



Nature-smart mining: Opportunities to reduce the nature impact of mining and metals

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Executive summary

The Gordon and Betty Moore Foundation has initiated a three-year exploration into the environmental impacts of the recent global increase in demand for transition minerals.

In 2025, the Moore Foundation commissioned ERM to help with this exploration, including a range of studies to understand supply and demand dynamics, innovation, regulatory structures, nature approach in the value chain, the role of China, and how decisions regarding new mine development and financing are made.

Studies consisted of desktop research and more than 70 interviews with mining industry leaders and stakeholders from the value chain.

This report outlines key findings to inform stakeholders in the mining sector and metals value chain about opportunities to reduce impacts on nature by changing behaviors in the mining and metals market.

Key drivers



Metal supply growth:

While the metals value chain will become more circular, mining activity for copper, nickel, lithium, and cobalt is expected to grow, primarily in Latin America and Indonesia.

The supply sources may vary based on changing technologies, geopolitical alignments, and regulatory incentives.



Overlap with biodiversity sensitivity:

Declining ore quality and rising metal demand are pushing mining into more biodiversity-sensitive areas, increasing pressure on nature and ecosystems particularly in the Andes, south-central Africa, China, and Indonesia.



Source of impact:

Mining activity has a greater potential to impact nature than refining, as refineries are often sited in clustered industrial areas and have more flexibility in their development.



Features that define impact:

Six core drivers shape mining's impact on nature: geology, financing constraints, regulation, development timelines, sustainability approach, and innovation. Each feature of the sector either locks in aspects of development or shapes how new mines are developed.



Role of the value chain in influencing outcomes:

The value chain has the potential to shape outcomes in the mining sector through demanding nature performance in the materials it procures. Currently, metals buyers are beginning to push for better performance, but the demand drivers are uneven and cover only small segments of demand.

To reduce nature impacts, the mining and metals sector has three pathways:

- **Eliminate:** Reduce the overall demand for metals, thereby reducing demand for new mining activity.
- **Substitute:** Eliminate the most harmful mines or substitute more harmful commodities with less impactful commodities.
- **Minimize/Optimize:** Optimize the supply-side through innovation, external pressures, or improving company performance to reduce impacts on nature.

Key takeaways from ERM's research

Declining ore quality and rising metal demand are pushing mining into more biodiversity-sensitive areas, increasing pressure on nature and ecosystems.

With most high-grade, accessible ore deposits already developed, mining is increasingly shifting to remote regions with lower-grade ores, intensifying pressure on nature in two ways. Lower-grade ores require more effort, equipment, and infrastructure to deliver the same output, and many of these deposits sit in key biodiversity areas, increasing environmental impact per unit of supply. Early intervention, better site selection, and lower-impact extraction methods will be critical to break the link between nature degradation and the growth in supply.

Ten mining clusters, producing 53% of the global copper, nickel, lithium, and cobalt supply, are located in highly biodiversity-vulnerable areas.

Production of copper, nickel, lithium, and cobalt is highly concentrated: 116 mining clusters account for 90% of global supply, and just 24 clusters produce 80%. Within that group, 10 clusters in South America, Africa, China, and Indonesia, all in areas of high natural value, supply over half of the total global output. This concentration increases the risk of biodiversity loss, as much of the needed growth in supply will rely on new mining in sensitive areas.

Secondary supply of critical metals is a key emerging source to meet growing demand while reducing reliance on mining and refining in sensitive areas.

Improved recycling technologies and collection methods will substantially expand the secondary supply of copper, nickel, lithium, and cobalt. Secondary supply is expected to meet 41% of total demand across these key metals by 2050. While this will not remove the need for new mining, it can materially reduce reliance on primary extraction and refining, lowering overall pressure on nature. Secondary metals also strengthen resilience against the geopolitical concentration that characterizes critical minerals mining and refining.

Current market signals are insufficient to speed up the adoption of lower-impact mining practices.

Interest in low-impact mining is rising among buyers, investors, and regulators. More investment in innovative, low-impact technologies and methods would positively affect both production and the biodiversity impact of critical minerals mining. However, the increased interest is still insufficiently reflected in price premiums, access to capital, or regulatory pressure to drive mining companies to address nature impacts more proactively. In sectors such as batteries and automotive, buyers increasingly demand responsibly mined minerals, but in most sectors, expectations remain too weak to drive broad change.



Market incentives, including financial instruments, preferential terms, and regulation, are required to stimulate low-impact mining.

Stronger incentives are needed to encourage the mining sector to embed nature into core project economics and decision-making. Market signals, such as preferred financing, preferred off-take terms, price protection, and regulatory pressure, would make a lifecycle approach to mining and investments in nature-related innovations commercially compelling and expected by customers and investors.

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Context | Increased mining activity needed to facilitate the energy transition will accelerate the sector's impact on nature

Context



Energy transition, digital infrastructure, and urbanization are driving rapid growth in projected metal demand.



The demand can only be met through development of up to 500 new mines, often in areas of natural sensitivity.



If existing industry models are followed, this could lead to significant habitat destruction.

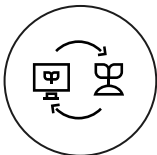
Complicating factors



The nature of the mining industry (long-term and capital-intensive) often makes it conservative and resistant to change.



Customers, investors, and governments are not sufficiently focused on nature to drive behavioral shifts by the mining industry.



The sector lacks the metrics and tools to compare relative merits of mine, refinery and infrastructure options from a nature perspective.

Key questions

- 1 Where will mineral supply likely come from in the coming decades?
- 2 Where does this overlap with the greatest biodiversity sensitivity?
- 3 Do new mines or new refineries have the greatest impact on nature?
- 4 What are the key systemic drivers of the impact of mining on nature?
- 5 What role does the mining value chain play in influencing outcomes?
- 6 What levers are available to influence the impact of mining and metals on nature?

Challenges | ERM's research identified six core challenges that hinder the mining sector's progress on the nature agenda

Supply Side and Value Chain

Consumer Demand

Addressing mine trade-offs and innovation	Allocating capital to nature outcomes	Defining commercial desirability of nature	Aligning societal and financial value	Creating data uniformity and simplicity	Restraining growing demand
<p>Market solutions are not adopted due to limitations in mine planning and decision-making.</p>	<p>Capital sources do not have an avenue to link nature outcomes and mine activity.</p>	<p>Buyers are asking for performance, while mining companies offer management systems.</p>	<p>Natural capital & ecosystem services offer societal & asset value not recognized in decision-making.</p>	<p>Nature data is incomplete, inconsistent, and complex, limiting its usability.</p>	<p>Mining is essential to enable a low carbon transition, but the rate can be constrained.</p>
<p>Key facts:</p> <ul style="list-style-type: none"> • <u>9.4% annual growth</u> of the smart mining market up to 2032. • <u>>50% reduction in tailings storage facility size</u> based on innovation. • One innovation in Rio Tinto and BHP's innovation portfolios focused on nature performance. 	<p>Key facts:</p> <ul style="list-style-type: none"> • <u>200 FIs with US\$26.7T AUM</u>, signed the Finance for Biodiversity Pledge. • <u>US\$430B in nature value-at-risk</u> for mining companies in the next 5 years. • No identified examples of nature-linked financial instruments in mining. 	<p>Key facts:</p> <ul style="list-style-type: none"> • <20% of mining customers view nature as a top 5 buying issue. • 0% price premium in most commodities across sustainability; no nature premiums identified. • Ranked as the 5th highest interest topic for buyers. 	<p>Key facts:</p> <ul style="list-style-type: none"> • <u>8% of known mining properties in IUCNs</u>, 7% in KBAs. • <u>71% of mines</u> and exploration sites in key ecosystem service areas. • <u>25%-50% of regulatory delays</u> are tied to environmental impact. 	<p>Key facts:</p> <ul style="list-style-type: none"> • <u>20.7% annual growth of the tech market</u> for biodiversity monitoring until 2030. • No available global baseline for biodiversity in mining. • <u>Impacts for half of the world's mining areas are undocumented.</u> 	<p>Key facts:</p> <ul style="list-style-type: none"> • > 500 new Cu, Ni, and Li mines required. • 41% of demand expected to be met by recycling in 2050. • Tech changes can influence metals demand up to 29% (Li battery chemistry); further innovation may reduce demand further (e.g., significant ride sharing adoption).

Strategies | Targeted interventions to overcome the key challenges are the best way to minimize nature-related impact across the mining and metals sector

Supply Side and Value Chain

Consumer Demand

Addressing mine trade-offs and innovation	Allocating capital to nature outcomes	Defining commercial desirability of nature	Aligning societal and financial value	Creating data uniformity and simplicity	Restraining growing demand
<p>Enable innovation in mining by better valuing trade-offs and creating conditions to expand technology adoption.</p> <hr/> <p>Potential interventions:</p> <ul style="list-style-type: none"> • Enabling open innovation ecosystems and the use of shared resources for development (e.g., consortia). • Advancing specific technologies such as bioleaching, in-situ extraction, DLE, and processing optimizations. 	<p>Create instruments that link nature performance to preferential financing.</p> <hr/> <p>Potential interventions:</p> <ul style="list-style-type: none"> • Creation of nature-linked sustainable finance instruments. • Leveraging nature valuation in decision-making to influence asset funding strategies. • Integrating nature performance into development standards (e.g. <u>EP4</u>, <u>IFC PS</u>). 	<p>Buyers are asking for performance, while mining companies offer management systems.</p> <hr/> <p>Potential interventions:</p> <ul style="list-style-type: none"> • Linking nature data to traceability programs and buying alliances. • Influence mining standards to mandate reporting on outcome metrics at a site-level. • Offering market incentives or access linked to nature performance. 	<p>Create methods for valuing nature through conventional processes, demonstrating the underpinning role of mine performance.</p> <hr/> <p>Potential interventions:</p> <ul style="list-style-type: none"> • Developing accessible nature value-at-risk tools for mining companies and financiers. • Building a knowledge base on the link between nature performance and financial performance. • Regulatory timeline reduction for lower impact mines (e.g., shorter review periods). 	<p>Improve both site-level and global nature data to inform decision-makers and portfolio selection.</p> <hr/> <p>Potential interventions:</p> <ul style="list-style-type: none"> • Improving cost competitiveness of nature data collection through drones, sensors, eDNA, and other measurement techniques. • Indexing nature indicators at a global scale to better define the relative nature performance of mines. 	<p>Enable demand substitution for primary metals through reduced consumption or alternative materials.</p> <hr/> <p>Potential interventions:</p> <ul style="list-style-type: none"> • Advancing advanced materials development to substitute metals. • Reducing structural barriers to the circular economy and end-of-life recirculation.

Critical metals supply growth

Where will critical mineral supply come from in the coming decades? New supply of copper, nickel, lithium, and cobalt will primarily be mined in South America and Indonesia.

Outcomes for the supply growth of primary metals aren't fixed. They depend on technological developments and interventions, driven by nations' desire to safeguard access to critical minerals. Not all supply needs to be mined and processed; a growing share of demand will be met by secondary metals extracted from existing products and reused.

This section covers:

- Supply and demand projections for key metals, the gaps between them, and how demand sensitivities could improve or worsen the situation.
- The growing role of recycled critical metals, and the geographic distribution of known and underexplored reserves of primary metals.
- The technological, geopolitical, and regulatory trends will influence supply and demand in the next 25 years.



Demand projections | Energy transition and digital infrastructure will drive copper demand; batteries will do the same for lithium, nickel, and cobalt (1 of 2)

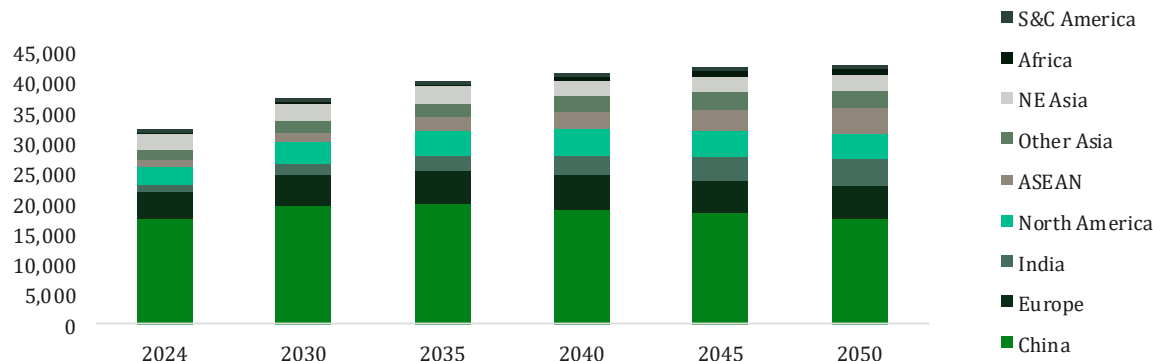
Copper

Moderate proportional demand growth, with current production pipeline peaking ~2035, driven by economic growth, electrification, and digital infrastructure. Diversified end uses, less reliant on EVs than other commodities.

Global Copper Demand, by end-use, %, 2024



Global Copper Demand, by region, kt Cu, 2024-50



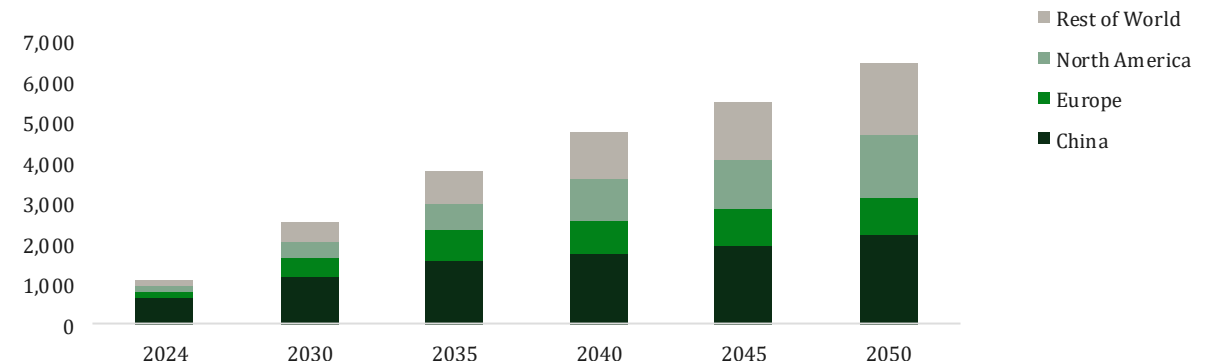
Lithium

Demand will more than double by 2030, almost entirely driven by EV demand, with end use dominated by batteries. Recycling will ease supply pressure from the 2030s onwards.

Global Lithium Demand, by first-use, %, 2024



Global Lithium Demand, by region, kt LCE, 2024-50



Demand projections | Energy transition and digital infrastructure will drive copper demand; batteries will do the same for lithium, nickel, and cobalt (2 of 2)

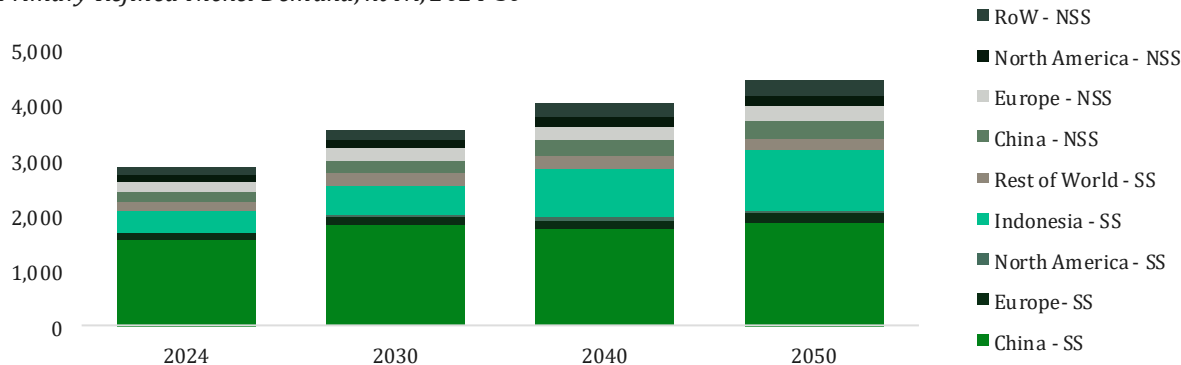
Nickel

Stainless steel is the primary driver of growth, with EV batteries a secondary driver. The supply-demand gap becomes a greater concern post-2050.

Global Nickel Demand, by first-use, %, 2024



Primary Refined Nickel Demand, kt Ni, 2024-50



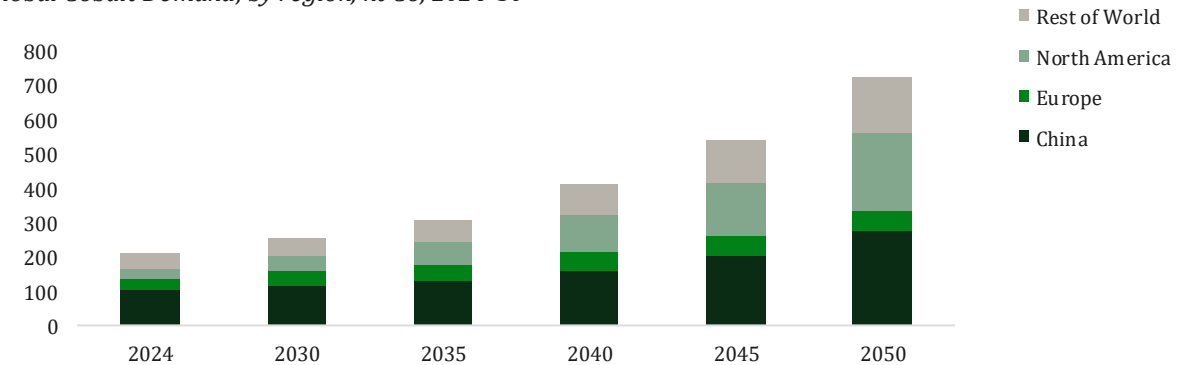
Cobalt

Demand driven almost entirely by EV batteries, though efforts to reduce cobalt content in battery cells could impact longer-term supply-demand dynamics.

Global Cobalt Demand, by first-use, %, 2024



Global Cobalt Demand, by region, kt Co, 2024-50



Note: SS= Stainless steel; NSS = Non-stainless steel
Source: ERM data and analysis; CRU data

Demand sensitivity | Demand for core metals fluctuates with possible efficiency and technology adoption scenarios

Cu

Primary copper demand reduction will most likely occur through recycling and efficiency gains; electrification is an exogenous driver to global demand.

Li

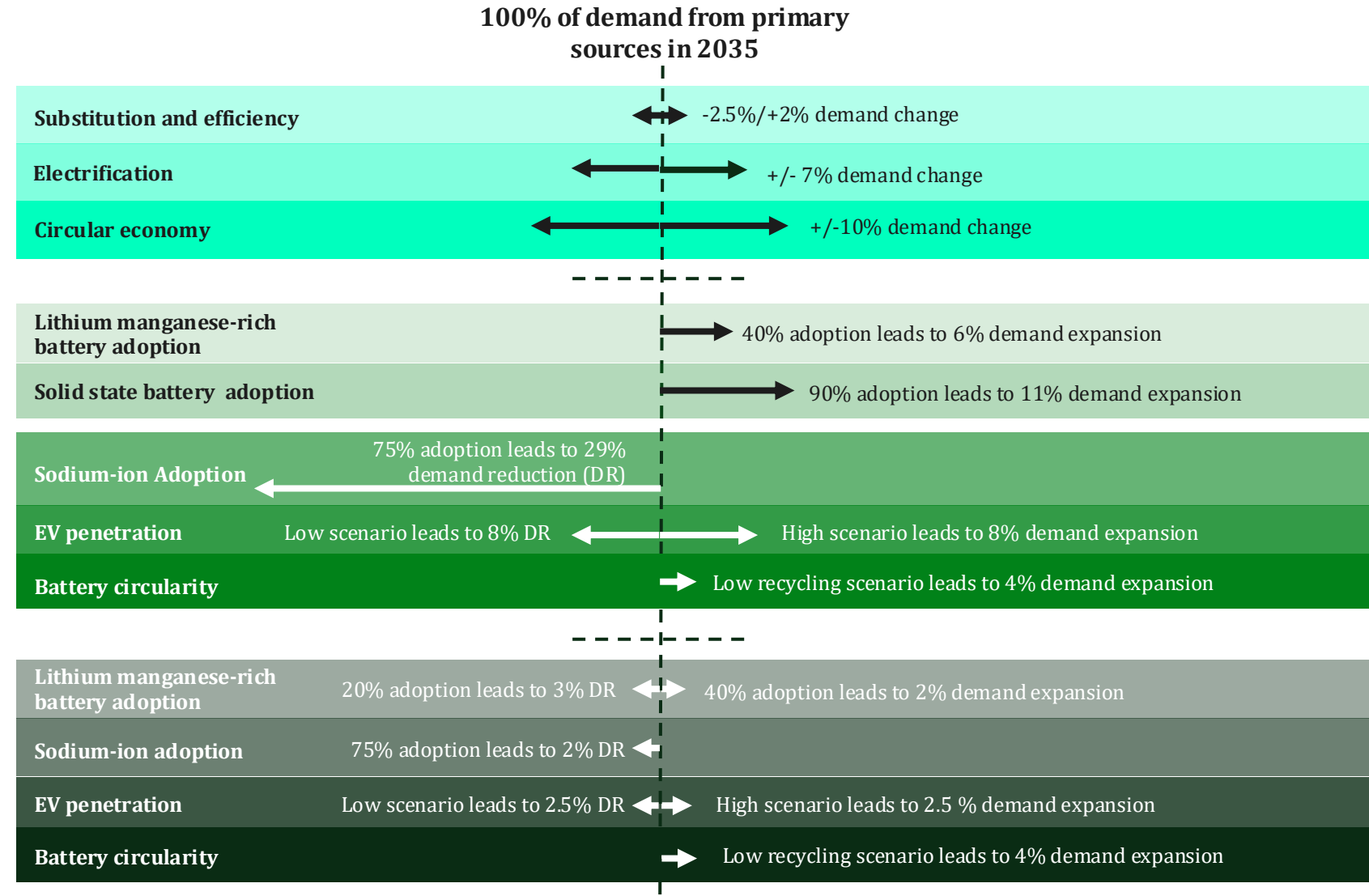
Lithium primary demand is most likely to be influenced through:

- Changing battery chemistry
- Rate of EV adoption
- Volume of new vehicles purchased

Recycling is an ongoing concern for BEVs.

Ni

Primary demand for nickel will most likely be influenced by the same drivers as lithium. Recycling will likely be a going concern for BEVs. Overall, nickel has less exposure to battery demand.

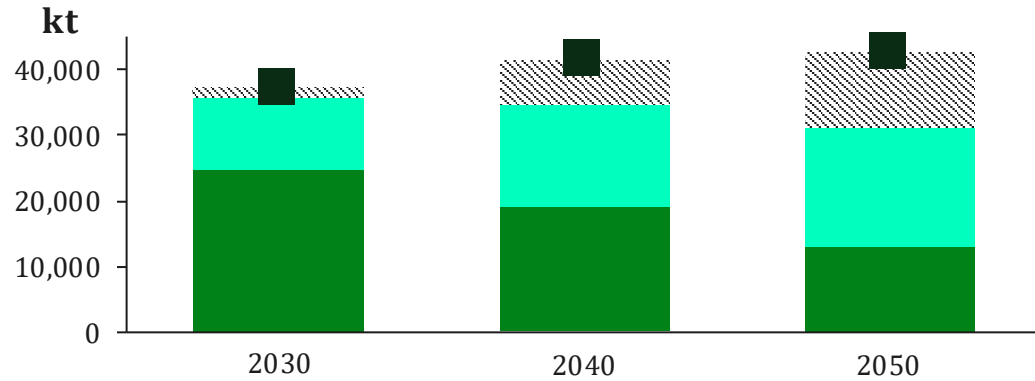


Note: Cobalt (Co) has been excluded due to the low volumes and primary production as a by-product, though its demand will primarily be influenced by battery chemistry
Source: ERM data and analysis; CRU data;

Supply projections | Projected supply gaps will grow for all four metals, increasing pressure to expand mining and processing and manage their impact on nature.

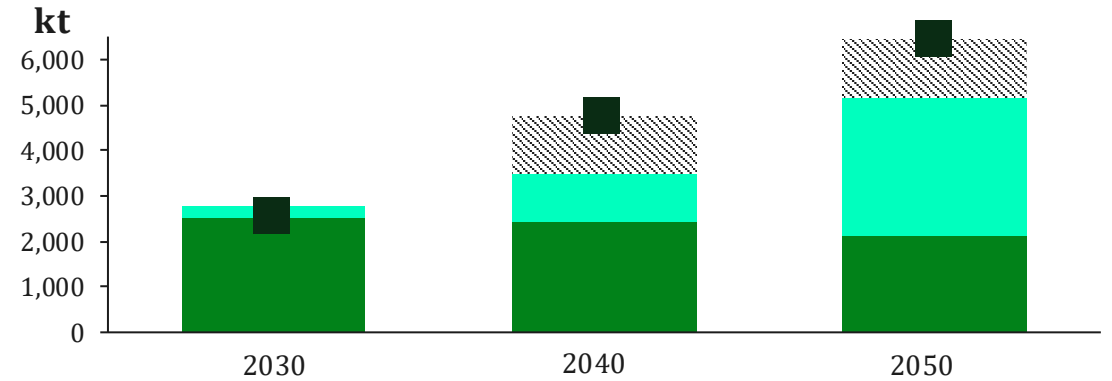
Copper

Supply concentrated in the Andes and south-central Africa, regions exposed to water stress and ecological constraints. Demand grows steadily across construction and electrification, with EVs remaining a smaller driver than for battery materials.



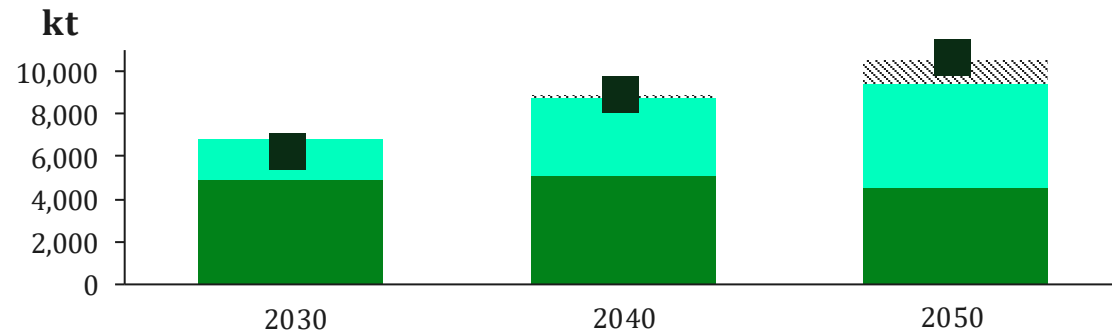
Lithium

Supply is increasingly centered on brines in Bolivia, Chile, and Argentina, though resources remain abundant and geographically diverse. Demand more than doubles by 2030, driven by EV batteries, with recycling expected to ease pressure from the 2030s onwards.



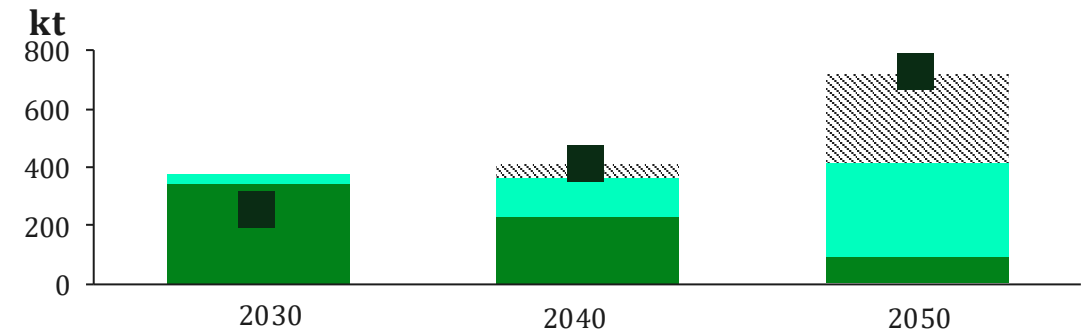
Nickel

Supply is dominated by Indonesia, with significant environmental impacts; alternative sources exist but at higher cost. Demand is led by stainless steel, while battery use grows rapidly and drives future tightness.



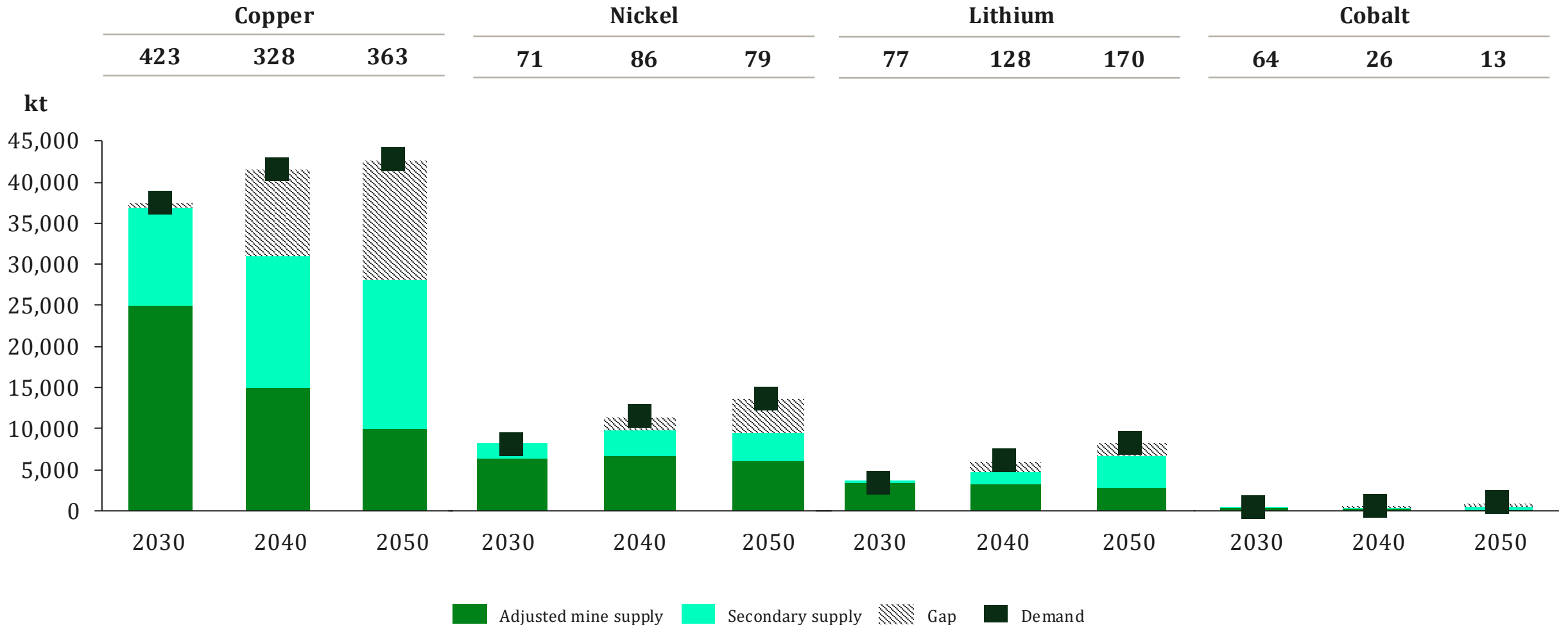
Cobalt

Supply remains highly concentrated in the DRC, though circularity and substitution may gradually reduce reliance. Demand is almost entirely battery-driven, with chemistry shifts tempering but not removing long-term pressure.



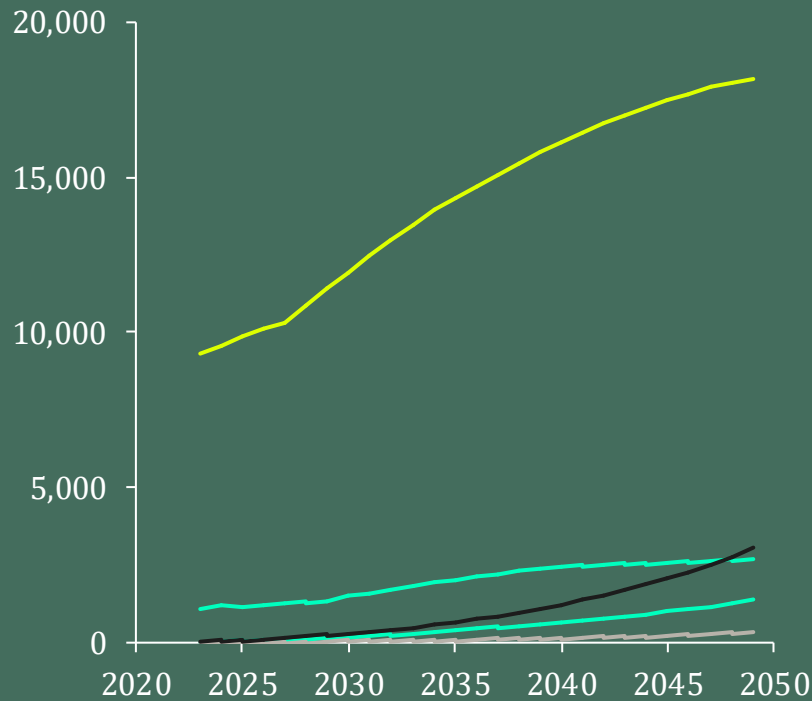
Supply projections | Secondary supply via metals recycling is expected to increase by 41% across all four metals by 2050, but it can't close the primary supply gap

Mines required to meet demand



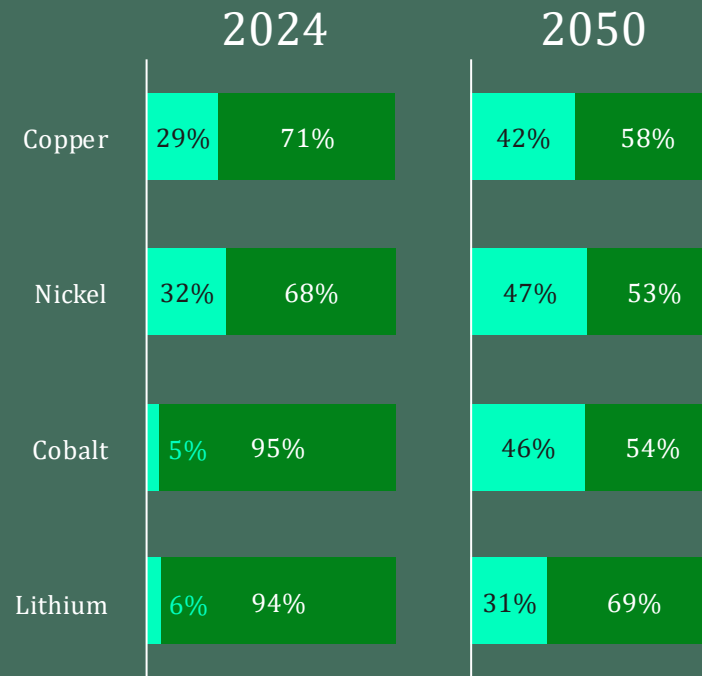
Supply projections | Better recycling technology and collection methods will substantially increase secondary metals supply, particularly for battery metals

Global secondary supply, kt



— Copper
— Nickel - stainless
— Nickel - batteries
— Cobalt - batteries
— Lithium - batteries

Share of demand by type of supply, %

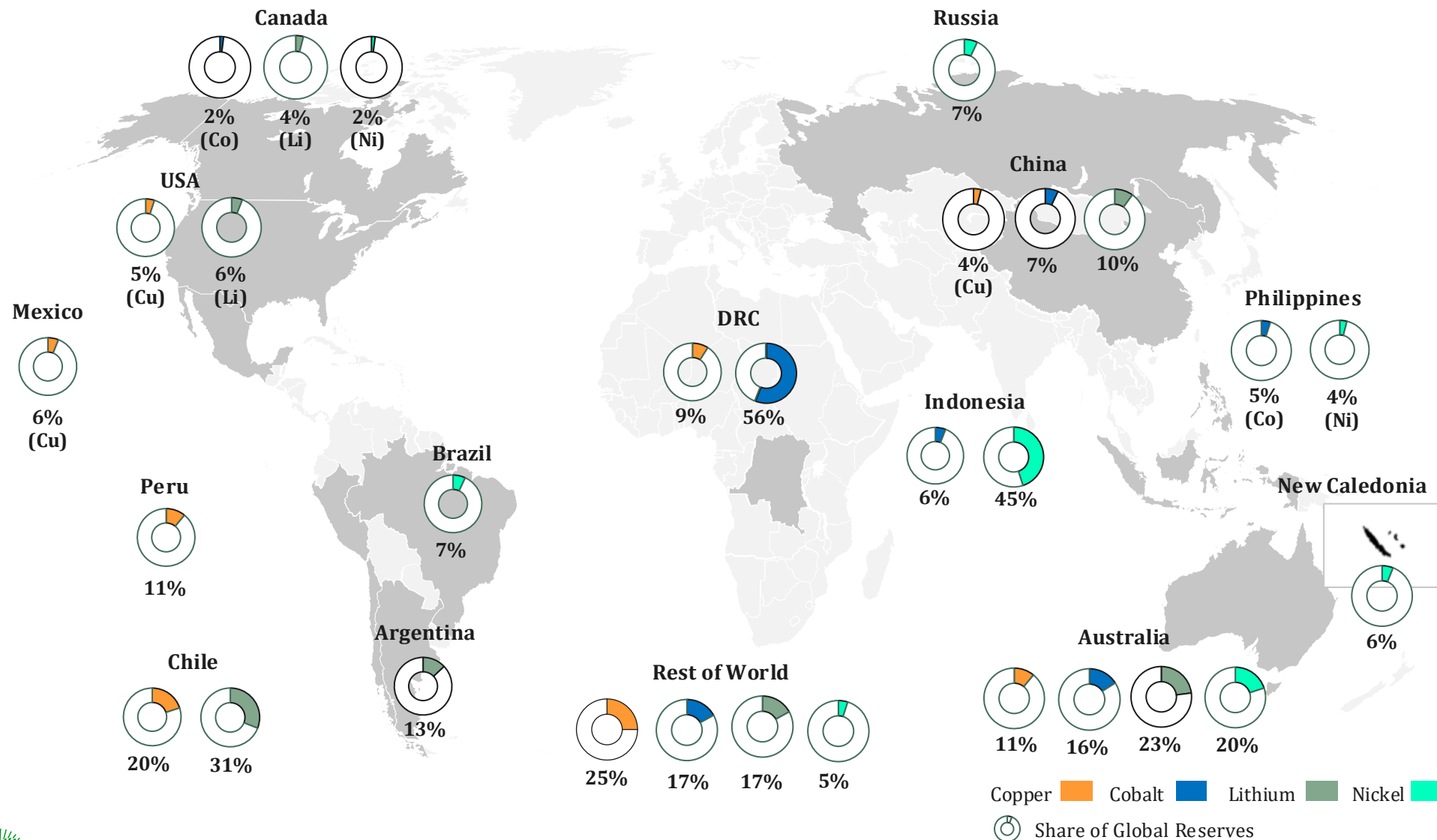


■ Secondary supply
■ Primary supply

The availability of secondary (recycled) material is expected to increase through 2050 across all commodities covered in the study.

- Expansions in battery recycling infrastructure, advances in technology, and a larger pool of end-of-life batteries will enable secondary supply to meet a significantly greater share of battery metal demand by 2050.
- Copper recycling rates are projected to rise, lifting secondary supply's share of copper demand from 29% in 2024 to 42% in 2050. While there is upside potential, persistent constraints on collection and processing will continue to limit further gains.
- In nickel, stainless steel recycling is already a mature industry. However, complications in alloy sorting and reuse restrict how much recycling can increase nickel's share of demand.

Geographic Supply Distribution | Future primary supply is highly dependent on the known reserves concentrated in a small number of countries



Exploration areas without proven assets:

Areas where current rates of project development are low do not feature within the forecasts as suppliers, but some have significant geological potential.

Africa

- There is a significant underexplored copper belt throughout southern and central Africa, including Botswana, Namibia, and Zambia.

Bolivia

- Bolivia has the potential to be a significant low-cost producer, with estimated lithium reserves of ~23 Mt.

If new mines in these areas came online, they could displace or supplement other production.

Geographic supply distribution | However, primary supply forecasts do not factor in under-explored jurisdictions with high mineral resource potential



Publicly reported resources reflect known discoveries, not geological potential.



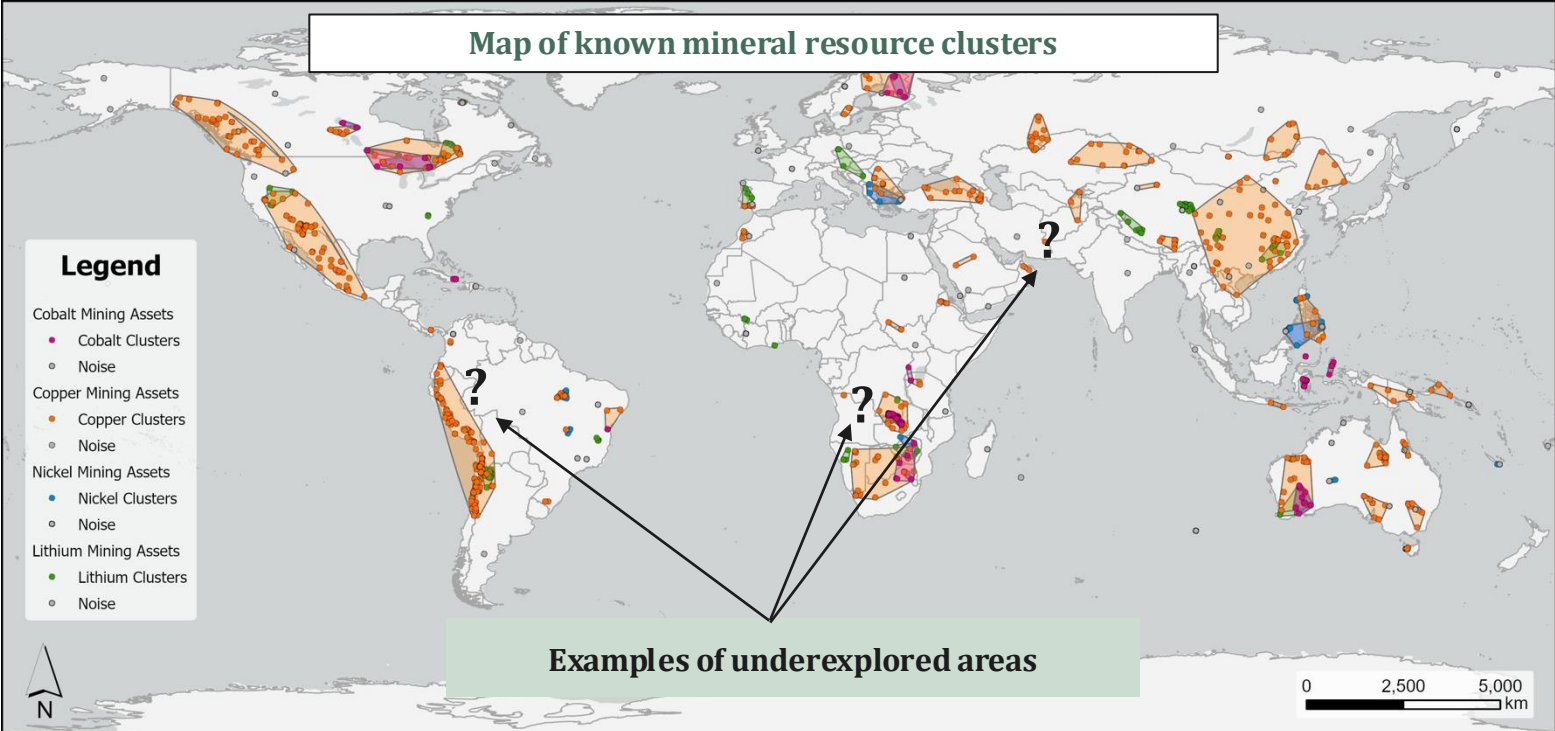
Vast areas remain underexplored or unexplored – particularly in Africa, Central Asia, and parts of Latin America.



Exploration in less established areas is generally higher cost and higher risk.



Targeting underexplored regions with low biodiversity and high resource potential could have a disproportionate effect on net nature impact.



Examples of underexplored areas:



Africa
Significant underexplored copper belt throughout southern and central Africa, including Angola, Botswana, and Namibia.



Pakistan/Afghanistan/Iran
These states indicate significant copper and lithium resource potential.

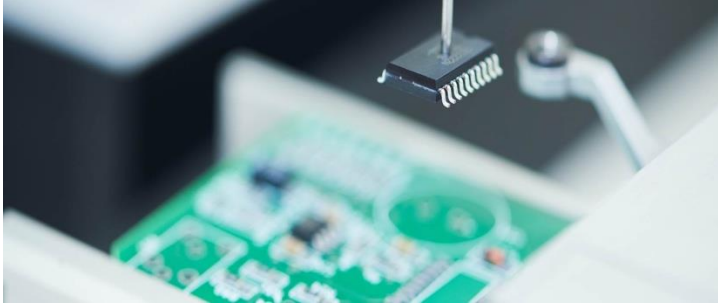


Bolivia/Colombia/Venezuela
Bolivia, Colombia, and Venezuela have the potential to be significant producers, with under-explored lithium and copper reserves.

The mapping of known reserves only reflects what has been discovered. 2050 demand may be met by new discoveries, some of which could be in relatively unexplored areas. **Some unexplored areas could present a particular opportunity from a nature perspective, where resource grade is high, nature impact is low, or both.**

Unpredictable factors of influence | Technological, geopolitical, and regulatory trends will help shape supply and demand over the next 25 years

Technology



Technology evolution has potential to impact demand for all commodities over the medium to long term.

- Disruptor technologies are unlikely to compete with lithium-ion batteries, sustaining lithium, nickel, and cobalt demand.
- Secondary supply accelerates in 2030s, global average collection rate expected to rise from ~60% to 68% between 2024 and 2035.
- Improved extraction technologies can increase recovery, e.g., with direct lithium extraction (DLE), lithium recovery can increase from 40-60% to 70-90%.

Geopolitics



Critical minerals are increasingly viewed as a matter of national security, while geopolitical developments could disrupt supply chains.

- Interventionist and protectionist policies have been introduced in 72 countries in the past 5 years.
- 13 bilateral partnerships on raw materials have been signed by the EU since 2021.
- Emerging powers will likely become new hubs for demand, e.g., India's Li demand could increase from ~58 tons in 2025 to ~20,845 tons by 2047.

Regulation



Regulatory mechanisms deployed to secure supply chains, gain strategic advantage and encourage domestic supply and production.

- Supply chain security-focused regulation increases local sourcing.
- ESG-related regulation increases downstream expectations for responsibly sourced minerals.
- Progress on net-zero targets will 'make or break' marginal projects, especially for Cu and Ni; demand for grid-enhancing technologies could add 25% to Cu demand.

Connection between mining and biodiversity sensitivity

This section examines the impact of future mining projects on the natural environment. To access the critical minerals required to facilitate the energy transition and expansion of digital infrastructure, mining activity will increasingly take place in key biodiversity areas (KBAs) that are sensitive to new mining, particularly in South America, Africa, China, and Indonesia.

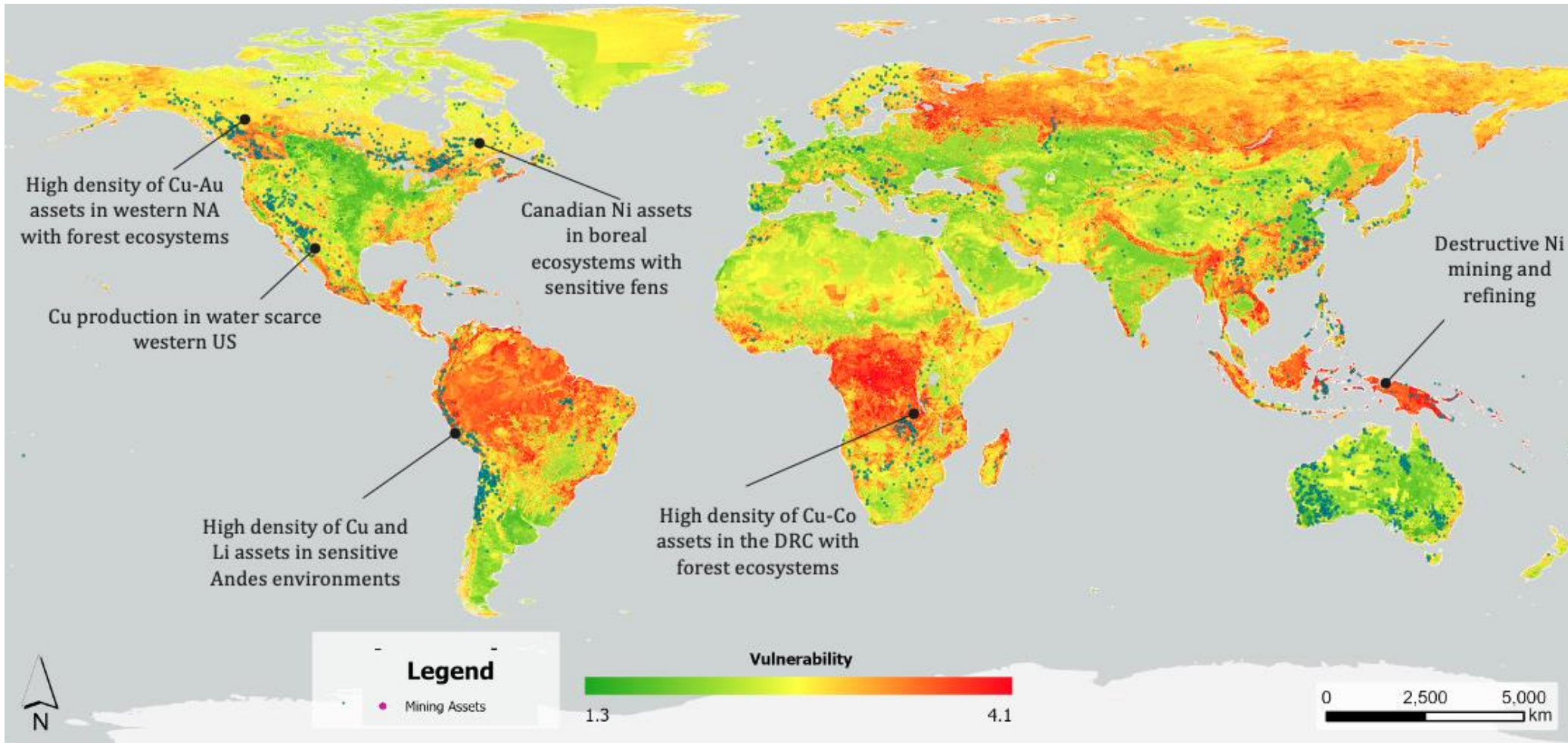
Where will future mining and processing of critical minerals overlap with the greatest biodiversity sensitivity?

This section will cover:

- Countries where dense mining and processing activity, high biodiversity vulnerability, and limited natural protection overlap.
- Profiles and risks of the top ten 'priority' clusters where additional mining and processing would impact biodiversity most severely.



Biodiversity sensitivity | Most copper (CU), nickel (Ni), Lithium (Li), and cobalt (Co) mines, as well as other critical mineral, are located in sensitive biodiversity areas



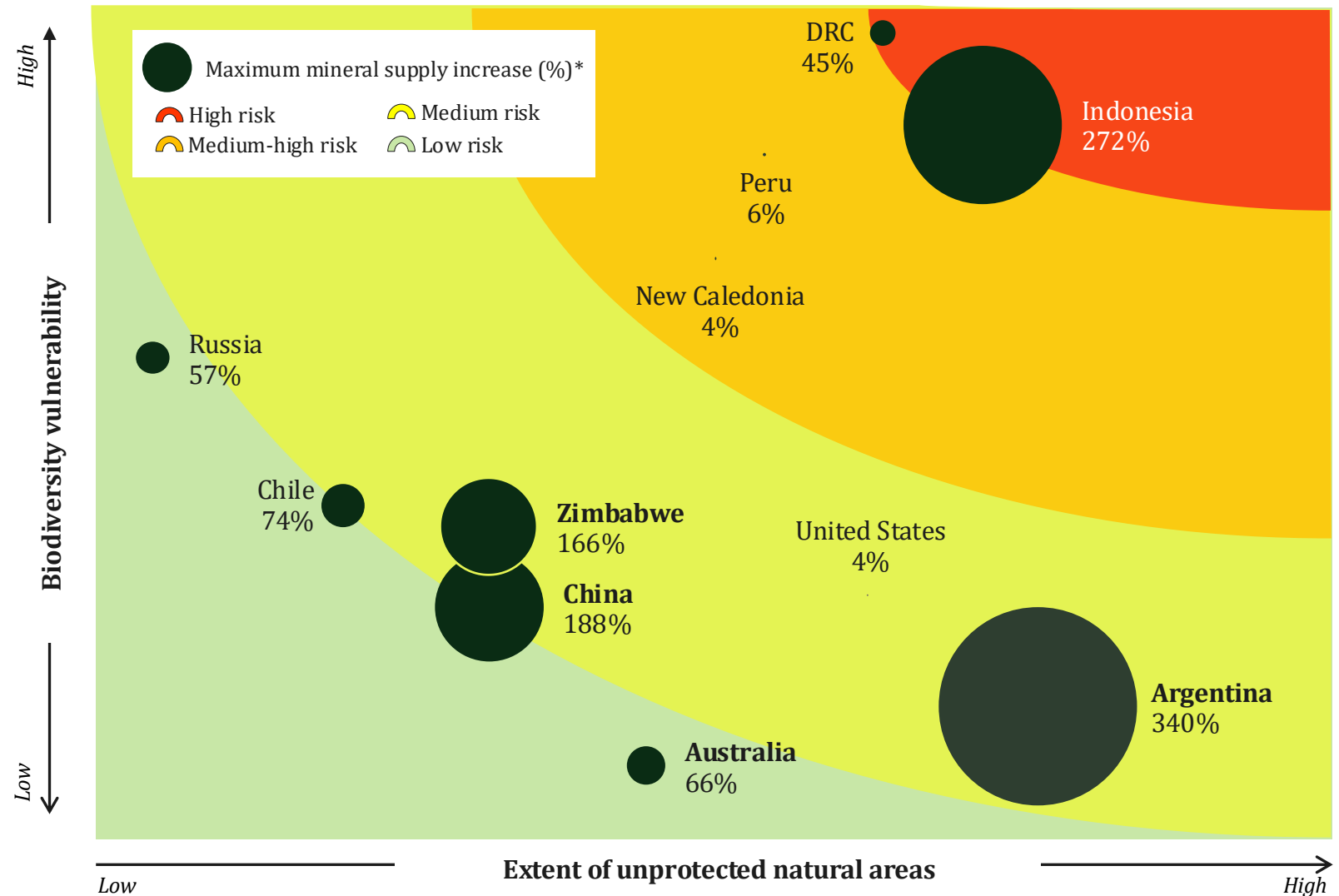
The visual representation of relative country-level vulnerability offers a first-layer screening tool to flag areas of potential concern. While not exhaustive, it supports prioritization for deeper analysis and policy attention.

Biodiversity sensitivity | For all four metals, mining is concentrated in countries that score high on biodiversity vulnerability and low on environmental protection

Among the top countries responsible for 80% of global production of copper, lithium, nickel, and cobalt, the chart on the right illustrates the relationship between environmental vulnerability and the extent of unprotected land.

Importantly, **Australia is the only country among these with active environmental assessment legislation applied to the mining sector**, highlighting a significant governance gap in strategic environmental planning elsewhere.

Priority countries (assessed in the next subsection) include **Indonesia, Democratic Republic of Congo, Peru, Argentina, China, and Zimbabwe**, which is based on a combination of scale of development, biodiversity vulnerability, and extent of unprotected natural areas.



* Max mineral supply changes = increase in average annual production between periods 2020-2025 and 2026-30, for whichever of the four commodities will see the greatest increase

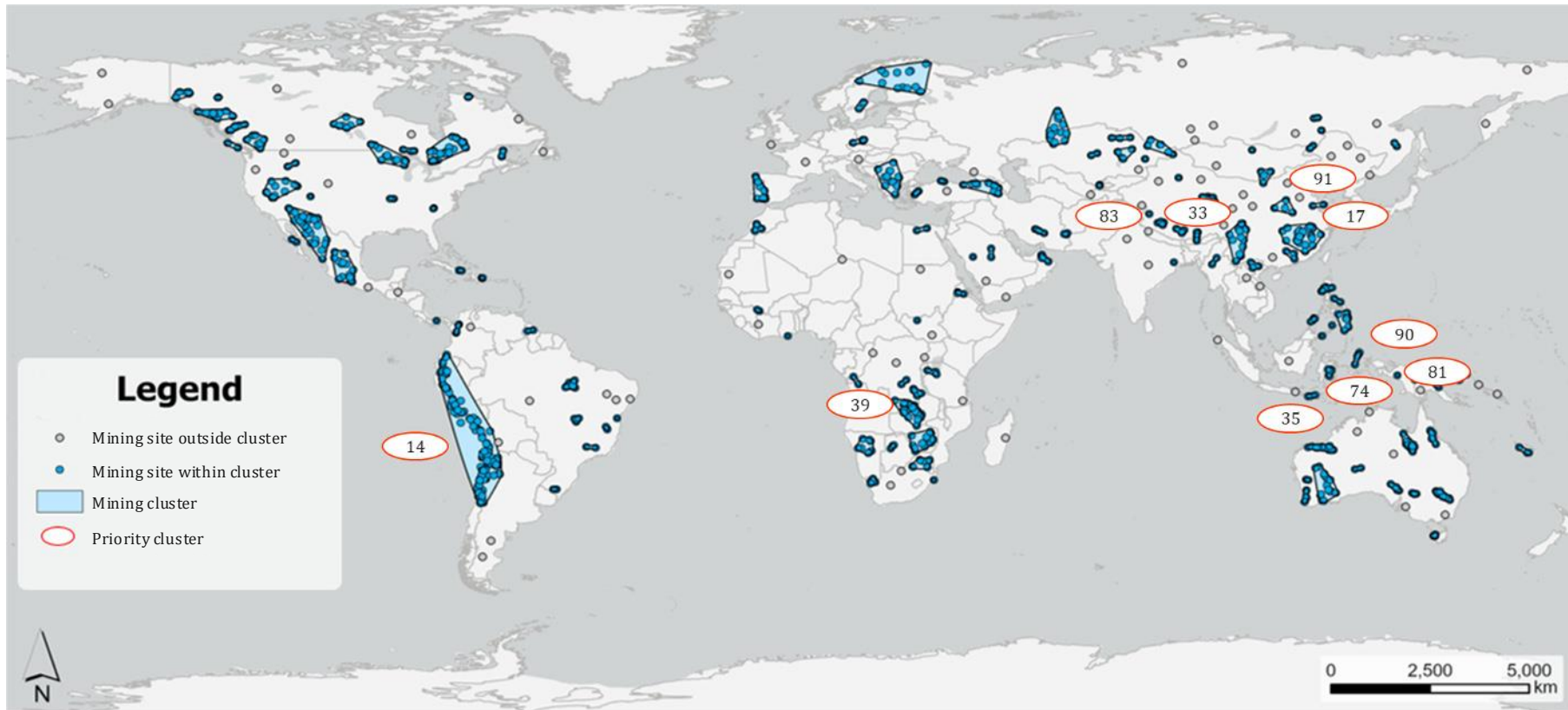
X-axis: Share of unprotected areas (higher values indicate greater sensitivity); Y-axis: Country-level biodiversity vulnerability; Bubble size: Projected increase in mineral supply between 2020-2025 and 2026-2030

Source: ERM data and analysis; CRU Data

Mining clusters | 24 strategic mining clusters will cover 80% of the global Cu, Ni, Li, and Co supply by 2050; ten are in areas that score high on biodiversity vulnerability

Mining Clusters

Cluster areas contain multiple mines within 200 km of each other and represent dense mining activity. These areas are likely to have a cumulative impact on biodiversity and are often located in sensitive ecosystems.



Over 90% of the global primary supply of copper, cobalt, lithium, and nickel is expected to come from 116 mining clusters by 2050.

Of these, 24 strategic clusters account for nearly 80% of supply, of which 10 'priority clusters' are located in countries with high nature vulnerability.

Cluster areas have both negative consequences associated with cumulative ecological degradation and, also, the potential to reduce impact via shared infrastructure corridors.

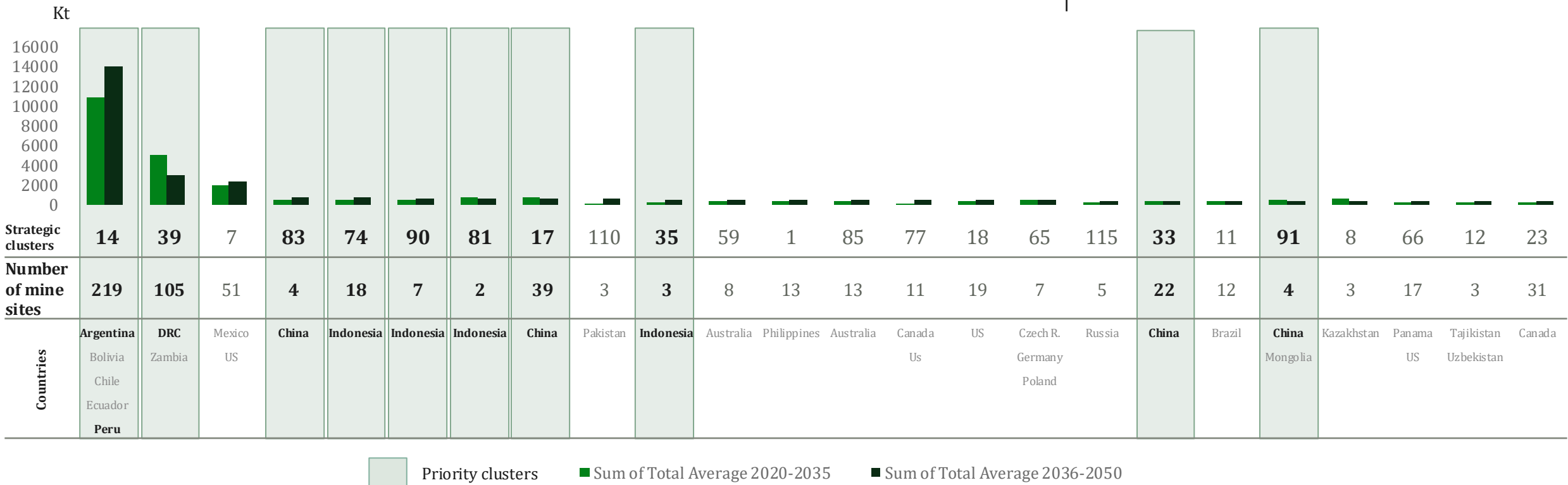
Mining clusters | Together, the 10 clusters in the most sensitive areas will account for 53% of the global output of copper, nickel, lithium, and cobalt by 2050

	Clusters	Mine sites	Sum of total average 2020-2035*	Sum of total average 2036-2050*
Total clusters	116	1078	32,907 kt	36,543 kt
Strategic clusters	24 (20.7%)	619 (57.4%)	25,833 kt (78.5%)	29,054 kt (79.5%)
Priority clusters	10 (8.6%)	423 (39.2%)	19,876 kt (60.4%)	21,450 (58.7%)

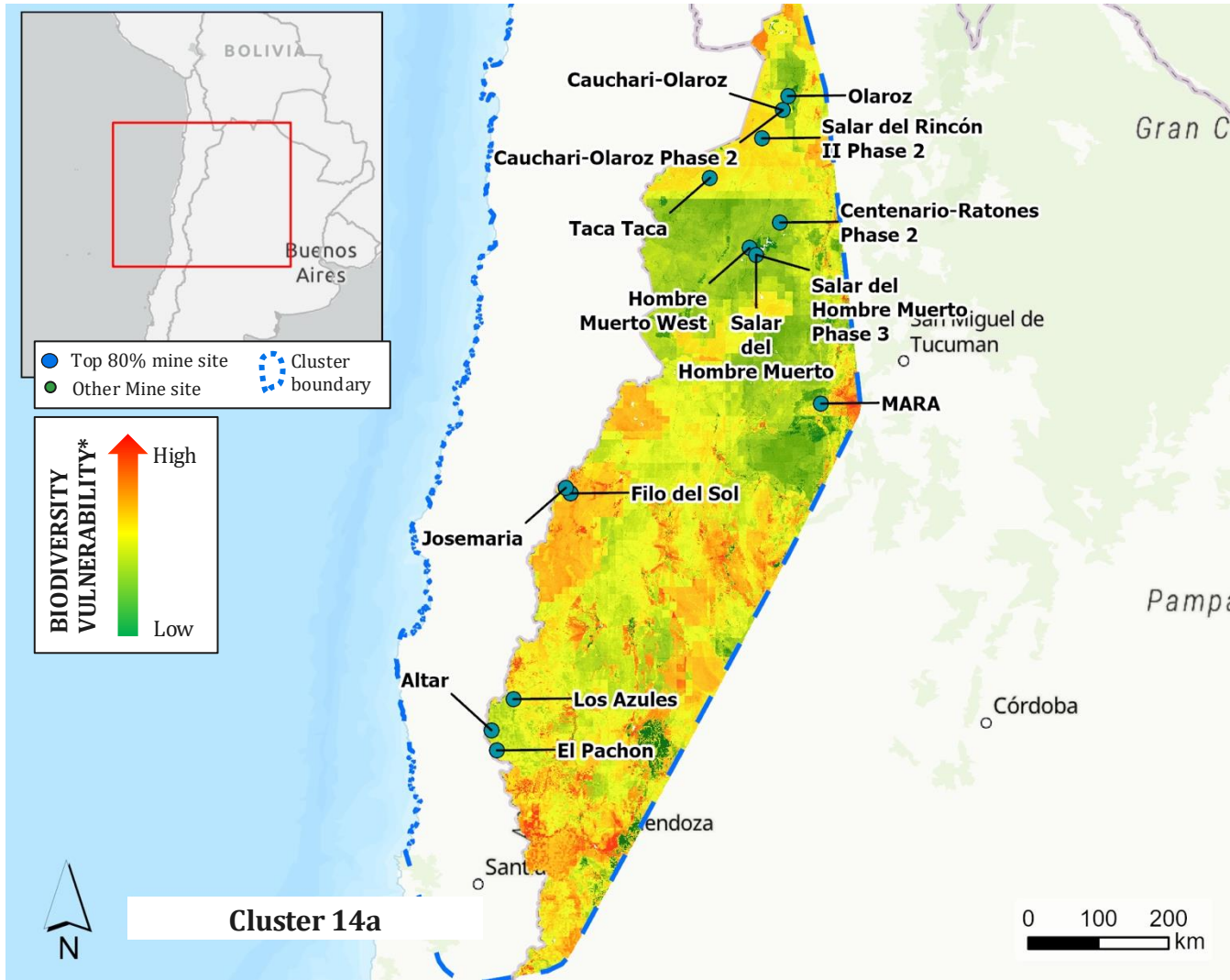
Mine sites excluded from the assessment (not surrounded by other mine sites within 200 km distance) account for:

- 84 mines, equal to 7.2% of the total
- 6% of average supply across all minerals (2020-2035)
- 7% of average supply across all minerals (2036-2050)

Note: * the sum of total average is calculated by adding the average production of each mineral in the future year supply.



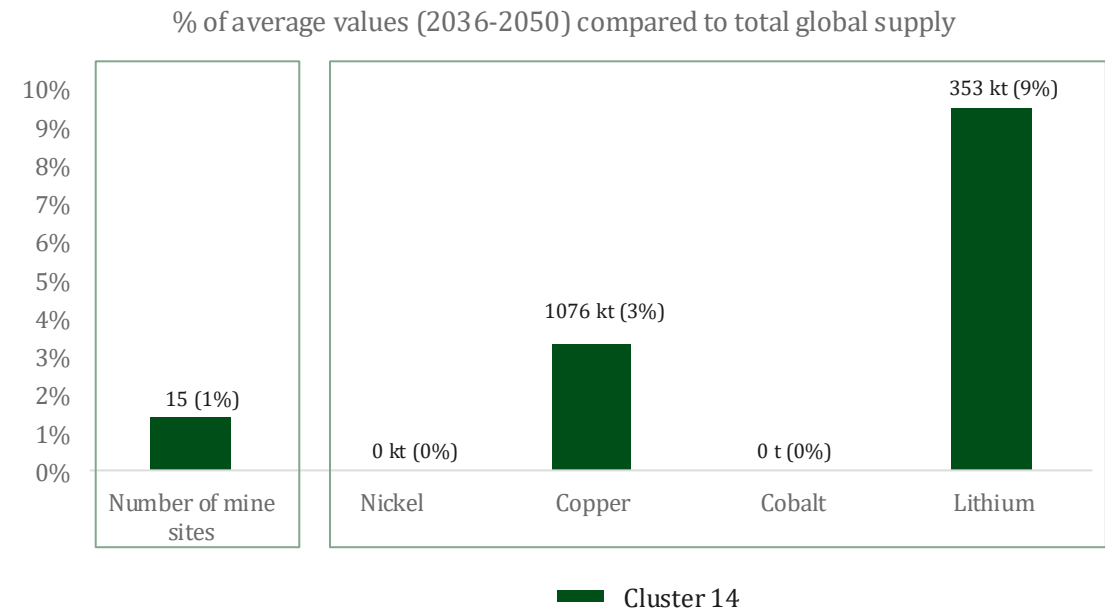
Argentina Priority Cluster | New copper and lithium mining activity is expected to concentrate in areas with sensitive and unprotected wetland and water ecosystems



In Argentina, 15 mine sites (1% of global mines) have been identified as strategic within the country's priority cluster.

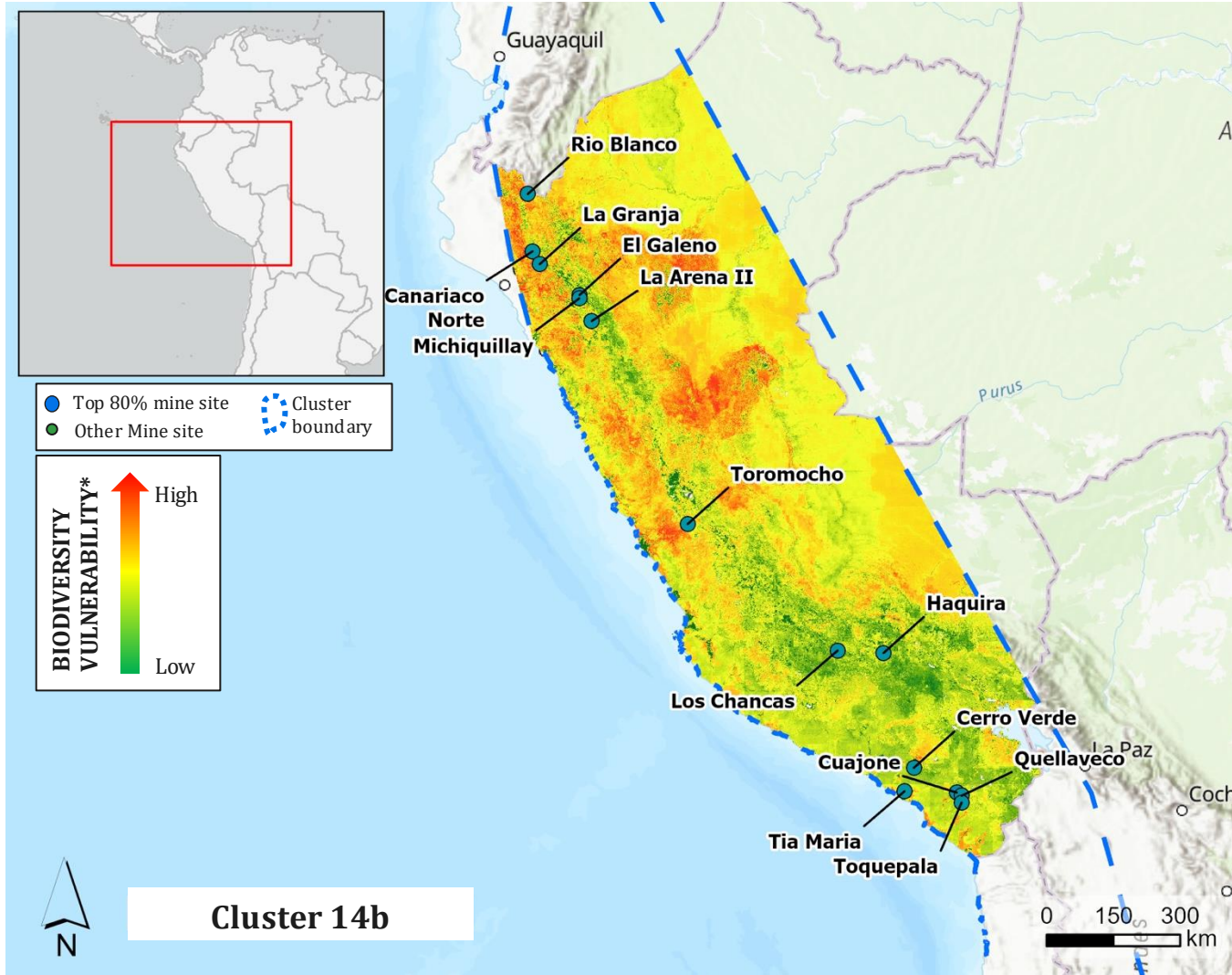
These strategic mine sites represent 42% of all mines across Argentina included in the analysis.

Lithium accounts for the largest share of the global supply at 9%, followed by copper at 3%.



* The map uses a relative vulnerability scale, where values are normalized between observed maximum and minimum levels. Colors do not represent absolute values on the intrinsic scale (1 to 5).

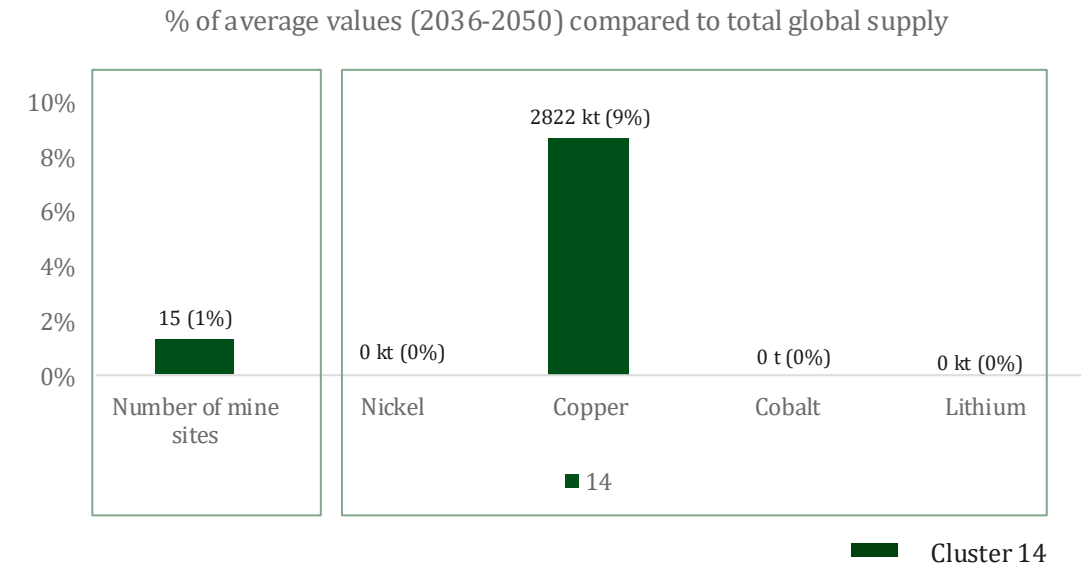
Peru Priority Cluster | Similar to Argentina, copper mining activity is expected to concentrate in areas with sensitive and unprotected wetland and water ecosystems



In Peru, 15 mine sites (1%) have been identified as strategic within the country's priority cluster.

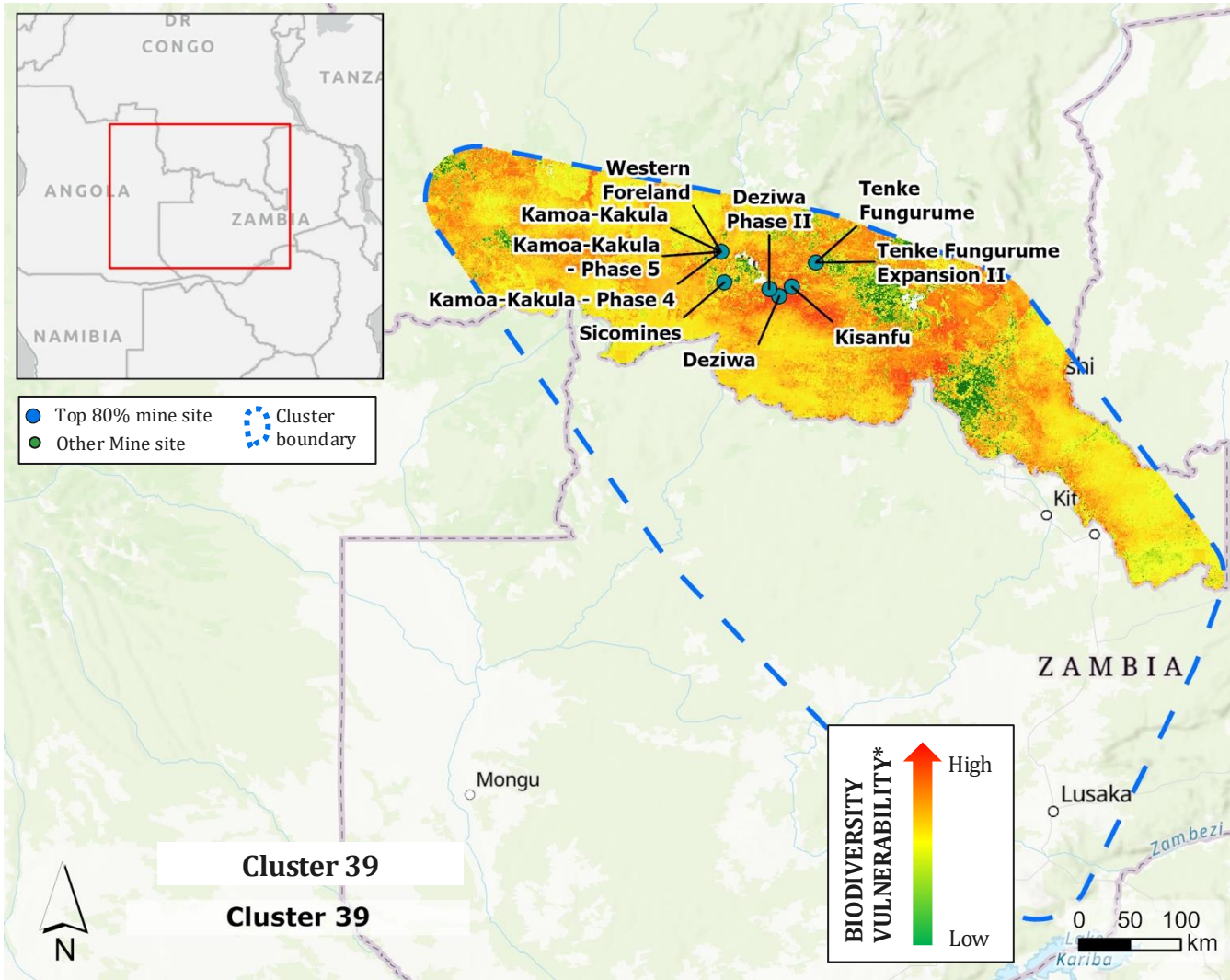
These strategic mine sites represent 21% of all mines across Peru included in the analysis.

Copper accounts for 9% of global supply. Other mining activity (silver, gold, zinc) is expected to start in the cluster as well.



* The map uses a relative vulnerability scale, where values are normalized between observed maximum and minimum levels. Colors do not represent absolute values on the intrinsic scale (1 to 5).

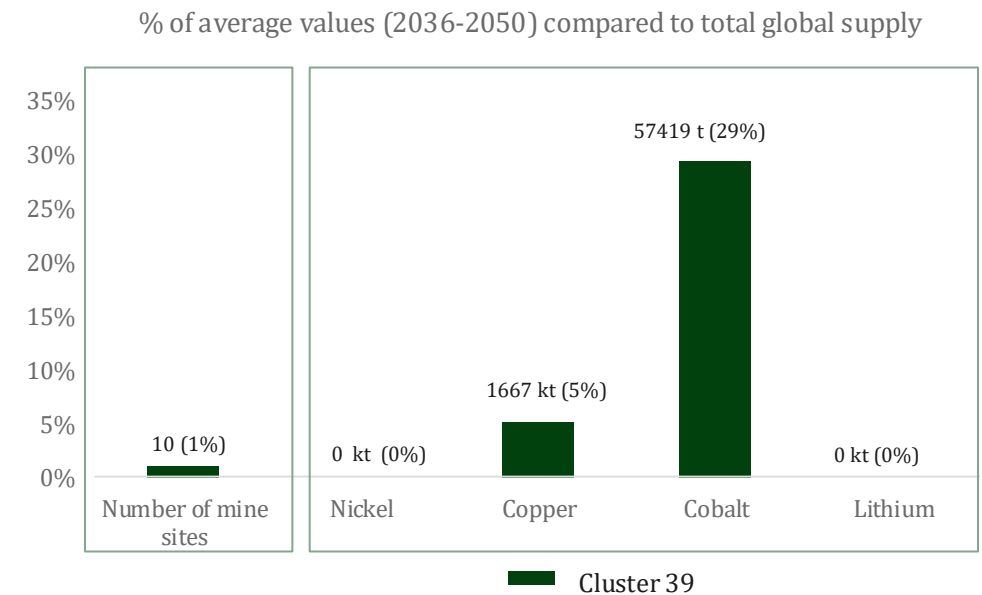
DRC Priority Cluster | Without protective action, copper and cobalt mines are expected to drive significant deforestation and ecosystem contamination



In the DRC, 10 mine sites (1% of global mines) have been identified as strategic within the country's priority cluster.

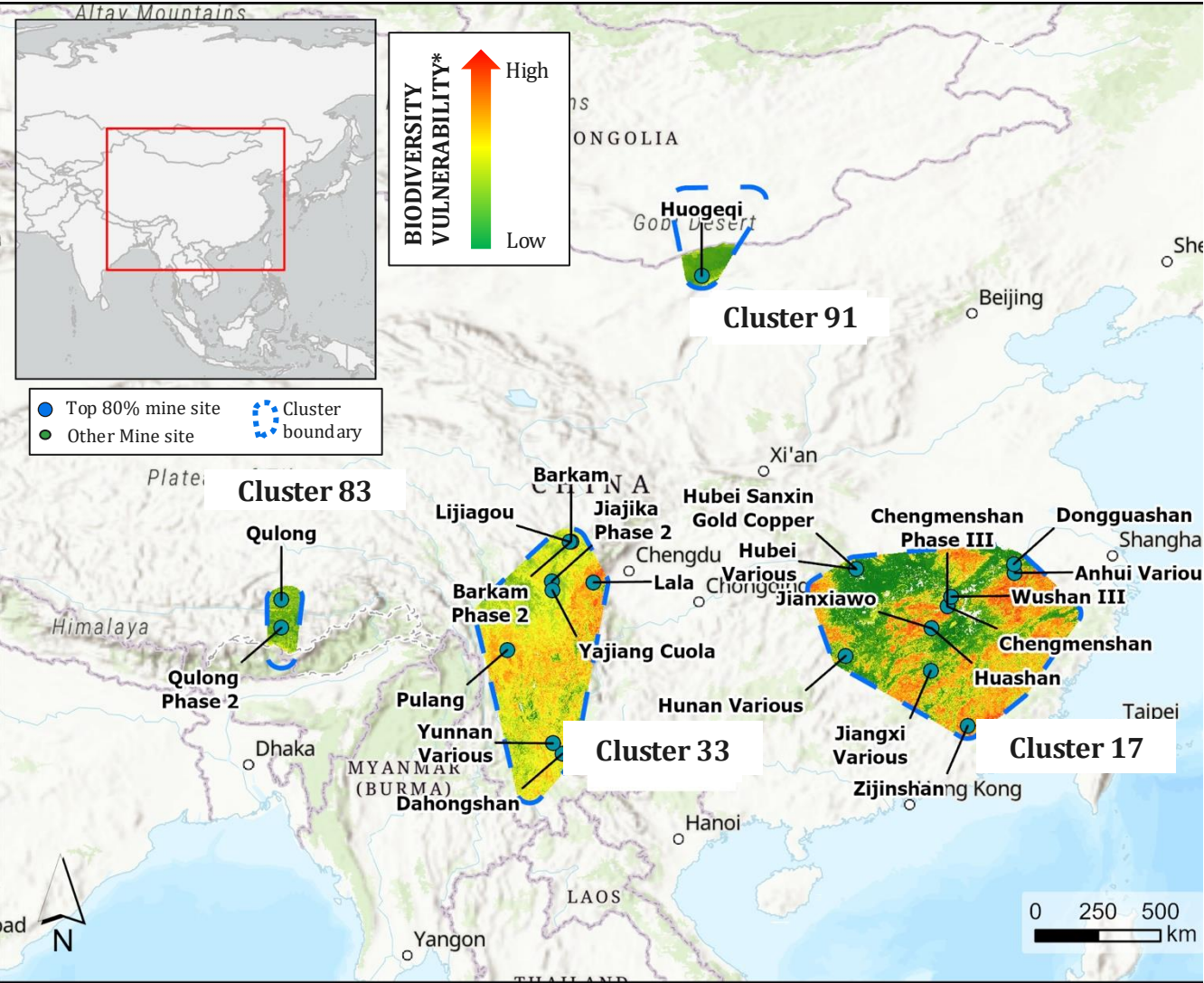
These strategic mine sites represent 16% of all mines across the DRC included in the analysis.

Cobalt accounts for the largest share of the global supply at 29%, followed by copper at 5%.



* The map uses a relative vulnerability scale, where values are normalized between observed maximum and minimum levels. Colors do not represent absolute values on the intrinsic scale (1 to 5).

China Priority Clusters | Without protective action, lithium, and copper mining in clusters within China may impact diverse sensitive ecosystems

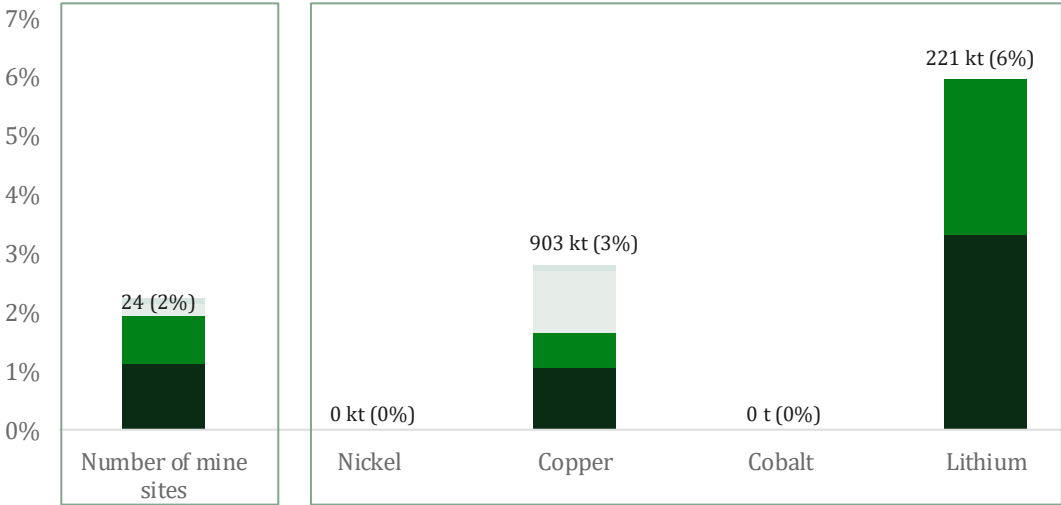


In China, 24 mine sites (2% of global mines) have been identified as strategic within the country's priority clusters.

These strategic mine sites account for 37% of all mines in China included in the analysis.

Lithium accounts for the largest share of the global supply at 6%, followed by copper at 3%.

% of average values (2036-2050) compared to total global supply



Legend: Cluster 17 (Dark Green), Cluster 33 (Light Green), Cluster 83 (Medium Green), Cluster 91 (Lightest Green)

* The map uses a relative vulnerability scale, where values are normalized between observed maximum and minimum levels. Colors do not represent absolute values on the intrinsic scale (1 to 5).

Sources and core drivers of impact on nature

Do new mines or new refineries have the greatest impact on nature? Compared with processing, mining has a substantially greater impact on nature, since refineries are typically located in industrial hubs rather than in areas of high natural value.

The impact of mining on nature is strongly linked to the systemic drivers that shape the economics of the metals markets and mining: deposit location, capital and finance, regulation, development timelines, sustainability trade-offs, and the innovation landscape. Each driver locks in aspects of new mine development, constraining project flexibility.

This section will cover:

- The characteristics of the nature impact of mining vs refining.
- Analysis of the six systemic drivers of metals markets and mining, and how they constrain mining projects in addressing their impact on nature and biodiversity.



Sources of nature impact | Critical minerals mining has a larger footprint than refining, since mining overlaps with sites of natural value, and relocation is not an option



Mines	Refineries
Direct area of disturbance	The average land footprint of each of the 1,313 copper mines studied is <u>5.5 km²</u> (2025).
Location flexibility Requirements for siting	Substantially smaller footprint than mines – modern high-efficiency copper smelters may occupy 1-2km ²
Typical locations Relevant biodiversity implications	Proximity to the mine is a consideration, but balanced against access to power, shipping, water, transport etc.
Capacity change Change in available resources or processing capacity	Typically, in developed industrial areas, dominated by China (Cu, LCE, Co, Ni) and Indonesia (Ni).
Requirement for infrastructure Additional off-site footprint to facilitate development	Expected capacity growth 2024-2030: lithium carbonate equivalent (115%); Ni (32%); Co (23%); Cu (16%).
Requirement for infrastructure Additional off-site footprint to facilitate development	Greater flexibility to locate in areas with existing infrastructure, with cost-related incentives for shared use.

Sources of nature impact | Six main systemic drivers shape metals markets and mining, resulting in significant negative impacts on nature and biodiversity



Deposit location

Geology is set. Mines must be constructed where mineral resources are found, which often is in sensitive biodiversity areas. With millennia of mining, ore grades for new mines are declining necessitating larger footprints for the same production with more infrastructure to access remote sites.



Capital and finance

Sector volatility is increasing cost sensitivity among financiers, as volatile commodity prices have trained investors to be price and cost-sensitive. Financial institutions mostly assess nature qualitatively, with almost no quantitative assessment, due to a lack of datasets, financial quantification standards, and asset types.



Regulation

Meeting regulatory expectations is a core driver for preventative and mitigative efforts in nature by mining companies. Weak enforcement and unclear structures can limit companies' actions to reduce impacts and their incentive to exceed minimum compliance obligations.



Development Timelines

Long development timelines influence decision-making: nature considerations are often deferred or discounted to maximize short-term value or conserve cash. Commodity markets and a lack of regulatory incentives exacerbate these challenges.



Sustainability trade-offs

Society's sustainability agenda for mining has centered on GHG emissions and social performance. Coupled with the ability to address these challenges without altering core mining practices, it creates inertia for delivering nature performance. Nature inertia is compounded by the complexity of nature and the lack of consensus around metrics and taxonomy.



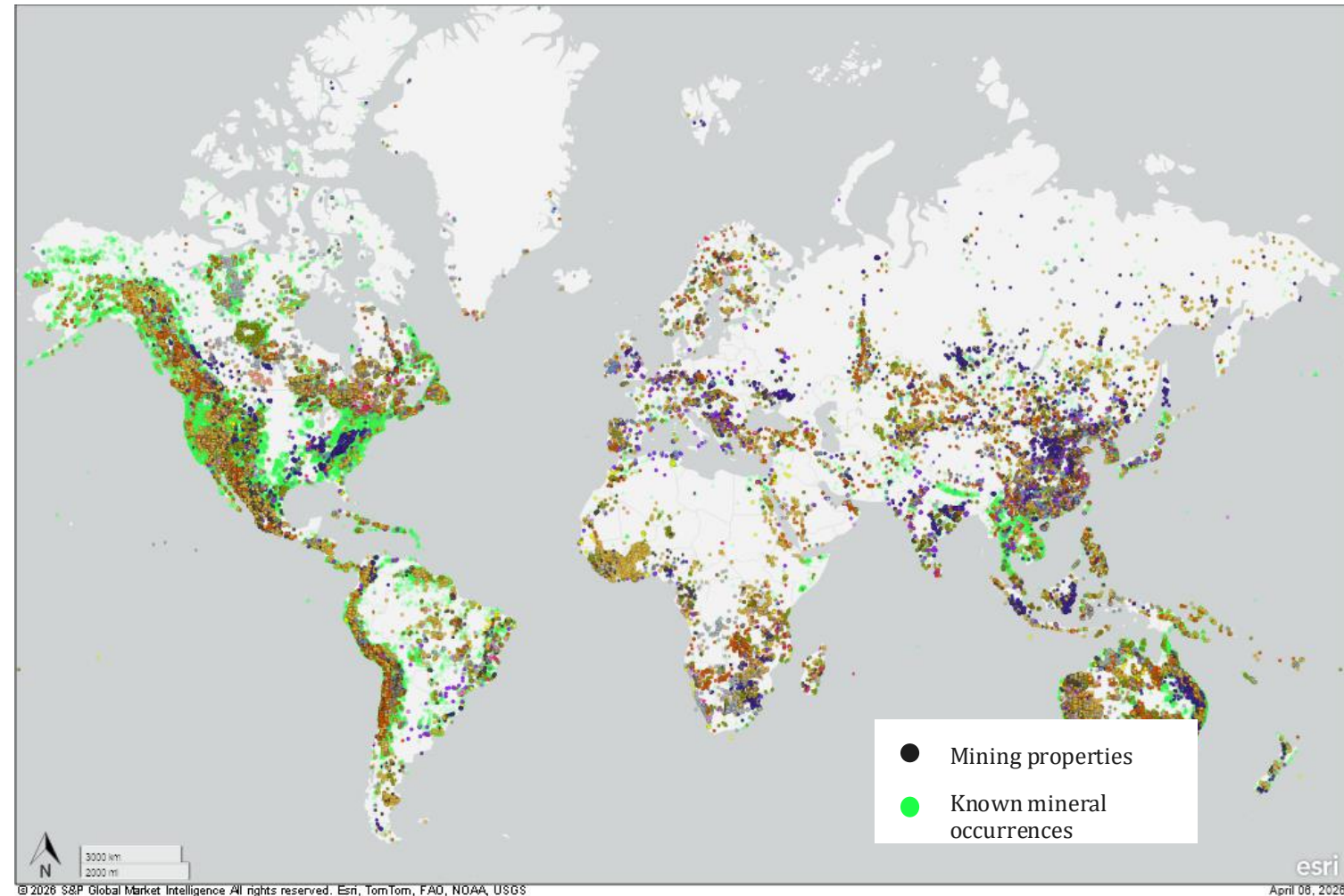
Innovation landscape

Innovation treats nature as a secondary benefit. Focus is placed on cost efficiency and energy solutions, with the limited innovation activity directed towards these outcomes. External venture capital interest is also limited compared with other sectors.

Deposit location | Declining reserves in developed mining areas are pushing mining into remote, lower-grade areas, increasing the negative impact on nature

Mineral occurrences overlaid with Mining Activity

Most known mineral occurrences have operating, planned, or closed mines. As illustrated by the map below, the majority of mineral occurrences are already heavily mined, with most high-grade ores depleted.



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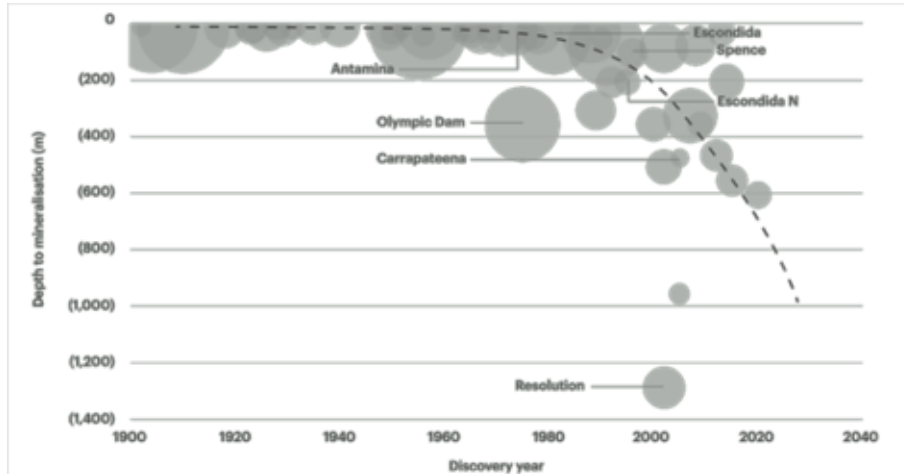
April 08, 2026

Need for new mining activities due to declining grades

Intense historical mining in known mineral occurrences makes finding new economic, high-grade deposits more challenging.

- Grades in transition metals such as copper have declined with fewer major discoveries in established mining areas.
- New mining areas will need to be explored in underexplored regions, such as Africa and the Middle East, to meet demand for critical minerals.
- Without innovation, mining lower grades will lead to more impact on nature as more land clearing will be required and more material will need to be moved and processed.

Selected Major Copper Deposits by Discovery Year



Source: S&P Mining and Metals; BHP (2025)

Capital and finance | Long payback times, volatile critical mineral prices, and other structural risks work against the integration of nature into investment decisions

Nature of mining capital

Access to capital in mining is restricted for structural factors and sustainability reasons.

- Long-term payback, technical risk, and exogenous value drivers make the sector challenging for multi-sector investors to back based on opportunity cost.
- Reputation and practices in the industry result in outsized sustainability risks – including biodiversity.

Mismatch in capital and mining strategies limits supply

18 years

To develop a mine

20-25 years

Of operations

< 5 years

Expected cross industry payback period

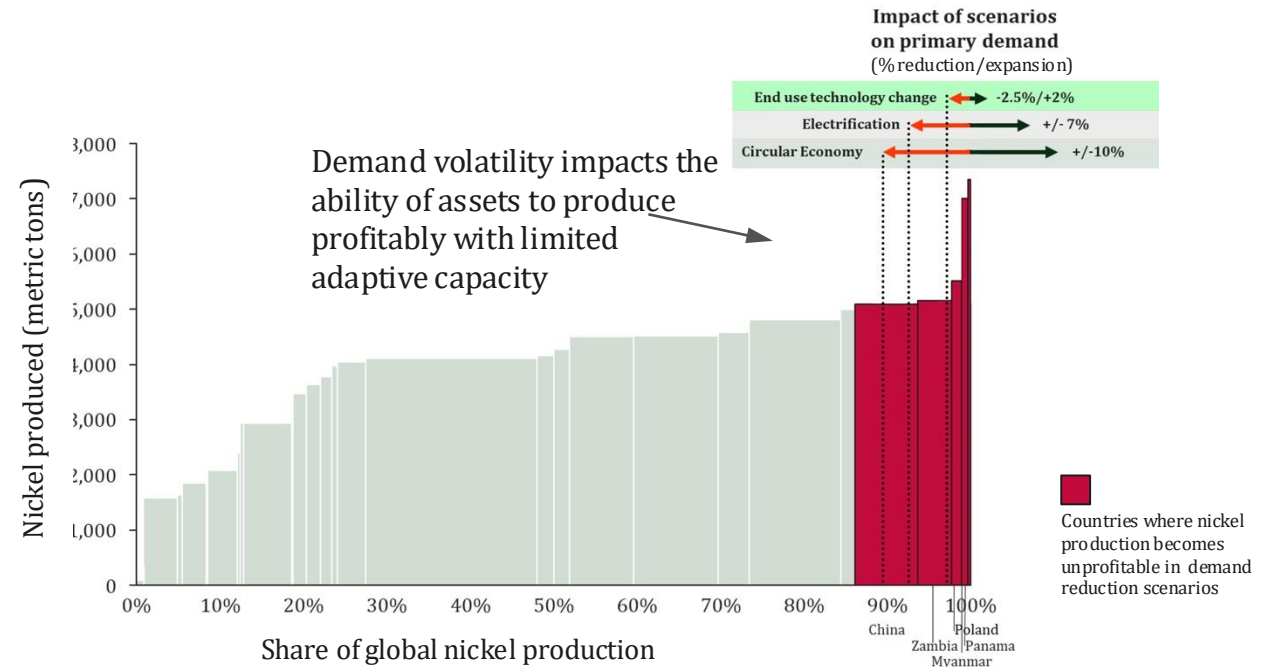
“The value of my deal on [mining project] hinges on getting permits within two years, otherwise the cost to hold is too high.”

-Mining P/E investment banker

Commodity price risk drives cost efficiency expectations

16%-53% of total shareholder return performance in mining and metals is derived from commodity price momentum, which drives cost focus

“The major variable in mining investment decisions is the commodity price.”
- James McClements, Resource Capital Funds



Royalty

Limited concern on operational impacts, except for reputational damage due to payback tied net smelter royalty



Reputation and revenue

Project Finance

Debt financiers are mostly focused on payback time, often shorter than the life of mine, but want projects to align with EP4/IFC standards



Reputation and free cash flow

Equity Finance

Provision of equity, which ties financier to full scope of financial impacts, including long-term closure liability



Reputation and overall financial performance

Regulation | Regulation exists in most key mining markets, but trade-offs between economic development and environmental protection drive poor enforcement

Regional regulatory structures

Regional government collaboration in areas with significant mining growth and biodiversity impact prioritizes economic development with weak environmental enforcement.

Europe

EU has the strongest regional regulatory framework, but enforcement can still be patchy

- Extensive body of legally binding regulations that set environmental requirements for the bloc.
- Soft law also exists to support compliance.
- However, reliance on national and sub-national levels for enforcement creates challenges.

South-East Asia

Lack of binding hard law at a regional level

- ASEAN supports regional collaboration but prefers non-binding declarations and frameworks.
- Focus is more on capacity building and information sharing, rather than strict requirements.
- **Example:** ASEAN Centre for Biodiversity supports PA management, with mining near PAs facing more scrutiny as a result.

Latin America and the Caribbean

Limited regional environmental governance

- Initiatives driven by NGOs, as opposed to strong regional bodies.
- Prevalence of national economic interests and lack of regional enforcement hinder effective regulation.
- **Example:** Escazú Agreement, which forces disclosure, participation, and access to justice in permitting.

Africa

Soft laws focus on harmonization of national approaches, but capacity challenges hinder enforcement

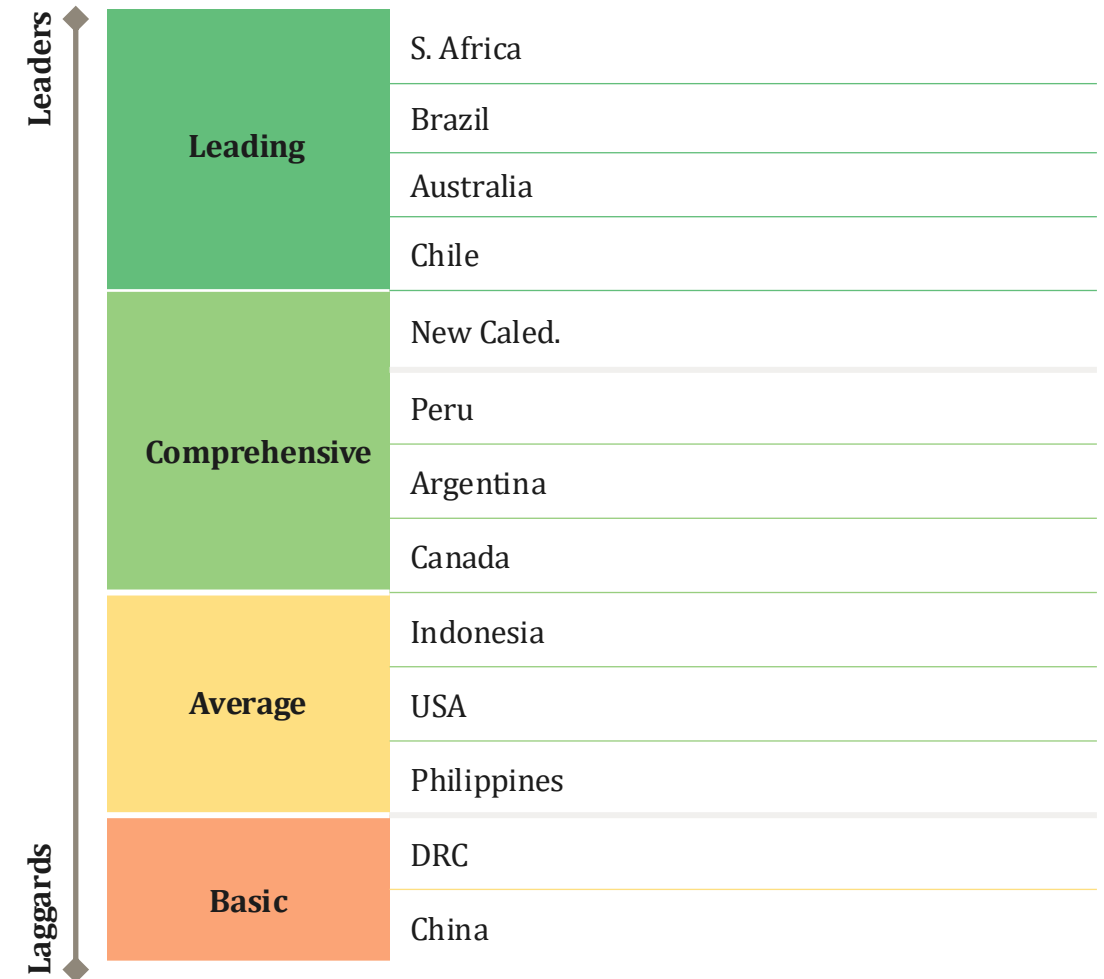
- Regional collaboration often focuses more on development than on nature or biodiversity-related issues.
- Some regional-level initiatives exist through international organizations, but adoption is variable.
- **Example:** Congo Basin Forest Partnership supports regional forest governance and expansion of protected areas, but with weak enforcement.

Regulation | Regulation exists in most key mining markets, but trade-offs between economic development and environmental protection drive poor enforcement






National Regulatory Frameworks

National nature regulatory frameworks are broadly consistent; implementation is where variance occurs

- **EIAs are typically included in permitting, though not always mandatory – e.g., in Canada (BC and ON),** not all projects are required to produce an EIA.
- In many cases, the **mitigation hierarchy is not legally enforced** in strategic planning or permit decisions outside of the EIA process, with only South Africa and Australia embedding it into national regulation.
- Countries are starting to establish **no net loss or net gain policies** – e.g. South Africa – but often frameworks are incomplete, lacking definitions (e.g. Philippines, Indonesia, Canada) and with inconsistent offset guidelines (e.g. Peru).
- Some countries lack publicly available **national biodiversity guidelines** to define baselines and best practice in line with local contexts – e.g. DRC.
- The **US is a laggard** on biodiversity ambition as it is not a party to the GBF, does not publish an NBSAP, and has no official biodiversity targets.



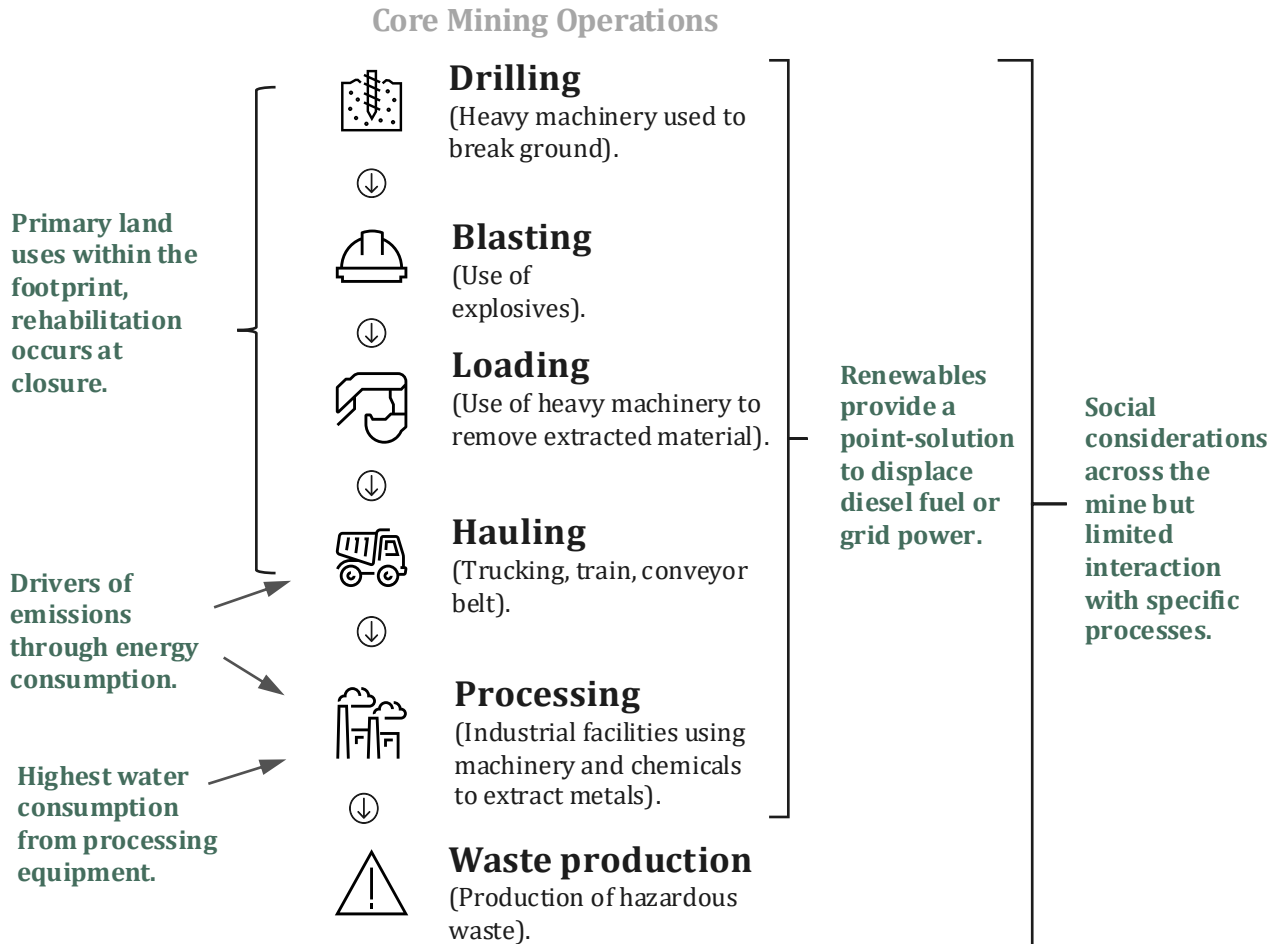
Development Timelines | During planning, geological, commercial, and legal priorities often trump well-designed management of nature impacts across a mine's life-cycle

	 Exploration and discovery	 Permitting and feasibility	 Construction	 Operations	 Closure and rehabilitation
Orientation	1-4 years	3-7 years	1-3 years	10-30 years	10-100 years
Timeline	Exploration company focused on understanding the resource and regional context.	Often small miner defining economic access to the resource and raising capital.	Mid-tier or major miner aiming to execute on time and on budget.	Mid-tier or major miner aiming to maintain profitable operations.	Minimizing costs associated with a non-producing site.
Decision points and key drivers	<p>Country-level go/no-go:</p> <ul style="list-style-type: none"> • Geology • Political / policy • Security <p>Selection of license:</p> <ul style="list-style-type: none"> • Geology • Security <p>Location of drilling and infrastructure:</p> <ul style="list-style-type: none"> • Geology • Communities • Existing infrastructure • Nature 	<p>Project design and siting, strategy on water, waste:</p> <ul style="list-style-type: none"> • Cost • Nature of deposit • Production strategy • Social license • Nature <p>Interim and final investment decisions:</p> <ul style="list-style-type: none"> • Profitability • Viability • Risk level 	<p>Operational responses to site issues (e.g. dewatering, erosion):</p> <ul style="list-style-type: none"> • Compliance • Cost • Schedule • Safety • Nature <p>Response to incidents:</p> <ul style="list-style-type: none"> • Compliance • Safety • Social license • Nature 	<p>Detailed closure plans:</p> <ul style="list-style-type: none"> • Cost • Compliance • Socio-economic legacy • Nature legacy <p>Operational responses to site issues:</p> <ul style="list-style-type: none"> • Cost • Production • Safety • Nature <p>Response to incidents:</p> <ul style="list-style-type: none"> • Compliance & safety • Social license • Nature 	<p>Operational closure decisions:</p> <ul style="list-style-type: none"> • Cost • Compliance • Socio-economic legacy • Nature legacy
Significance of decisions in determining nature impacts	Low	Medium	High	High	High

Sustainability trade-offs | Mining companies often focus on sustainability topics that are not directly operations-related rather than those that are core to their operations

Sustainability efforts focus beyond the mining process

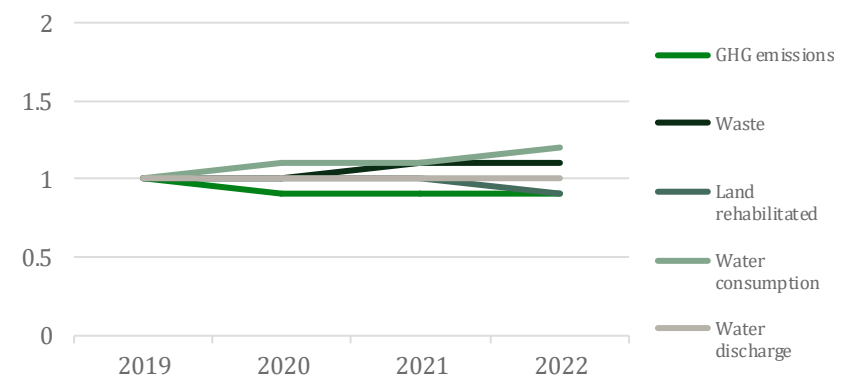
Illustrative mining value chain and the interaction with key sustainability priorities demonstrates core versus non-core sustainability interactions.



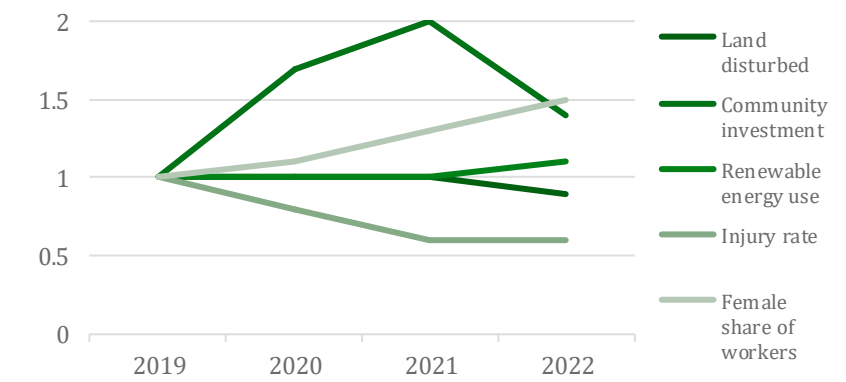
Lack of progress on operational sustainability issues

IEA analysis of selected environmental, social, and governance indicators for critical mineral developments, 2019-2022.

Environmental indicators are largely static or trending poorly, reflecting limited changes in operating practices related to core mining activities affected by mine plans.



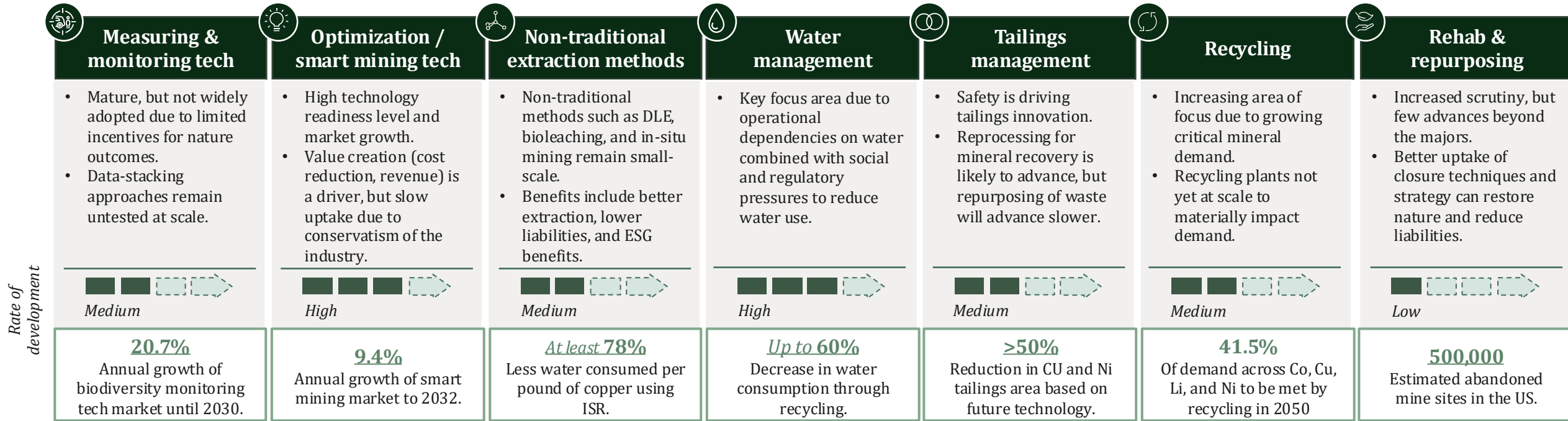
Social topics, renewables, and land trend positively, which are often non-core to operations reflecting progress on sustainability topics that do not influence core mine and processing planning.



Innovation landscape | Although innovation can significantly reduce nature impacts and generate financial returns, it often stalls during commercialization

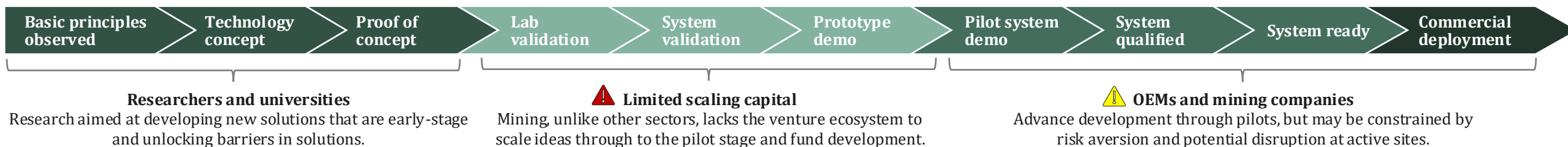
Technology landscape

Broad suites of technology that can reduce impacts on nature across a mine site and the mining lifecycle are advancing and nearing commercialization









Technology development barriers

Innovation often stalls in the middle stages, where more capital is required and limited mining tech developers exist to advance technologies to commercialization



Sources of nature impact | Summary of why the six systemic drivers that shape metals markets and mining make it difficult to minimize impacts on nature

Drivers	Challenge	How it impacts nature
<p> Co-location with KBAs* Remote areas Ore grades</p> <p>Deposit location</p>	<p>Managing impacts and biodiversity loss. Need for infrastructure in untouched landscapes Declining ore grades in more remote areas.</p>	<p><i>Lithium mines in salt flats or nickel mining in Amazon Roads, rail lines and power facilities in mine footprints Larger pits and tailings for the same volume of copper.</i></p>
<p> Capital scarcity Sensitivity to AISC Asset classes</p> <p>Capital and finance</p>	<p>Limited available capital for development Push for cost optimization in financing Limited structures to value natural capital.</p>	<p><i>Projects delayed and abandoned due to capital scarcity Removing environmental actions beyond compliance No financial returns for major ecosystem restoration.</i></p>
<p> Lack of enforcement Unclear policy on goals Lack of incentives</p> <p>Regulation</p>	<p>Regulation on the books is not well enforced Policy commitments on nature are not regulated No benefit for companies to exceed compliance.</p>	<p><i>Consistent non-compliances without enforcement National commitments don't have regulatory mechanism Environmental mitigations submitted at minimum reqs.</i></p>
<p> Long timelines Less experienced developers Complex trade-offs</p> <p>Development timelines</p>	<p>Extended timeline restricts willingness to invest Small companies with capex constraints design mines Managing trade-offs between time, cost, and impact.</p>	<p><i>It takes 20 years to develop a mine from discovery Minimizing capex in design often increases impact Optimization primarily on cost as easier to control.</i></p>
<p> Focus on social outcomes Focus on carbon Measurement challenges</p> <p>Sustainability trade-offs</p>	<p>Easier to address without challenging operations Drives environmental narrative over nature issues No clear unit of measurement or account for nature.</p>	<p><i>Community investment over impact management Capital into solar for the mine over ecosystem services Different KPIs across mining companies and value chain.</i></p>
<p> Focus on cost and energy Unclear drivers Limited venture capital</p> <p>Innovation landscape</p>	<p>Nature is a secondary outcome of innovation efforts Payback on nature-led innovation is unclear Stagnating innovation and cross-sector pollination.</p>	<p><i>Bioleaching is valued through cost rather than footprint Few nature tech options in a pilot ready state Mining VC concentrated in large corporates.</i></p>

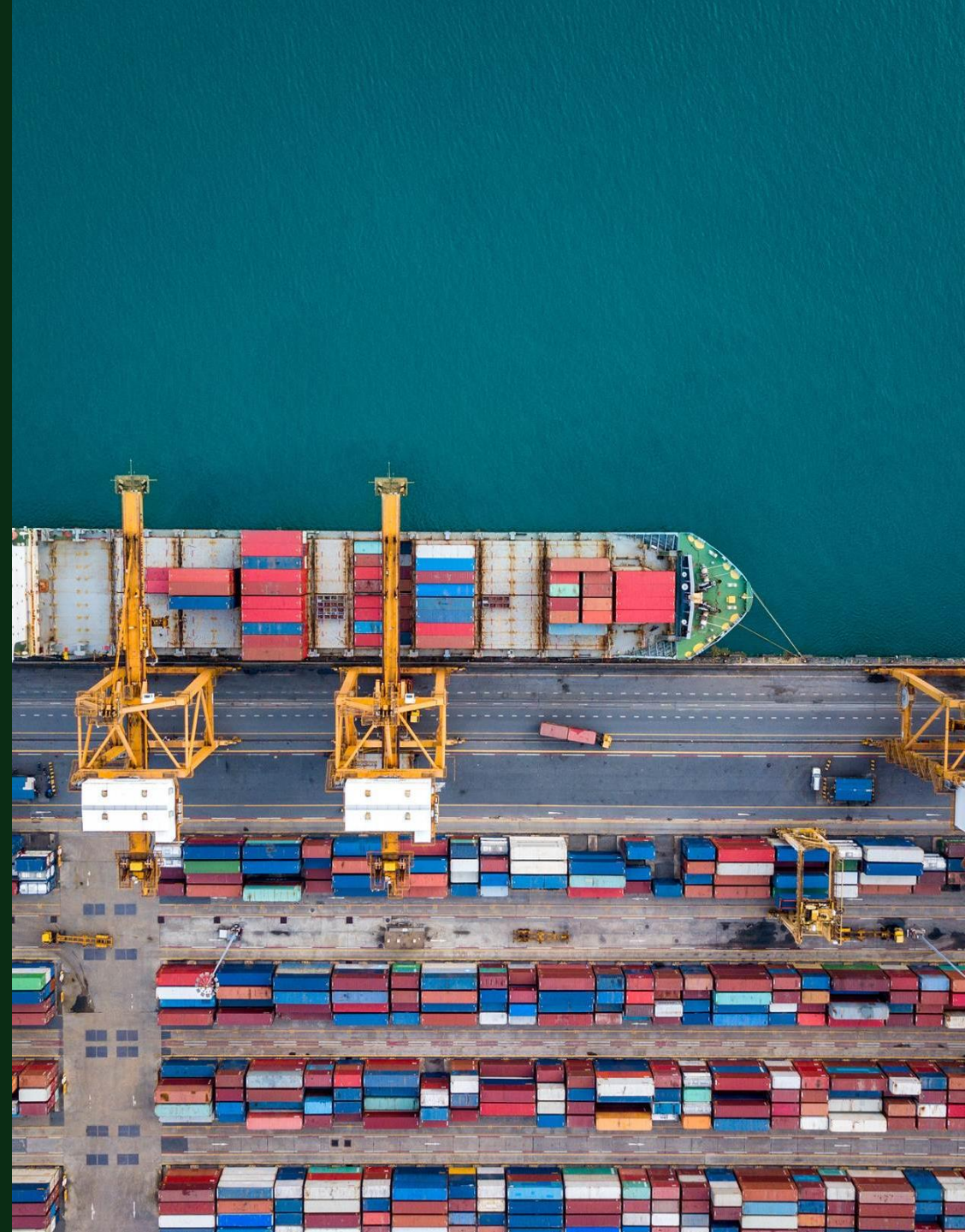
Value chain scrutiny and nature impact

What role does the broader mining value chain play in mitigating mining's impact on nature and biodiversity? Value chain scrutiny certainly has the potential to shape outcomes. Companies can demand that the critical metals and minerals they procure are mined and refined with minimal impact on nature.




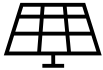























Currently, metals buyers are beginning to push for better performance on nature and biodiversity. Still, incentives vary by sector, and value chain scrutiny only covers small segments of the critical minerals and metals market.

This section covers:

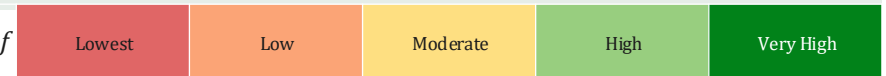
- How the value chain approach to nature and water in the mining sector compares to other sectors.
- The level of nature-related expectations different buyers have from mining companies, and what influences their level of commitment.
- How innovation and cross-sector collaboration can increase value chain scrutiny by customers, regarding nature-related impact.



Value chain scrutiny | Battery and renewables players have the highest expectations of themselves and of their metals suppliers regarding mitigating nature impact*

	MIDSTREAM					DOWNSTREAM			
	 Smelters & refiners	 Commodity traders	 Battery manufacturing	 Renewables manufacturing	 EV manufacturing	 Infra / Construction	 Renewables operators	 Investors & Finance	 Technology 'Giants'
Own performance	 Not included	 Acknowledges strategic risk	 Actively integrating into strategy	 Actively integrating into strategy	 Water more integrated than nature	 Higher maturity on water, though still low	 Actively integrating into strategy	 Recognition of importance, but challenges for integration	 Nature low maturity, water high maturity
Expectations on miners	 Low pressure on miners, with some exceptions among European players.	 Environmental due diligence regulations are increasing engagement, but nature is still a high-level concern.	 Efforts expanding due to regulations. Less advanced than EV original equipment manufacturers (OEMs).	 Upstream nature impacts not yet on radar; mostly concerned with human rights.	 Leading good practice. Top performers directly engage and audit.	 Expectations are limited and rarely expand beyond Tier 1 or Tier 2 suppliers.	 Focus is on own operations. Nature is not a key focus in relation to supply chain.	 Nature & water a common due diligence factor in mining financing.	 Considered within broader due diligence; part of low impact product decisions.

* This assessment is indicative and based on publicly available information using ERM's N-MAT tool; it does not represent a formal evaluation of any individual company / sector rather qualify overall market trends and different maturity levels.



Value chain scrutiny | The mining sector's value chain approach to nature and water is of average maturity compared to others, but still well below TNFD expectations*

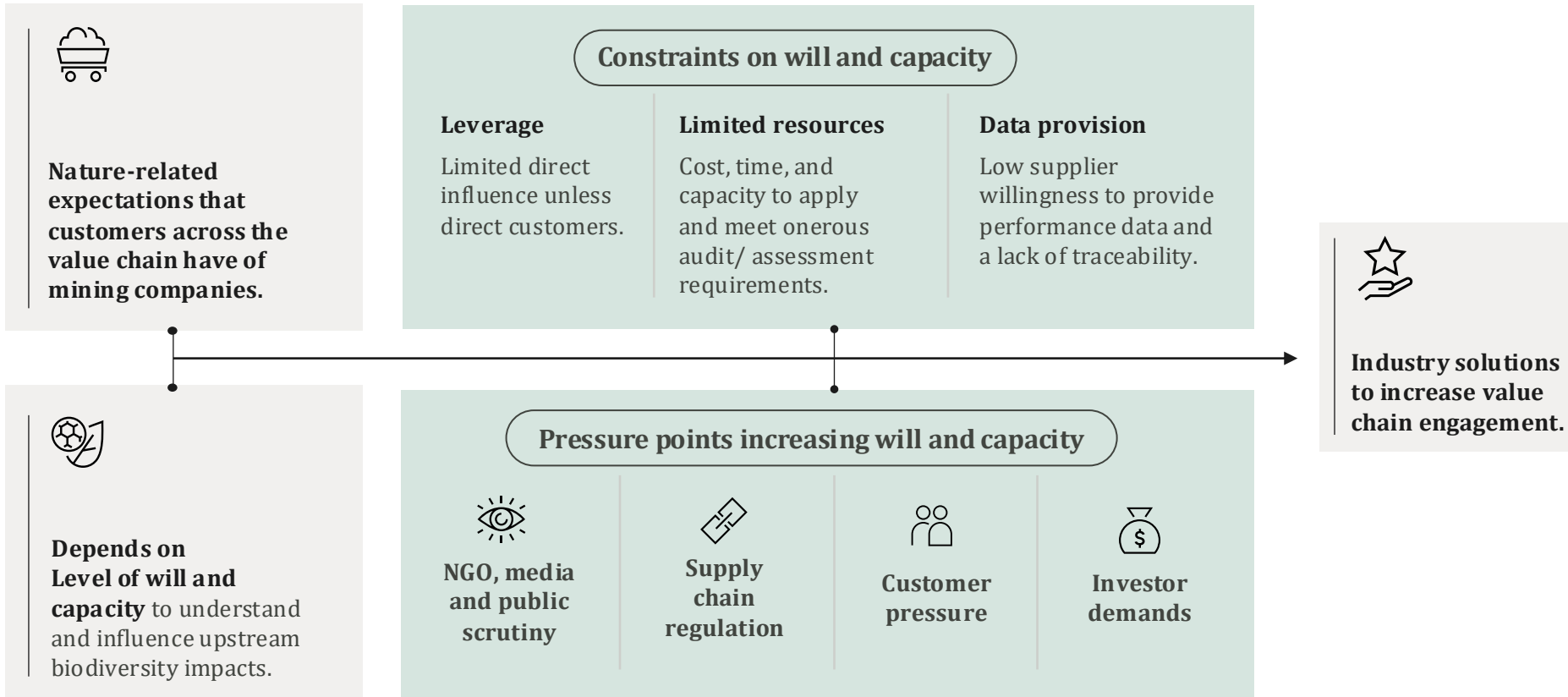
	Criteria	Miners & Mine Contractors	Logistics & Shipping	Commodity Traders	Manufacturers (batteries)	Manufacturers (renewables)	Electric vehicles	Infra Developers	Renewables (operators)	Financial institutions	Development Banks	Tech Companies
Nature	Assess	51.8	43.8	25	66.7	75	45.8	50	58.3	38.2	29.2	35.7
	Prioritize	42.9	37.5	25	62.5	68.8	41.7	41.7	54.2	27.9	20.8	25
	Commit	46	31.3	12.5	37.5	37.5	33.3	41.7	62.5	19.1	33.3	21.4
	Governance	46.4	25	25	50	62.5	41.7	41.7	58.3	42.6	45.8	35.7
	Management	35.7	31.3	25	54.2	50	37.5	25	62.5	36.8	41.7	28.6
	Reporting	46.4	31.3	25	45.8	56.3	41.7	33.3	54.2	22.1	25	17.9
Water	Assess	53.6	37.5	37.5	66.7	75	33.3	50	66.7	38.2	37.5	57.1
	Prioritize	32.1	25	37.5	33.3	25	20.8	50	29.2	33.8	20.8	42.9
	Commit	58.9	25	12.5	50	56.3	41.7	58.3	66.7	25	16.7	53.6
	Governance	60.7	37.5	37.5	50	62.5	58.3	66.7	66.7	41.2	45.8	53.6
	Management	51.8	31.3	12.5	62.5	68.8	33.3	41.7	66.7	35.3	45.8	50
	Reporting	46.4	31.3	25	54.2	62.5	33.3	41.7	50	32.4	25	53.6

* This assessment is indicative and based on publicly available information using ERM's N-MAT tool; it does not represent a formal evaluation of any individual company / sector rather qualify overall market trends and different maturity levels.

Key:


No/minimal evidence (0)	Basic (25)	Average (50)	Comprehensive (75)	Integrated (100)
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Value chain engagement | Various factors limit the nature-related expectations clients have of mining companies



<20%

Of mining sector customers view biodiversity as a top 5 sustainability priority in purchasing decisions

 Value chain pressure can incentivize responsible mining, including improved nature performance. However, sectoral commitment varies due to differing scrutiny levels and constraints.

Value chain engagement | Innovation and cross-sector collaboration can address limiting factors, raise value chain expectations, and drive effective customer pressure



Awareness /capacity

- Awareness-raising and capacity building targeting **high-leverage, low commitment** sectors (e.g., smaller smelters and refiners, construction given high copper demand).

2%

Adoption of OECD 5-Step DD Framework by construction sector



Cross-sector collaboration

- Cross-industry bodies and initiatives to facilitate **collective pressure** and messaging, particularly in high-risk contexts that dominate supply (e.g., Indonesian nickel).

>600

Members of the Responsible Business Alliance



Standards optimization

- Streamlining audit processes and facilitating **broad and effective use** of standards via consolidation, cross-recognition and innovation to 'raise the floor' on nature performance.

100

Members of the Consolidated Mining Standards Initiative (CMSI)



Supply chain visibility

- Pragmatic solutions for near-term visibility, e.g. schemes using **chain of custody** and **documentation systems**.
- Potential longer-term focus on innovative physical traceability solutions.

43%

Involvement in visibility schemes amongst companies reviewed



Value chain engagement | Leading examples of cross-industry bodies and schemes promoting responsible critical minerals supply chains

Responsible Business Alliance / Responsible Minerals Initiative (RBA / RMI)

- RBA is the largest industry coalition advancing responsible supply chains (>600 members).
- RMI is an RBA subsidiary focused on responsible minerals supply chains (>400 members).
- Applies collective pressure on high-risk suppliers using collective pressure / messaging from respected brands.
- Advances best practice guidance / tools and working groups focused on specific commodities, risks or contexts.



Global Battery Alliance (GBA)

- Largest multi-stakeholder organization working on battery sustainability (over 150 members).
- Aims to develop the Battery Passport to advance traceability in the sector to the mine level, supported by transfer of data on environmental performance (including nature impact).
- High-level of buy-in from major Chinese manufacturers, including CATL (board member), Jinko, Jiangsu, Xiamen Hithium and others.



Drive Sustainability

- Drive Sustainability is an automotive partnership between 18 leading manufacturers aiming to improve ESG performance of automotive supply chains.
- Engages in capacity building activities and provides template materials to be using for supplier assessments.
- Over 127,000 questionnaires provided by the scheme have been conducted in more than 126 countries, while over 3000 suppliers have been engaged in capacity building efforts.



Nickel Efforts for Sustainable Transition (NEST)

- Biodiversity identified as a high-risk issue by Tesla in Indonesia.
- In collaboration with NGOs, launched the NEST program to promote forest and biodiversity conservation in areas impacted by Indonesia's nickel mining sector.
- Year 1 involved identification of sites, partners, and operators. Now moving into Year 2, which will begin implementation with concrete outcomes.



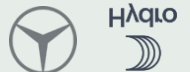
Responsible Lithium Partnership (Chile)

- Cross-value chain collaboration to promote responsible lithium mining in Chile's Salar de Atacama.
- Established multi-stakeholder roundtable (Mesa Multi-actor) to tackle ecosystem fragility and water resource impact.
- 26 meetings over 3 years led to formation of a joint action plan with 30 measures (of which 15 implemented by February 2025).



Corridor Program (Para State, Brazil)

- Although aluminum-related, the Mercedes-Hydro partnership is a strong example of vertical integration and nature engagement across the metals value chain.
- Alongside an existing decarbonization roadmap, the two entities signed an MoU to advance the Corridor coalition, engaging NGOs to foster biodiversity in the Amazon, amongst other goals.
- Reducing degradation of forests will be a first target, followed by an ambition to regenerate nature.



Levers to reduce mining's impact on nature

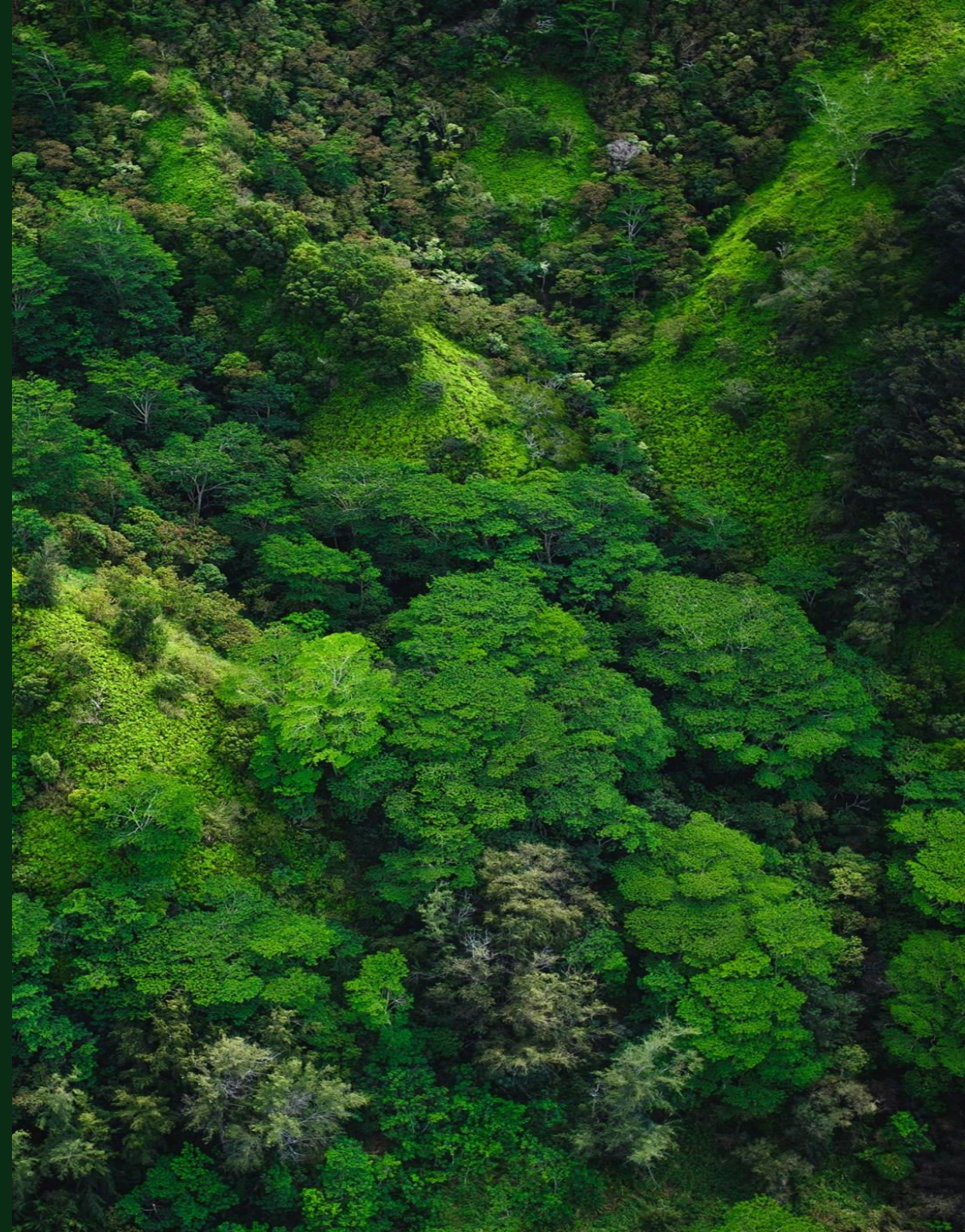
What levers are available to get to positive nature-related outcomes in mining? There are three pathways:

- Elimination - Demand side changes that reduce the overall demand for metals, thus demand for new mining activity.
 - Substitution - Actions eliminating the most harmful mines or substituting more harmful commodities with less impactful ones.
 - Optimization - Optimizing the supply-side through external pressures or improving the company's impact performance.
-

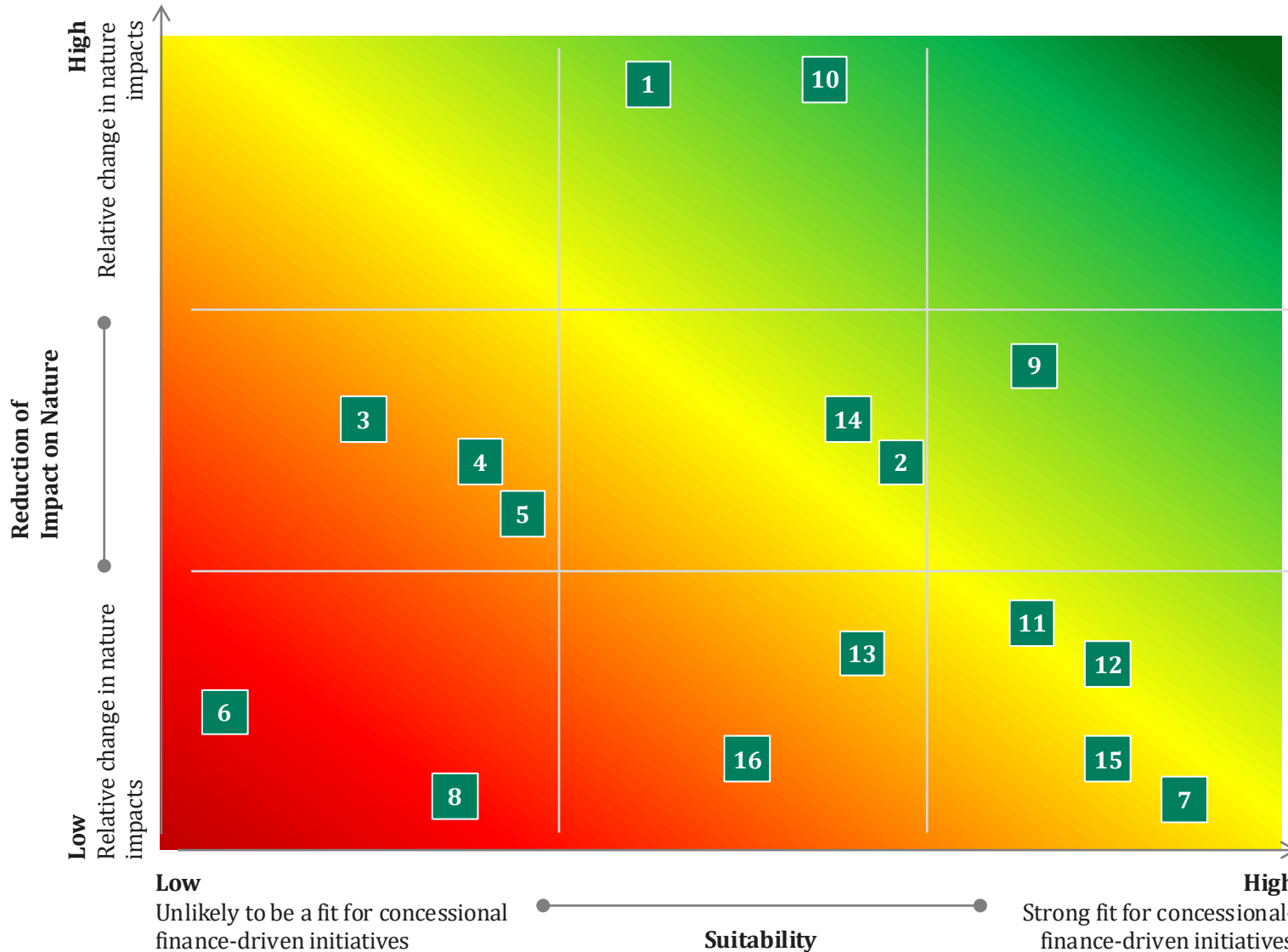
Each pathway has levers on the supply and demand side. The report identifies 16 high-potential levers. However, although all levers have high potential, some are harder to implement than others.

This section covers

- The logic behind the three pathways, and a deeper dive into all levers and why the supply side ones offer the most viable route to positively influence mining's nature-related impact.



Priority levers | This report has identified 16 supply and demand side levers with high potential to reduce mining's impact on nature



Lever

Eliminate

- 1 Improve recycling rates to reduce primary demand
- 2 Deployment of bioleaching technologies
- 3 Support globalization addressing market asymmetry and reducing oversupply
- 4 Reduce demand for BEVs through pursuing ride-sharing adoption

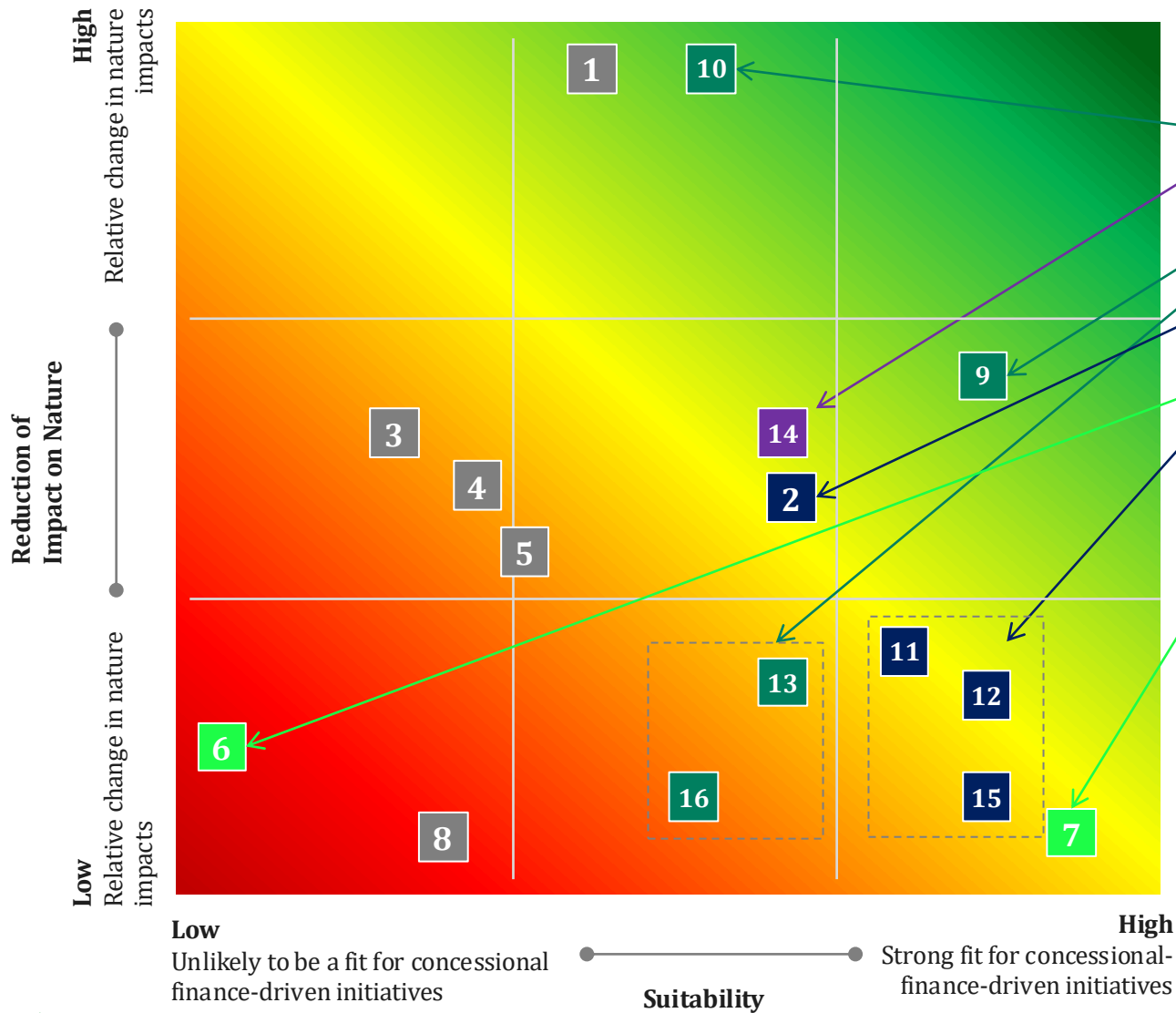
Substitute

- 5 Increase adoption of sodium ion battery chemistries
- 6 Remove most impactful mines from production
- 7 Improve site selection to avoid key biodiversity areas
- 8 Shift nickel production to lower impact jurisdictions

Optimize

- 9 Improve the Lithium Triangle's environmental regulatory and legal regime
- 10 Improve the requirements for closure bonds so they fully reflect ecosystem impacts
- 11 Accelerate adoption of direct lithium extraction (DLE)
- 12 Reduce tailings storage facilities through targeted innovation
- 13 Improve Indonesia's environmental regulatory and legal regime
- 14 Development of nature and ecosystem credits/valuation
- 15 Accelerate the adoption of technologies that reduce freshwater consumption
- 16 Improve the DRC's environmental regulatory and legal regime

Supply side | Pricing nature, regulation, innovation, and value chain action are the most promising levers to substantially mitigate mining's nature-related impact



- Financial instruments
- Regulatory instruments
- Innovation and technology advancements
- Optimizing infrastructure and avoiding key areas

Defining the interventions that move multiple supply-side inputs is critical to driving transformational change. This is achieved by creating market conditions that spur financing, value chain action, and innovation.

Questions to Address

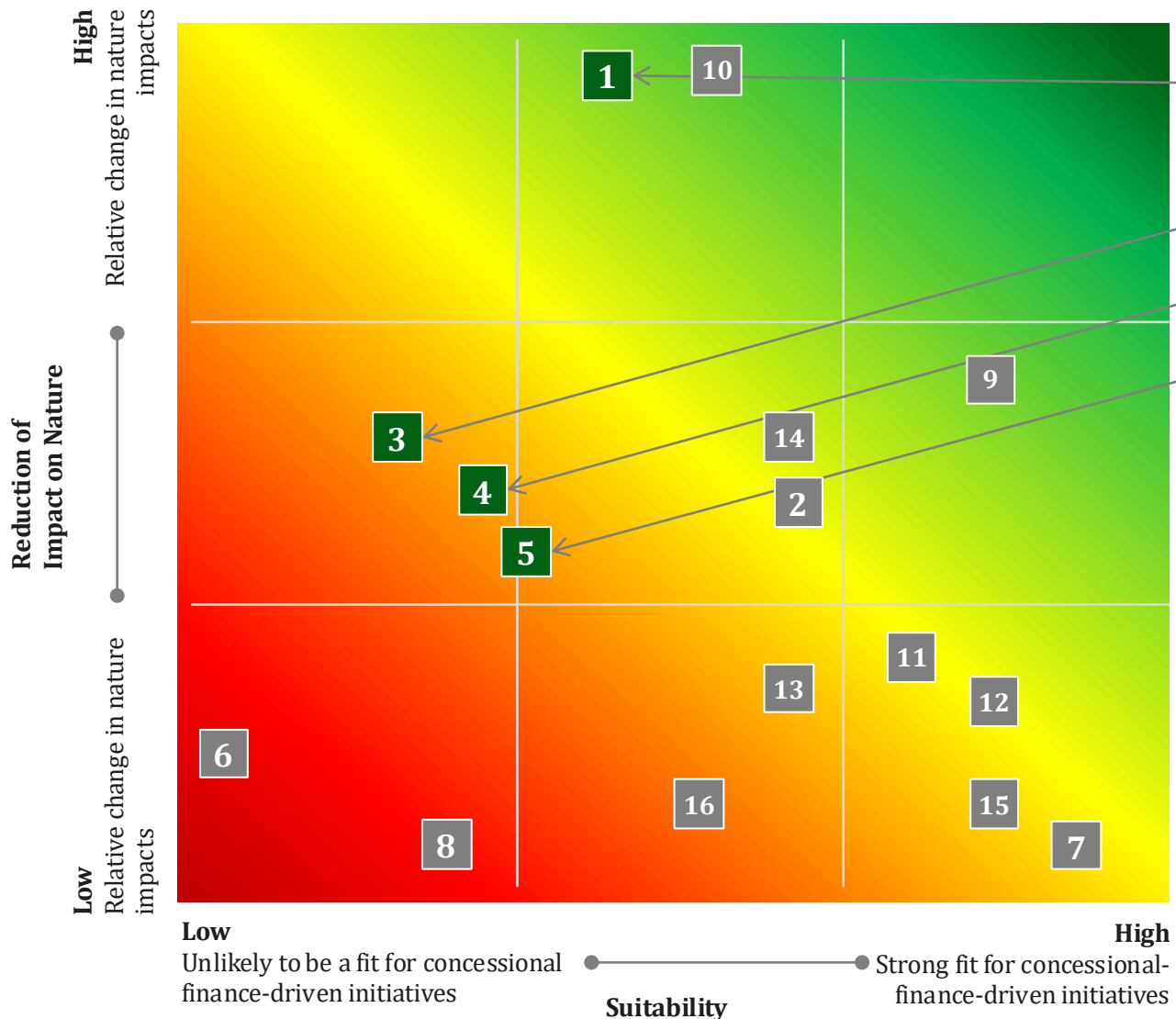
1. What are the underlying drivers that can unlock multiple supply-side levers and drive transformational change?
2. What supply side interventions are feasible to advance within a grant? Which can be 'unstuck' by grants?
3. What market conditions need to be shifted to influence behaviors and decisions within the mining sector? Which stakeholders drive those market conditions?

Relevant Challenges

Address mine trade-offs and innovation.	Providing capital for nature outcomes.	Commercial desirability of nature.	Aligning societal and financial value.	Uniformity and simplification of data.
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Demand side | Consumer demand reduction could be a very impactful lever to reduce mining's negative impact on nature, but it is difficult to influence



- Improve recycling rates (lowers demand for primary metals)
- Reduce oversupply in metals markets
- Metals substitution
- Reduce BEV demand

Demand-side interventions are highly impactful but often face challenges in demonstrating impact on conservation and incremental returns.

Questions to Address

1. Which changes are inevitabilities based on exogenous conditions (e.g., societal preferences, economic performance, policy, etc.)?
2. Can Moore materially influence or expedite demand side initiatives?
3. Can demand side improvements be credibly measured relative to Moore grants?

Relevant Challenges

- Commercial desirability of nature
- Restraining growing demand



Conclusion

The energy transition and other critical economic activities will require a dramatic expansion of the critical minerals supply. Our analysis suggests that the way supply is scaled up will determine whether the transition imposes a prohibitive cost on nature.

Declining ore quality and rising metal demand are pushing mining into more biodiversity-sensitive areas, increasing pressure on nature and ecosystems. So incremental improvements will not be enough. Structural constraints such as geology, finance, and long development timelines further complicate nature preservation. Without a shift in market logic, the nature impacts of new mining projects will accelerate.

Another outcome is possible. What current mining practices lack is not solutions but alignment. Nature remains weakly priced, poorly measured, and inconsistently demanded across the value chain, so it is often deprioritized in investment and operational decisions despite clear risks and opportunities. The most effective response is to reshape incentives and market signals, linking nature performance to access to capital, regulatory advantage, innovation decisions, and customer demand rather than relying on voluntary action alone.

A more nature-smart mining system will also depend on using the right levers in the right places. Where possible, mines with disproportionate impacts on nature should be avoided. Most production is likely to be clustered in a small number of high-impact geographies. This is why interventions, such as accelerating the adoption of low-impact technologies and strengthening value chain accountability, should focus on these locations. A second route is targeting underexplored, low-biodiversity regions that could expand supply with less pressure on nature.

The goal is not to eliminate the footprint of critical minerals mining, but to decouple supply growth from nature loss.

Mining companies, buyers of critical minerals, regulators, politicians, and investors should embrace three principles.

- **Define the economic value of nature:**
Embed nature into financing, pricing, policy, and procurement decisions so that lower-impact mining becomes commercially advantaged.
- **Focus on high-impact sites:**
Immediate actions to address nature impacts should prioritize high-risk countries where supply growth and biodiversity sensitivity overlap; avoid high-impact mines with marginal production, where possible.
- **Build on and improve what is already there:**
Innovation is surely needed. But accelerating the deployment of proven low-impact technologies and standardizing nature data to enable consistent, decision-grade metrics should be the first big steps.

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About the Gordon and Betty Moore Foundation:

Gordon and Betty Moore established the foundation to create positive outcomes for future generations. In pursuit of that vision, we advance scientific discovery, environmental conservation, and the special character of the San Francisco Bay Area.

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