Development of best practice advice to support the transition to post-mining land uses in Queensland

Mine rehabilitation in Queensland

Mining is a temporary land use and there is an increasing recognition that rehabilitation and the delivery of beneficial post-mining land uses (PMLUs) is an intrinsic part of the mining lifecycle (Keenan and Holcombe, 2021). Mine rehabilitation is the return of disturbed land to a stable, safe condition that supports a PMLU (*Environmental Protection Act 1994 s 111A*). It differs from the concept of remediation, which focuses only on achieving physical and chemical stability of land (Keenan and Holcombe, 2021). However, the establishment of safe, non-polluting and stable landforms is a prerequisite to any proposed PMLU. In Queensland, the two most commonly proposed PMLUs are a) grazing and b) native ecosystem (or habitat/ecosystem services). This research brief summarises background research and future research opportunities that will support the effective transition from mining to these and other PMLUs in Queensland.

Mine rehabilitation to grazing

Land suitability assessment and benchmarks for grazing land

Not all land in Queensland will be suitable for grazing. The suitability of the land and its limitations for a PMLU of grazing need to be evaluated before grazing can be considered as a viable rehabilitation goal. Existing guidelines for 'agricultural land evaluation in Queensland' provide a basis to assess land limitations and determine whether grazing is an appropriate PMLU (DSITI and DNRM, 2015). Anecdotal evidence provided during early stakeholder consultation indicated that grazing outcomes for many existing mines in Queensland are targeting a land suitability class that is by definition unsuitable for grazing (i.e., land suitability class 4 or 5). Assessing the likely limitations of a rehabilitation area and determining that the land will be suitable for grazing (i.e. will be able to achieve land suitability class 1, 2 or 3) is necessary before grazing is considered as a viable PMLU in future.

After land limitations are assessed and the land is considered suitable for a future grazing end use, both land condition and water condition need to be rehabilitated, and maintained, if grazing is to be a sustainable PMLU on that land. The Office of the Queensland Mine Rehabilitation Commissioner (OQMRC) will be undertaking research to provide guidance on best practice with respect to assessing land suitability for grazing, as well as rehabilitation benchmarks for rehabilitating land condition to a level that will sustain grazing on that land into the future. Although land suitability assessment and land condition assessment tools provide a useful platform for rehabilitation of mined land to grazing land, a question remains as to how post-mining grazing regimes will be monitored to ensure grazing pressure does not result in future deleterious impacts to landform stability.

Weed management

Important indicators of grazing land condition include the proportion of organic groundcover, the density and diversity of perennial, palatable and productive (3P) pasture species, the extent of erosion, and the presence of weeds (DES, 2020). Weed infestation presents a significant threat to the achievement of sustainable grazing as a PMLU in Queensland. Weeds are plants with invasive properties, that require some management action to reduce their negative effect on the economy, environment and/or human health and amenity (Invasive Plants and Animals Committee 2016, 2017). Best practice rehabilitation involves ongoing land management, including weed control, to maintain land condition both during and after mining operations have ceased. OQMRC is engaging with the Department of Agriculture and Fisheries to tailor existing grazing land condition assessment platforms (e.g., Stocktake https://stocktakeglm.com.au/index.html, Land Condition Assessment Tool

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https://www.stateoftheenvironment.des.qld.gov.au/liveability/case-studies/case-study-2) into tools that the mining industry can use to demonstrate grazing rehabilitation performance. These platforms include weeds as a key determinant of grazing land condition. Future research will focus on strategies that support best practice rehabilitated techniques to minimise weed establishment, and best practice management of grazing land, both while mines are operational and post-mining.

Mine rehabilitation to native ecosystem

Native and novel ecosystems

Native ecosystem rehabilitation is more complex than rehabilitation to grazing, as ecosystem succession is not linear. Furthermore, the objectives of ecosystem rehabilitation are often misunderstood by stakeholders and incorrectly used interchangeably with the differing concept of 'ecosystem restoration'. Ecosystem rehabilitation aims to "*reinstate ecosystem functionality and land productivity*" and may assume different land use and species composition than the pre-disturbance ecosystem (Australian Government, 2016). This is in contrast to ecosystem restoration which seeks to re-establish an image of a pre-disturbance state or replicate a desired reference ecosystem (Australian Government, 2016).

Where the objectives of mine rehabilitation relate to targets in a reference ecosystem, best practice involves development of state-and-transition models for the target ecosystem, to map the restoration trajectory as well as identify interventions that can be made to drive ecosystem development in the desired direction. State-and-transition models have been used to successfully guide the non-linear process of native ecosystem restoration towards nearby (or pre-mining) reference site targets in Western Australia (Grant, 2006) and the Northern Territory (Hernandez-Santin et al., 2020). A useful case study on best practice principles for ecosystem restoration is Glencore's Mangoola Mine, NSW (Ryba, 2021).

However, it is clear that highly disturbed sites often do not lend themselves to re-instatement of pre-disturbance ecological communities or to the development of communities reflective of undisturbed reference ecosystems (Doley and Audet, 2013). Furthermore, seed availability at the time of rehabilitation, and costs also influence the species mixes used during rehabilitation. Thus, in contrast to true restoration efforts, native ecosystem rehabilitation may produce novel ecosystems, comprising a stable assemblage of new abiotic and biotic attributes (Doley et al., 2012; Doley and Audet, 2013) that do not meet reference site criteria for species composition or richness (Erskine and Fletcher, 2013; Doley and Audet, 2016; Manero et al., 2021). In these cases, rehabilitation objectives may be better related to ecosystem functionality, broad biodiversity goals, landscape stability including no adverse effects on the surrounding ecosystems, and/or the provision of ecosystem services, for example, biodiversity refugia or corridors (Erskine and Fletcher, 2013; Gillespie et al., 2015; Manero et al., 2021). These types of native ecosystem rehabilitation objectives are inherently less quantitative than targets that relate directly to reference ecosystems.

OQMRC is undertaking research to compare and evaluate the feasibility and the value of various native ecosystem outcomes (i.e., ecosystem restoration, as well as the establishment of unique ecological forms). Best practice methodologies for evaluating native ecosystem rehabilitation success, such that rehabilitation to natural or novel ecosystems could consistently be evaluated across the state, are also being investigated. Stakeholder perspectives on native ecosystem rehabilitation outcomes and methodologies for determining success will be incorporated.

Biodiversity corridors and other ecosystem services

Presently, PMLUs are nominated by mining companies on a site-by-site basis, during the environmental approvals process or during rehabilitation planning. An opportunity exists for cumulative benefit from connectivity of high value native ecosystems in Queensland if rehabilitation efforts are considered more broadly, for example at a regional level rather than only at the site level. This might include native ecosystem rehabilitation that connects existing regional ecosystems in Queensland or coordinated native ecosystem rehabilitation goals and objectives across multiple mine sites to develop biodiversity corridors. The Fitzroy Basin is a useful region to test this opportunity, as it is home to the vast majority of coal mines in Queensland, and is entirely within the Brigalow Belt Bioregion, where 81% of the remnant vegetation is considered of state significance and 80% has state or regional-level biodiversity values (DES, 2018). OQMRC is undertaking research to identify and comparatively evaluate the potential of mine rehabilitation areas in the Fitzroy Basin to enhance relevant biodiversity values by connecting existing regional ecosystems of high ecological potential. The research involves integration of spatial data on regional ecosystems and mines within the Fitzroy Basin with ecosystem and biodiversity values for example, threatened species habitat and other criteria outlined in the Biodiversity Assessment and Mapping Methodology for the Brigalow Belt (EHP, 2014). This will assist to identify opportunities for maximised biodiversity outcomes (e.g. via development of new corridors) as a result of ecosystem rehabilitation on mining leases.

Future research opportunities relating to PMLUs

In addition to the technical challenges relating to implementation of PMLUs, there are important legislative and regional planning considerations that cannot be overlooked. An effective transition to PMLUs in Queensland will need to consider how mine relinquishment can be integrated into state planning regimes including local government planning schemes. There may be opportunities to unlock regional benefits from rehabilitated land more efficiently, for example, making successfully rehabilitated land on long-life mining leases accessible to post-rehabilitation landholders who can access financial instruments that encourage best practice land management (e.g., carbon farming, biodiversity credits). Rehabilitated mine lands also present opportunities for future, alternative economic development in regional Queensland, and understanding the barriers and opportunities to realising value from rehabilitated land presents areas of socio-economic research to be explored. Finally, the regulatory context within which post-rehabilitation landholders will be supported remains an important question for future consideration.

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