUD50 million per year across the north (Russell-Smith *et al.* 2013, 2015; Edwards *et al.* 2021; ICIN 2022; CoA 2023*b*). The voluntary market, particularly institutions with corporate social responsibility (CSR) obligations, has also been a major supporter of Indigenous projects and buyer of generated ACCUs.

Expansion of the current carbon economy to broader nature-based economies (including biodiversity, land and water management, weed and pest management) is also important to meet Australia's commitment to the Global Biodiversity Framework for protecting 30% of land and

oceans by 2023 (CoA 2024*a*). Nature-based opportunities will help realise such targets but require appropriate policy infrastructure, design and overall operating arrangements. Currently <10% of conservation projects in Australia are privately funded (Sangha *et al.* 2024). The total required for nature restoration is estimated at AUD2 billion per annum (PWC 2022). To attract more private investment, the Australian Government aims to create an independent market framework allowing landholders (private individuals, Aboriginal and Torres Strait Islander peoples, conservation groups, farmers) to trade/exchange biodiversity credits to interested businesses, organisations, governments and individuals in voluntary markets. However, this requires a deeper understanding of the processes to encourage, especially for Aboriginal and Torres Strait Islander peoples, safe and secure participation in these emerging opportunities. The appetite for voluntary investment in biodiversity markets is currently unknown.

In this paper we undertake a critical assessment of opportunities and challenges afforded by current and emerging NbS market-based instruments, associated technical issues and policy settings, as these apply to rapidly growing and evolving Aboriginal and Torres Strait Islander interests in lands and seas, with a particular focus on northern Australia. In the Discussion, we also address significant broader environmental and cultural stewardship issues and opportunities that have mostly fallen outside of current NbS market considerations. We acknowledge that this contribution is not framed on specific consultations with, nor represents, the views of relevant Aboriginal and Torres Strait Islander parties, but draws from cited and acknowledged resources and the informed experiences of respective authors.

Indigenous land use context

The Indigenous Carbon Industry Network (ICIN), a membership-based organisation serving the interests of 34 Indigenous organisations, asserts that Indigenous rights and interests continue to extend over the entirety of Australia. The ICIN has however mapped Indigenous rights and interests through regulatory frameworks recognising Indigenous NbS engagement opportunities (ICIN 2022, 2024). The classification system used by ICIN accords with the Australian Government's *Carbon Credits (Carbon Farming Initiative) Act 2011,* and the requirements that are similarly set out in the *Nature Repair Act 2023* for developing the Nature Repair market. Current Commonwealth legal rights of and opportunities for Aboriginal and Torres Strait Islander peoples to participate in NbS markets are set out in CoA (2018*a*) and considered further below. With respect to Australian political jurisdictions and generalised land cover mapping referred to throughout this paper (Fig. 1*a*), the ICIN mapping amalgamates publicly available spatial datasets using a systematic, objective process to define the Indigenous estate (Fig. 1*b*), with respective Classes described in Table 1. A description of the input layers is in the metadata file available on the Seamap Australia website (https://seamapaustralia.org).

Indigenous rights and interests are classified by ICIN into seven categories, based on the relative 'strength' of rights in relation to the ACCU Scheme and the emerging Nature Repair Market (ICIN 2024). The strongest form of legally recognised rights ('Class 1') is where Aboriginal or Torres Strait Islander people would by default have the legal right to run a project and claim Australian Carbon Credit Units (ACCUs). Class 1 lands are those where the tenure is either Indigenous owned, land held by others for Indigenous purposes, or where exclusive possession Native Title has been determined. Class 1 lands cover 28% of the Australian land mass, including 27% of the north's savanna region (Table 1 and Fig. 1*b*).

The 2024 ICIN report also identified that Aboriginal and Torres Strait Islander peoples are likely to hold an eligible interest over an additional 28% of the Australian land mass, and 36% of the savanna. Importantly, a project cannot be issued ACCUs (or Biodiversity Certificates) without the consent of all eligible interest holders (CoA 2018*a*). 'Class 2' lands are those where nonexclusive possession Native Title has been determined. Areas of jointly managed national parks where the underlying tenure is not Indigenous owned (Class 3) represent a further 1% of Australia. For Class 3, ICIN identified that some formal agreement may be required to undertake a carbon project. Classes 4 to 7 do not have legally recognised rights in regards to carbon or nature repair under Australian law.

Collectively, for Classes 1–3, Aboriginal and Torres Strait Islander peoples either have the legal right to implement a carbon or nature repair project, or have the right to veto others from implementing a project (if agreement cannot be reached between parties) over 57% of the Australian land mass. This increases to 63% of the land area if the focus is narrowed to the savanna region only, and 85% for desert regions (ICIN 2024).

When considering either blue carbon or coastal nature repair opportunities, Indigenous people hold the legal right to implement a project along 39% of the coastline, and hold an eligible interest in a further 27% of the coastline. Indigenous rights and interests are strongest in the Northern Territory, with Aboriginal and Torres Strait Islander peoples holding either legal rights or an eligible interest in more than 86% of the coastline (ICIN 2024).

Current opportunities and challenges for Indigenous market-based projects

Certified methods are effectively the gateway to the market; if there is no applicable and practical method available that aligns with Indigenous land management aspirations, there is little opportunity for Aboriginal and Torres Strait Islander

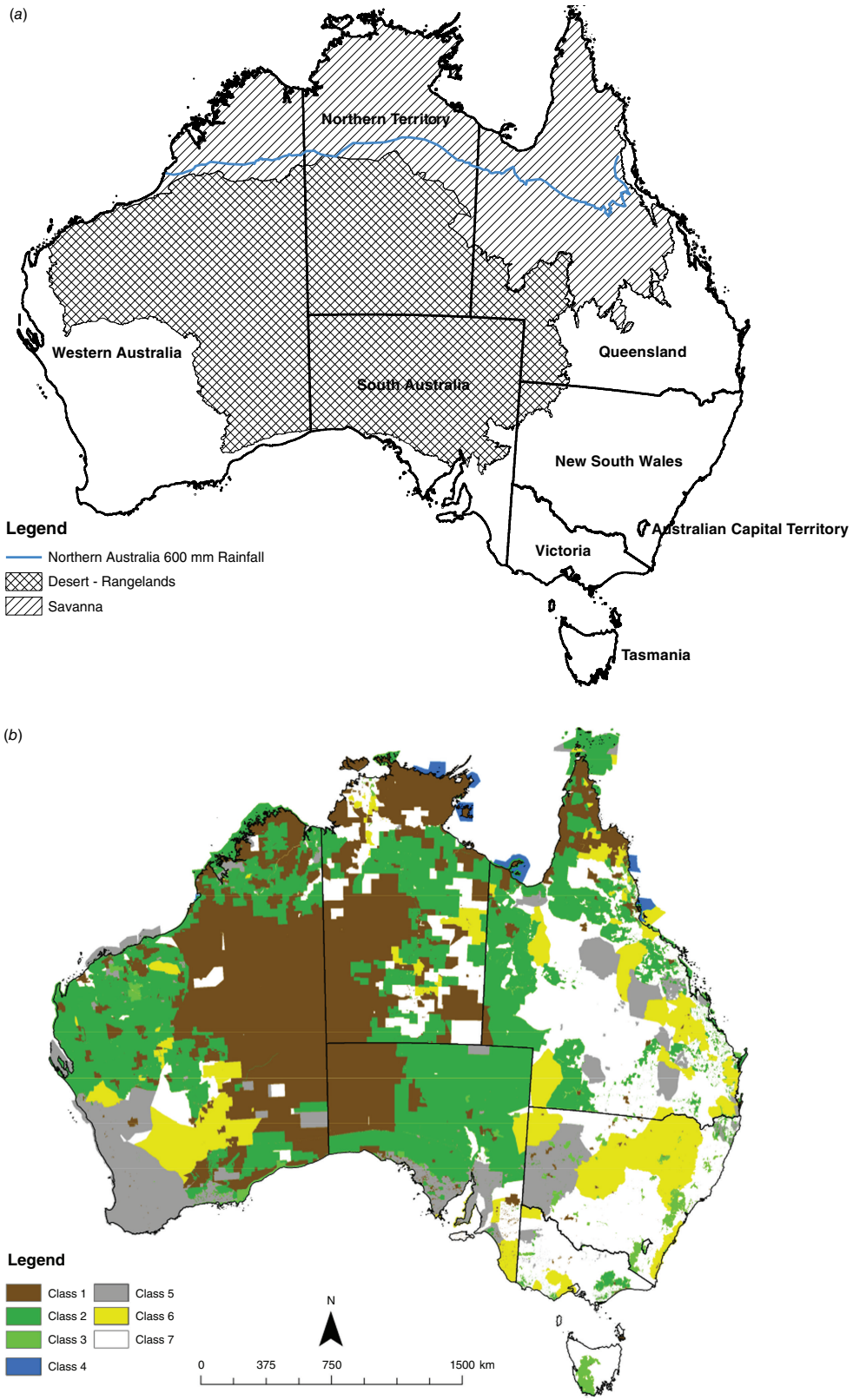


Fig. 1. (*Caption on next page*)

Fig. 1. (*a*) Map of Australia broadly outlining landscape contexts discussed in text – desert rangelands, tropical savannas, 600 mm rainfall isohyet delimiting southern extent of Savanna Fire Management projects, (*b*) Indigenous land use and carbon interests (ICIN 2024) – refer to Table 1 for Class descriptions; (*c*) active north Australian ACCU Scheme project boundaries (revoked projects excluded) overlaid on fire frequency mapping 2000–2023; (*d*) location of Indigenous and nonIndigenous SFM and HIR projects in northern Australia. Map sources for maps (*c*), (*d*): CoA (2024*b*, 2024*c*) – project boundaries; NAFI fire mapping derived from MODIS imagery (https://firenorth.org.au/nafi3/). NAZ, Northern Arid Zone.

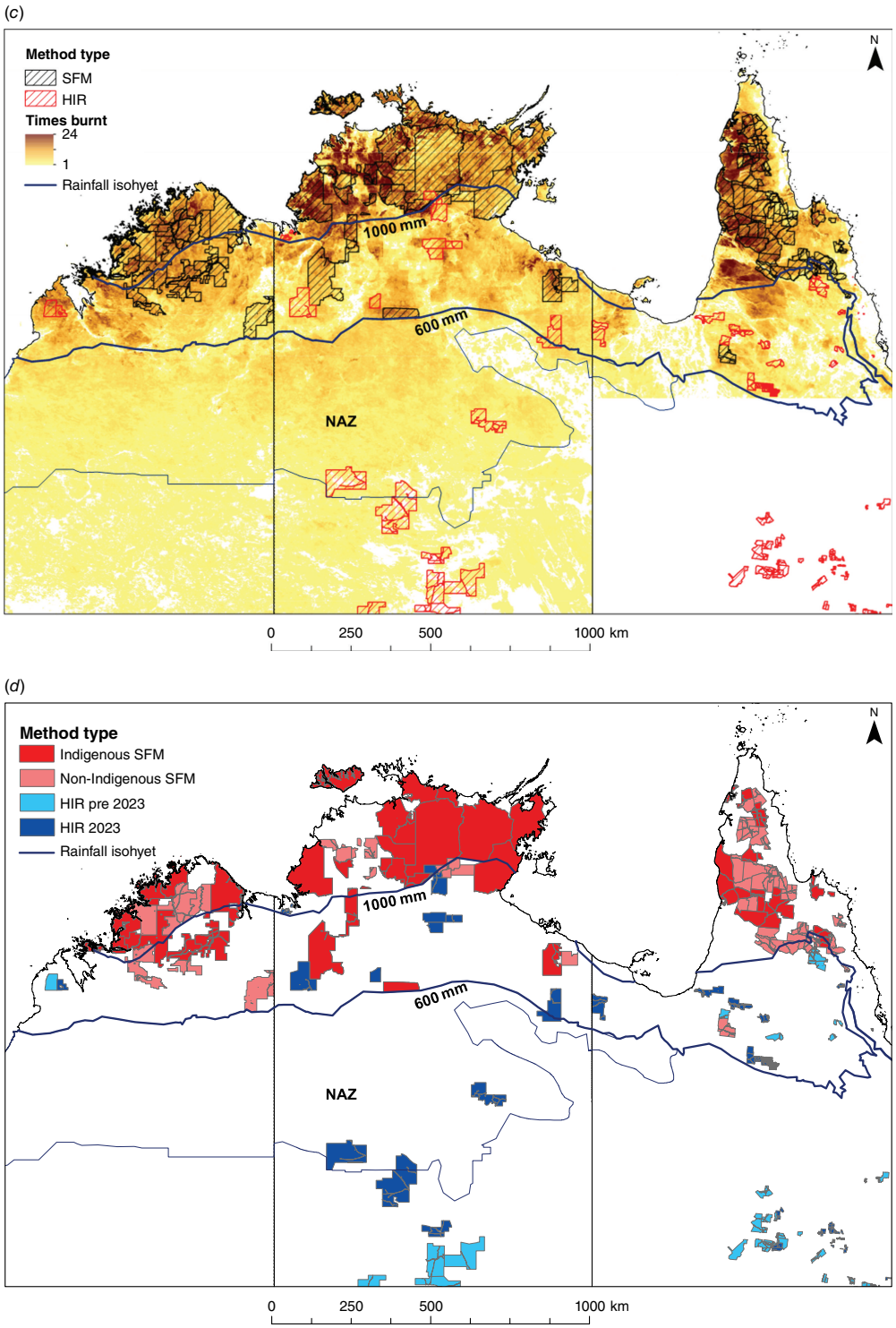


Fig. 1. (*continued*)

Table 1. Classification of Indigenous Land and Carbon interests, following ICIN (2024).

Class	Applicable tenure or interest	Class description
1 Legal right	Exclusive possession native title, and Indigenous-owned land (including jointly managed parks with underlying Indigenous tenure) or land held by others for Indigenous purposes	Exclusive possession native title, and Indigenous-owned land (including jointly managed parks with underlying Indigenous tenure) or land held by others for Indigenous purposes.
2 EIH consent	Nonexclusive possession native title	Aboriginal or Torres Strait Islander people are an Eligible Interest Holder under the ACCU Scheme.
3 EIH or agreement	Joint/comanaged parks where Aboriginal or Torres Strait Islander people do not own the underlying tenure	For this Class, legal right to undertake a project might be established but should not be assumed, as is the case for EIH consent rights. Some other formal agreement may be required. Park specific.
4 Agreement. Management responsibilities	Sea Country Indigenous Protected Areas	Indigenous management responsibilities recognised by Commonwealth via declared community-led Protected Areas, although these are not legally recognised rights (legal or consent rights) under the ACCU Scheme, hence some other formal agreement may be required.
5 Agreement. Determined (no native title)	Native Title Determination made, determined to either be 'extinguished' or 'does not exist'	This Class consists of areas where Aboriginal and Torres Strait Islander peoples' rights are currently not formally recognised under the ACCU Scheme through native title, however rights may exist via other mechanisms (i.e. Indigenous Land Use Agreements).
6 Agreement. Pending Native Title	Pending native title claims that have been accepted for registration	Aboriginal or Torres Strait Islander people have future/ emerging rights that may give rise to a legal right or eligible interest in the future or position them to negotiate certain rights or benefits from a carbon project.
7 Agreement. Other	Other – all remaining areas	This Class consists of areas where Aboriginal or Torres Strait Islander peoples' rights in regard to carbon projects are currently not formally recognised in law/formal agreements (at least not in publicly available information).

peoples to participate in carbon and/or nature repair markets. With respect to market-based Indigenous project opportunities, currently the main focus has been on the successful application of one ACCU Scheme method, Savanna Fire Management (SFM), with prospects for an ACCU Scheme (Integrated Farm and Land Management – IFLM) method under development, and a future Blue Carbon method currently being researched. Additionally, the Queensland Government's Land Restoration Fund (LRF) supports carbon projects undertaken in Queensland that value complementary biodiversity and/or cultural benefits. Although still under development, the Commonwealth's proposed nature repair market is designed to support private financing of biodiversity conservation and remediation projects. Other certified methods, often with significant transactional costs, are increasingly available – for example, methods developed under the *Accounting for Nature Standard* (https://www.accountingfornature.org/standard) may be utilised in Queensland's LRF scheme.

ACCU scheme methods

Despite having extensive land interests across Australia, there is a concerningly low level of intersection between areas of strong Indigenous rights and suitable ACCU Scheme methods, restricting opportunities for Indigenous participation in the scheme. The exception has been Savanna Fire Management (SFM) methods. Of the 38 Indigenous owned and operated ACCU Scheme projects across Australia, 34 are SFM projects within the savanna (refer Fig. 1*c*, *d*), with only four known Indigenous Human Induced Regeneration (HIR) projects occurring across the 76% of lands where Aboriginal or Torres Strait Islander peoples hold legal right to run a project outside of the savanna (ICIN 2024; CoA 2024*c*). Recently the Australian Government has announced the opportunity to develop independent proponent-led methods – which, as discussed below with reference to Blue Carbon methods, may assist the development of a method focused on carbon abatement in coastal wetlands through the removal of feral animals.

Savanna fire management – SFM

Opportunities

Methods development. In October 2021 the Australian Government announced that a new SFM method had been prioritised for development in 2022. The new method would build on the existing method with updated carbon accounting, and by expanding the carbon pools and vegetation types covered. The additional opportunities from an updated

method relate to the inclusion of the Pindan (*Acacia*-dominated shrubland) vegetation type (Lynch *et al.* 2018), expanded eligible carbon pools including the living biomass component (Murphy *et al.* 2023), and expansion of the Low Rainfall Zone to include an additional vegetation type characterised by shrubby spinifex (*Triodia*) hummock grasslands in the Northern Arid Zone (NAZ) (Yates *et al.* 2023). Inclusion of the NAZ alone would increase the total area of Indigenous owned or managed lands covered by SFM Methods by more than 50% (ICIN 2022; refer Fig. 1*c*, *d* for proposed NAZ).

Although SFM projects currently focus on market-based opportunities to reduce greenhouse gas (GHG) emissions and, potentially in future biomass sequestration, significant related contractual opportunities exist for reducing fuel load hazards and associated emergency management activities focused on asset protection around and within community and urban centres (Russell-Smith *et al.* 2022), and targeted management of fuel hazards to reduce significant smoke impacts on human health (Johnston *et al.* 2012; Williamson *et al.* 2016). To date, such operations have been undertaken mostly as voluntary activities by Indigenous Ranger Groups (IRGs) in limited situations (Russell-Smith *et al.* 2022), but government procurement policy settings are increasingly valuing local and Indigenous provision, with limited examples of IRGs being contracted to provide prescribed burning services on crown land estate around townships (e.g. Katherine in the Northern Territory). Such PES opportunities are in addition to many others currently undertaken by IRGs (e.g. quarantine, surveillance activities, cultural and natural resource management (CNRM) services (Hill *et al.* 2013).

Challenges with the proposed new SFM methodology. As noted, a revised SFM method incorporating two submethod components respectively addressing emissions reduction and carbon sequestration in above ground biomass (AGB – living biomass, standing dead biomass, debris) is in preparation and potentially due for release in late 2024. Among the many challenges involved in transitioning from the widely adopted CoA (2015*a*) method to the revised SFM method is the need to account fairly for the woody biomass sequestration already achieved, for example by retaining original project baselines. The proposed new method also provides a fundamental step-change from earlier approaches accounting either for avoided emissions (CoA 2013, 2015*a*), or for sequestration only in dead woody debris biomass pools (CoA 2018*b*). These enhanced new submethods will be included within the national carbon accounting modelling framework (FullCAM) both to enhance the accuracy and functionality both of Australia's National Inventory Reporting (NIR) responsibilities, and accounting for net abatement from registered savanna fire management projects.

A framework for the proposed combined SFM FullCAM method is outlined in Paul and Roxburgh (2024), which essentially collates extensive field data to calibrate model parameters for predicting emissions and sequestration derived from savanna fire regimes. Despite the substantial work involved, the framework acknowledges significant outstanding methodological challenges that need to be effectively addressed in order to meet appropriate integrity standards, including: validated model-based estimates of maximum AGB (*M*) at appropriate scales, including accounting of project baselines and ensuing changes; accounting for stochastic regional climatic/resource variability instead of assuming 'constant *M*'; fire intensity mapping at appropriate pixel (ha) scale; nonfire and fire-resultant stem mortalities; fire intensity effects; AGB recovery rates, Transfer Factors and biomass decomposition rates. Similar challenges with application of FullCAM modelling to robustly account for woody biomass sequestration have been identified in other Australian ACCU Scheme methods (MacIntosh *et al.* 2024).

Additionally, the fire seasonal cutoff date of 1 August used for distinguishing between relatively lower GHG emissions under early dry season conditions, which is applied to all current and proposed methods across the SFM project geographical envelope, requires renewed assessment given both significant existing longitudinal and latitudinal seasonal variability (Perry *et al.* 2020), as well as emerging climate change issues associated especially with projected significant increases in temperature and allied evapotranspiration impacts (Moise *et al.* 2015). Although regional annually flexible approaches to determining the onset of late dry season conditions have been proposed based on identification of dates when savanna fires start burning more-or-less consistently through the night (Maier and Russell-Smith 2012; Eames *et al.* 2023), in any 1 year this does not provide operational surety for SFM projects, which need to commence management planning and subsequent prescribed burning operations well in advance of such an assessment. Perhaps a more feasible approach would be to explore climatic (e.g. rainfall, evapotranspiration) records to assess regional trends in onset of fuel dryness and curing, and adjust seasonal cutoffs in advance of annual fire management programs based on rolling annual or multiyear (e.g. 3–5 year) assessment periods.

These unresolved methodological issues have significant implications for current SFM emissions reduction projects needing to transition to the new method, and prospective sequestration projects: (1) the level of parity between emissions estimates under current and proposed methods; (2) the need for independent validation of sequestration predictions – especially in the context of concerns that FullCAM predictions may likely need major refinements down the track with significant accounting, crediting, financial, and sustainability implications. With respect to the integrity of sequestration estimates, Paul and Roxburgh (2024: Supplementary Material F) note that emerging high-resolution earth observation and LiDAR (Light Detection and Ranging) technologies afford opportunities for direct measurement and monitoring of relationships between woody cover and AGB, and

subsequent calibration of FullCAM modelled outputs. It is notable that ACCU Scheme project developers have recently begun to utilise direct measurement landscape-scale LiDAR assessments in Human Induced Regeneration (HIR) projects (see below), in response to criticism levelled at the integrity of modelled sequestration estimates (MacIntosh *et al.* 2024). Our informed view is that such validation exercises will require both significant further research and development, and appropriate Commonwealth coinvestment, in order to ensure confidence in the integrity of SFM sequestration estimates.

Criticisms and misperceptions. Despite the demonstrable success of market-based SFM projects to deliver GHG emissions reduction (see latest data for savanna burning ACCUs issued at https://cer.gov.au/markets/reports-and-data/accu-project-and-contract-register?view=Map), enhanced landscape fire management (Evans and Russell-Smith 2019; Edwards *et al.* 2021), and transformative community-based and economic outcomes for remote Aboriginal communities (Ansell *et al.* 2020), such programs have also attracted their share of both fair and unfair criticism.

An initial criticism has involved legitimate concerns that SFM projects, especially in the early years of implementation, have not effectively engaged with prospective participating communities, and have involved the subordination of customary rights and practice under imposed operational models and institutional frameworks (Fache and Moizo 2015; Petty *et al.* 2015; Perry *et al.* 2018; Larson *et al.* 2023). While acknowledging these ongoing tensions, it is salutary to note that the original regional fire management project, the Western Arnhem Land Fire Abatement project (WALFA) in the Northern Territory, was borne out of years of collaborations between regional Indigenous land owners, Indigenous representative bodies, fire researchers, government agencies, and subsequently industry partners, where well-informed regional land owners strongly supported trialling the project especially to realise tangible cultural (e.g. access to country; resuming fire and land management responsibilities), community development, economic and employment benefits (Whitehead *et al.* 2008, 2009; Russell-Smith *et al.* 2009, 2013). The fire management program was developed with a profound understanding of and with reference to regional traditional fire management practice (Garde *et al.* 2009), and recognition that such practice was broadly applicable to similar savanna landscape conditions across northern Australia (Russell-Smith *et al.* 2003; Vigilante *et al.* 2009). The success of WALFA resulted in expansion of the current program to over 80,000 km^2 of contiguous Indigenous lands in Arnhem Land under an entirely Indigenously run governance model with strong community endorsement and engagement (Ansell *et al.* 2020), including participation of previously sceptical communities (McKemey *et al.* 2020). However it remains the case that Aboriginal communities and organisations should consider carefully whether SFM projects meet their cultural requirements and development aspirations.

Secondly, despite the demonstrable success of SFM projects to deliver significant GHG emissions reduction across the northern savannas (Edwards *et al.* 2021), and landscape-scale conservation management outcomes in regional projects (Evans and Russell-Smith 2019), recurring criticism is that SFM projects do not address specific biodiversity conservation challenges requiring fine-scale intensive management (Perry *et al.* 2018; Corey *et al.* 2020). As countered by Edwards *et al.* (2021), it needs to be appreciated that SFM projects are not designed nor funded to provide a fire management panacea but, rather, they can provide an effective operational landscape-scale framework, which can serve to deliver various intensive management objectives (e.g. targeted fine-scale fire management for small mammal conservation; safe application of seasonally intense fires for woody plant management). As discussed below, the emerging nature repair market is better suited for such management requirements. Notably, the SFM methodology specifically excludes certain vegetation and landscape types that are vulnerable to woody thickening and deleterious habitat change, and/or conflict with long-standing cultural practices of Aboriginal peoples, under early dry season-dominated fire management regimes (Russell-Smith *et al.* 2014).

Thirdly, recent modelling assessments have attributed significant respiratory health issues in Darwin from smoke and entrained fine particulates 2.5 micrometres (μg) or less (Johnston *et al.* 2007), typically referred to as $PM_{2.5}$, to savanna burning projects undertaken at considerable distances (>200 km) from Darwin, associated especially from early dry season (EDS) south-easterly upwind locations including Kakadu National Park and Arnhem Land (Jones *et al.* 2022; Bowman *et al.* 2024). These assessments derive principally from $PM_{2.5}$ data collected at three urban air pollution monitoring stations established consecutively from 2011, where, under national air quality standards, average daily $PM_{2.5}$ exceedances must not exceed >25 μg m^{-3}. In contrast with the above modelled findings, formal assessment of these same data undertaken by the Northern Territory Environmental Protection Agency found that: (1) average daily $PM_{2.5}$ exceedances have exhibited marked annual variability at respective monitoring stations over respective temporal assessment periods – implying locally derived sources; (2) in 2021, average monthly $PM_{2.5}$ observations exhibited a strong EDS seasonal peak that correlated strongly with monthly fire extent within a 50 km radius of outer Darwin; and (3) analysis of annual fire activity data showed that daily $PM_{2.5}$ exceedances were rarely associated with fires occurring greater than 150 km from Darwin (NTEPA 2023). Combined with the observation that Darwin's $PM_{2.5}$ monitoring is undertaken at ground (breathing)-level, the Jones *et al.* (2022) and Bowman *et al.* (2024) modelling studies do not account for emissions dilution in the vertical atmospheric column

associated with atmospheric transport, especially over long distances (e.g. Luhar *et al.* 2008; Williamson *et al.* 2016).

As noted above, contracted management of fuel hazards to reduce significant smoke impacts on human health affords a significant opportunity for IRGs – and where such costs conceivably might be met by the health insurance industry to deliver both significant health and broader societal benefits. Reducing smoke risks to human health through prescribed fuel management would doubtless be assisted with access to enhanced near-real-time atmospheric modelling capability, as currently being implemented through the establishment of a national smoke monitoring network (see https://research.csiro.au/aqfx/smoke-observation-network/) and allied aerosol transport modelling research (e.g. Sowden *et al.* 2024).

Human induced regeneration (HIR) and integrated farm and land management (IFLM)

The Human Induced Regeneration (HIR) method aims to increase forest cover and associated biomass by carrying out eligible activities (reducing livestock, feral animal impacts) additional to climate effects (e.g. increased rainfall) that encourage regeneration of Australian native tree species native to the project's local area. There are only four registered Human Induced Regeneration (HIR) Projects on Indigenous (Class 1) lands. The HIR method was primarily designed for pastoral lands. Possible reasons as to why the HIR method has had minimal applicability to the Indigenous estate include restricting creditable abatement to only those areas transitioning from nonforest to forest (woody vegetation >2 m, 20% canopy cover on areas >0.2 ha), and not identifying fire management practice as an eligible management activity. IFLM, as originally proposed when prioritised for methods development, did not have the same restrictions as per the HIR Method with regard to what vegetation could be credited, nor was fire management excluded from being an eligible activity. Hence, the development of the IFLM method was identified as a significant opportunity to increase access of Aboriginal and Torres Strait Islander peoples to the ACCU Scheme (ICIN 2022), because, as originally intentioned, the method would be applicable to both pastoral and nonpastoral lands, to a greater array of vegetation types, and provide a mechanism that could credit abatement from Indigenous fire management practice outside of the savanna.

Attempting to design a method that combines multiple accountable activities for all Australian climatic regions, across all property types and sizes, with multiple approaches to calculating abatement, and with only one approach to baselining has been challenging. Unsurprisingly, the IFLM method currently remains incomplete. The ICIN have identified differing challenges facing the development of the IFLM method for two distinct geographic areas. Firstly, for Indigenous rangelands in the arid interior of Australia subject to considerable annual climatic variability, concerns about the HIR method (MacIntosh *et al.* 2024) require a satisfactory resolution. Primarily this requires being able to distinguish between sequestration that is additional due to human intervention, and sequestration resulting from non-human controlled factors such as rainfall, achievable via alternative baseline approaches (e.g. the dynamic performance benchmark approach, as required for Verra 2023).

The second key challenge facing the IFLM method concerns consistency with approaches to carbon accounting in frequently burnt savanna regions. As demonstrated in Fig. 1*c*, relatively frequent fire occurs across both pastoral and nonpastoral lands, hence ~50% of all registered SFM projects are on pastoral leases. Although the HIR method was eligible for application to the savanna region, only 6 HIR Projects were registered in the savanna prior to 2023; before an additional 13 savanna HIR projects were registered in the final months prior to the HIR method sunsetting in September that year. It is anticipated that proponents may register projects under the IFLM method, the planned successor to HIR, in the savanna once the method is finalised. Allowance for orderly transitioning between methods, including potentially between SFM and IFLM, will also require clear guidance; for example, ensuring that credit liabilities (negative uncertainty buffer) incurred under one method are fully accounted for when transferring to another.

The concern in savanna regions is thus to ensure consistency across ACCU Scheme methods such that carbon accounting approaches for effectively the same management activities are applied. For example, in regards to both the developing SFM and IFLM methods, both should have consistent approaches to identifying what vegetation types are eligible for sequestering carbon, similar accounting for proscribed weeds, applying similar baselines in frequently burnt environments (where currently SFM applies historical averages, versus IFLM's proposed net gain approach), what types of models are acceptable for use (currently FullCAM for SFM, versus user-defined for IFLM), and other issues such as approaches to uncertainty buffers and credit issuance. Having multiple regionally appropriate IFLM methods (or modules within a method) may be more appropriate than one method applicable to the entire nation.

Blue carbon

There is currently only one blue carbon ACCU Scheme method (*Tidal Restoration of Blue Carbon Ecosystems*) available in Australia, which involves the reintroduction of tidal flows into coastal wetlands via the removal or changing of a tidal restrictive mechanism such as bunded walls (CoA 2022). The method's applicability is largely confined to high-intensity agricultural areas, predominately the east coast of Australia, where legally recognised Indigenous interests are generally limited (refer Fig. 1*b*). A recently initiated Australian government funded Indigenous blue carbon

project involving Nywaigi Traditional Owners in north Queensland focuses on reintroducing salt-water tidal flows to degraded wetlands through the removal of bund walls and assessing the potential for generating ACCUs (https://www.greeningaustralia.org.au/blue-carbon-the-next-frontier).

Although Australia is considered a global 'blue carbon hotspot' with approximately 12% of the world's blue carbon ecosystems (CoA 2024*d*), having a healthy blue carbon ecosystem does not necessarily equate to an opportunity to undertake a blue carbon project. A limiting factor for Aboriginal and Torres Strait Islander communities is that blue carbon methods, like land-based methods, are often prioritised for activities that restore already degraded systems, rather than incentivising activities that maintain relatively healthy ecosystems. Although Indigenous rights and interests are legally recognised along 66% of the Australian coastline (ICIN 2024), blue carbon opportunities are likely to remain limited without the explicit prioritisation of the development of methods that are applicable to the Indigenous estate. One such method currently being researched is for the management of feral animals (e.g. Asian Water Buffalo) in coastal wetlands (NESP 2024).

Valuing additional benefits: Queensland's land restoration fund (LRF)

The Queensland Government established an AUD500 M Land Restoration Fund (LRF) in 2017 to expand carbon farming in the State supporting carbon projects that deliver additional environmental, socio-economic, and cultural 'cobenefits' – or rather, more aptly described as 'core benefits' (https://www.abcfoundation.org.au/carbon-farming/core-benefits). In addition to cobenefits, other LRF objectives include facilitating private investment, and investing in related research and development to support emerging carbon farming initiatives and markets. The LRF buys carbon credits (following the ACCU Scheme process) at a premium price for additional cobenefits, which it either trades in the private market or uses to meet State Government emissions targets (Queensland Government 2023).

As at 22 November 2023, there were 21 projects registered under the LRF, including five that are Indigenous. Each project is registered under an ACCU Scheme method and is committed to providing additional cobenefits to Aboriginal and Torres Strait Islander peoples. As part of the cobenefit eligibility requirements for Indigenous projects, the project must be registered on Indigenous lands including Aboriginal Freehold, Native title (claim registered or determined), or under Indigenous Land Use Agreements. An Indigenous LRF project must demonstrate Indigenous ownership or participation such as involvement of rangers in fire management. Cobenefit verification approaches involve either proponent assurance where cobenefits are verified based on annual reporting and photo points, or third-party assurance where cobenefits are verified based on evidence certified by an approved third-party framework; e.g. Accounting for Nature accreditation addressing environmental cobenefits (https://www.accountingfornature.org/overview), and Core benefits verification for cultural cobenefits (https://www.abcfoundation.org.au/carbon-farming/core-benefits).

Payments for cobenefits are determined by the LRF's Investment Panel, depending upon the opportunity cost, ecosystem services provided, or the cost of delivering the outcomes. However, there is a lack of clear expectation from the LRF on what type and quantity (i.e. how much improvement), of environmental and/or socio-economic benefits are required. Likewise, it is unclear whether certain types of cobenefits are valued more than others.

Nature repair market

As noted earlier, the *Nature Repair Act 2023* was passed by the Australian Government in December 2023 to create a national framework for establishing a voluntary national biodiversity market (CoA 2023*a*). The Act is meant to establish a nature repair framework and various methodologies currently under development. The main focus of this scheme is to improve biodiversity outcomes through the establishment of a national voluntary market. Examples of activities to be considered for funding include restoring native vegetation through fencing or weeding, planting a mix of local species, and protecting rare grasslands for endangered species. Major unresolved methodological challenges involve the development of consistent equitable crediting standards for application across multiple eligible project activities and varied site-based methods, and addressing likely significant institutional transactional costs involving related engagement, monitoring, reporting and administrative scheme responsibilities.

The ICIN (2024) considers that the Nature Repair market, if appropriately developed, could provide market-based opportunities for the 75% of Indigenous lands that, to date, have been largely ineligible from participating in the ACCU Scheme because of a lack of applicable carbon methods. Application of the Nature Repair scheme to the Indigenous estate may be restricted to situations where significant repair is required for implementing activities such as feral animal or weed management to remediate biodiversity outcomes. It is yet to be seen if the Nature Repair scheme will attach importance to supporting ongoing stewardship of *country* to maintain biodiversity and other ecological values that require additional and ongoing management intervention (e.g. fire management) but are in a relatively good health and state for delivering ecological benefits to present and future generations.

Policy conundra

Despite over a decade's experience implementing ACCU Scheme projects, significant legal and policy barriers confront Indigenous participation in NbS projects, including:

Opacity of rights

It can be difficult (and costly) for Indigenous groups to determine what rights they have to undertake a project and to set out those rights. For example, in the absence of formal Indigenous Land Use Agreements (ILUAs) between Native Title holders and SFM project proponents, it is uncertain whether emissions reduction and especially sequestration projects (requiring long-term 25–100 year contracted commitments), undertaken essentially as 'nonpastoral activities' on pastoral lease lands, invoke Future Act provisions of the Commonwealth's *Native Title Act 1993* (NTA) (refer to CoA 2018*a*). Equally, the application of Native Title rights and their interaction with disparate State and Territory carbon right schemes (where these exist) continues to be unclear and contested (Dore *et al.* 2014; CoA 2015*b*; Russell-Smith and Sangha 2019).

Complexity

Significant difficulties exist for Indigenous groups to access independent (and costly) advice to navigate project development, especially given overlapping land tenure requirements and application of different legislative and regulatory schemes (Dore *et al.* 2014; Bell-James *et al.* 2023). Additionally, the NTA and *Carbon Credits (Carbon Farming Initiative) Act 2011* are constantly being amended.

Institutional capacity

Indigenous organisations are often under-resourced and overcommitted, typically with negligible capacity to develop appropriate Indigenous in-house expertise and support Native Title holder organisations (e.g. Prescribed Body Corporates – PBCs) with potential interests in developing NbS projects with high start-up costs. Although effective project governance models exist (e.g. Ansell *et al.* 2020), development of governance arrangements that address the needs both of stakeholders from Aboriginal or Torres Strait Islander communities and formal regulatory reporting and auditing requirements, as well as providing effective operational oversight, represents a singular challenge.

Applicable methods

As noted previously, limited ACCU Scheme method options are available to potential Aboriginal or Torres Strait Islander participants, including those with strong Indigenous legal rights (e.g. Class 1–3 lands; Fig. 1*b*) over extensive regions; e.g. current lack of SFM, HIR opportunities on non-pastoral lands in central Australia.

Consent

Along with opportunities for developing ILUAs with ACCU Scheme and future Nature Repair project proponents, the right of project veto available to Exclusive and Nonexclusive Native Title holders (CoA 2018*a*) potentially affords significant leverage in negotiating mutually beneficial agreements. However, lack of institutional capacity has meant that opportunities to date to empower Native Title organisations (e.g. PBCs) to take leadership positions and shift paradigms from accepting trickle-down arrangements to ownership/coownership models (Hamrick *et al.* 2023) have been limited. As well, current conditional consent arrangements under the ACCU Scheme (CoA 2018*a*) have enabled third party carbon service providers to rush to register projects without proper/any engagement with Native Title holders. In alignment with the principles of FPIC (Free Prior Informed Consent), a recent recommendation to require project proponents ensure Native Title holders' consent is obtained prior to project registration application (Recommendation 11 of Chubb *et al.* 2022) will bolster the bargaining power of Native Title holders.

Policy inconsistencies – savanna burning projects and land clearing in the Northern Territory

An illustrative example of the complexities and inconsistencies associated with current carbon policies and market instruments in north Australian land sector settings is afforded by stark contrasts between delivering SFM emissions reduction outcomes and pastoral land clearing policies in the Northern Territory. As described in annual reports (see https://kkt.org.au/reports/alfa-2022-annual-report-email.pdf), in recent years Indigenous SFM projects undertaken over 86,000 km^2 in Arnhem Land have consistently delivered annually in excess of 500,000 Australian Carbon Credit Units (1 ACCU = 1 t CO_2-e), valued at well over AUD15 M using the current ACCU market spot price (as at 27 March 2024). Additionally, these formally regulated emissions reductions count directly to offsetting Australia's national GHG accounts and international reporting obligations.

Under agency of the *Pastoral Land Act 1992* (Northern Territory), the Pastoral Lands Board (PLB) is the statutory authority responsible for assessing and granting applications for clearing of native vegetation for accepted pastoral purposes and for nonpastoral use (e.g. irrigated cropping) on leasehold pastoral lands. Under PLB land clearing guidelines (https://nt.gov.au/__data/assets/pdf_file/0003/902289/northern-territory-pastoral-land-clearing-guidelines.pdf), applications for clearing up to 1000 ha of native vegetation for nonirrigated pastoral processes can be streamlined. For applications for clearing up to 5000 ha in aggregate, a pastoral lessee is required to self-refer, or to obtain appropriate advice from the appropriate government Authority, that self-referral is not required. Under the NT Government's Large Emitters Policy (https://depws.nt.gov.au/environment-information/large-emitters-policy), land clearing resulting in emissions >500,000 t CO_2-e, either from a single event or cumulatively from multiple land clearing actions, requires an environmental authorisation and the development of a GHG Abatement Plan aimed at achieving net zero emissions by 2050 as the default expectation.

In the period 2021–2023, the PLB granted land clearing permits for pastoral purposes covering 41,410 ha throughout the NT, including 8 permits for clearing ~3000 ha or greater (https://nt.gov.au/property/land-clearing/pastoral-land/pastoral-land-clearing-applications-and-permits). Outstanding applications (as at March 2024) have been lodged for clearing 26,377 ha, including four for pastoral purposes and one for intensively irrigated nonpastoral purposes, all >3000 ha. It is envisaged that future land clearing applications for nonpastoral purposes are likely to expand significantly, associated with the needs of the emerging northern cotton industry (https://industry.nt.gov.au/_data/assets/pdf_file/0005/1062518/cotton-facts-and-stats.pdf).

In addition to ecological sustainability and legal accountability questions concerning the biodiversity impacts of extensive land clearing in the NT (Brown *et al.* 2022; Quinlan and Silbert 2023), related issues concern the largely unaccounted-for impacts of such clearing on GHG emissions. For illustration, based on research published by Bristow *et al.* (2016), clearing and burning 3000 ha of typical savanna woodland vegetation under ~1000 mm mean annual rainfall conditions (equivalent to the Katherine and Daly River regions of the NT) can generate ~500,000 t CO_2-e – an equivalent quantum earning millions of dollars for SFM projects in Arnhem Land and contributing to Australia's international GHG accounting obligations. Fundamental currently unresolved equity questions follow, for example:

- who should pay/compensate for these land clearing emissions – the pastoral (or nonpastoral use) enterprise, or the public purse?
- who should benefit from emissions credits generated under proposed new SFM sequestration and IFLM accounting methodologies – the lessee and/or the joint State landowners and Native Title holders?
- what are the economic rights and responsibilities of Native Title holders when pastoral lands are cleared for nonpastoral purposes? Does such land clearing trigger legal redress under Future Act provisions?

It is notable that business development risks and uncertainties arising from these same sorts of tenure-related issues and inconsistencies were highlighted as needing concerted attention in the Australian Government's 2015 Northern Development White Paper (CoA 2015*b*).

Discussion

Opportunities and challenges

Although Aboriginal and Torres Strait Islander people have the legal right to run a NbS project (or right of project veto) over much of Australia, limited market-based NbS methods opportunities currently exist over that vast estate. The notable exception is SFM, which supports extensive community-based fire and resource management projects across fire-prone regions of the north. Prospects for Aboriginal and Torres Strait Islander participation in emerging market-based ACCU Scheme (IFLM, Blue Carbon) and Nature Repair methods are unclear to date. These schemes, although geographically extensive, are still under development and lack essential information and assurance concerning core methodological and administrative design features (Table 2). Carbon and additional ecological and cultural benefits are encouraged and rewarded under Queensland's Land Restoration Fund. Collectively, available schemes focus essentially on remediation of damaged or degraded lands and seas, especially in agriculturally developed landscapes in eastern and south-western Australia, not on managing and maintaining the relatively intact landscapes in northern and central Australia.

For their sustainable and economically viable management, significant NbS opportunities are readily feasible but require firstly, a broader appreciation of the inherent value of and support for stewardship arrangements (e.g. Douglass *et al.* 2011; Russell-Smith *et al.* 2019), and second, addressing current policy and regulatory complexities, uncertainties and ambiguities, and thereby barriers to developing mutually beneficial enterprise partnerships, on jointly held title lands and seas (e.g. CoA 2015*b*). The majority of current NbS schemes fail to consider land stewardship, which is vital for maintaining the flow of ecosystem services (e.g. regulation of water and climate, biodiversity protection, land conservation) benefiting both production and natural environmental systems at local, regional and global scales (Sangha *et al.* 2021, 2024, KK Sangha, R Ahammad, J Russell-Smith, M Hernandez-Blanco, O Perez-Maqueo, R Costanza, unpubl.). More broadly conceived, within the one defined project area, the Nature Repair market could assist both with remediation, for example of degraded pastoral lands, as well as investing in stewardship activities aimed at maintaining highly valued biodiversity assets and processes. In effect, similar types of project-scale investments aimed at supporting carbon and cultural cobenefit outcomes already exist (e.g. in voluntary, and mixed market arrangements such as Queensland's LRF). Given that the proposed Nature Repair market is envisioned to be at least partly nongovernment funded, it is realistic to consider that private and corporate investors will be interested in funding a range of environmental and community cobenefits similar to those already supported in many SFM projects.

Admittedly more complex are recognised challenges to develop effective NbS governance arrangements in Indigenous land and sea title-holding institutions and, in extensive situations where Native Title is jointly held with pastoral lessees or the State/Crown. The responsible Indigenous bodies often lack negotiating capabilities required to navigate mutually beneficial NbS enterprise arrangements with project partners. Practical examples of

Table 2. Summary of key opportunities and challenges provided by current and emerging NbS activities, particularly with respect to Indigenous lands and seas.

Method/Issue	Opportunities	What needs to be done?
Methods development engagement	In contrast to former Department-led approaches to methods development activities (e.g. resulting in little adopted CoA 2018*a* SFM method), it is widely acknowledged (e.g. Recommendation 5 of Chubb *et al.* 2022) that effective stakeholder engagement and input is essential	Ongoing support for committed stakeholder engagement in developing widely adopted NbS methods
SFM – Savanna Fire Management	Proposed new method updating emissions avoidance with additional sequestration component incorporating living and dead woody biomass pools	• Method still to include project opportunities for extensive, periodically burnt, shrubby spinifex grasslands in the monsoonal northern rangelands – the great majority of which are under Indigenous ownership and management – based on a focused regional fire emissions study (Yates *et al.* 2023). • To ensure integrity of new method, prioritise data collection to independently validate and, where required, calibrate modelled FullCAM emissions and sequestration estimates – robust baseline and trend measurements of standing biomass at project scales are achievable with contemporary resources, e.g. fine-scale optical satellite imagery, high resolution multi-layer LiDAR; extensive plot-based inventory data • To ensure methods integrity, support ongoing research into key model parameters as described in main text (e.g. potential maximum biomass (*M*); fire intensity/severity mapping; seasonal cut-off date flexibility) • Ensure baseline measurement approaches under proposed new SFM methods effectively take into account/credit sequestration previously achieved in ongoing/transitioning projects • Actively promote community, ecological, emissions benefits of SFM approach to engage with, inform, address wider community concerns and misperceptions
IFLM – Integrated Farm & Land Management	Proposed new multipool method potentially providing significant new geographically extensive Indigenous project opportunities	• Ensure regional consistency in accounting approaches where multiple methods are accounting for the same processes (e.g. fire in the savanna under SFM and IFLM) • Assess new approaches to baselining/additionality (e.g. use of a dynamic performance benchmark) in rangelands projects to distinguish between sequestration that is additional due to human intervention, versus sequestration resulting from underlying exogenous factors such as rainfall
Blue carbon	Limited Indigenous opportunities given relatively unmodified/non-degraded coastal land and sea habitats	• Prioritise development of methods that are applicable to the Indigenous estate (e.g. management of feral ungulate populations, and reducing associated emissions impacts, in coastal wetlands)
Cobenefits/Core benefits	Widely recognised that NbS projects can deliver significant ancillary benefits other than simply carbon and nature repair credits	• Encourage development of NbS incentive schemes that specifically include and reward cobenefit/core benefit targets, e.g. as per Queensland's Land Restoration Fund • Ensure that such cobenefit/core benefit targets can be readily recognised or measured without recourse to inhibitory transactional costs (e.g. exorbitant monitoring, reporting)
Nature Repair	Emerging market-based opportunity for undertaking of biodiversity remediation projects, with broad application to Indigenous lands and seas given recognition of their relatively undisturbed states	• Little known at this stage about proposed design, other than scheme aims to provide fungible credits regulated by the Commonwealth (as per ACCU Scheme), in return for projects that address, measure, monitor site-based biodiversity-remediation activities, funded principally by the varied priorities of private and corporate investors

(*Continued on next page*)

Table 2. (*Continued*)

Method/Issue	Opportunities	What needs to be done?
		• Prioritise the development of methods that are applicable for Indigenous lands and seas • Still to develop consistent equitable crediting standards for application across multiple eligible project activities and varied site-based methods; nor associated likely significant institutional transactional costs to address engagement, monitoring, reporting, administrative responsibilities • Currently provides little scope for cost-effective stewardship, and associated rewarding of agreed general management inputs rather than itemised performance outputs
PES opportunities	Growing recognition of substantial PES opportunities for Indigenous Ranger Groups and related community organisations to undertake a variety of contracted activities (e.g. weed, fuel, smoke management; quarantine and surveillance activities; road maintenance; remote emergency services)	• Provision of adequate resources to assess available and potential business development opportunities in pertinent regional contexts • Explore regional development opportunities as conceptualised in The Nature Conservancy's *Development by Design* principles (e.g. NAILSMA 2014) • As per policy and regulation issues, prioritise support and funding for developing effective Indigenous institutional governance arrangements to oversee successful implementation of NbS projects
Policy and regulation	Significant opportunities benefiting development and implementation of NbS projects, including in multitenured settings, could be achieved once (admittedly complex) current policy and regulatory inadequacies, limitations, inconsistencies are effectively addressed (e.g. CoA 2015*b*; Morrison *et al.* 2019)	• As a first step, prioritise encompassing review of policy and regulatory barriers and impediments impacting on the development and implementation of NbS projects, including currently vexed multititle holder issues • On basis of above, address potential practical solutions supporting implementation of FPIC-informed agreements (e.g. ILUAs), or multiparty demonstration projects (as per CoA 2015*b*) • Work towards consistent State/Territory/national policy and regulatory frameworks that can produce tangible community benefits – e.g. carbon rights, biodiversity conservation, enterprise diversification and agreements • As per PES opportunities, prioritise support and funding for developing effective Indigenous institutional governance arrangements to oversee successful implementation of NbS projects
Stewardship	Recognition of the essential need to support and reward ongoing cost-effective stewardship activities, in addition to and complementary with incentivising deficit-based carbon and nature repair schemes	• Prioritise evaluation of the ecosystem services, sustainability and associated economic benefits of stewardship/avoided loss arrangements for Indigenous land/seas and communities • Assess benefits and broader applicability of stewardship models for lands and seas that focus on rewarding management inputs • On basis of above, trial implementation or extension (e.g. NSW's Biodiversity Conservation Trust) of appropriate governance model(s) in support of stewardship arrangements more widely, especially Indigenous lands and seas given recognition of their relatively undisturbed state

enterprise development opportunities provided through both the current ACCU Scheme and developing Nature Repair regulatory frameworks could conceivably involve: (1) pastoral lessees wishing to establish a SFM project on nonproductive parts of their cattle station(s) and entering into an arrangement (e.g. through an Indigenous Land Use Agreement (ILUA)) with the Native Title holders involving both the contracting of a local Indigenous Ranger Group (IRG) to undertake the required fire management, and sharing of generated credits; (2) Native Title corporations entering into an agreement with State/Crown lands to contract a local Indigenous business to undertake specified feral animal management activities to earn credits under an accredited Nature Repair method.

However, as described earlier with respect to ambiguous land management policy and regulatory settings associated with land clearing, carbon projects and related enterprise diversification opportunities in the Northern Territory, and

as summarised more broadly in the Northern Development White Paper (CoA 2015*b*, pp. 15–39), are not fully utilised. Complex title and property right arrangements under separate State and Commonwealth frameworks offer uncertainty both for Indigenous and nonindigenous interests. Although it is beyond our remit and capacity to provide guidance, we note that the White Paper usefully proposed supporting the trialling of pilot projects to demonstrate the building of effective community partnerships:

> A pilot approach to land tenure reform in the north offers a way to work with communities to develop reforms that have their support. Individual projects will help develop model approaches for Indigenous, pastoral and Crown land, subject to native title, that could be shared more widely and rolled out over time where there is support in Indigenous communities and the private sector. (CoA 2015*b*, p. 19)

> Building on the White Paper, the recently released *Northern Australia Action Plan 2024-2029* reiterates the need to address complex tenure issues associated with developing NbS projects on Native Title lands, including funding commitments supporting "participation in up-front consent processes for ACCU Scheme projects on Native Title lands", "PBCs supporting Native Title holders to take advantage of their Native Title rights" (CoA 2024*e*: 24–25).

Indigenous value systems, communal relationships to 'country', stewardship solutions

Current SFM, HIR, and emerging IFLM and Nature Repair markets mostly concern the delivery of management services in exchange for addressing recognised environmental damage and deficit whereas the Indigenous estate is recognised as being in relatively better condition due to nonexploitative use (e.g. TNC 2019; SOE 2021). Moreover, current programs target and trade typically one outcome or market product at a time; e.g. HIR and SFM methods deal with GHG emissions abatement and/or carbon sequestration only, not broader biodiversity and ecosystem services benefits. This is contrary to communal value systems of Aboriginal and Torres Strait Islander peoples, where lands and seas are managed holistically by clan members under different sets of socio-cultural obligations and responsibilities (e.g. Altman *et al.* 2011; Stoeckl *et al.* 2021). A significant part of the Indigenous estate in Australia is registered under communal lands, such as Native Title or Northern Territory Aboriginal Land Trusts, where Aboriginal and Torres Strait Islander peoples have collective, ongoing familial and cultural relationships, including responsibilities, towards their estates – better designated as '*country*' (e.g Altman and Markham 2014; Archer *et al.* 2019).

On the contrary, it is recognised that the primary profit motive of land-based businesses does not guarantee sustainable management practice; for example, especially under poor seasonal conditions, northern pastoral enterprises often operate beyond inherent stocking carrying capacities, and their statutory lease obligations, leading to significant degradation of land and water resources (Crowley 2015). It is well accepted that conservative pasture and soil stewardship in Australia's rangelands far outweighs the long-term environmental, economic and social costs associated with remediation, even where the latter is possible (e.g. Ash *et al.* 1997; McKeon *et al.* 2004; Brodie and Pearson 2016; Rolfe *et al.* 2016; Western Australian Agricultural Authority 2021). Land degradation and associated impacts on ecosystem services are estimated to cost Australia billions of dollars annually (e.g. ELDI 2015; Sutton *et al.* 2016). We argue that emerging market opportunities need to better appreciate and embrace value systems and stewardship of Aboriginal and Torres Strait Islander peoples, delivering outcomes to the benefit of natural systems generally.

From an environmental perspective, nature's assets and services are interconnected and interrelated, requiring holistic management – in line with value systems of Aboriginal and Torres Strait Islander peoples. Within ecological sciences, there is an extensive understanding of how improvement in one ecological function is linked with other functions and that natural systems operate at a landscape/catchment scale. For example, enhanced fire management of fire-prone savanna systems through the undertaking of carbon projects also delivers tangible biodiversity, socio-economic, and cultural outcomes (Ansell *et al.* 2020; Edwards *et al.* 2021). Nature's resources are typically considered as common pool resources requiring collective management and offering communal benefits, thus demanding community and landscape-based solutions (Costanza *et al.* 2021). To address the communal nature of nature's resources and manage them effectively, in Indigenous contexts there is a need to develop innovative economic opportunities that embrace value systems of Aboriginal and Torres Strait Islander peoples, and which are codeveloped with and ideally led by those peoples (Stoeckl *et al.* 2021; Robinson *et al.* 2022; Larson *et al.* 2023).

Another important concern of current market-based programs is that these are designed to 'pay the polluter to fix a problem', or 'prevent degradation of nature' (Gomez-Baggethun and Ruiz-Perez 2011; Gomez-Baggethun and Muradian 2015; Sangha *et al.* 2024, KK Sangha, R Ahammad, J Russell-Smith, M Hernandez-Blanco, O Perez-Maqueo, R Costanza, unpubl.). For example, under the Queensland Government sponsored Reef Credit Scheme, nutrient and sediment polluters are rewarded for implementing remedial activities, whereas those farmers who have maintained effective soil management systems are ineligible. Likewise, SFM and the emerging IFLM Methods are not designed to reward enterprises or activities that already implement effective conservation practices. The need is to understand the importance of sustainably managing the landscape, which delivers multiple ecosystem services but

requires targeted resources to carry out on-ground activities. Incentivised fire management projects in northern Australia offer an instructive example.

Another concern with contemporary approaches is establishing baselines for problems to be fixed, which is a standard market technique but does not adequately address the measurement and management of nature's assets and services. For example, SFM project sites where fire regimes have been well managed over preproject baseline periods (previously 10 or 15 years depending on rainfall regime) are significantly financially disadvantaged compared with sites with poorly managed fire regime baselines. The baseline deficit approach and associated requirements for NbS projects to demonstrate 'additionality' are significant issues needing to be addressed in the development of equitable market-based instruments. Notably, other environmental accounting standards define the 'natural' (System of Environmental Economic Accounting – https://seea.un.org), or 'natural undegraded/best possible' (Accounting for Nature – https://www.accountingfornature.org/standard) state as the Reference Condition, thus recognising the ongoing role of stewardship and potential rewarding of sustainable land management practices.

Globally, there are long-standing examples where innovative mechanisms embracing nature's and community's perspectives are delivering sustainable, effective environmental and community outcomes. One such solution involves the establishment of community-based Trust mechanisms embracing stewardship and communal principles, which focus on rewarding management inputs rather than itemised contracted performance outputs. Costanza *et al.* (2021) propose a Common Assets Trust (CAT) model that can be established by government (at State/Territory, or national level) to implement, administer, monitor and evaluate scheme effectiveness with low transactional costs, providing a central platform for efficient contracting of land managers, private and public investors, and of Aboriginal and Torres Strait Islander stakeholders alike to address required public good ecosystem services outcomes. Such Trusts can incorporate management and governance principles applicable to Common Pool Resources, as described by Ostrom (1990). The experience of successful CAT schemes in Costa Rica and Mexico (operating from the 1990s and early 2000s, respectively; Grima *et al.* 2016; Hernández Blanco 2020), and NSW's Biodiversity Conservation Trust established in 2016 (Elton and Fitzsimons 2023), demonstrates that such innovative approaches are practicable, possible, and make sound economic sense (KK Sangha, R Ahammad, J Russell-Smith, M Hernandez-Blanco, O Perez-Maqueo, R Costanza, unpubl.).

Although significant progress evidently has been made in Australia with the development of NbS market-based approaches in recent years, as this assessment illustrates, there are still substantial steps required to understand and solve the complexity of Indigenous land rights, raise awareness of Native Title rights, recognise intrinsic holistic value systems as exemplified by of Aboriginal and Torres Strait Islander communities and custodians, and further develop complementary schemes that incentivise both ongoing maintenance and remediation of natural and associated cultural resources.

References

Altman J, Markham F (2014) Inquiry into the Development of Northern Australia: Submission 136. (Centre for Aboriginal Economic Policy Research, Australian National University: Canberra, ACT)

Altman J, Kerins S, Hunt J, Ens E, May K, Russell S, Fogarty B (2011) Indigenous cultural and natural resource management futures. CAPRE Topical Issue No. 9/2011. (Centre for Aboriginal Economic Policy Research, Australian National University: Canberra, ACT)

Ansell J, Evans J, Rangers A, Rangers AS, Rangers D, Rangers J, Rangers M, Rangers NN, Rangers W, Rangers Y, Rangers YM (2020) Contemporary Aboriginal savanna burning projects in Arnhem Land: a regional description and analysis of the fire management aspirations of Traditional Owners. *International Journal of Wildland Fire* **29**, 371–385. doi:10.1071/WF18152

Archer R, Russell-Smith J, Kerins S, Costanza R, Edwards A, Sangha K (2019) Change and continuity: the North Australian cultural landscape. In 'Sustainable Land Sector Development in Northern Australia: Indigenous Rights, Aspirations, and Cultural Responsibilities'. (Eds J Russell-Smith, G James, H Pedersen, K Sangha) pp. 9–34. (CRC Press: Boca Raton, FL, USA)

Ash AJ, McIvor JG, Mott JJ, Andrew MH (1997) Building grass castles: integrating ecology and management of Australia's tropical tallgrass rangelands. *The Rangeland Journal* **19**, 123–144. doi:10.1071/RJ9970123

Badola R, Ahmed T, Gill AK, Dobriyal P, Das GC, Badola S, Hussain S (2021) An incentive-based mitigation strategy to encourage coexistence of large mammals and humans along the foothills of Indian Western Himalayas. *Scienctific Reports* **11**(1), 5235. doi:10.1038/s41598-021-84119-7

Baumber A, Metternicht G, Cross R, Ruoso L, Cowie A, Waters C (2019) Promoting co-benefits of carbon farming in Oceania: applying and adapting approaches and metrics from existing market-based schemes. *Ecosystem Services* **39**, 100982. doi:10.1016/j.ecoser.2019.100982

Bears RC (2020) 'Nature-Based Solutions to 21st Century Challenges.' (Routledge) doi:10.4324/9780429294600

Bell-James J, Foster R, Shumway N (2023) The permitting process for marine and coastal restoration: a barrier to achieving global restoration targets. *Conservation Science and Policy* **5**, e13050. doi:10.1111/csp2.13050

Bowman DMJS, Borchers-Arriagada N, Macintosh A, Butler DW, Williamson GJ, Johnston FH (2024) Climate change must be factored into savanna carbon-management projects to avoid maladaptation: the case of worsening air pollution in western Top End of the Northern Territory, Australia. *The Rangeland Journal* **46**, RJ23049. doi:10.1071/RJ23049

Bristow M, Hutley LB, Beringer J, Livesley J, Edwards AC, Arndt SK (2016) Quantifying the relative importance of greenhouse gas emissions from current and future savanna land use change across northern Australia. *Biogeosciences* **13**, 6285–6303. doi:10.5194/bg-13-6285-2016

Brodie J, Pearson RG (2016) Ecosystem health of the Great Barrier Reef: time for effective management action based on evidence. *Estuarine, Coastal and Shelf Science* **183**, 438–451. doi:10.1016/j.ecss.2016.05.008

Brown A, Howey K, Black J (2022) 'Our nature, our future: the case for next-generation biodiversity conservation laws for the Northern Territory.' (Environment Centre NT: Darwin) Available at https://assets.nationbuilder.com/ecnt/pages/759/attachments/original/1670951406/ECNT_Nature_Laws_Discussion_Paper_WEB.pdf?1670951406

Chubb I, Bennett A, Gorring A, Hatfield-Dodds S (2022) 'Independent Review of ACCUs.' (Department of Climate Change, Energy, the Environment and Water, Australian Government: Canberra, ACT)

CoA (2011) *Carbon Credits (Carbon Farming Initiative) Act* 2011. Commonwealth of Australia. Available at https://www.legislation.gov.au/C2011A00101/latest/text

CoA (2013) Carbon Credits (Carbon Farming Initiative) Reduction of Greenhouse Gas Emissions through Early Dry Season Savanna Burning–1.1) Methodology Determination 2013. Commonwealth of Australia. (Australian Government). Available at http://www.comlaw.gov.au/Series/F2013L01165

CoA (2015*a*) 'Carbon Credits (Carbon Farming Initiative–Emissions Abatement through Savanna Fire Management) Methodology Determination 2015.' Commonwealth of Australia. (Australian Government). Available at http://www.comlaw.gov.au/Details/F2015L00344)

CoA (2015*b*) 'Our North, Our Future: White paper on developing Northern Australia.' Commonwealth of Australia. (Commonwealth Government: Canberra, ACT)

CoA (2018*a*) 'Native title, legal right and eligible interest-holder consent guidance.' Commonwealth of Australia. (Clean Energy Regulator, Australian Government) Available at https://cer.gov.au/document/native-title-legal-right-and-eligible-interest-holder-consent-guidance

CoA (2018*b*) 'Carbon Credits (Carbon Farming Initiative–Savanna Fire Management–Emissions Avoidance) Methodology Determination 2018.' Commonwealth of Australia. (Dept Environment and Energy, Australian Government) Available at https://www.legislation.gov.au/F2018L00560/latest/text

CoA (2022) 'Carbon Credits (Carbon Farming Initiative– Tidal Restoration of Blue Carbon Ecosystems) Methodology Determination 2022.' Commonwealth of Australia. (Department of Climate Change, Energy, the Environment and Water, Australian Government) Available at https://www.legislation.gov.au/F2022L00046/latest/versions

CoA (2023*a*) 'Nature Repair Bill, 2023.' Commonwealth of Australia. (Department for Climate Change, Energy, the Environment and Water, Australian Government) Available at https://www.aph.gov.au/Parliamentary_Business/Bills_Legislation/Bills_Search_Results/Result?bId=r7014

CoA (2023*b*) 'Australian carbon credit units issued.' Commonwealth of Australia. (Clean Energy Regulator, Australian Government) Available at https://cleanenergyregulator.gov.au/markets/accu-project-and-contract-register?view=Projects

CoA (2024*a*) 'Commonwealth of Australia (2024) Updates to Australia's Strategy for Nature.' (Australian Government: Canberra) Available at https://www.dcceew.gov.au/environment/biodiversity/conservation/strategy [accessed 29 April 2024]

CoA (2024*b*) 'Emissions Reduction Fund project register. Clean Energy Regulator, Australian Government'. (Commonwealth of Australia: Canberra) Available at https://cer.gov.au/markets/reports-and-data/accu-project-and-contract-register?view=Projects [data downloaded 9 April 2024, file last updated 17 March 2024]

CoA (2024*c*)' Area-based Emissions Reduction Fund (ACCU Scheme) projects.' (Clean Energy Regulator, Australian Government) (Commonwealth of Australia: Canberra) Available at https://data.gov.au/dataset/ds-dga-4eac1209-869f-466f-b583-70ffded90a56/details [data downloaded 9 April 2024, file last updated 17 January 2024]

CoA (2024*d*) 'Coastal Blue Carbon Ecosystems.' Commonwealth of Australia. (Department of Climate Change, Energy, Environment and Water) Available at https://www.dcceew.gov.au/climate-change/policy/ocean-sustainability/coastal-blue-carbon-ecosystems [accessed 4 April 2024]

CoA (2024*e*) 'Northern Australia Action Plan 2024–2029.' Commonwealth of Australia, (Office of Northern Australia). Availabale at https://www.infrastructure.gov.au/sites/default/files/documents/northern-australia-action-plan-2024-2029.pdf

Corey B, Andersen AN, Legge S, Woinarski JCZ, Radford IJ, Perry JJ (2020) Better biodiversity accounting is needed to prevent bioperversity and maximise co-benefits from savanna burning. *Conservation Letters* **13**, e12685. doi:10.1111/conl.12685

Costanza R, Atkins PWB, Hernandez-Blanco M, Kubiszewski I (2021) Common asset trusts to effectively steward natural capital and ecosystem services at multiple scales. *Journal of Environmental Management* **280**, 111801. doi:10.1016/j.jenvman.2020.111801

Crowley GM (2015) 'Trends in natural resource management in Australia's Monsoonal North: The beef industry.' (The Cairns Institute, James Cook University: Cairns, Qld)

Dawson NM, Coolsaet B, Sterling EJ, Loveridge R, Gross-Camp ND, Wongbusarakum S, Sangha KK, Scherl LM, Phan HP, Zafra-Calvo N, Lavey WG, Byakagaba P, Idrobo CJ, Chenet A, Bennett NJ, Mansourian S, Rosado-May FJ (2021) The role of Indigenous peoples and local communities in effective and equitable conservation. *Ecology and Society* **26**, 19. doi:10.5751/ES-12625-260319

Dore J, Michael C, Russell-Smith J, Tehan M, Caripes M (2014) Carbon projects and Indigenous land tenure in northern Australia. *The Rangeland Journal* **36**, 389–402. doi:10.1071/RJ13128

Douglass LL, Possingham HP, Carwardine J, Klein CJ, Roxburgh SH, Russell-Smith J, Wilson KA (2011) The effect of carbon credits on savanna land management and priorities for biodiversity conservation. *PLoS One* **6**(9), e23843. doi:10.1371/journal.pone.0023843

Eames T, Vernooij R, Russell-Smith J, Yates C, Edwards A, van der Werf GR (2023) Division of the tropical savanna fire season into early and late dry season burning. *International Journal of Applied Earth Observation and Geoinformation* **125**, 103575. doi:10.1016/j.jag.2023.103575

Edwards A, Archer R, De Bruyn P, Evans J, Lewis B, Vigilante T, Whyte S, Russell-Smith J (2021) Transforming fire management in northern Australia through successful implementation of savanna burning emissions reductions projects. *Journal of Environmental Management* **290**, 112568. doi:10.1016/j.jenvman.2021.112568

ELDI (Economics of Land Degradation initiative) (2015) 'The value of land: Prosperous lands and positive rewards through sustainable land management.' (ELD Secretariat: Bonn, Germany)

Elton P, Fitzsimons J (2023) Framework features enabling faster establishment and better management of privately protected areas in New South Wales, Australia. *Frontiers in Conservation Science* **4**, 1277254. doi:10.3389/fcosc.2023.1277254

Evans J, Russell-Smith J (2019) Delivering effective savanna fire management for defined biodiversity conservation outcomes: an Arnhem Land case study. *International Journal of Wildland Fire* **29**, 386–400. doi:10.1071/WF18126

Fache E, Moizo B (2015) Do burning practices contribute to caring for country? Contemporary uses of fire for conservation purposes in Indigenous Australia. *Journal of Ethnobiology* **35**, 163–183. doi:10.2993/0278-0771-35.1.163

Garde M, Nadjamerrek LB, Kolkiwarra M, Kalarriya J, Djandjomerr J, Birriyabirriya B, Bilindja R, Kubarkku M, Biless P (2009) The language of fire: seasonality, resources and landscape burning on the Arnhem Land Plateau. In 'Culture, ecology and economy of savanna fire management in northern Australia: rekindling the Wurrk tradition'. (Eds J Russell-Smith, PJ Whitehead, PM Cooke) pp. 85–164. (CSIRO Publishing: Melbourne, Australia)

Gomez-Baggethun E, Muradian R (2015) In markets we trust? Setting the boundaries of market-based instruments in ecosystem services governance. *Ecological Economics* **117**, 217–224. doi:10.1016/j.ecolecon.2015.03.016

Gomez-Baggethun E, Ruiz-Perez M (2011) Economic valuation and the commodification of ecosystem services. *Progress in Physical Geography* **35**, 613–628. doi:10.1177/0309133311421708

Grafton RQ, Wheeler S (2018) Economics of Water Recovery in the Murray-Darling Basin, Australia. *Annual Review of Resource Economics* **10**, 487–510. doi:10.1146/annurev-resource-100517-023039

Grima N, Singh S, Smetschka B, Ringhofer L (2016) Payment for Ecosystem Services (PES) in Latin America: analysing the performance of 40 case studies. *Ecosystem Services* **17**, 24–32. doi:10.1016/j.ecoser.2015.11.010

Hamrick K, Myers K, Soewito A (2023) 'Beyond beneficiaries: fairer carbon market frameworks.' (The Nature Conservancy) Available at https://nature4climate.wpenginepowered.com/wp-content/uploads/2023/08/TNC_Beyond-Beneficiaries-220823.pdf

Hernández Blanco M (2020) Modelo general de un nuevo programa de pago por servicios ecosistémicos para Costa Rica. San Jose, Costa Rica. Available at https://biofin.cr/wp-content/uploads/2021/11/undp_cr_PAGO_SERVICIOS_ECOSITEMICOS_21-1.pdf

Hill R, Pert PL, Davies J, Robinson CJ, Walsh F, Falco-Mammone F (2013) 'Indigenous land management in Australia: extent, scope, diversity, barriers and success factors.' (CSIRO Ecosystem Sciences:

Cairns, Australia) Available at https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/natural-resources/landcare/submissions/ilm-report.pdf
ICIN (2022) 'Mapping the opportunities for Indigenous Carbon in Australia: Identifying opportunities and barriers to Indigenous participation in the Emissions Reduction Fund.' (Indigenous Carbon Industry Network: Darwin, Australia) Available at https://www.icin.org.au/resource_files
ICIN (2024) 'Blue Carbon in Australia: Understanding the opportunity for Indigenous People.' (Indigenous Carbon Industry Network: Darwin, Australia) Available at https://www.icin.org.au/resource_files
IPBES (2019) 'The global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.' (IPBES secretariat: Bonn, Germany)
IPBES (2022) 'Methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.' (IPBES secretariat: Bonn, Germany) doi:10.5281/zenodo.6522522
IPCC (2022) Climate Change 2022: Impacts, Adaptation, and Vulnerability. In 'Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.' (Cambridge University Press: Cambridge, UK) doi:10.1017/9781009325844
IUCN (2020) 'Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS', 1st edn. (IUCN: Gland, Switzerland)
Johnston FH, Bailie RS, Pilotto LS, Hanigan IC (2007) Ambient biomass smoke and cardio-respiratory hospital admissions in Darwin, Australia. *BMC Public Health* **7**, 240. doi:10.1186/1471-2458-7-240
Johnston FH, Henderson SB, Chen Y, Randerson JT, Marlier M, DeFries RS, Kinney P, Bowman DMJS, Brauer M (2012) Estimated global mortality attributable to smoke from landscape fires. *Environmenatl Health Perspectives* **120**, 695–701. doi:10.1289/ehp.1104422
Jones PJ, Furlaud JM, Williamson GJ, Johnston FH, Bowman DMJS (2022) Smoke pollution must be part of the savanna fire management equation: a case study from Darwin, Australia. *Ambio* **51**, 2214–2226. doi:10.1007/s13280-022-01745-9
Larson S, Jarvis D, Stoeckl N, Barrowei R, Coleman B, Groves D, Hunter J, Lee M, Markham M, Larson A, Finau G, Douglas M (2023) Piecemeal stewardship activities miss numerous social and environmental benefits associated with culturally appropriate ways of caring for country. *Journal of Environment Management* **326**, 116750. doi:10.1016/j.jenvman.2022.116750
Luhar AK, Mitchell RM, Meyer CP, Qin Y, Campbell S, Gras JL, Parry D (2008) Biomass burning emissions over northern Australia constrained by aerosol measurements: II–Model validation, and impacts on air quality and radiative forcing. *Atmospheric Environment* **42**, 1647–1664. doi:10.1016/j.atmosenv.2007.12.040
Lynch D, Russell-Smith J, Edwards AC, Evans J, Yates C (2018) Incentivising fire management in Pindan (Acacia shrubland): a proposed fuel type for Australia's savanna burning greenhouse gas emissions abatement methodology. *Ecological Management & Restoration* **19**, 230–238. doi:10.1111/emr.12334
MacIntosh A, Butler D, Larraondo P, Evans MC, Ansell D, Waschka M, Fensham R, Eldridge D, Lindenmayer D, Gibbons P, Summerfield P (2024) Australian human-induced native forest regeneration carbon offset projects have limited impact on changes in woody vegetation cover and carbon removals. *Communications Earth & Environment* **5**, 149. doi:10.1038/s43247-024-01313-x
Maier SW, Russell-Smith J (2012) Measuring and monitoring of contemporary fire regimes in Australia using satellite remote sensing. In 'Flammable Australia: Fire Regimes, Biodiversity and Ecosystems in a Changing World'. (Eds RA Bradstock, AM Gill, RW Williams) pp. 79–95. (CSIRO Publishing: Melbourne, Australia)
McKemey M, Ens E, Yugal Mangi, Rangers, Costello O, Reid N (2020) Indigenous knowledge and seasonal calendar inform adaptive savanna burning in northern Australia. *Sustainability* **12**, 995. doi:10.3390/su12030995
McKeon GM, Hall WB, Henry BK, Stone GS, Watson IW (2004) 'Pasture degradation and recovery in Australia's rangelands: learning from history.' (Queensland Dept Natural Resources, Mines and Energy: Brisbane)
Millennium Ecosystem Assessment (2005). 'Ecosystems and human well-being: synthesis.' (Island Press: Washington, DC, USA)
Moise A, Abbs D, Bhend J, Chiew F, Church J, Ekström M, Kirono D, Lenton A, Lucas C, McInnes K, Monselesan D, Mpelasoka F, Webb L, Whetton P (2015) Monsoonal North Cluster Report. In 'Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports'. (Eds M Ekström, P.Whetton, C Gerbing, M Grose, L Webb, J Risbey) (CSIRO and Bureau of Meteorology: Australia)
Morrison J, Yu P, George M (2019) 2-way country – challenges for inclusive, equitable, and prosperous development in North Australia. In 'Sustainable Land Sector Development in Northern Australia: Indigenous rights, aspirations, and cultural responsibilities'. (Eds J Russell-Smith, G James, H Pedersen, K Sangha) pp. 1–7. (CRC Press: Boca Raton, FL, USA)
Muradian R, Corbera E, Pascual U, Kosoy N, May PH (2010) Reconciling theory and practice: An alternative conceptual framework for understanding payments for environmental services. *Ecological Economics* **69**, 1202–1208. doi:10.1016/j.ecolecon.2009.11.006
Murphy BP, Whitehead PJ, Evans , Yates CP, Edwards AC, MacDermott HJ, Lynch DC, Russell-Smith J (2023) Using a demographic model to project the long-term effects of fire management on tree biomass in Australian savannas. *Ecological Monographs* **93**, e1564. doi:10.1002/ecm.1564
NAILSMA (North Australian Land & Sea Management Alliance Ltd) (2014) Development by Design: opportunities in northern Australia and the potential role of Indigenous people, with particular emphasis on the Northern Territory. NAILSMA Working Paper 01/2014. Available at https://nailsma.org.au/uploads/resources/Development-byDesign-Working-Paper-SEP2014.pdf
NESP (2024) Feral ungulate control to reduce greenhouse gas emissions from wetlands. Project 3.8. National Environmental Science Program. Available at https://www.nespmarinecoastal.edu.au/project/3-8/
NTEPA (2023) 'Northern Territory ambient air quality report 2021.' (Northern Territory Environmental Protection Agency, Northern Territory Government) Available at https://ntepa.nt.gov.au/_data/assets/pdf_file/0012/1295967/annual-compliance-report-for-the-nt-2021-ambient-air-quality-nepm.pdf
Ostrom E (1990) 'Governing the Commons: The Evolution of Institutions for Collective Action.' (Cambridge University Press)
Paul KI, Roxburgh SH (2024) A national accounting framework for fire and carbon dynamics in Australian savannas. *International Journal of Wildland Fire* **33**, WF23104. doi:10.1071/WF23104
Perry JJ, Sinclair M, Wikmunea H, Wolmby S, Martin D, Martin B (2018) The divergence of traditional Aboriginal and contemporary fire management practices on Wik traditional lands, Cape York Peninsula, Northern Australia. *Ecological Management & Restoration* **19**, 24–31. doi:10.1111/emr.12301
Perry JJ, Cook GD, Graham E, Meyer CP, Murphy HT, VanDerWaal J (2020) Regional seasonality of fire size and weather conditions across Australia's northern savanna. *International Journal of Wildland Fire* **29**, 1–10. doi:10.1071/WF19031
Petty AM, deKoninck V, Orlove B (2015) Cleaning, protecting, or abating? Making Indigenous fire management "work" in Northern Australia. *Journal of Ethnobiology* **35**, 140–162. doi:10.2993/0278-0771-35.1.140
PWC (2022) 'A nature-positive Australia: The value of Australian biodiversity market.' (PricewaterhouseCoopers) Available at https://www.pwc.com.au/environment-social-governance/nature-positive-australia-value-of-australian-biodiversity-market.html#:~:text=Our%20latest%20report%20A%20nature,examines%20the%20possibility%20of%20a
Queensland Government (2023) The Land Restoration Fund: Co-benefits Standards (v1.4). Available at https://www.qld.gov.au/_data/assets/pdf_file/0025/116548/lrf-co-benefits-standard.pdf
Quinlan J, Silbert N (2023) 'Legal analysis of the adequacy of pastoral land clearing laws for biodiversity protection in the Northern Territory.' (Environmental Justice Australia: Melbourne)
Rights and Resources Initiative (2023) Who Owns the World's Land? Rights and Resources Initiative. doi:10.53892/MHZN6595
Robinson CJ, Macdonald JM, Douglas M, Perry J, Setterfield S, Cooper D, Lee M, Nadji J, Nadji S, Nayinggul A, Nayingul A, Mangiru K, Hunter F, Coleman B, Barowei R, Markham J, Alderson J, Moyle F,

May K, Bangalong N (2022) Using knowledge to care for country: Indigenous-led evaluations of research to adaptively co-manage Kakadu National Park, Australia. *Sustainability Science* **17**, 377–390. doi:10.1007/s11625-021-01015-9

Rolfe JW, Larard AE, English BH, Hegarty ES, McGrath TB, Gobius NR, DeFaveri J, Srhoj JR, Digby MJ, Musgrove RJ (2016) Rangeland profitability in the northern Gulf region of Queensland: understanding beef business complexity and the subsequent impact on land resource management and environmental outcomes. *The Rangeland Journal* **38**, 261–272. doi:10.1071/RJ15093

Russell-Smith J, Sangha KK (2019) Beneficial land sector change in far northern Australia is required and possible – a refutation of McLean and Holmes (2019). *The Rangeland Journal* **41**, 363–369. doi:10.1071/RJ19030

Russell-Smith J, Yates CP, Edwards A, Allan GE, Cook GD, Cooke P, Craig R, Heath B, Smith R (2003) Contemporary fire regimes of northern Australia: change since Aboriginal occupancy, challenges for sustainable management. *International Journal of Wildland Fire* **12**, 283–297. doi:10.1071/WF03015

Russell-Smith J, Whitehead PJ, Cooke PM (Eds) (2009) 'Culture, ecology and economy of savanna fire management in northern Australia: rekindling the Wurrk tradition.' (CSIRO Publishing: Melbourne, Australia)

Russell-Smith J, Cook GD, Cooke PM, Edwards AC, Lendrum M, Meyer CP, Whitehead PJ (2013) Managing fire regimes in north Australian savannas: applying Aboriginal approaches to contemporary global problems. *Frontiers in Ecology and the Environment* **11**(s1), e55–e63. doi:10.1890/120251

Russell-Smith J, Yates CP, Evans J, Desailly M (2014) Developing a savanna burning emissions abatement methodology for tussock grasslands in high rainfall regions of northern Australia. *Tropical Grasslands–Forrajes Tropicales* **2**, 154–166. doi:10.17138/TGFT(2)175-187

Russell-Smith J, Yates C, Evans J, Meyer CP, Edwards A (2015) Application of a 'lower rainfall' savanna burning emissions abatement methodology. In, 'Carbon accounting and management in fire-prone Australian savannas'. (Eds BP Murphy, AC Edwards, CP Meyer, J Russell-Smith) pp. 219–234. (CSIRO Publishing: Melbourne, Australia)

Russell-Smith J, James G, Pedersen H, Sangha KK (Eds) (2019) 'Sustainable land sector development in Northern Australia: Indigenous rights, aspirations, and cultural responsibilities.' (CRC Press: Boca Raton, FL, USA)

Russell-Smith J, James G, Dhamarrandji AM, Gondarra T, Burton D, Sithole B, Campion OB, Hunter-Xenie H, Archer R, Sangha KK, Edwards AC (2022) Empowering Indigenous natural hazards management in northern Australia. *Ambio* **51**, 2240–2260. doi:10.1007/s13280-022-01743-x

Sangha KK (2020) Global importance of Indigenous and local communities' managed lands: building a case for stewardship schemes. *Sustainability* **12**, 7839. doi:10.3390/su12197839

Sangha K, Russell-Smith J (2017) Towards an Indigenous Ecosystem Services Valuation Framework: A North Australian Example. *Conservation and Society* **15**, 255–269. doi:10.4103/cs.cs_16_156

Sangha KK, Evans J, Edwards A, Russell-Smith J, Fisher R, Yates C, *et al.* (2021) Assessing the value of ecosystem services delivered by prescribed fire management in Australian tropical savannas. *Ecosystem Services* **51**, 101343. doi:10.1016/j.ecoser.2021.101343

Sangha KK, Ahammad R, Russell-Smith J, Costanza R (2024) Payments for Ecosystem Services opportunities for emerging Nature-based Solutions: integrating Indigenous perspectives from Australia. *Ecosystem Services* **66**, 101600. doi:10.1016/j.ecoser.2024.101600

SOE (State of the Environment) (2021) 'Australia state of the environment 2021.' (Commonwealth of Australia: Canberra, ACT)

Sowden M, Hanigan IC, Robbins DJV, Cope M, Silver JD, Noonan J (2024) Characterizing smoke haze events in Australia using a hybrid approach of satellite-based Aerosol Optical Depth and Chemical Transport Modeling. *Remote Sensing* **16**, 1266. doi:10.3390/rs16071266

Stoeckl N, Jarvis D, Larson S, Larson A, Grainer D, Ewamian Aboriginal Corporation (2021) Australian Indigenous insights into ecosystem services: beyond services towards connectedness – people, place and time. *Ecosystem Services* **50**, 101341. doi:10.1016/j.ecoser.2021.101341

Sutton PC, Anderson SJ, Costanza R, Kubiszewski I (2016) The ecological economics of land degradation: impacts on ecosystem service values. *Ecological Economics* **129**, 182–192. doi:10.1016/j.ecolecon.2016.06.016

TNC (The Nature Conservancy) (2019) How humans have impacted Australia's nature over time: A brief history of the impacts of Indigenous and non-Indigenous Australians on nature. Available at https://www.natureaustralia.org.au/what-we-do/our-insights/perspectives/human-impact-nature-australia/

TNC (The Nature Conservancy) (2020) Conservation financing for conservation programs with Indigenous People and Local Communities. Available at https://www.nature.org/content/dam/tnc/nature/en/documents/EA_IPLC_Full_Report_2020.pdf.

UNEP (United Nations Environment Programme) (2023) 'State of Finance for Nature 2023: The Big Nature Turnaround – Repurposing $7 trillion to combat nature loss.' (UNEP: Nairobi, Kenya) doi:10.59117/20.500.11822/44278

Verra (2023) Verified Carbon Standard Methodology VM0047, Afforestation, Reforestation and Revegetation. Available at https://verra.org/methodologies/vm0047-afforestation-reforestation-and-revegetation-v1-0/

Vigilante T, Murphy BP, Bowman DMJS (2009) Aboriginal fire use in Australian tropical savannas: ecological effects and management lessons. In 'Tropical fire ecology'. (Ed. MA Cochrane) pp. 143–169. (Springer Praxis Books. Springer: Berlin and Heidelberg)

Western Australian Agricultural Authority (2021) 'State Soil Health Strategy, Western Australia.' (Department of Primary Industries and Regional Development: Perth, WA) Available at https://soilswest.org.au/wp-content/uploads/2023/01/WA-Soil-Health-Strategy_PDF.pdf

Whitehead PJ, Purdon P, Russell-Smith J, Cooke PM, Sutton S (2008) The management of climate change through prescribed Savanna burning: emerging contributions of indigenous people in northern Australia. *Public Administration & Development* **28**, 374–385. doi:10.1002/pad.512

Whitehead PJ, Russell-Smith J, Cooke PM (2009) Fire management futures: new northern directions for environmental and socio-economic benefit. In 'Culture, ecology and economy of savanna fire management in northern Australia: rekindling the Wurrk tradition'. (Eds J Russell-Smith, PJ Whitehead, P Cooke) pp. 379–394. (CSIRO Publishing: Melbourne, Australia)

Williamson GJ, Bowman DMJS, Price OF, Henderson SB, Johnston FH (2016) A transdisciplinary approach to understanding the health effects of wildfire and prescribed fire smoke regimes. *Environmental Research Letters* **11**, doi:10.1088/1748-9326/11/12/125009

World Economic Forum (2020) 'The Global Competitiveness Report: How Countries are Performing on the Road to Recovery.' (World Economic Forum: Geneva, Switzerland)

WWF UNEP-WCMC, SGP/ICCA-GSI, LM, TNC, CI, WCS, EP, ILC-S, CM, IUCN (2021) '"The State of Indigenous Peoples' and Local Communities' Lands and Territories: A technical review of the state of Indigenous Peoples' and Local Communities' lands, their contributions to global biodiversity conservation and ecosystem services, the pressures they face, and recommendations for actions'.' (Gland, Switzerland) Available at https://wwflac.awsassets.panda.org/downloads/report_the_state_of_the_indigenous_peoples_and_local_communities_lands_and_territories.pdf

Yates C, Evans J, Vernooij R, Eames T, Muir E, Holmes J, Edwards A, Russell-Smith J (2023) Incentivizing sustainable fire management in Australia's northern arid spinifex grasslands. *Journal of Environmental Management* **344**, 118384. doi:10.1016/j.jenvman.2023.118384

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