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Research article

Abandoned mine clusters and their intersection with Indigenous peoples' land rights in Australia

Corinne J. Unger, John Burton, Deanna Kemp *

Centre for Social Responsibility in Mining, Sustainable Minerals Institute, The University of Queensland, Brisbane, Qld, 4072, Australia

A B S T R A C T

Empirical research on the intersection of Indigenous peoples and abandoned mines has primarily focused on the impacts of individual, large-scale mines in the settler states of Australia, Canada and the United States. In contrast, research on the extent and effects of dense clusters of relatively small, abandoned mines has been largely overlooked. Australia has 50,000+ abandoned mines and their overlap with Indigenous peoples' legally recognised rights to land has not been mapped or quantified. This study presents a novel methodology to map and quantify this intersection using the state of Queensland as a case study. Through spatial data and document analysis, we find that 54.8 % of Queensland's abandoned mines are located where Indigenous peoples have rights to land and we identify five dense clusters that warrant further examination. Our findings provide an empirical basis for regulators, mining companies, land use planners and Indigenous communities to address significant policy and practice shortcomings. Recognising abandoned mines as a pressing governance challenge—not merely a historical remnant—is a crucial step towards advancing environmental sustainability, Indigenous land justice, and equitable land management.

1. Introduction

Abandoned mines are former mining sites that are no longer in use and have not been reclaimed.[1] Without an owner to take responsibility, the obligations for managing these sites default to host governments and landowners. Globally, there is no agreement on how many abandoned mines exist because data are poor, but estimates extend to several million (Unger et al., 2012; Worrall et al., 2009). Impacts from abandoned pits, shafts, slopes, diggings, waste dumps, tailings dams, water bodies, decaying infrastructure, and various forms of contamination can persist intergenerationally. Permanent solutions to abandoned mines pose challenges, and the cost of remediation can be significant. For example, the estimated cost to fully rehabilitate the former Rum Jungle uranium and copper mine in Australia is AUD 300 million (Everingham, 2018). Some AUD 16.2 million was spent on rehabilitation in the 1980s (Verhoeven, 1988), but heavy metals from acid water continue to leach into the environment and traditional owner[2] land access is restricted due to health and safety risks.

In Australia, high-profile, large-scale abandoned mining legacies such as Rum Jungle in the Northern Territory, Mount Morgan in Queensland, Mount Lyell in Tasmania, and Wittenoom in Western Australia, have triggered environmental campaigns, adverse media coverage, government commissions of inquiry, and other scientific investigations. Far less studied are the almost 50,000[3] (mostly) small to medium abandoned mines that pockmark the continent (Unger et al., 2012). Many of Australia's abandoned mines are likely to be situated on lands where Indigenous peoples hold legally recognised rights to land. In the global literature, research about abandoned mines and Indigenous peoples' lands consists primarily of case studies detailing the histories and legacies of large, individual, complex and contaminating abandoned mines, primarily in the settler states of Australia, Canada and the United States (US) (e.g., Lin et al., 2020; Sandlos and Keeling, 2016a; Sarkar et al., 2019). Cases relating to the tens of thousands of small to medium abandoned mines on Indigenous peoples' lands in these and other jurisdictions are comparatively understudied.

Despite dense clusters of thousands of small, abandoned mines in Australia, the gaps in abandoned mine policy and management practice are significant. This is illustrated by the significant extent of historical metalliferous mining in river channels and floodplains in Australia and elsewhere (Macklin et al., 2023) while at the same time, government

* Corresponding author.
E-mail addresses: c.unger@business.uq.edu.au (C.J. Unger), john.burton@uq.edu.au (J. Burton), d.kemp@smi.uq.edu.au (D. Kemp).

[1] While 'reclamation' is the term commonly used to describe repair of mined landscapes in north America, in Australia 'rehabilitation' is commonly applied and 'remediation' addresses contamination within this process.

[2] In the Australian context, 'traditional owners' is a term used to refer to customary landowners.

[3] We note here that some estimates have extended to 60,000 abandoned mines (Campbell et al., 2017) and even 80,000 by including additional unclosed mines (Werner et al., 2020).

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policy prioritises the expansion of metal mining to meet rising global demand (Owen et al., 2022). In policy and governance, the issues of historical impacts and present-day priorities are entirely disconnected. This disjuncture means that abandoned mines are treated as a historical problem, as mining activities continue to expand. This disconnect is apparent despite federal and state-level policies (e.g., Australian Government, 2022) encouraging resource developers to create 'genuine partnerships' with regional and First Nations communities (Burton et al., 2024; Sinclair and Coe, 2024). Without a governance approach that integrates past, present and future mining legacies, the cumulative impacts of abandoned mines will remain unaddressed.

This study examines the extent to which small, abandoned mines intersect with Indigenous peoples' formally recognised rights to land in Australia. We address this question by integrating spatial datasets of abandoned mines and Indigenous peoples' lands in the state of Queensland, Australia. Queensland provides a context of historic abandoned mines and a basis for developing a methodology for mapping the extent of this intersection. While previous studies have explored abandoned mine risks, none have taken a systematic approach to mapping their overlap with Indigenous peoples' lands at scale. This study contributes a novel, spatially explicit analysis to quantify this intersection and inform policy responses. In this paper, we review scholarly literature at the intersection of abandoned mines and Indigenous peoples' lands and clarify our specific contribution to knowledge (Section 2). Section 3 provides background context on relevant policy and Section 4 describes the Queensland context. We outline methods and data sources (Section 5 and Supplementary Information) before presenting our results in a series of maps, supporting data and historical information (Section 6). Section 7 discusses the accumulation of legacy issues alongside the expansion of Indigenous peoples' legally recognised rights to land. Section 8 concludes by framing abandoned mines not as historical remnants, but as an ongoing governance challenge requiring urgent policy attention.

2. Literature on mining legacies and indigenous peoples

The concept of 'legacy' – what is left behind after a certain activity or period – occupies a prominent position in the global literature on mining, communities, and Indigenous peoples. This is because mining impacts can be profound, long-lasting, and intergenerational, particularly for Indigenous peoples where adverse impacts are often significant and cumulative. Researchers have documented the egregious impacts from mining on Indigenous peoples' lands (Leddy, 2022; Sandlos and Keeling, 2016b), cultural and social systems (Bernauer, 2020; Kemp et al., 2023), health and safety (Lin et al., 2020; Sarkar et al., 2019; Voyles, 2015), and the exclusion of traditional knowledge (Barnes and Holcombe, 2023; Sandlos and Keeling, 2016a), amongst other things. In Canada, Keeling and Sandlos (2015) document how economic displacement from subsistence and trade economies to wage economies has affected Aboriginal peoples, while Sarkar et al. (2019) analyse the vulnerability of Indigenous peoples to chronic radiation exposure. In the US, Lin et al. (2020) document environmental contamination of the Navajo Nation lands, and in Australia, Beckett (2021) studies social injustices and O'Faircheallaigh (2013) the conflicts spurred by inadequate compensation following loss and damage to land and culture. Other scholars highlight the potential benefits of mining for Indigenous peoples, such as employment, local business development (Condello, 2018), social investment programs (Newman et al., 2006), and involvement in land rehabilitation, restoration and environmental monitoring activities (Barnes et al., 2020; Bond and Kelly, 2020; Leyton-Flor and Sangha, 2024), despite the broader legacy of environmental and social harm to Indigenous peoples.

Mining legacies are complex and mixed where different groups and individuals can experience an array of impacts and benefits during and beyond the life of a mine. For instance, people may be involved in a positive social investment project with a current owner after having experienced negative impacts with a previous owner through unresolved grievances. Nonetheless, Indigenous peoples are often heavily impacted by mining because of their deep connection to lands and territories, proximity to disturbance or contamination (Sarkar et al., 2019), and economic and cultural reliance upon the environment (Keeling and Sandlos, 2015; Leyton-Flor and Sangha, 2024). In global terms, Indigenous peoples are more likely to face negative impacts from mining, while being less likely to have shared equitably in the benefits (O'Faircheallaigh, 2023).

Some of Australia's most iconic mines are described as having legacy issues (Bainton and Holcombe, 2018), including while they were under active management or still processing ore. The closure of large mines also creates social and environmental legacies, such as occupational disease, unemployment, and the economic decline of mining towns, the latter of which has become an active area of research in the context of coal phase out and the global energy transition (Anderson, 2014; Svobodova et al., 2022). There are a number of important case studies of mine closure legacies on Indigenous peoples lands, including the Argyle Diamond Mine on the lands of the Miriuwung Gidja, Malgnin and Wularr people in Western Australia (Dowell and Holcombe, 2025) and the Ranger Uranium Mine on the lands of the Mirarr people in the Northern Territory (Lawrence, 2022; Lawrence and O'Faircheallaigh, 2022; Pepper et al., 2021; Pepper et al., 2020).

In sum, the concept of 'legacy' encompasses knowledge about mining impacts from active operations, dormant, closed, and abandoned mines, and includes cases and issues where legacies impact Indigenous peoples' lands. While legacy is an appropriate concept in all these instances, investigative interest is yet to extended to the ways in which the tens of thousands of small to medium, historical abandoned mines intersect with Indigenous peoples' lands. Establishing the nature and extent of this intersection is a vital step to addressing this knowledge gap. We seek to contribute to the literature on mining legacies by applying a novel research design that maps and calculates the extent of intersection between small, abandoned mines and Indigenous peoples' lands in the state of Queensland, in Australia.

3. Policy context

This section outlines the policy context surrounding abandoned mine legacies, internationally and within Australia. For more than half a century, the global mining industry has deprioritised the issue of mine abandonment, with smaller historical mines furthest from policy attention. We describe some initiatives that have begun to address abandoned mine legacies, while noting that these initiatives focus on single site, high-profile, abandoned mines rather than clusters of smaller mines. Aggregate knowledge about the scale and extent of the abandoned mine problem (from small to large mines) continues to lag as do relevant laws and policies. Notably, no existing policies explicitly address the cumulative effects of small, abandoned mines on Indigenous peoples' lands, including in Australia.

A starting point for understanding persistent policy gaps on this issue lies with the standards set by the International Council on Mining and Metals (ICMM), established in 2002 as an industry leadership organization that promotes the idea of sustainable development. ICMM membership includes the world's largest mining companies, including major operators in Australia and Queensland. The ICMM's stated goal is to create a safe, fair and sustainable industry. To that end, the council has formulated policies on Indigenous peoples and mine closure, amongst other priority issues (International Council on Mining and Metals, 2017). However, no policy or program explicitly addresses the intersection between abandoned mines and Indigenous peoples' lands (International Council on Mining and Metals, 2024). This gap has existed from the outset of the ICMM's establishment some 25 years ago. A brief recap of policy formulation process from the 1990s to the present day helps to put the present situation in context and highlight the longstanding challenges associated with prioritising abandoned mine legacies.

The Mining Minerals and Sustainable Development (MMSD) project of 1998 was a precursor to the formation of ICMM in 2002. The final MMSD report, *Breaking New Ground* (International Institute for Environment and Development & World Business Council for Sustainable Development, 2002), described abandoned mines as 'widespread' and 'poorly accounted for'. The report establishes a tentative link between abandoned mines and Indigenous peoples even though the main point of intersection was Indigenous peoples' opposition to large-scale mines. The MMSD report recommended that the industry compile inventories of abandoned mines to identify priority locations and estimate total liabilities; released public information about inventories and environmental effects (p. 299); include Indigenous knowledge in studies about abandoned mines (p. 309); establish funding mechanisms to reduce the burden on future generations (p. 247); and outline a multi-stakeholder strategy for managing legacies (p. 368). Since the release of the report 25 years ago, little progress has been made on these recommendations.

At the 2002 World Summit on Sustainable Development, the World Conservation Union and the ICMM committed to a joint dialogue on mining and biodiversity explored options for addressing the related issues of restoration (of legacy sites), prior informed consent, and empowerment of the Indigenous peoples and local communities. In 2008, these organisations hosted a legacy mine roundtable in Toronto. Canadian Indigenous peoples were reluctant to participate:

> Representatives from Indigenous Peoples organisations underlined the importance of including and engaging representatives from local communities when addressing legacy site issues. It was noted that over time the politics of marginalisation has caused communities to feel angry and powerless and has led to a breakdown of confidence and trust with respect to working with the mining industry to address legacy sites. Furthermore, participants stated that local communities were reluctant to attend the roundtable because they feel that they are being used by the mining industry to help 'green' mining companies. (Post-Mining Alliance, 2008)

By 2012, it was noted that 'there has been little advancement on environmental issues surrounding legacy sites where legal responsibility for clean-up is unclear' (Buxton, 2012, p. 20). In 2018, the International Organisation for Standardization initiated a working group to prepare a voluntary standard published as 'Managing Mining Legacies ISO–24419' (ISO, 2023) requiring Indigenous peoples' involvement in managing abandoned mines on their lands. As with other voluntary standards, enforcement remains relatively weak.

Since the early 2000s, mining footprints have become larger, more complex, and more disruptive to local communities, yet policy formulation to address the issue of abandoned mine legacies has been neglected. This was recognised in 2024 by a United Nations panel on critical energy transition minerals that recommended a global mining legacy fund 'to build trust and address legacy issues as a result of derelict, ownerless or abandoned mines, and strengthen financial assurance mechanisms for mine closure and rehabilitation' (UN, 2024). Nonetheless, abandoned mines and their interaction with Indigenous peoples' lands remains a longstanding policy gap at multiple scales.

Under Australia's federated model of government, mining is regulated by states and territories, including the management of abandoned mines (Unger et al., 2015). This differs from other major mining jurisdictions such as South Africa, Chile and Peru (Department of Mineral Resources, 2009; Edraki and Unger, 2015) where mining is regulated at a national level. Australian Government involvement in national abandoned mine policy has been transient (Ministerial Council on Mineral and Petroleum Resources & Minerals Council of Australia, 2010; Noetic, 2016) with agencies only becoming involved when there is a legal requirement (e.g., Australian Government, 2020), a compelling national interest, or a potential economic benefit from secondary mining (Parbhakar-Fox, 2024).

Canada also has a federal system of provinces and territories, but its National Orphaned and Abandoned Mines Initiative has played an active role in connecting subnational jurisdictions since 2002. This national initiative operates through a multistakeholder model, enabling diverse perspectives in decision-making, including those of First Nations. This federal government initiative maintains a comprehensive abandoned mine inventory, contributes to policy development, holds regular workshops and actively shares knowledge. Without a national point of contact, Australia has limited its participation in global forums on mining legacies and abandoned mines – its governments were not represented at the international legacy mine roundtable forum in Canada (Post-Mining Alliance, et al., 2008) nor those hosted in former brown coal and uranium mining regions of Germany. Unger et al. (2018) work highlights the relative immaturity of the Australian programs compared to Canada, and the immaturity of both nations in cultural heritage management as part of remediation of abandoned mines.

In the absence of a unifying national policy, Australia has an inconsistent approach managing abandoned mines. Western Australia (WA) introduced the Mine Rehabilitation Fund in 2012, requiring companies to pay an annual levy of 1 % of estimated mine closure costs. The fund's earnings in interest were intended to sustain the program, but falling interest rates in 2020-21 severely limited the available funds and the program's scope of activities. More recently, the Northern Territory's Mines Remediation Act 2023 established a framework for remediating legacy mines, with a more resilient financial structure than in WA. Queensland established a funding mechanism for the Abandoned Mine Land Program (AMLP) in 2019 through the Financial Provisioning Scheme enabled by Treasury-led reforms. The primary focus of these state-level programs is high-risk, large-scale abandoned mines with major issues and associated costs. None of the programs have mapped the extent of the intersection between abandoned mines and Indigenous peoples' lands or dense concentrations of small, abandoned mines.

4. Study context: Queensland

While the policy landscape surrounding abandoned mines in Australia is fragmented, Queensland serves as a useful case study to illustrate the scale of the issue and demonstrate a methodological

Table 1
Five clusters of abandoned mines in Queensland.

Cluster	Principal Local Government Area	All Abandoned Mines		Abandoned Mines on Indigenous Lands	
		N	%	*N*	%
1	Mareeba, Tablelands	4,218	27.5	3,152	74.7
2	Etheridge, Croydon	1,040	6.8	958	92.1
3	Cloncurry, Mount Isa	1,879	12.3	1,753	93.3
4	Charters Towers	1,738	11.3	733	42.2
5	Rockhampton, SE Queensland, Southern Downs	2,964	19.4	397	13.4
Cluster Total		**11,839**	**77.3**	**6,993**	**59.1**
	Unclustered	3,478	22.7	1,401	40.3
Grand Total		**15,317**	**100.0**	**8,394**	**54.8**

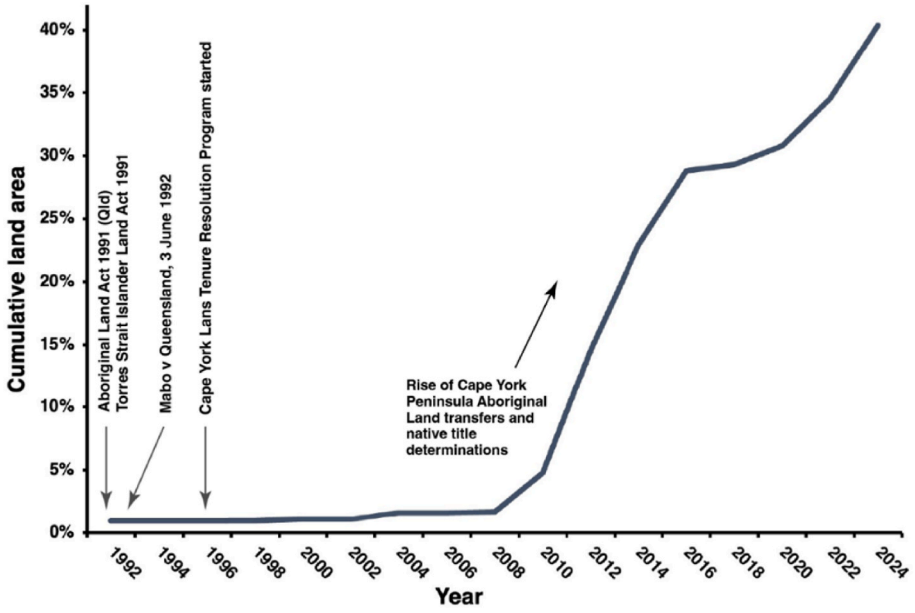

Fig. 1. Cumulative area of Queensland for which Indigenous peoples have all forms of legally recognised rights to land, over time.

approach for mapping abandoned mine intersections with Indigenous peoples lands. Queensland has approximately 15,000 abandoned mines, primarily small to medium-sized (Queensland Government, 2018, p. 2). A decade ago, the estimated cost of fully rehabilitating these sites was AUD 1 billion (Queensland Audit Office, 2014). Since its establishment, the AMLP has expanded by one to two large, abandoned mines each year (Stones et al., 2024). It is difficult to establish a clear picture of the AMLP's financial position because the state's liability is not reported with the prior year's expenditure or future budgets (Queensland Government, 2024a). Nonetheless, it is possible to discern that the 2024 to 2025 budget for the AMLP approved AUD 36.6 million (Stones et al., 2024) and that the total budget is AUD 153.7 million (Queensland Government, 2024b), indicating that funds are from more than one source. One such source is the Financial Provisioning Scheme, from which a claim of AUD 1 million and a grant of AUD 2.5 million were dispersed in 2023–2024 (Queensland Government, 2024c, p. 4).

The objectives of the AMLP relate to safety, security, and durability of solutions, and productivity, including future use. The AMLP has prioritised shaft capping in historical mining areas near the regional towns of Charters Towers and Gympie (Stones et al., 2024). Publicly available records about shaft capping in the more remote, less populated areas of the state are incomplete. In terms of prioritising lands over which Indigenous peoples have rights, the AMLP reports high-priority abandoned mines on state or leasehold land on which native title has been determined to coexist, Aboriginal freehold land and land under assessment for transitioning to Aboriginal freehold. Sites ranked as a low to medium risk are classified as 'surveillance' sites, while those ranked as a high to extreme risk, are 'prioritised'. The AMLP is not explicit about Indigenous peoples' participation in the prioritisation process (Queensland Government, 2021c). The state's risk mitigation process focuses on remediation works, not the impacts associated with historical disturbance. Presently, Queensland Government policy is not to prioritise small to very small, abandoned mines (Table 1, p6 Queensland Government, 2021c) which means the impacts of these sites on Indigenous and other regional land users are not evaluated.

From a historical perspective, mining became a major part of Queensland's economy in the 1870s. The principal legislation, the Mining Act, 1898 (Qld), obliged leaseholders to keep active workings fenced and to fill all shafts and open cuttings when leaving or be fined up to £50 (s 145). Nevertheless, when mines were exhausted, abandoned workings were routinely abandoned. Complaints about public safety are documented from an early date (Charters Towers Evening Telegraph, 1911; Gympie Times and Mary River Mining Gazette, 1897; Northern Miner, 1902).

Historians such as Reynolds (1981) and Evans (2007) have detailed conflict on Queensland's mining frontier, but a lesser-known example of the effects on Aboriginal land use was that in 1882, settler miners shooting game around the Thornborough area, exhausted the local food supply and 'some 200 starving Aborigines presented themselves within the small township' (Evans et al., 1975, pp. 90–91). The government responded by allocating £65 per year to the town for the provision of rations (Tozer, 1897). Allocating land for bushland reserves (for provisioning through foraging and hunting) was not contemplated.

Many decades later, avenues to gain legally recognised rights over land became available to the First Nations people of the state. Queensland began land transfers to community councils in 1984 as DOGITs ('Deeds of Grant in Trust'). Later, the Aboriginal Land Act 1991 (Qld) and the Torres Strait Islander Land Act 1991 (Qld) enabled 'transferable land' to be converted into inalienable freehold ('Indigenous freehold'). Almost all such land is in the far north of the state. In 1982, Meriam plaintiffs began the case that became Mabo v Queensland (No. 2) [1992], establishing that common law recognises customary systems of land tenure, and leading to the federal Native Title Act 1993 (Cth). Fig. 1 shows the cumulative area of the state covered by transfers under the two land acts and native title determinations until 2024. The figure includes exclusive and non-exclusive native title, for which interests are shared with other land users. At the time of writing, 40.4 % of Queensland was covered by these three types of rights to land. Fig. 2 shows the location of these areas.

The Native Title Act classifies historical mining leases as 'Category C Past Acts' (s 231), meaning native title rights and interests can be reinstated upon lease expiry, regaining their 'full effect' (s 238). If any rights have been impaired, compensation is payable. The High Court of Australia affirmed this principle in the 1990s, and again in 2002, but the question of compensation is unresolved. In 2023, the Federal Court of Australia found that the 'just terms' requirement of the Australian Constitution applies to mineral leases issued by the Commonwealth from 1958 in the Northern Territory (Yunupingu v Commonwealth of Australia (2023)). This case was on appeal in the High Court in 2024.

The intersection of historical mining leases and native title areas was less material in Queensland as recently as 2010, when 4.5 % of the state was covered by various forms of Indigenous tenure. Now, the figure is

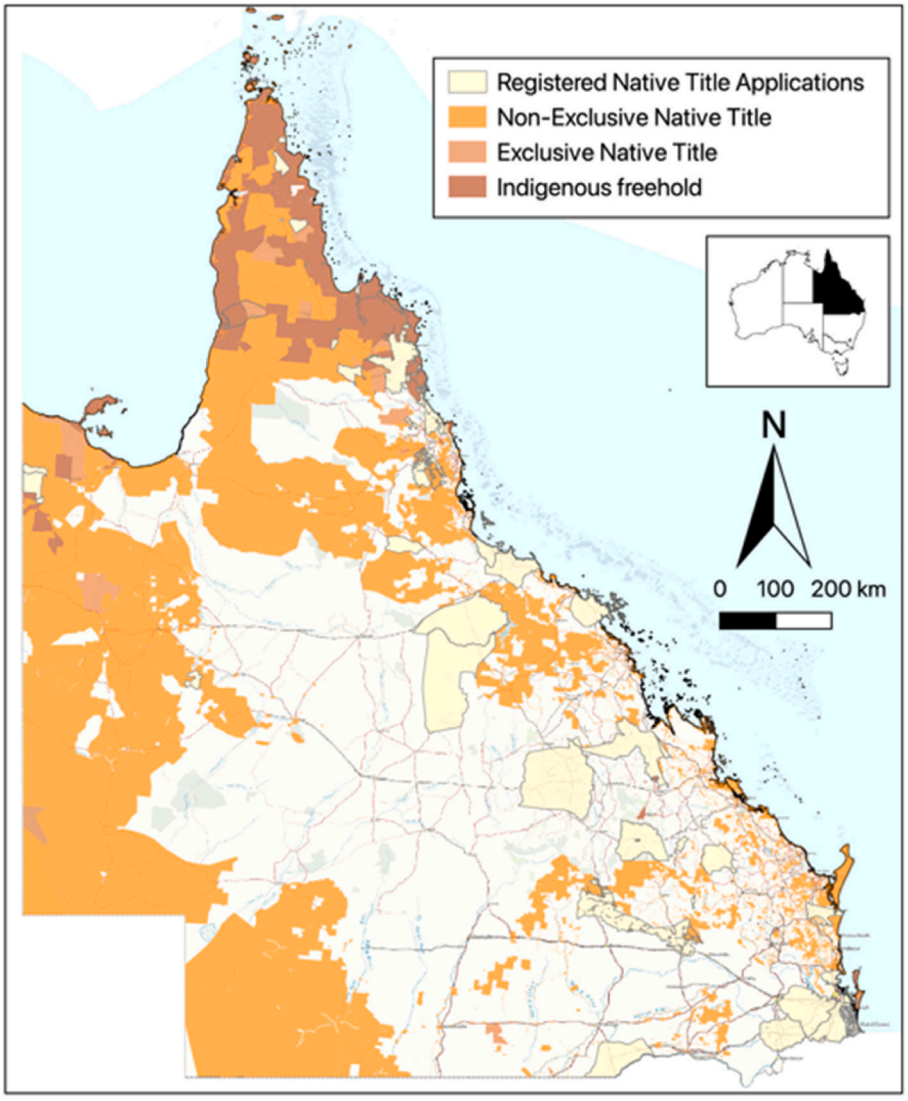

Fig. 2. Areas of Indigenous freehold, exclusive and non-exclusive native title, and registered native title applications in Queensland, November 2024

nine times higher at 40.4 %. Environmental assessment is not routinely conducted before or during a native title land claim, so the condition of land because of abandoned mining legacies is undocumented at the time of determination. We examine this and other implications in the sections that follow.

5. Research design

To identify the intersection of abandoned mines with Indigenous peoples' formally recognised rights to land in Queensland, we access publicly accessible spatial datasets relevant to each. Spatial data on abandoned mine sites are available in layers published on the Queensland Government's QSpatial data portal by the Queensland Department of Resources (QDoR)[4] and are derived from their long-term MINOCC (Mineral Occurrence) database. Spatial data on land to which Indigenous people have legally recognised rights to land are available from the National Native Title Tribunal (NNTT) for native title land and QSpatial for land transferred into Aboriginal or Torres Strait Islander ownership under state legislation. Earlier releases of some of the QSpatial layers had shortcomings—including deprecated geographic datums, records with no location data, and inconsistent date formats—but most of these matters have now been resolved. (See the Supplementary Information for additional details and limitations of available data.)

We use a four-step method outlined in Fig. 3 and Supplementary Information to visualise the intersection of abandoned mines with Indigenous peoples' formally recognised rights to land in Queensland at the scale of the state, regions within the state, and the local level.

Step 1: We select the relevant QSpatial mine site and 'Indigenous land interest' layers and NNTT native title layers. The first of these yields data on all mine sites (N = 21,380) in the state, including active mines. Filtering the data yields locational data for 15,317 sites classified by QDoR as 'abandoned mines'. This layer does not contain the start and finish years of noncurrent mines.

Step 2: Across Australia as a whole, Indigenous peoples hold a range of legally recognised rights to land similar to those we have noted for Queensland covering 59.6 % of the continent. In Step 2, we replicate the approach applied by Burton et al. (2024) to map Indigenous peoples' lands across Queensland and overlay abandoned mines data. This work delineates areas where Indigenous peoples' rights and interests in land are formally recognised under Australian

[4] Recently becoming part of the Department of Natural Resources and Mines, Manufacturing, and Regional and Rural Development.

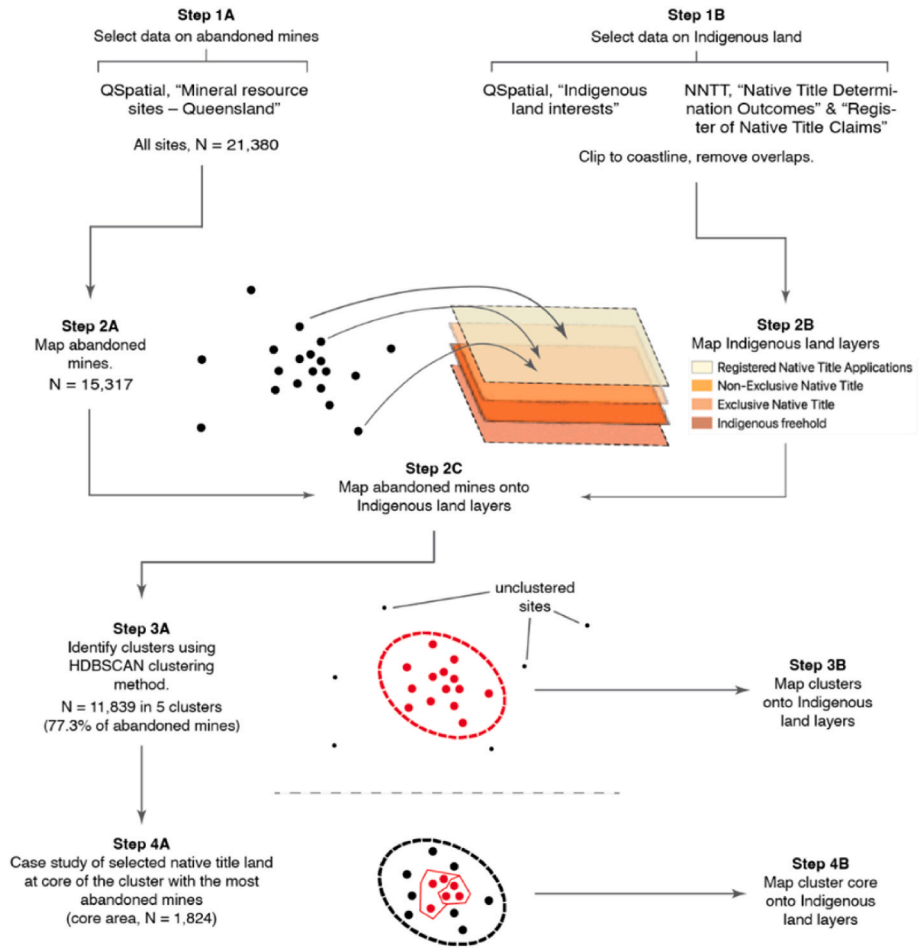

Fig. 3. Four-step approach to assembling the spatial intersection of abandoned mines and Indigenous peoples' lands (see Supplementary Information).

legislation, and they are legally empowered to negotiate over development.

Step 3: We use a mathematical clustering method (HDBSCAN, see Supplementary Information) to identify concentrations of abandoned mines. The method is designed to find the statistically most appropriate number of geographical clusters in the data, given only a minimum number of points that should be in each cluster. It leaves sparsely distributed sites unclustered. We set the minimum number at 500.

Step 4: We select the cluster that has the most abandoned mines, Cluster 1, and inspect its core area using the same data layers as in the previous steps.

6. Results

Results show that 54.8 % (8,394 of 15,317) of abandoned mines in Queensland are located on Indigenous peoples' lands (see Table 1 and Fig. 4). The clustering method used in Step 3 (Fig. 3) identifies five clusters of varying numbers and density of abandoned mines on these lands (Fig. 4), accounting for 77.3 % of the total number of abandoned mines (Table 1). Four of the clusters are in the more remote North and Far North Queensland regions, reflecting the contribution of mining to the economic development of northern Queensland (Bolton, 1970). Thus, there are more abandoned mines in less populated regions of northern Queensland and fewer in the more populated south of the state. We describe each cluster before focusing on Cluster 1 (see Section 6.2), which has the largest number of abandoned mines of the five clusters.

6.1. Describing and comparing clusters

This section describes the five clusters, including the status of native title claims and determinations and excluding scattered abandoned mines outside clusters. Each cluster has denser patches of mines (see Supplementary Information). This in turn has implications for the physical impact on native title land, as we discuss in Section 7.

Cluster 1 comprises 4,218 abandoned mines, more than any of the other clusters, and is spread across the Mareeba Shire and Tablelands Region. Some 74.7 % of the sites lie on native title land owned by multiple Aboriginal groups: the Western Yalanji, Kuku Djungan, Wakaman, Muluridji, Ngadjon-Jii, and Tableland Yidinji, Jirrbal and Mbabaram peoples, among others. There is little Aboriginal freehold in this area. Violent contact occurred during the Palmer River gold rush of 1873, followed by the founding of the principal towns from 1880. Some groups, such as the Jirrbal, were able to take refuge in the rainforests of the Atherton-Tully area and retain their language and traditional way of life into the 1920s (Idriess, 1958). A particularly dense patch of abandoned mines, representing 43.2 % of the cluster and forming its core, occurs on the native title land of the Mbabaram and Jirrbal peoples, which we examine further in Section 6.2.

Cluster 2 comprises 1,040 abandoned mines in two subgroups across the adjacent Croydon and Etheridge Shires in northern Queensland. The sites are mostly small gold mines worked from an initial gold rush in the 1880s, and 92.1 % is on the land of the Tagalaka (Croydon) or Ewamian (Etheridge) peoples.

Cluster 3 comprises 1,879 abandoned mines across the Cloncurry–Mount Isa area, a region of intensive mining since the first finds of copper near Cloncurry in 1867 and the copper-silver-zinc ore body at

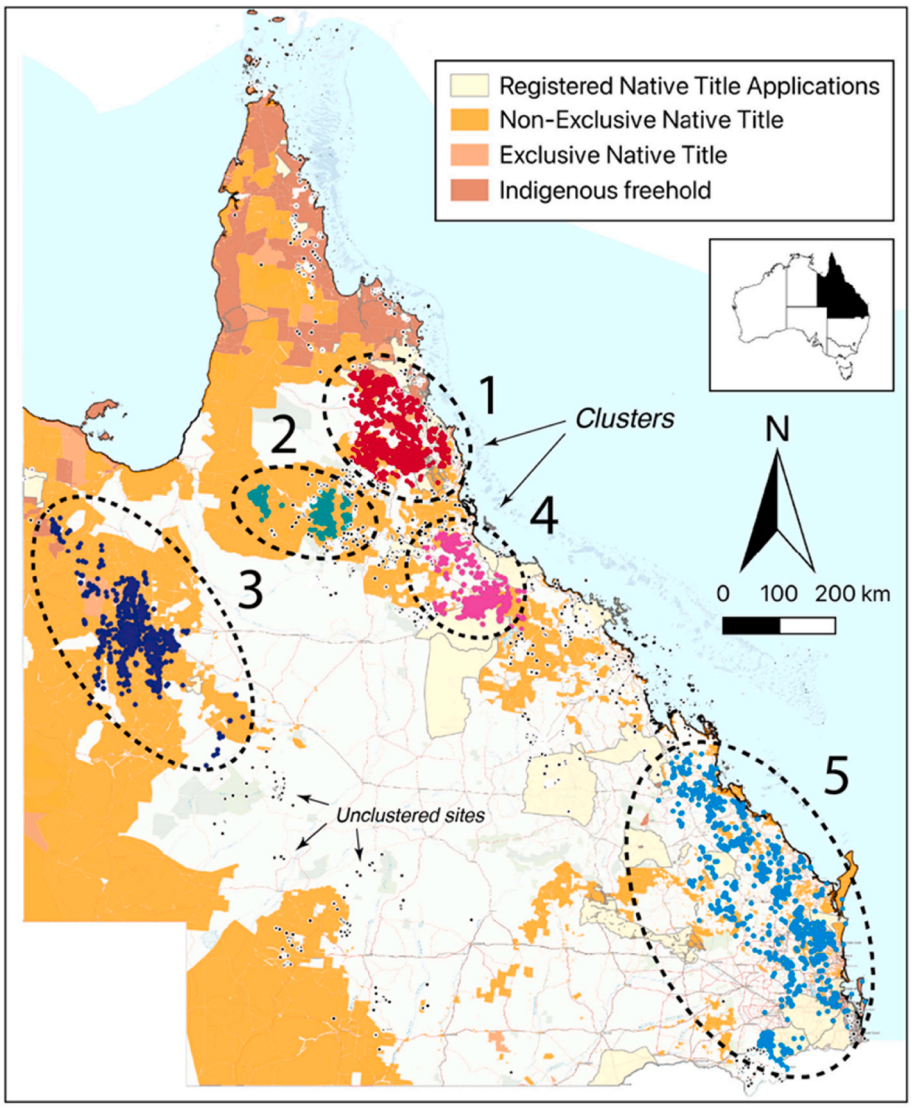

Fig. 4. The five clusters of major concentrations of abandoned mines in Queensland.

Mount Isa in 1923 (Blainey, 1960). In this cluster, 93.3 % of the abandoned mines lie on native title lands, with 80 % is on the lands of the Kalkadoon people (Mount Isa) and Mitakoodi and Mayi people (Cloncurry).

Cluster 4 comprises 1,738 abandoned mines around Charters Towers, of which 42.2 % are on the native title land of the Gugu Badhun, Gudjala and Birriah peoples. A substantial part of the cluster is located on the southern side of Charters Towers in an area for which the Jangga people have registered a claim.

Cluster 5 is spread across a broad coastal band from Rockhampton in the north to South East Queensland and the Southern Downs region. Only a small number of native title claims have succeeded in this area, and few (13.4 %) of the nearly 3,000 abandoned mines in the cluster lie on land to which Aboriginal people have legally recognised rights.

6.2. *Mbabaram and Jirrbal native title land in Cluster 1*

The core of Cluster 1, south-west of Cairns, comprises an especially dense concentration of abandoned mines. Specifically, 1,824 abandoned mines are on the land of the Mbabaram and Jirrbal peoples. This 'dense patch' amounts to 43.2 % of the 4,218 abandoned mines in Cluster 1. Fig. 5 enlarges this area, while the native title holdings of adjacent groups are omitted for clarity.

The area shown in Fig. 5 is generically known as the Herberton Mineral Field. Its mineral occurrences were systematically assessed in the past (Blake, 1972) and, more recently, as part of Geoscience Australia's New Economy Minerals Initiative (W. H. Bryan Mining & Geology Research Centre, 2021). Most of these mines are classed by QDoR as 'very small'. An example is Gibraltar, a tin mine in the Silver Valley, which was active from 1913 to 1917 (Fig. 6).

The concentration of abandoned mines in this location amounts to one mine for every 188 ha of Mbabaram native title land and one mine for every 48 ha of Jirrbal native title land in the Silver Valley and Herberton. In the latter case, this amounts to an average distance between mines of as little as 220 m. The Jirrbal people have additional native title lands, including a pastoral station and portions of national park that were not mined and are not included in this calculation. The abandoned mines on these native title lands have not been systematically surveyed. However, a small subset was recently described in the North East Queensland Mineral Deposit Atlas (W. H. Bryan Mining & Geology Research Centre, 2021) and is included in Table 2. Given that the inclusion of sites in the atlas was in accordance with geological criteria, the subset may be treated as a small, but essentially random, sample from the perspective of land tenure and extent of landscape disturbance. Note that assessments of the physical condition of land and waters are not routinely conducted as part of native title claim processes.

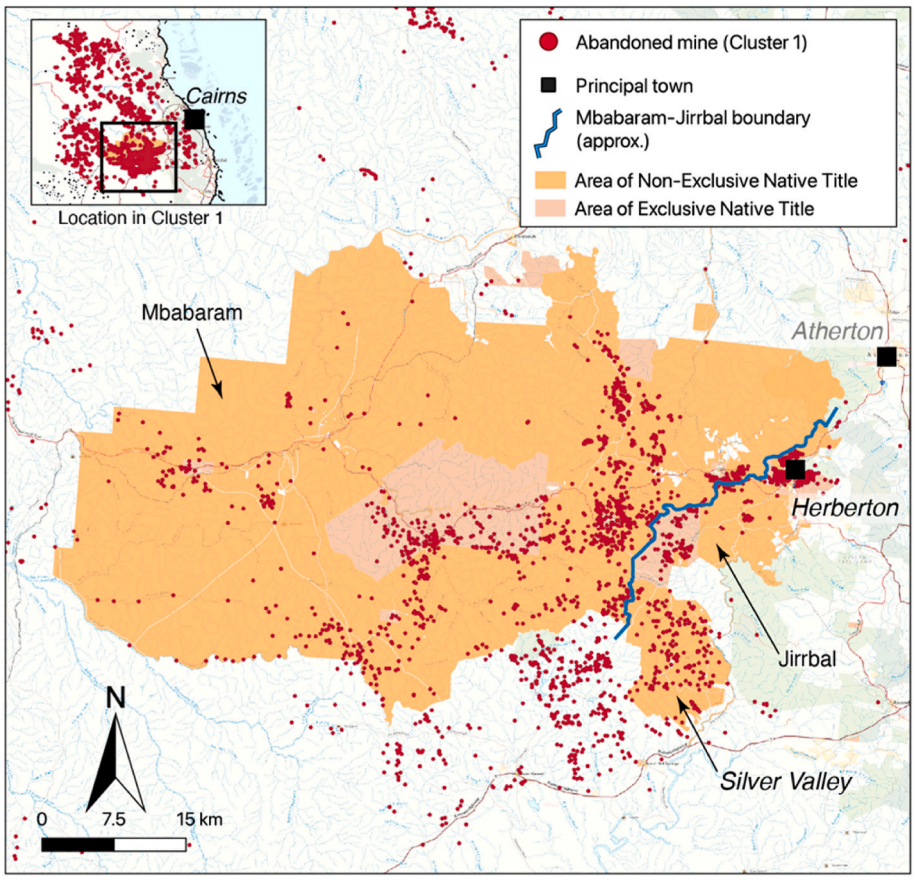

Fig. 5. Dense patch of abandoned mines in Cluster 1 on Mbabaram and Jirrbal native title land, Atherton Tableland.

Fig. 6. Gibraltar, an abandoned mine in the Silver Valley, Jirrbal native title area (13 August 2019).

The 14 sites in Table 2 are treated as point locations in QDoR data. However, closer inspection shows that this is only realistic for 'very small' mines, such as Gibraltar, because sites can represent a larger area, illustrating the problem of what counts as a mine and the difficulty in estimating areas of land disturbance. To illustrate:

- The Great Northern mine created a tailings dump in the centre of Herberton to store mill wastes. While the tailings dump is on native title land, the mine is not. The dump covers more than 6 ha. It is now known as the 'Herberton tailings storage facility' and is part of a remediation project by the Queensland Government. The interests of the Jirrbal people are noted on the AMLP website (Queensland Government, 2021a).
- Herberton Deep Lead is given a point location but the area mined was a buried alluvial channel extending south from the Herberton town boundary for several kilometres. The Herberton Deep Lead mineral development licence, MDL448, approved in 2012, covered 3,388 ha (Consolidated Tin Mines, 2017), of which 1,667 ha (49.2 % of the licence) were on Jirrbal native title land.
- The Loudoun Mill is not counted as an abandoned mine but was integral to the operation of now-abandoned mines around Irvinebank. When commodity prices collapsed after World War I, it was acquired as a state enterprise. It is now listed on the Queensland Heritage Register as 'Irvinebank State Treatment Works'. It is on Mbabaram native title land, as noted on the AMLP website (Queensland Government, 2021b).

Temporal patterns of mine abandonment in our case study area are found in the Mbabaram people's first successful claim (Congoo v Queensland (2001)), in which 669 'mining tenures', granted before the *Racial Discrimination Act 1975* (Cth), came into operation and are listed in an appendix. The reason for the list, and the designation of the leases specifically as 'tenures', appears to reflect the then recent finding that mining leases could extinguish native title (Western Australia v Ward (2000)). However, shortly after *Congoo v Queensland* the High Court of Australia overturned this (Western Australia v Ward (2002)), nullifying any effect the leases may have had. However, their presence gives us an opportunity to match dated mining operations to native title land: 529 of them match lease codes in the QDoR 'Historic mining

Table 2
Sample of historic mines on Mbabaram and Jirrbal native title land.

Name	Resource Type	Location	Native Title Holder	Description (Size based on QDoR 'Mineral resource sites – Queensland' dataset)
Great Northern	Tin	Herberton	Jirrbal	Size: 'Medium'. Active from 1880. Sixteen mine shafts, maximum depth 198 m, and open-cut pit. Listed on the Register of the National Estate and the Queensland Heritage Register (James Cook University, 2016). Tailings dump now managed by Queensland Government as 'Herberton tailings storage facility remediation project'.
Herberton Deep Lead	Tin	Herberton	Jirrbal	Size: 'Medium'. A buried alluvial channel that was mined 1906–1920s.
Governor Norman	Tin	Irvinebank	Mbabaram	Size: 'Medium'. Active 1905–1920s, 1940s–1987. The site was re-explored in the 2010s (Monto Minerals, 2014).
Great Southern	Tin	Irvinebank	Mbabaram	Size: 'Medium'. Active 1880s–1945. Pits and shafts.
Loudoun Mill	Tin processing	Irvinebank	Mbabaram	Size: Not available. A tin-processing plant acquired as a state enterprise in 1919 and now listed on the Queensland Heritage Register as 'Irvinebank State Treatment Works'.
Vulcan	Tin	Irvinebank	Mbabaram	Size: 'Medium'. Active 1893–1930. Main shaft reached 445 m. Mine and headframe listed on the Queensland Heritage Register.
Gift	Tin	Silver Valley	Jirrbal	Size: 'Medium'. Active from 1913. 300 m long by 50 m wide by 15 m deep.
Lancelot	Tin	Silver Valley	Jirrbal	Size: 'Medium'. Active 1891–1960s.
Mount Ogston	Tin	Silver Valley	Jirrbal	Size: 'Very small'. Active 1910–1913.
Sailor	Tin	Silver Valley	Jirrbal	Size: 'Very small'. Active in 1970s and 1980s. Recent interest (2010s) from Newmont.
White Elephant	Tin	Silver Valley	Jirrbal	Size: 'Very small'. Active from 1914.
Zig Zag	Antimony	Silver Valley	Jirrbal	Size: 'Small'. Active from 1913.
Baal Gammon	Zinc, copper, silver, bismuth	Watsonville	Mbabaram	Size: 'Medium'. Active 1930s–2012. Included in Queensland's Abandoned Mine Lands Program as an abandoned mine in 2019 after breaches of permit conditions. Waste recently re-analysed to evaluate potential for secondary mining.
Federation	Tin	Watsonville	Mbabaram	Size: 'Medium'. Active 1885–1930s.

leases—Queensland' dataset and are mapped in Fig. 7. A first observation is that more than a hundred were outside the *Congoo v Queensland* claim area, illustrating the response of the then Department of Natural Resources and Mines to validate long-disused leases rather than focus on the land under claim or consider how its condition might affect the exercising of native title rights. Almost all have both grant and relinquishment dates or can be matched with other information to show that they went out of use in the early 1900s. The average life span of the 91 % of leases, that had both dates recorded, was 5.1 years. Given the lack of rehabilitation in the period covered by the historic leases, it is likely that all qualify as abandoned mines, not leases (and certainly not active tenures).

7. Discussion

This study provides the first systematic mapping of the overlap between abandoned mines and Indigenous peoples' legally recognised rights to land in Queensland. The findings show that more than half (54.8 %) of all abandoned mines in official data fall within areas where Indigenous peoples hold formally recognised rights to land. It is likely that a high level of intersection exists in other mining jurisdictions, in Australia and elsewhere (Unger et al., 2012; Worrall et al., 2009). While the Queensland Government has focused on remediating a handful of high-risk, large-scale abandoned mines, thousands of smaller, historical sites are being overlooked (Queensland Government, 2021c). These sites are more than just remnants of past mining and patterns of colonisation—they represent a risk for people and ecosystems, including Indigenous peoples' ability to use, manage, and restore their lands.

The expansion of Indigenous land tenure in Queensland over the past two decades has not been matched by a shift in abandoned mine policies and programs. As native title claims have been determined, and land grants have increased, the legacy of historical mine sites has, in many cases, shifted to Indigenous peoples without adequate consultation. Existing governance structures assume that abandoned mines on Crown land remain the responsibility of state governments or default to freehold owners, or (in the case of small, historical mines) are too insignificant to address. This ignores the fact that historical recognition of Indigenous peoples' rights to land continues to evolve, and the clustering effects of these mines may have accumulated significant risks. In Australia, there has been no discernible effort to integrate abandoned mine risks into native title processes or to consider how these sites affect Indigenous peoples' ability to use or develop their lands.

The lack of a clear and discernible processes for Indigenous peoples' participation in abandoned mine remediation is a significant shortcoming of the current system. Governments and companies claim to be building 'partnerships' with Indigenous communities, promising consultation and benefit-sharing (Australian Government, 2022). Yet these commitments disappear when it comes to historical and abandoned sites, where decision-making about remediation priorities happens behind closed doors. Queensland has not publicly articulated a process for Indigenous peoples' participation in risk assessments or rehabilitation efforts or ongoing management of these sites. This exclusion is not just a policy failure, it is an example of how mining's long-term impacts continue to unfold 'under the radar' in ways that disadvantage remote and rural communities and Indigenous peoples.

A fundamental rethink of abandoned mine governance appears to be long overdue. The assumption that governments remain liable for abandoned mines does not match the reality that many of these sites are now located on Indigenous freehold or native title determined lands. Yet traditional owners have not been allocated financial or logistical support to deal with these legacies. If abandoned mines are not formally addressed when land is transferred, these mines may become a permanent liability that limits how Indigenous peoples can use their land. Successive governments have failed to develop a policy framework that acknowledges this issue, effectively sustaining an uneven system where landowners are left with degraded landscapes and no clear pathway for remediation.

Another major concern is the lack of available data on abandoned mines. Many abandoned sites have little or no public documentation on the extent of contamination, risks to water sources, or long-term ecological damage. This means that even when Indigenous peoples regain legal rights over lands, they are often unaware of the risks posed

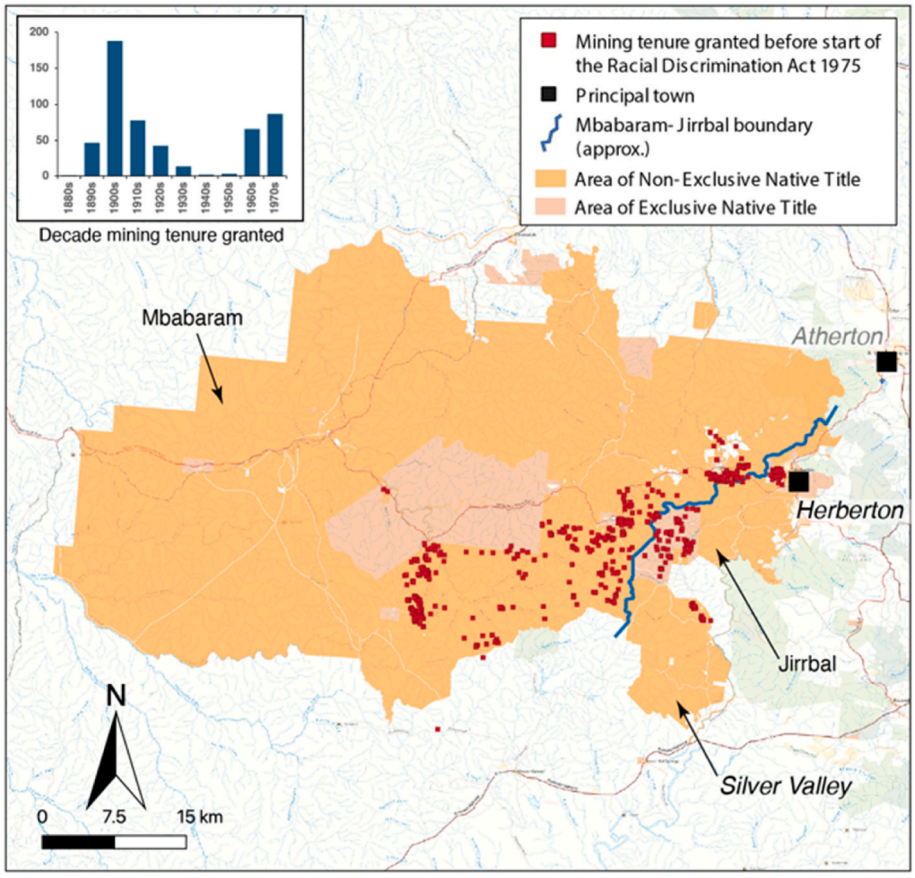

Fig. 7. Distribution of historic 'mining tenures' noted in *Congoo v Queensland* and decade of grant (inset).

by abandoned mining infrastructure. The failure to systematically track contamination risks from mining (Purtill et al., 2022) also makes it harder to predict future legal and financial liabilities. As more native title claims in Australia are determined, there is growing potential for compensation disputes over the environmental damage left by historical mining. Cases such as Yunupingu v Commonwealth (2023) have demonstrated how historical land use decisions can have long-term legal consequences. Similar cases could emerge if governments continue to ignore the presence of abandoned mines, including dense clusters of small, abandoned mines on Indigenous peoples' lands.

The risks of leaving these sites unassessed extend beyond legal liabilities. Many abandoned mines continue to cause water pollution, habitat destruction, and public safety hazards, but without proper data, these effects remain largely invisible in policy discussions. This creates a situation where the worst legacies—especially those in remote and rural areas—remain out of sight and out of mind. In Australia, governments have largely taken a reactive approach, addressing abandoned mines only when they become high-profile public concerns, rather than systematically identifying risks using diverse forms of knowledge and perspectives.

Future mine abandonment is another issue that has not been properly addressed. Demand for critical minerals is driving new mining developments, yet price volatility means that some of these operations could be abandoned before closure planning is in place (Browne et al., 2011). The recent collapse in the global nickel price is a reminder of how quickly markets can shift, leaving companies unable or unwilling to meet their rehabilitation obligations (de Poloni et al., 2004; Smith and Chounding, 2024). If mine governance is not improved now, history will repeat, with new generations of abandoned sites adding to the thousands already left unaddressed. Governments need to treat abandoned mines not as isolated failures but as part of a broader pattern of mining's long-term and cumulative impacts, which require ongoing oversight, not just short-term intervention.

To break this cycle, governments could shift from passive management to active engagement across a fuller spectrum of mines. This would include assessing the risks from clusters of small, abandoned mines and including Indigenous peoples' knowledge and perspectives before land transfers take place, rather than being left for Indigenous groups to deal with afterward. Public access to abandoned mine data could be improved so that landholders, researchers, and policymakers have more accurate information needed to conduct empirical analysis and make informed decisions. At the same time, policies governing native title could include mechanisms for addressing environmental liabilities so that Indigenous peoples do not inherit the liabilities associated with historical mining damage. We concur with Lawrence and O'Faircheallaigh that:

> Aboriginal Australians have more to lose from inadequate rehabilitation and closure practices than any other segment of the population … Mining companies come and go, but Aboriginal communities are connected to their ancestral homelands and are left with environmental legacies for future generations. (2018, p. 2)

Our study highlights the urgent need for a more inclusive and transparent approach to abandoned mine governance. Abandoned mines are often treated as a problem of the past, but they are present-day issues that require long-term management and accountability. Failing to address abandoned mines in a systematic way is already affecting Indigenous landowners, and without action, the issue will continue to grow. Governments must recognise that the issue of abandoned mines is not just about remediation—it is also about land justice, environmental responsibility, and governance reform. If policymakers continue to ignore these sites, including clusters of small, historical mine sites, the

consequences will not only be environmental but also economic and social, deepening inequalities for years to come.

8. Conclusion

This study provides the first systematic analysis of the intersection between abandoned mines and Indigenous peoples' legally recognised rights to land in Queensland, Australia. Our findings reveal that 54.8 % of abandoned mines in Queensland are located on Indigenous peoples' lands, with the vast majority located in dense clusters. Our findings highlight a significant governance and policy gap: while governments and industry focus on high-risk, high-profile abandoned mines, thousands of smaller, abandoned mines remain unassessed and unaddressed. Despite the rapid expansion of Indigenous land tenure in Queensland, abandoned mine governance has not adapted to reflect this shift. Indigenous peoples are excluded from remediation decision-making, even when abandoned mines affect their lands, territories, and cultural heritage. This situation contradicts stated aspirations by companies and the state government to partner with Indigenous peoples and reinforces long-standing injustices.

Moving forward, policy responses must prioritise Indigenous participation in abandoned mine governance including Indigenous participation in state-funded abandoned mine remediation programs, site risk assessments, and the integration of abandoned mine considerations into native title processes. This includes expanding data transparency, strengthening regulatory accountability, and ensuring that abandoned mine risks are factored into native title claims. Without these changes, abandoned mine legacies will remain an unresolved burden on Indigenous landowners, further entrenching historical inequalities.

Our study highlights the urgent need for further research into abandoned mine impacts on Indigenous peoples' lands, including detailed risk assessments, historical contamination mapping, and studies on the social and cultural consequences of abandoned mining legacies. Future research should be Indigenous-led and co-designed, where rights-holding groups play a central role in shaping the knowledge and policies that influence their lands.

The push for new mining projects to meet global demand, particularly for energy transition and critical minerals, makes addressing historical mining legacies more urgent than ever. Without proactive policy reform, abandoned mines will continue to accumulate, compounding environmental and social risks. Addressing abandoned mines as a contemporary governance challenge—not merely a historical remnant—is critical to environmental sustainability, Indigenous land justice and equitable land management in Australia and beyond.

CRediT authorship contribution statement

Corinne J. Unger: Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Conceptualization. **John Burton:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Deanna Kemp:** Writing – review & editing, Supervision, Resources, Project administration, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix ASupplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2025.125357.

Data availability

Data will be made available on request.

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