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Considering natural capital in mining, and its implications for mine closure

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Abstract

Better incorporation of 'nature positive concepts' into mine closure practices can improve the management of risks and opportunities arising from the sector's impact and dependence on nature, delivering value to companies.

Nature positive concepts—the range of efforts from Science Based Target for nature to improved biodiversity monitoring to the implementation of natural climate solutions—help ensure that businesses align with the planetary boundaries. As we approach and cross these boundaries (e.g., 1.5 degrees increase in temperatures, 50-60% of natural ecosystem area) due to excessive emissions of greenhouse gases, unchecked conversion of ecosystems, among other impacts, nature is becoming an increasingly material risk to businesses. Because of the dependence and impact that mining has on nature, nature is especially material to the sector as it drives material risks and opportunities.

In response, several efforts have been launched to better integrate these concepts into mining practices. Frameworks such as the Taskforce on Nature-related Financial Disclosures (TNFD), Science Based Target for nature and corporate natural capital accounting are among them. They are complemented by industry specific efforts including TNFD guidelines for mining and numerous cross sector guides. However, none address how nature positive concepts can be directly integrated into mine closure.

Ten nature positive concepts are described and placed into the International Council for Mining and Minerals' Integrated Closure Planning framework (ICP). Firms can identify the internal procedure that most closely aligns with each step of the ICP and integrate the respective nature positive concept into it. This is a pragmatic way to operationalise nature positivity in closure, improving the management of nature related risks and opportunities, delivering value to corporations.

Keywords: *nature positive; natural capital; biodiversity; no net loss; net positive impact; mitigation hierarchy; TNFD; SBTs for nature; environmental markets; mine closure*

1 The mining sector, nature, and risk

Nature creates material risks and opportunities for the mining sector.

Life on Earth is underpinned by biodiversity, the variability among living things and the ecological complexes of which they are part. Biodiversity makes up ecosystems that are sometimes collectively referred to as nature. These stocks of renewable and non-renewable resources (e.g., biodiversity, flora, fauna, forests, water, soil) enable the flows of final ecosystem services that humans use (e.g., freshwater for mining, insect pollination for farming) (Finisdore & Rhodes, 2020). Collectively, stocks and flows are called 'natural capital' upon which more than half of the world's Gross Domestic Product is moderately or highly dependent (Herweijer & Evenson, 2020).

This natural capital has been in decline. Growth over the past 50 years has come at an environmental cost. At least 75% of terrestrial and 66% of marine environments are significantly altered. Ecosystems have declined in size and condition by 47% globally compared to estimated baselines. And the current rate of extinction is tens to hundreds of times higher than the baseline rate over the past 10 million years (IPBES

2019). Several planetary boundaries—the seven natural systems that define the safe limits in which humans can thrive (Rockstrom et al., 2009)—have been or are in the process of being exceeded (Global Challenges Foundation, 2022). As a result, the World Economic Forum (WEF) identify biodiversity loss and ecosystem collapse as one of the top risks in terms of likelihood and impact (WEF, 2022). A modest loss of final ecosystem services flows is estimated to cost 2.3% of the global GDP (USD 2.7 trillion) (World Bank, 2021).

The mining industry both impacts and depends on natural capital. Over 65,000 km^2 of land are occupied by mining activities (Tang & Werner, 2023) and hundreds more mines are needed to enable the energy transition (Benchmark Source, 2022). Mined land experiences major transformations, causing significant impact on natural capital (The Cross Sector Biodiversity Initiative, 2015). Not only are ecosystems converted for pits; but invasive species can be spread; and air, water and soil is often impacted (WEF, 2022). In addition, mining depends on natural capital for operations (e.g., water for tailings, washing infrastructure, processing and dust suppression; vegetation to prevent erosion) (WEF, 2022).

These impacts and dependencies on natural capital create material risk and opportunities (IEA, 2022; WEF, 2022) for the sector. They are summarized in Tables 1 and 2.

Table 1 Nature related impacts in the mining sector (adapted from TNFD, 2023)

Risk category	Description	Example
Physical	Changes to the state of ecosystems on which the organization is dependent on or has an impact (e.g., soil condition, water condition), resulting in changes to the flow of final ecosystem services.	• Change of waterflows, possibly forcing use restrictions operations • Loss of coastal wetlands, damage from storms • Loss of vegetation, increasing costs of erosion maintenance
Transition—policy and legal	Changes to legislation or regulation aimed at improving the state of ecosystems More stringent reporting obligations	• More stringent permitting requirements • Inclusion of more stringent criteria in trade requirements • EU's CSRD/EFRAG reporting requirements or mandated use of TNFD
Transition—market	Shifting customer/investor values or preferences to products and/or services that have lower impacts on nature Stakeholder conflicts due to competition over ecosystem services	• Lower demand for company's products • Loss of investor goodwill and increased capital costs • Reduction in asset value
Transition—reputation	Change in sentiment towards the organization due to impacts on nature or performance against peers	• Lower demand for company's products • Increased employee turnover costs • Increased costs due to reduction in loyalty of stakeholders • Increased permitting or stakeholder engagement costs • Project delays
Transition—technology	Requirements to transition to less environmentally damaging technologies New monitoring technologies and methods used by regulators and other stakeholders	• Increased research and development costs • Increased operational costs to meet nature goals • Lack of access to technology

Table 2 Nature related opportunities in the mining sector (adapted from TNFD, 2023)

Opportunity category	Description	Example
Resource efficiency	Transition to processes with lower impacts on nature (e.g., reduced water use) Adoption of nature based solutions within service and product lines	• Reduced operational and compliance costs • Increased market valuation through resilience planning • Reduced infrastructure costs • Revenue from environmental markets (e.g., carbon markets, biodiversity credits)
Products and services	More resource efficient products Innovations that reduce impact of other sectors (e.g., precision farming tools)	• Increased resilience to availability of natural resources • New revenue streams • Reduced costs of raw materials and production inputs • Increased revenue due to better competitive position • Increased market valuation through resilience planning • Reduced capital/infrastructure costs
Markets	Access to markets with an interest in sustainability minerals Access to new assets and locations	• Increased revenues • Increased revenue due to better competitive position
Capital flows and financing	Access to nature-related green funds, Bonds, or loans Use of financial incentives for educed operational costs (suppliers) suppliers to improve nature and ecosystem management Use of public-sector incentives (e.g., biodiversity credits, payments for ecosystem services)	• Access to new sources of finance • Access to capital for high-risk projects • Reduced operational costs (suppliers)
Reputational capital	Collaborative engagement with stakeholders Improved sentiment towards the organization due to reduced impacts	• Increase in revenue due to improved reputation • Decrease in employee turnover costs • Reduced costs due to engagement of suppliers and stakeholders
Ecosystem management	Direct restoration, conservation or protection of ecosystems or habitats Indirect restoration, conservation or protection of ecosystems through collaboration with NGOs, communities, governments, or other companies	• Increased resilience to storms • Avoided fines/penalties • Reduction in operational costs due to improved readiness and response to regulatory changes

Because of growing pressures on ecosystems from climate change, ecosystem conversion (e.g., land clearing), over consumption, invasive species, among others, these risks and opportunities are expected to get worse at least in the short term (WEF, 2022).

2 Responding to the biodiversity crisis

In response to these trends, the global sustainability and mining communities have been responding. While not linear, there is a cascading effect from global agreements that drive global voluntary standards that, in turn, influence mandatory reporting frameworks, legislation, and then corporate behavior (Figure 1). The Paris Climate Agreement is telling. Its guidance, translated into the Taskforce on Climate-related Financial Disclosures and the Science Based Targets initiative (SBTi), is now being mandated by legislation around the globe. Of course, many corporations have been voluntarily adopting Paris aligned goals and actions in advance of legislation.

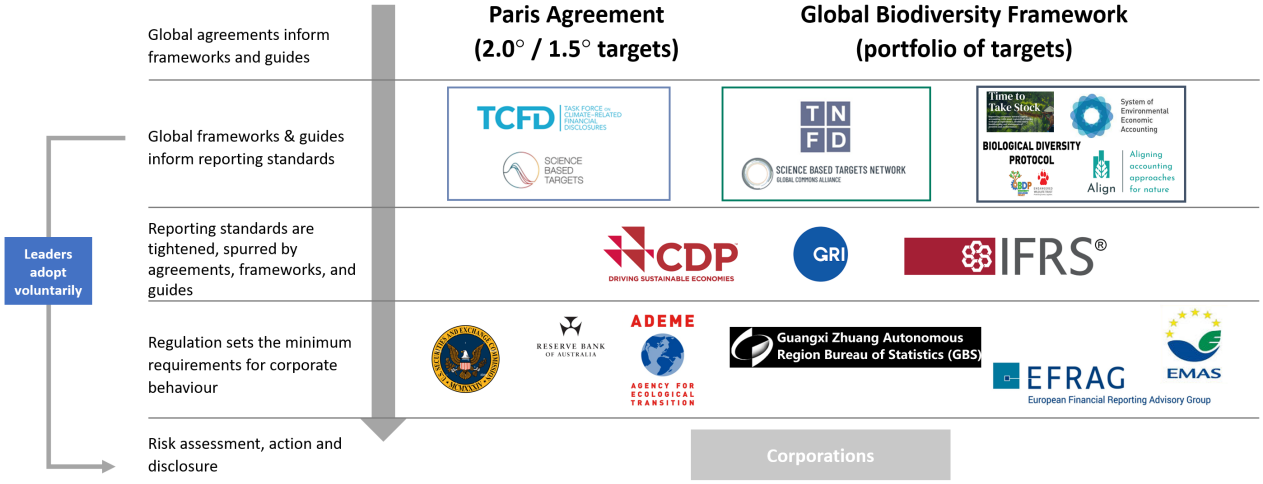

Figure 1 Architecture for nature risk assessment, accounting, action, and reporting

The same trends are being observed for nature, only at a quicker pace. Recommendations from last year's Kunming-Montreal Global Biodiversity Framework (GBF) are already being considered in legislation and corporations are using guidance from the Taskforce on Nature-related Financial Disclosures (TNFD).

The GBF, similar to the Paris Agreement, is an international agreement adopted by some 180 countries. It aims to preserve nature and biodiversity by calling for, among other items:

- A global goal to halt and reverse nature loss by returning 30% of land and marine ecosystems to nature by 2030—the 30 X 30 Goal
- Mandatory requirements for all large business and financial institutions to assess and disclose their impacts and dependencies on nature
- Raised ambition on reforming all environmentally harmful subsidies (Craig, 2023)

Australia, the United States and the European Union, to name a few, have already started advancing legislation and guidance to advance these aims, the 30 x 30 goal in particular.

Global frameworks including TNFD—with guidance for identifying, measuring and disclosing nature related risks and opportunities—and the Science Based Targets for nature (SBTs for nature)—with guidance for developing and implementing SBTs for land, water, biodiversity and oceans—had been tracking GBF's development before it was signed. These draft frameworks are being piloted by corporations and also reference the Global Environment Facility's (GEF) goals as they all work towards harmonization. As these voluntary frameworks advance, more mandatory reporting requirements are expected. In addition, more companies and financial investors are expected to integrate nature and biodiversity into their proforma risk assessment and strategic planning (Camenzuli & Green, 2023; Craig, 2023).

In totality, these initiatives helped bring the term 'nature positive' into the sustainability vernacular. While still evolving, nature positive can be defined as:

> *"…halt[ing] and revers[ing] the loss of nature… reducing future negative impacts alongside restoring and renewing nature, to put both living and non-living nature measurably on the path to recovery"* (IUCN, 2022)

Along with an alignment with the planetary boundaries, nature positive is aligned with the 30 X 30 goal and the GBF more broadly. One survey of nature positive literature summarised 20 concepts of a corporate nature positive approach. The key ones related to mining are:

1. The full scope needs to be covered:
    a. Land, freshwater, oceans and atmosphere
    b. All parts of the value chain (business) or spheres of influence (financial institution)
    c. A double materiality[1] approach is highly recommended
2. Netting out negative and positive impacts needs to be done with respect to the local context and the ecological equivalency principle (like for like, kind for kind)
3. 'Corporate natural capital accounting' methods are highly recommended (see Capitals Coalition 2022 for a description)
4. Full compliance with the mitigation hierarchy (which can be framed within the conservation hierarchy [Conservation Hierarchy, 2023]) is necessary
5. Targets need to be linked to the company's own historical footprint, consider the company's historical contribution to 'harm', and can be underpinned by SBTs for nature
6. Both impact drivers (e.g., land clearing) and the state of nature (e.g., hectares cleared) need to be measured (EU Business & Biodiversity Platform, 2022).

This nature positive vision may seem ambitious, but it is based on best available science and sustainability practice. The net-zero agenda, that seeks hold temperatures below 1.5°, is equally ambitions and the two need to be addressed in tandem as one cannot be addressed without the other (Pörtner, 2023). The mining sector should expect ever stronger nature positive expectations from communities, governments, supply chains, customers, and NGOs (Camenzuli & Green, 2023).

3 Mining turning nature positive

In response, the mining sector has started integrating nature positive concepts into its practices. These developments build on decades of work by the industry to better manage its impacts and dependencies on natural capital. A few points demonstrate this updated ambition:

The International Council on Mining and Metals (ICMM) has been actively engaging in the nature positive agenda, including:

- Working on "commitments and developing the metrics, standards and practices needed to maximise the mining sector's contribution to the" GBF (ICMM, 2023a)
- Advancing the ICMM Mining Principles that call for use of the mitigation hierarchy and no-net-loss of biodiversity and that the Principles need to go further, "contributing to halting and reversing nature's decline globally" (ICMM, 2023a)
- Developing a nature positive roadmap with stakeholders (ICMM, 2023a)
- Working with TNFD on a TNFD guidance for the mining sector (ICMM, 2023a)

[1] Double materiality is understood considering both on how a company is affected by sustainability issues (e.g., loss of natural capital) and how company impacts society and the environment (e.g., how the company's natural capital impacts affect society and the planet). These concepts are defines in the European Sustainability Reporting System (Baumüller & Sopp, 2022).

In addition, there are nearly two dozen mining companies that have started moving toward being nature positive. A few examples include:

- Teck has set a goal of being nature positive by 2030 (Teck, 2023)
- In support of the 30 X 30 goal, Vale helps protect 1 million hectares in its operations around the world, including 800,000 hectares in the Amazon (ICMM, 2023b)
- BHP (Meney & Pantelic, 2023) and Sibayne-Stillwater (Endangered Wildlife Trust, 2023) have implemented corporate natural capital accounting

There are numerous efforts to create frameworks, guidelines and methods for advancing nature positive concepts into the sector. However, the authors of this paper are not aware of any focused on operationalising these concepts in closure practices.

4 Practical steps for operationalising nature positive concepts

Nature positive concepts can be operationalized by integrating them into mine closure. There are over 12,000 active mines globally (Center for Disease Control, 2023) that were started before nature positive concepts and the planetary boundaries were conceived. Integrating these concepts now not only addresses our updated understanding of ecosystem science and restoration needs, but also speaks to the long term positive impacts of improved closure planning. Indeed, the objective of closure is commonly to achieve safe, stable, non polluting and self sustaining ecosystems capable of supporting an agreed land use (Kragt & Manero, 2021).

Integrated Closure Planning (ICP) provides a framework (ICMM, 2019) for identifying where specific nature positive concepts can be introduced (**Figure 1**). Ten nature positive concepts can be introduced into the six IPC steps.

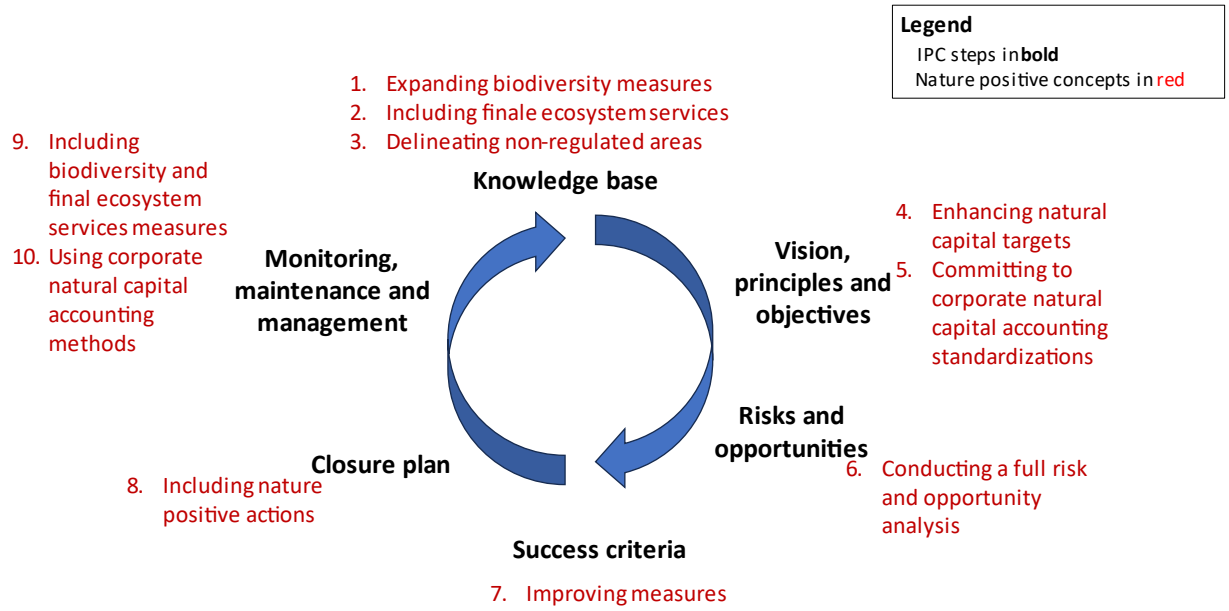

Figure 2 Integrated closure planning steps (Adopted from ICMM, 2019)

4.1 Knowledge base

This step involves the collection of site-specific information about the physical site constraints, environment, socio-economic and regulatory issues at the site. Gathering the correct data enables the implementation of nature positive actions. Nature positive concepts that can be included are:

1. *Expanding biodiversity measures* so they aligned with nature positive concepts (EU Business and Biodiversity Platform, 2022; IUCN 2023) and corporate natural capital accounting (Capitals Coalition, 2022) including:
    a. Measuring the full scope of nature, not only those aspects required by nature. For example, regulations may only require management of impacts to the parts of a site that are endangered, rather measuring and monitoring biodiversity health on the entire site. In addition, measuring impacts in the value chain can be introduced.
    b. The mitigation hierarchy must be used and any necessary data must be collected to demonstrate compliance (The Cross Sector Biodiversity Initiative, 2015).
    c. While not required under definitions of nature positive, Corporate Natural Capital Accounting (CNCA) should be considered. These methods yield data that is comparable from site to site, auditable, can be consolidated across a company, among other benefits. Effectively this requires delineating the entire site's ecosystem types, their extent, and their conditions and then using this data to compute the state of the site's ecosystems through condition adjusted hectares. (Capitals Coalition, 2022)

    While this may appear to be an excessive amount of data, mines typically collect this data already, especially during the permitting stages. However, it is often not managed efficiently and not updated throughout all mine stages. Moreover, gaps can typically be addressed with public datasets.
2. *Including final ecosystem services* in the site analysis which requires (1) understanding how the land has been used, (2) identifying the data required to model those uses and (3) collecting this data. Here too, much of this data is likely to have already been collected. Measuring final ecosystem services provides a way to connect the state of nature with social and economic uses from foraging to hunting to cultural ceremonies.
3. *Delineating non-regulated areas* of the site such as buffer zones from those that have been acquired. These sites are more likely to qualify for use in environmental markets (e.g., carbon trading, species trading, wetland banking). Hence, they offer revenue opportunities and are likely to form a large part of post closure land use in coming years.

4.2 Closure vision, principles, and objectives

In the vision and objectives step, sites align their aspirational goals and concrete measurable statements with corporate and external expectations. The shift underway towards nature positive is driving closure towards conducting more ecosystem restoration. Two groups of nature positive concepts can be adopted.

1. *Enhancing natural capital targets* so that they align with a nature positive vision of the world. For most sites, this equates with net positive or no net loss goals in two ways. One, they are focused on the state of ecosystem (i.e., extent and quality of ecosystems). Two, they meet or exceed the Science Based Targets for nature (SBTN, 2023) or other regional or local conservation targets that are consistent with the planetary boundaries.
2. *Committing the corporate natural capital accounting standardizations* that include:
    a. Defining ecosystem as stock of natural capital
    b. Developing 'asset registers of stocks'

c. Measure changes using appropriate methods including:
    i. Using the principle of ecological equivalency
    ii. Consolidating ecosystem impact data by using condition adjusted hectares
d. Employing recording rules and journal entries
e. Building statements of performance and position
f. Targets that include both accumulated and periodic changes (Capitals Coalition, 2022)

These nature positive concepts, components of which are already part of industry best practices, may not be achievable for all sites. Exploring them, however, stretches closure to achieving more.

4.2.1 Post closure land use planning and engagement

Post closure land use planning and engagement of stakeholders is often initiated during the visioning step to help sure that the closure process is better aligned with regional goals, opportunities, stakeholder interest, among other key areas. The following screen can be helpful:

1. Explicitly seek nature positive land uses (e.g., environmental markets) when identifying potential land use opportunities.
2. Identifying existing nature positive projects in the region and how they may connect with closure. This could result in added value and cumulative impacts towards nature goals. Such efforts can be undertaken with regional, state, national and/or international institutions and communities.
3. Developing site specific suitability criteria for key options and ensure appropriate data is collected in the knowledge base step outlined above.

4.3 Risk assessment

During the risk assessment step, nature positive risk and opportunity should be integrated into the process. This includes:

- *Conducting a full risk and opportunity analysis* related to natural capital helps ensure that not only are all material issues covered, but that the rationale for a specific nature positive action is thoroughly justified. Key guides for conducting this analysis include TNFD and SBTs for nature.

4.4 Success criteria

In this step, specific measurable criteria or metrics are set to track progress towards the objectives of specific land uses. Here sites should be:

- *Improving measures* by including the monitoring themes mentioned in natural capital above (numbers 1 and 2). The measures need to be focused on the state of nature and be aligned with the SBTs for nature or local measures/goals that are aligned with the planetary boundaries. Guidance is available in the TNFD and SBTs for nature.

4.5 Closure plan

In finalizing the closure plan, sites incorporate the learning from the previous stages. Ensuring that nature positive concepts are fully embedded means:

- *Including nature positive actions* (e.g., ecosystem restoration, environmental markets) in the closure plan and more to the point, building procedures that direct a review of nature positive actions. These actions should be reviewed with the same financial and risk screens that other projects are, although care should be taken to ensure the multiple benefits are considered. For

example, a restoration program may bring in revenue from a carbon market, reduce downstream flooding and provide foraging opportunities for communities.

4.6 Monitoring, maintenance, and management

The final step that occurs following completion of the closure is continued monitoring, maintenance, and management of the site. Mentioned in previous steps, this full range of nature positive monitoring must continue. Specifically, sites should be:

1. Including biodiversity and final ecosystem services measures in long term monitoring programs.
2. Using corporate natural capital accounting methods to ensure the robustness of monitoring.

Both of these are detailed above.

In implementing these steps as part of closure, companies should gain a fuller and clearer understanding of their site's nature related risks and opportunities, create more advanced targets, build stronger strategies for achieving them and create new revenue opportunities (most commonly these revenue opportunities are in environmental markets). Exploring these market opportunities could be the easiest route to integrating nature positive concepts into closure planning. Not only should markets have broad interest within companies, but the measurement methods used for many markets align with CNCA.

5 Conclusion

The nature positive agenda is advancing rapidly. Internal and external pressure on mining companies to adopt nature positive concepts is likely to grow. Mine closure is a wise place to employ these concepts—the number of sites due for closure, the long term impact of effective closure, and the gap in application of nature positive concepts calls for it. Ten nature positive concepts are evident that can be immediately integrated into standard closure procedures. Those that bring in new revenue, such as environmental markets (e.g., carbon trading, species trading) offer a way to engage numerous internal stakeholders before broadening a site's use of nature positive concepts. Companies that make this shift are likely to see first mover advantage as the shift toward nature positive mining seems unavoidable.

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