Metals and Mining Industry Report

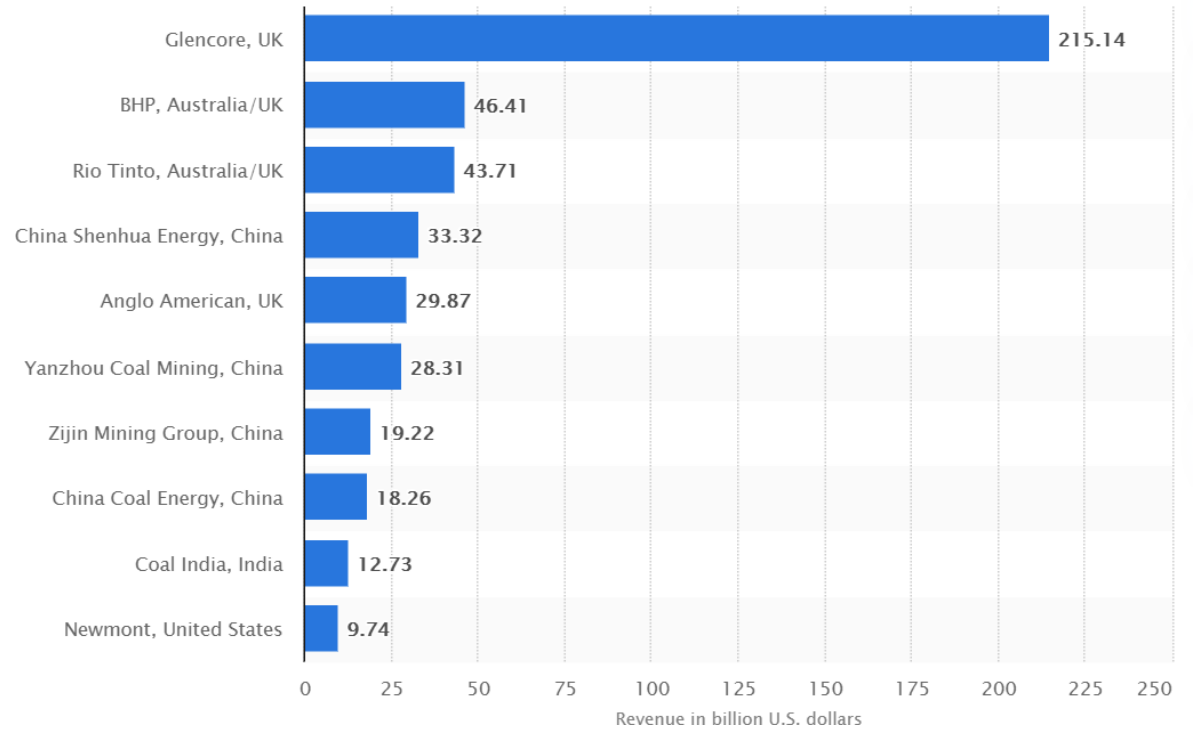
KARNER BLUE CAPITAL

INTRODUCTION

On January 25, 2019, over 200 men and women put on their hardhats and grabbed their pickaxes for a workday at the Córrego de Feijão iron ore mine near the southeastern border of Brazil. Employed by Vale S.A., one of the world's largest mining companies, workers assembled near the Brumadinho dam, a massive storage facility containing hazardous waste from the mine's operations. Just after noon, the walls of the dam crumpled, and 11.7 million cubic meters of toxic sludge surged through the valley and the city of Brumadinho, crushing forests, houses, and people.[1] The toxic flood, with all of its pent up energy, swallowed everything in its path, killing almost 300 people. This incident, although extreme, accentuates the high risks associated with the metals and mining industry.

ECONOMIC IMPACTS

While the process of extracting and refining minerals has destructive impacts on the environment and biodiversity, the industry employs millions of workers and produces commodities that are in high demand worldwide. By tapping into valuable veins of ore, the mining operations of national and international companies perform an essential service and supply the $1 trillion-dollar global market for earthen materials. In 2019, the gross revenue of the 40 largest mining companies alone totaled nearly $700 billion.[2] Vale helps to shed light on the expansive scope of the industry. This one company has more than 70,000 employees engaged in global mining operations that produce coal in Mozambique and China; nickel in Canada, Indonesia, Brazil, and New Caledonia; iron in Brazil, China, and Oman; copper in Brazil and Canada; and manganese in Brazil.[3] Similarly, Rio Tinto Group is a global iron and aluminum mining corporation with nearly $44 billion in gross revenue in 2019,[4] and a market cap of more than $100 billion.[5] In terms of employment, Rio Tinto employs 46,000 people throughout its supply chain across 36 different countries.[6] From 2010 to 2018, the industry in the United States alone has employed an average of 720,000 people, with tens of millions more employed worldwide.[7]



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While most mining companies are far from household names, the commodities they produce touch our lives every day – from aluminum foil to diamond rings to steel bars. And what about cellphones? Each phone consists of aluminum, carbon, and platinum group metals, with specific amounts of gold, silver, and copper comprising the wiring.[9] Over six different metals, starting as raw ore from as many mines, have been smelted, refined, processed, distributed, and sold, right into your pocket. In 2017, iron, bauxite, aluminum, copper, zinc, silver, gold, salt, diamonds, and coal were among the top commodities mined in terms of volume. To help put this into context, the Eiffel Tower in Paris consists of 7,000 metric tons of iron,[10] its primary metal, which is just 0.0005% of the 1.5 billion metric tons of iron that the world produced in 2018.[11] Simply put, in order to meet the massive consumer demand for commodities, companies mine metals and other earthen substances in many of the most far-flung corners of the planet.

ENVIRONMENTAL AND BIODIVERSITY IMPACTS

Unfortunately, the industry's conspicuous economic benefit does not come without a steep price – the environment. Aside from high-profile catastrophes like the Vale disaster, the immense impact that the industry has on biodiversity and the world's wildlife population may not be readily apparent. But ore extraction is a long and complicated process that requires large amounts of land, massive machinery and vehicles, people, and time, all of which can have significant detrimental impacts on animals and their habitats.

Each mine's impact varies based on a multitude of factors, including the type of mine. The two most common forms of mining are open-pit and underground mining. Open-pit mines are large pits torn out of the earth through a massive excavation process to reach ore that generally is less valuable. While pit mining is cheaper it also devastates surface ecosystems and produces significantly more waste rock than underground mining. On the other hand, underground mining is far more environmentally friendly. In the case of an underground mine, a tunnel or shaft runs through the earth to the mine, typically to reach more valuable ore, without removal of topsoil and overburden,[12] keeping terrestrial forests and wildlife habitats largely intact.[13] Underground mining operations also require fewer vehicles for similar amounts of extraction.

In addition to the type of mine, the extraction and use of certain ores causes more damage than others. For example, coal, one of the key commodities in the energy industry, is one of the largest contributors to air pollution, and ultimately climate change. Copper, an essential metal for electrical equipment, requires a massive amount of overburden removal for extraction and is a highly acidic element. Thus, it is a primary culprit with respect to the generation of hazardous waste.

Every single mine disrupts the environment and poses a direct threat to animals through all stages of its industrial life. Fossil fuel emission, overburden removal, and hazardous waste generation are but a few contributors to climate change and the degradation of our planet's biodiversity. The following four key performance indicators have the largest and most direct impact on biodiversity and wildlife: (1) tailings storage facility (TSF) and acid mine drainage (AMD) management, (2) emergency preparedness, (3) site location, and (4) site reclamation and rehabilitation. Over the past five years or so, the industry has made concerted efforts to improve its practices and mitigate its environmental impacts, as increased public awareness and engagement has focused attention on the need to address climate change and biodiversity loss. Top performing mining companies have implemented strong initiatives regarding these four animal-welfare specific indicators at a minimum, while the best global corporate citizens have also demonstrated a commitment to ensuring minimal harm to wildlife and enhancing disturbed ecosystems at the end of a mine's useful life.

The walls of tailings dams are typically built with waste rock and solid tailings, as it is a cheaper and easier way for mines to put their waste rock to use. These makeshift containment facilities may be structurally unsound and vulnerable to breaching.

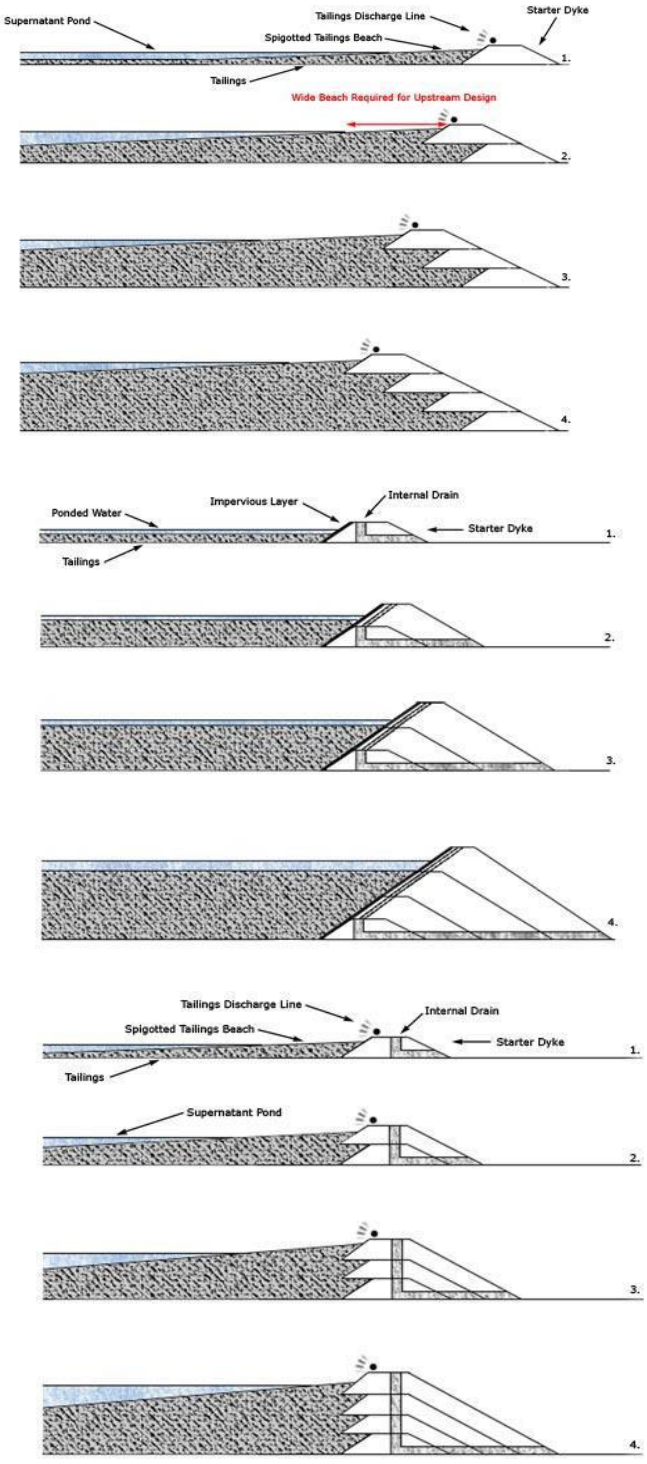
PRIMARY KEY PERFORMANCE INDICATORS

Tailings Storage Facility (TSF) and Acid Mine Drainage (AMD) Management

Every mine generates waste in the form of waste rock, tailings waste, and mine water waste that are byproducts of digging and separating valuable ore from rock. Unrecoverable metals, rock, and water are typically discharged in a watery and sandy slurry known as tailings, which is fairly interchangeable with mine water waste. Waste can be treated and stored in various ways. It can be recycled, incinerated, disposed of, or sent to a form of landfill. Tailings and other waste are often stored in Tailings Storage Facilities (TSF), which are commonly in the form of dams. Rather than a standard freshwater dam, the walls of tailings dams are typically built with waste rock and solid tailings, as it is a cheaper and easier way for mines to put their waste rock to use. These makeshift containment facilities may be structurally unsound and vulnerable to breaching. As a mine generates more tailings and waste, the dam is raised to accommodate new water levels which are often so high that towards the end of a mine's operations, tailings dams can rival the surface area of a lake.

In the case of the Brumadinho dam collapse, the acidity of the tailings compounded the damage. AMD creates hazardous tailings that form through an oxidation reaction when water comes into contact with potential acid-forming (PAF) rock. PAF rock is not present in all mines, but some, especially copper mines, produce rock loaded with sulphur residue that quickly becomes acidic upon contact with water. The resulting AMD can reach low pH levels (2.0-4.5), which are especially harmful to aquatic life. One study revealed that 68 of 100 fish species that were evaluated live in water with pH levels of at least 6.4, and that they cannot survive at pH levels caused by AMD.[14] Accordingly, mining companies must monitor toxic waste and mitigate the risks of accidents involving toxic spillage, which can lead to water pollution, the degradation of aquatic systems, and wildlife deaths.

Tailing dams are typically built with upstream, downstream, or centerline construction methods. Upstream is the cheapest method but has the greatest risk. Upstream dam walls are built with a starter



Upstream (top panel), Downstream (middle panel), and Centerline (bottom panel) construction methods.

dike, a trapezoid-like structure made of condensed tailings and waste rock. These dams essentially form a beach, with tailings slurry as the sand. As more tailings are discharged, a new dike is placed on top and upstream of the starter dike. This is significantly less stable because each additional dike only rests partially on the previous one, while most of the dike is supported by tailings. Vale's Brumadinho dam was built with the upstream construction method. In contrast, when downstream construction is used dikes are added downstream so they rest on top of the ground and previous dikes, rather than unstable tailings. Centerline construction is a hybrid of the upstream and downstream construction methods, as dikes are built vertically on the previous dike. Although some embankment is supported by tailings with the centerline method, dikes are primarily added to a solid foundation. Both downstream and centerline raising methods are sturdy enough to have an internal drainage system, which allows companies to smoothly channel wastewater out of the dam if necessary.[15]

Kinross Gold Corp. is an outlier in the mining industry with regard to TSF dam construction. None of Kinross' tailings dams are constructed with waste rock or tailings sands. Rather, Kinross implements centerline construction, and builds dam walls with sturdy material. This is an expensive and inefficient process, but the results are impressive. Kinross effectively manages AMD and ensures high water quality and has not had one dam breach in its 25-year history.[16]

There are various stages in the mining process where companies have opportunities to mitigate the impact of AMD. This includes de-acidifying the tailings, recycling, and preventing AMD from forming all together. While some companies, such as Kinross, have made great strides in their TSF and AMD management, others have lagged behind, devoting insufficient attention to waste management.

Vale and BHP Group PLC, despite recently implementing stronger policies, have already paid the price for poor TSF and AMD management. Vale and BHP operate a 50-50 joint venture called Samarco, a mining company also in Brazil that had a dam a mere 300 km away from the Brumadinho dam. On November 5, 2015, 32.6 million cubic meters of AMD broke through Samarco's Fundão dam, killing 19 people. Fortunately, most of the deadly tailings were trapped by a second dam below Fundão, undoubtedly preventing far more deaths and environmental damage.[17]

Dry-stacked tailings storage facility (TSF) from La Coipa. Chile [18]

There are multiple ways that a mining operation can treat and lower the volume of hazardous waste, reducing the impact of AMD. Lime treatment is the most common. Companies spray thousands of liters of lime into tailings dams to neutralize the acidic water.[19] This does not entirely reverse the effects of acidification, but it does make the water pure enough to gradually be emptied from its storage facility into groundwater. This is a particularly appealing strategy for companies closing nearby operations, as a mostly emptied TSF does not require as much ongoing attention.

Tailings and waste rock can also be recycled through technologies such as water filtration and dry stacking. This is essentially a two-step process. First, ore residue is placed through large filters which squeezes and recycles water from the tailings.[20] A thick mud of approximately 20% moisture is left and gets stacked compactly into layers and placed in a "dry-stacked" TSF.[21] This process has numerous advantages. It increases water recycling, reduces the size and potential impact of the TSF, is easier to close and rehabilitate, and ultimately has a much smaller environmental footprint than tailings dams or large landfills of waste rock. Norsk Hydro ASA, a global aluminum and renewable energy company, implements dry stacking for its bauxite mining residue at the Alunorte alumina refinery in northern Brazil. Hydro's technology "allows for residue storage at steeper slopes, reducing the disposal area requirements. This reduces the relative environmental footprint. The new bauxite residue deposit area at Alunorte includes more advanced press filters. These are capable of reducing the residue moisture

content to 22 percent, down from 36 percent achieved with the previous drum filter technology."[22] Birds and subterranean fauna, typically the most harmed animals from tailings dams, benefit from dry-stacking because they are not exposed to acidic water. However, no matter the security of TSFs, all can cause mass destruction that must be mitigated with appropriate preparedness.

Newmont Goldcorp's Akyem Mine TSF Cell 1 (Left) and TSF Cell 2 (right), Ghana, Downstream Construction. [23]

Transparency of TSF data is a core responsibility for mining companies. Newmont Goldcorp, a top performer in this indicator reports the integrity of each of its TSFs. Newmont's disclosed information includes location, volume, hazard categorization, raising method, inspection measures, closure plans, and other important details of its TSFs.[24] Essentially, Newmont reports the integrity of each TSF and how its practices are intended to mitigate the footprint of that TSF. The industry is taking a large step in the right direction as recently more and more companies disclose their TSF data.

In addition to threatening biodiversity, tailing dams pose a very real hazard to local human inhabitants. In severe instances such as Brumadinho and Samarco, death totals were 248[25] and 19, respectively. Beyond the obvious dangers to local villages, dam breaches can harm people

living across the whole region. After hazardous ore tailings from Brumadinho poured into the Paraopeba River, the government advised people as far away as 155 miles to refrain from using the Paraopeba's water.[26] Even small volumes of uncontrolled tailings spillage can poison groundwater and other freshwater sources used by local villages causing government officials to designate those water systems as unusable. These events result not only in a scarcity of water for people and livestock but also significant economic harm to the nearby communities that rely heavily on revenue from continued mining operations. Mayor Avimar de Melo Barcelos of Brumadinho stated that the taxes paid by iron mining account for 60% of the municipality's revenue and noted that "the city would literally stop" if the tragedy triggered an interruption in these payments.[27] It creates an unfortunate scenario where the company faces serious and costly regulatory consequences after an incident, but a break in operations can crush the financial stability of a village like Brumadinho. It is therefore crucial for mining companies to implement strong policies and practices to respond to and remediate any spillages or damage that result from environmental emergencies.

Emergency Preparedness

Given the complexity of mining operations, it is very difficult for companies to prevent all minor environmental incidents or spillages. Thus, a company must not only manage its waste but must also have an effective emergency preparedness plan. Gold Fields Ltd. is an outperforming company when it comes to waste rock management, and more specifically, its emergency preparedness. As a member of the International Council of Metals and Mining (ICMM) since 2007, Gold Fields has worked to exceed the Council's standards.

In 2016, the ICMM's Tailings Working Committee formed and created the ICMM Position Statement which includes key elements of TSF governance. ICMM standards ensure that "processes are in place to recognize and respond to impending failure of TSFs and mitigate the potential impacts arising from a potentially catastrophic failure."[28] This includes monitoring and inspections for continual improvement, specification of "roles, responsibilities, and communication procedures" and periodic testing of emergency response plans.[29] In its 2018 Sustainability Report, Gold Fields disclosed that it has a Crisis Management Support Team, Regional Incident Response Team, and Emergency Response Team for different levels of emergencies. Gold Fields' "guidelines define all relevant roles and responsibilities, including: role; profile; pre-incident responsibilities; responsibilities during an incident; and post-incident responsibilities. They cover Team Leaders, Team Coordinators, Finance, Legal, Human Resources, Sustainable Development (including Community Relations), Protection Services, Risk, ICT, and the Team Administrator. The guidelines also define relevant crisis management facilities."[30] Gold Fields has clearly emerged as an industry leader in emergency preparedness.

Concerns over TSF and AMD management are entangled with emergency preparedness. Vale and BHP both had strong emergency preparedness plans, but their waste management was so flawed that even the best responses could not prevent catastrophic damage.

However, as minor waste spillages are a norm within the industry, Gold Fields recently had its emergency preparedness protocol tested. In December of 2018, environmentalists accused Gold Fields of contaminating a river in Cajamarca Peru with tailings from its Cerro Corona mine, killing up to 17,000 fish in a nearby breeding site. The Agency for Environmental Assessment and Inspection "ordered the mining company to remedy, within 45 calendar days, the soil, bed and riverbank of the La Hierba stream and the

Tingo Maygasbamba River, where water with tailings flowed."[31] When Gold Fields became aware of the spillage, its emergency preparedness protocols were triggered, immediately sending personnel to the contaminated areas and ameliorating the situation. Gold Fields has since announced that the situation is fully under control.

On the opposite end of the spectrum, Russian diamond miner PJSC ALROSA lacks emergency preparedness almost entirely, which shone through in a recent environmental controversy. On August 17, 2018, heavy rains in the Sakha Republic of Northeastern Russia caused a tailings dam operated by ALROSA to spill iron and copper AMD into the Vilyui, Irelya and Malaya Botuobiya rivers.[32] Not only did this breach destroy aquatic systems, it also polluted a common source of drinking water for residents of the nearby Yakutia and Skuldyukar villages. ALROSA does not disclose any emergency preparedness in its reports, nor were there sufficient responses to this incident. Although ALROSA was supposedly providing safe drinking water to those affected, complaints have risen from September and January that provisions have been insufficient.[33]

Concerns over TSF and AMD management are entangled with emergency preparedness. In the cases of Vale and BHP, both had strong emergency preparedness plans, but their waste management was so flawed that they allowed severe dam ruptures to occur, and even the best responses could not prevent catastrophic damage. On the other hand, if a company has no emergency response plan and very strong waste management, an unanticipated waste spillage would not be effectively remediated. Thus, it is essential that

companies excel in both TSF and AMD management, and emergency preparedness.

Site Location

Mining operations have varying impacts on surrounding environments based on location. Typically, when there is valuable ore below the earth's crust, the surface is rich with biodiversity. Polymetal International, a precious metals miner in Europe and Asia, is an outlier because it does not operate in or adjacent to protected areas and has minimal impact on biodiversity.[34] Unfortunately, most mining companies, including the top performers, have operations located in or adjacent to protected areas and/or biodiversity hotspots. Even mines within an approximately 50-kilometer radius of these areas still affect biodiversity because of emissions, roads, TSFs, and other factors.[35] Given this circumstance, companies should provide full disclosure of the exact locations of all operations. In addition, they should report the number and degree of vulnerability of animal species that are influenced by their operations. Top performers have animal welfare initiatives that do not merely assess and monitor wildlife, but also take necessary measures to mitigate, and in some cases, benefit wildlife.

Fortescue Group Metals, an Australian iron miner, is a paragon of moral corporate behavior for this indicator. Although numerous wildlife species are affected by its operations, Fortescue treats wildlife protection as a priority. Not only does Fortescue disclose all significant animal species near its four Australian mines, it has disclosed a 100+ page "Conservation Significant Fauna Management Plan (FMP),"[36] which details its extensive monitoring and support of fauna. Fortescue writes that:

> The primary objectives of the FMP are to identify impacts, conserve significant fauna species and develop management and monitoring measures that maximise the ongoing protection, and long-term conservation, of these species within, and adjacent to Fortescue controlled sites. A similar focus is applied to understanding inland aquatic features adjacent to its operations.[37]

The FMP provides complete maps that reveal the precise location of wildlife habitats in relation to its operations with an especially strong emphasis on certain species such as the night parrot, northern quoll, and Pilbara olive python. Fortescue

provides in depth descriptions of its monitoring programs for these species, among others, in the FMP, including various monitoring techniques and technologies that it uses to collect information on biodiversity. For example, its monitoring of night parrots utilizes point monitoring, bird calling, sniffing dogs and motion cameras, or "camera traps," which is the most common of these techniques. [38] [39] Fortescue's monitoring systems break down individual and biometric data of the animals, including sex, body measurements, health, breeding statuses, and reproductive conditions, as well as habitat characteristics, meteorological data, and environmental threats. Fortescue operates in Australia's Pilbara region, home to approximately 3,000 subterranean fauna species. Since 2009, Fortescue has conducted 17 complex surveys of these fauna and undertaken DNA analyses to preserve fauna under the earth's surface. All this knowledge allows Fortescue to manage fauna in a progressive manner, modeling corporate behavior that other companies in the industry should replicate. Fortescue has also donated $2.5 million to fund biodiversity protection initiatives at the Fortescue Marsh, a wetland

of national significance just south of Fortescue's Cloudbreak and Christmas Creek mines in the Pilbara region. [40]

Hindustan Zinc Ltd., the world's second largest zinc-lead miner, is another mining company that treats biodiversity as a priority and not an afterthought. It operates near rich wildlife habitats and has worked to mitigate biodiversity risk throughout its operations by conducting multiple biodiversity assessments. Hindustan's initiatives have included the following:[41]

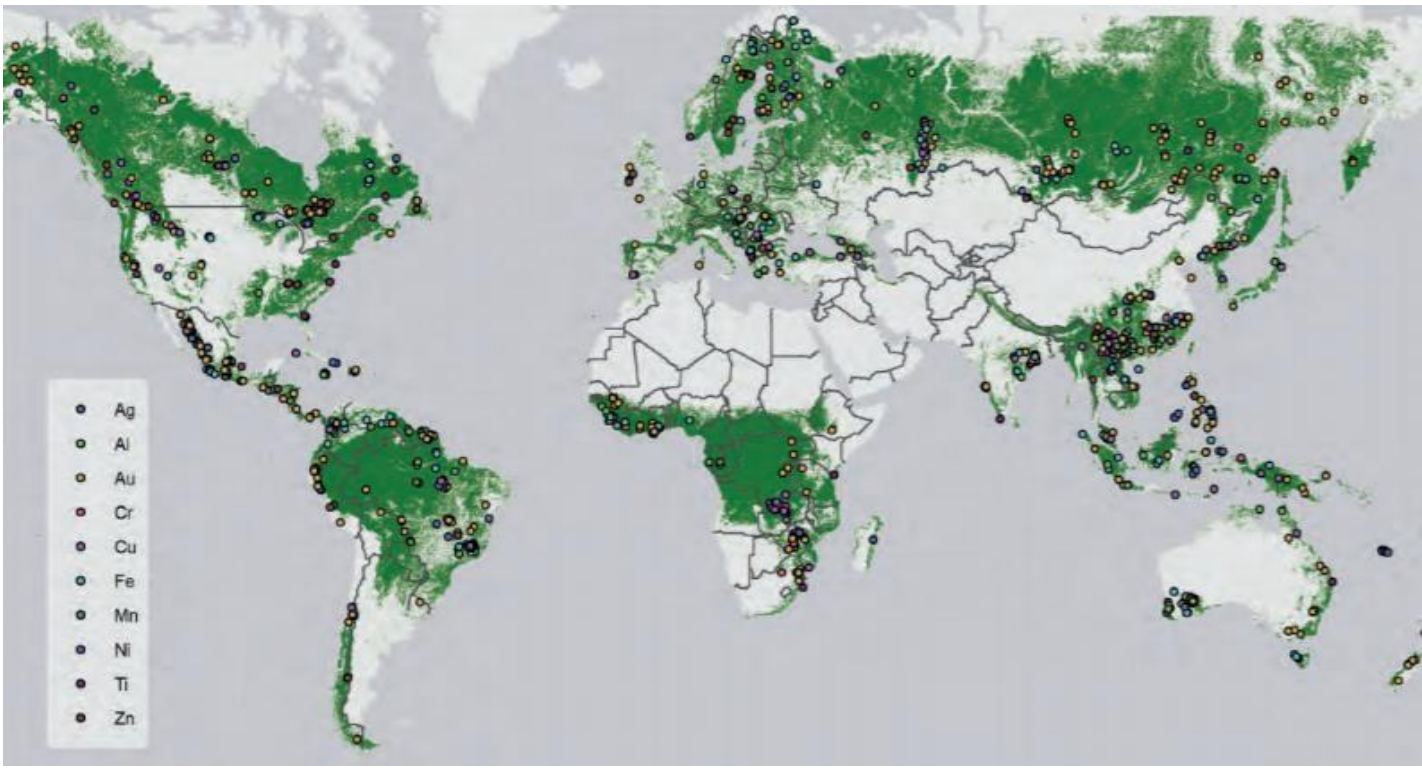
- Development of the Peacock Conservation Park and an endangered species nursery at the Kayad mine;

- Development of a peacock and herbal bank in the city of Udaipur;
- Development of water ponds for birds and a butterfly garden at the Pantnagar metals refinery; and
- Implementation of artificial bird nesting and feeding throughout all Hindustan sites.

Fortescue and Hindustan are prime examples of strong site location and progressive initiatives to preserve biodiversity and aid wildlife impacted by their operations. Their efforts are exemplary. Many other companies also implement programs that provide for very strong management of influenced fauna, such as Newmont, Freeport McMoRan Inc., and Lundin Mining Corp., to name a few.

Forest Mining

Forest mining has a particularly strong impact on wildlife given the high biodiversity of forests and their isolation from concentrated civilization and infrastructure. Forest ecosystems are some of the richest, in terms of diversity, compared to other habitat types. A study done in 2015 revealed that approximately 44% of active mines are located in forested areas. Assuming mines influence forests



within a 50km radius, approximately 10% of the world's forests are impacted by mining operations. That number jumps to around 33% if decommissioned and in-development mines are included.[42] The map above illustrates the commodities that are extracted in relation to the world's forests.[43]

Merely constructing a mine requires clearing large segments of a forest. However, the impacts of mine construction go far beyond forest clearance. The construction of a mine requires significant capital expenditures including roads, railways, machinery, and buildings. Since new transportation systems are appealing to those looking for somewhere to live, mine construction encourages major population shifts into the newly mined forest. Essentially, the construction of one mining operation can create an entirely new infrastructure ecosystem.

From a climate change perspective, air and water quality suffers from chemical pollutants, given the increase in vehicle and machinery use. In forests with high rainfall, bodies of water and aquatic life located near roads are contaminated when settled pollutants are washed into water systems. Roadkill also inevitably rises with the introduction of additional roads and vehicles. The most significant issue, however, emerges from hunting by local villagers. "Hunting intensity is so elevated near roads that it strongly affects the large-scale distribution of forest elephants, buffalo, duikers, primates, and other exploited species."[44] A study from 2009 revealed that an average of eight killed mammals were transported hourly on just one highway in Sulawesi, Indonesia,[45] which just so happens to be located near nickel mines of the Sulawesi Mining Investment.[46] The combination of all of these factors threaten thriving wildlife populations and the natural flow of strong ecosystems.

Poaching and COVID-19

Particularly in countries where poaching and mining are poorly regulated, larger populations and forest access related to mines spur the hunting of wildlife for food and trophies. Known as "bushmeat," this custom has a devastating impact on wildlife populations and poses a grave threat to animal welfare. Wild mammals, reptiles, and birds provide a cheap and readily available source of protein and are in high demand due to the influx of workers and

civilians near mines. About 1 million metric tons (~1 billion kg) of bushmeat are consumed annually in Central Africa *alone*.[47] In the Democratic Republic of Congo (DRC), approximately 8-10 million people are involved in the country's mining industry which includes several illegal mines.[48] According to the World Wildlife Fund, poaching and disease are primarily responsible for the 60% decline in the DRC's eastern lowland gorilla population since the 1990's which has caused the species to become critically endangered.[49]

Unfortunately, illegal wildlife trade fueled by mining operations extends beyond Africa. In South America, where mining comprises a large portion of the economy, bushmeat is the primary source of protein for up to 8 million people, and an estimated 900,000 tons (~800 million kg) of bushmeat are consumed each year in the Amazonian region.[50] In addition, in certain areas of China there are reports of trafficking in nearly extinct species, including rhinos, tigers, and pangolins.[51] Even in Europe and the US, substantial amounts of bushmeat are smuggled in often for cultural events.[52]

Bushmeat trade is not only a threat to wildlife, but it poses a serious threat to humans via zoonotic virus transmission. Carcasses sold at markets are likely not tested for diseases, making humans quite vulnerable. According to researchers, zoonotic viruses such as COVID-19 most likely originated in an unsanitary "wet market," where primates, reptiles, and other animals are treated inhumanely, slaughtered,

and sold. In fact, up to 60% of new infectious diseases in humans originated in animals, and as we are well aware, a novel zoonotic virus can spread exponentially in a matter of weeks.[53] Given the concentrated increases in human activity and the wildlife and ecosystem disruptions that result from mining operations, mining companies should proactively implement policies and procedures to curb the bushmeat trade related to their operations.

Site Reclamation and Rehabilitation

While a mine is particularly impactful to the environment during its years of operation, which typically lasts around 10-30 years, decommissioned mines have nearly the same environmental footprint for many additional decades.[54] If left alone, the infrastructure will decay and toxic metals will threaten the local ecosystem. Reclamation and rehabilitation are the processes of returning mine-degraded land to its former state or close to it. Top-performing companies initiate strong "progressive rehabilitation" prior to, during, and after the life of a mine. Although results of progressive rehabilitation are generally not as evident until post-closure stages, each phase is equally important to mitigating impacts. Ultimately, companies, aim to create an ecosystem in which flora and fauna species can thrive as if there was never a mine in the first place.

While designing the mine, specialists collect information through various studies of the existing environment to understand exactly what will be damaged and the revegetation necessary to fix it. To prepare for operations, mines establish government approved closure plans early in the process. Their studies help to create protection plans for wildlife habitats; often companies

relocate animals in safe conservation areas to keep them out of harm's way. The mining site is then prepared for extraction with careful land clearing to minimize impact on flora and fauna. This typically includes collection of native seeds to be kept for revegetation years later. The clearance stage is essential, as poor land removal eliminates the opportunity to rehabilitate effectively.

Once the extraction process begins, rehabilitation is undertaken wherever practical. Companies can revegetate as soon as a section of earth is fully mined. If a TSF is full and is not going to be enlarged to accommodate more waste, then that facility can either be left alone, or rehabilitated. Companies consistently report their rehabilitation progress in the form of a data table that compares the ratio of newly disturbed hectares (ha) (~2.5 acres) of land to rehabilitated land. Freeport-McMoRan Inc. (FCX) is an example of a company that engages in strong reclamation and rehabilitation efforts. Since 2015, FCX has progressively rehabilitated its land so that despite disturbing hundreds of hectares of new land each year, its total land disturbed and not rehabilitated has decreased by nearly 2,000 hectares from 2015-2018.[55] This quote from FCX's "Mining Reclamation in North America" document encapsulates the necessary research for this phase of the reclamation process.

> By studying different forms of vegetation, we aim to better understand the response and establishment of vegetation on reclaimed land. This involves research to learn site-specific criteria for improving revegetation efforts on reclaimed land relative to species planted as well as the timing and method of planting. Currently, annual surveys are conducted at six different sites in Arizona. Surveys include collecting data on species present, species frequency, vegetation density, canopy cover and vegetation changes over time. In addition to studying vegetation dynamics on reclaimed land, native undisturbed comparable sites are also evaluated annually. By studying areas with similar soils, we seek to create seed mix that may enhance revegetation efforts.[56]

After a mine concludes operations, the rest of the rehabilitation efforts can be completed. This is a prime opportunity for companies to thrive in their sustainability efforts by particularly helping wildlife. Using information collected prior to and during extraction, revegetation can be tailored specifically to the local wildlife. Companies with the best practices report what they call a "net positive impact on biodiversity." For example, near one of FCX's two mines in Colorado, FCX created a wetland habitat for the boreal toad. In Arizona, FCX worked with Bat

Conservation International to create a "bat-compatible gate at a cave populated with Mexican free-tailed bats."[57] Lastly, the company worked with the Arizona Game and Fish Department to relocate the declining population of big-horn sheep to an area unaffected by its mines.[58] FCX has reclaimed thousands of hectares of land, while still maintaining full operations. Although it is hard to be convinced that any mining operation has an overall beneficial impact on the environment, it is valid to say that mines owned by top-performing companies often leave some areas with more vibrant vegetation and richer with wildlife than before mining operations began.

Mining Reclamation in North America by Climax McMoRan [59]

Another opportunity for companies to excel in their sustainability efforts involves the acquisition of "biodiversity offsets" or legacy mines. A biodiversity offset is an area of land separate from the destroyed mine land that could benefit from biodiversity improvements or enhancements. Legacy mines are abandoned mines that closed years ago, prior to public concern

over the environment. The Bureau of Land Management estimates that 500,000 abandoned mines are littered throughout the United States alone.[60] In theory, a company can offset any permanent damage caused by its current mining operations by rehabilitating the land associated with a biodiversity offset or legacy mine. For example, Canadian gold miner Agnico Eagle Mines Ltd. purchased the "Cobalt Legacy Sites" in Ontario and its rehabilitation efforts have included the creation of protected bat habitats.[61] Put simply, site reclamation and rehabilitation efforts are crucial to ensuring the continuation of vibrant biodiversity after a mine closes and present a golden opportunity for mining companies to meet their responsibilities as global corporate citizens.

ADDITIONAL KEY PERFORMANCE INDICATORS

Travel and Transport

The "travel and transport" indicator is based on both the proximity of a company's operations to biodiversity hotspots, and its efforts to reduce the environmental impacts of travel and transportation infrastructure. As discussed above, transportation systems increase roadkill and expose surrounding fauna and flora to heightened levels of scope 1 emissions from increased fuel consumption. The operation of open-pit mines as opposed to underground mines is also a consideration when evaluating a mining company on this key performance indicator because underground mines typically have lower scope 1 emissions. When Australian miner OZ Minerals Ltd. moved its Prominent Hill copper, gold, and silver mine underground in 2018, scope 1 emissions decreased by 19% from the previous year and OZ disclosed that "there was a reduction in waste, fewer trucks were operating and less diesel was consumed."[62] Companies are encouraged to operate mines far from highly biodiverse areas, but, if they do operate in or near biodiversity hotspots, it is essential that, like OZ, they implement initiatives to mitigate the adverse biodiversity impacts of the required travel and transportation infrastructure.

Coal, Technology, and Alternatives

Coal is the world's largest source of energy and electricity production and it is abundant and cheap. Miners extract both metallurgical and thermal coal for heat

generation and electricity, respectively. In 2018, nearly 8,000 million tons (Mt) of coal were produced worldwide, primarily from China (3,550 Mt), India (771 Mt), the United States (685 Mt), Indonesia (549Mt), and Australia (483Mt). Russia, South Africa, Germany, Poland, and Kazakhstan round out the top ten coal producers in 2018. [63]

While undeniably valuable to companies and economies, coal is also rich with carbon, containing anywhere from 60% to over 80%. When burned, coal emits significant quantities of greenhouse gases including carbon dioxide (CO_2). To get a better sense, when fully combusted, 1 ton (1,000kg) of coal with a carbon content of 78% generates approximately 5,700lbs (~2600kg) of carbon dioxide.[64] As the industry adapts to a rising crescendo of environmental concerns, coal divestment is rapidly gaining momentum in an effort to mitigate climate change. Since October of 2018, six US coal companies have declared bankruptcy.[65] BHP Group, the second largest thermal coal miner in 2018 at 29 Mt, has accelerated its plans to exit thermal coal by divesting the business.[66] Similarly, Rio Tinto entirely eliminated coal mining and sold its coal assets in 2018.[67]

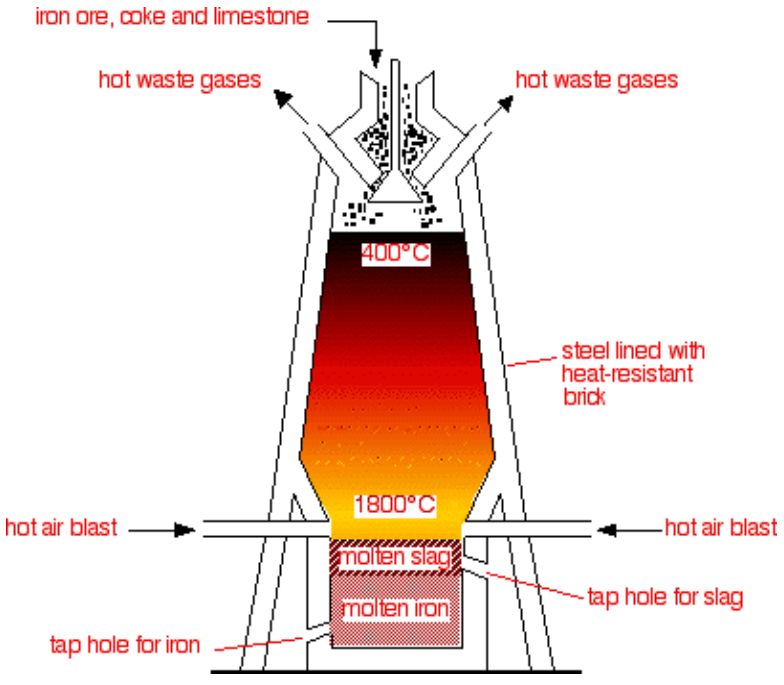
Fortunately, coal is a fuel that can be replaced with equally effective, environmentally friendly alternatives, including solar, wind, nuclear, and other forms of reusable and self-sustainable energy. The primary rival to these alternative energy sources is clean coal technology (CCT), which is designed to significantly reduce combustion emissions. One form of CCT is known as scrubbers, which wash the coal prior to combustion, removing large amounts of sulfur and other impurities. Another form uses heat and pressure to convert coal into a refined form of gas or liquid, enabling it to be used more cleanly.[68] All CCTs are better than not using them at all. However, as effective as CCT is, it is still not as environmentally friendly as renewable energy alternatives.

All clean coal technologies are better than not using them at all. However, as effective as CCT is, it is still not as environmentally friendly as renewable energy alternatives, such as solar, wind, and nuclear power.

In the metals industry, coal is used to heat blast furnaces that melt other minerals for the purpose of separating valuable ore from rock. The most common form is melting iron ore for steel production. Over 71% of steel produced today uses metallurgical coal to heat large blast furnaces loaded with large quantities of iron and a bit of steel scrap metal. Steel is an alloy that society needs for the construction of railroads, bridges, buildings, and other infrastructure. In 2019, the US alone produced 88 million metric tons of steel.[69]

Blast furnaces are massive, ranging from 20 to 35 meters tall with a diameter of 6 to 14 meters and requiring temperatures of about 1,800ºC (3,272ºF) to melt iron. The most common furnace is the basic oxygen furnace which burns nearly 0.85 tons of coal (~800kg),[70] generating about 2.4 tons (~2,200kg) of CO_2 [71] to produce just 1 ton of steel. However, steel is theoretically 100% recyclable through the use of electric arc furnaces (EAF). Charcoal and electricity from electrodes enable EAFs to generate sufficient heat to melt the scrap and remove and drain impurities from the steel. Many EAFs do use some coal for necessary heat generation, but even these methods require only 0.17 tons (~150kg) of coal to produce one ton of steel.[72]

Aperam S.A., a European steel producer, uses a charcoal substitute from a Brazilian forest to sufficiently heat its EAFs. Although using trees for charcoal is not ideal, Aperam discloses that "this allows [the company] to eradicate entirely the use of extractive coke and makes [its] steel a leader in terms of CO_2 footprint."[73] Companies should strive to meet Aperam's standards by finding environmentally friendly alternatives to reduce their carbon footprint.



Oxygen Blast Furnace [74]

LITHIUM

While highly detrimental ore like coal is slowly being phased out, demand for lithium is on the rise due to its ability to create high powered batteries for electric vehicles (EVs). In 2018, Australia, Chile, China, Argentina, and Zimbabwe were the world's top lithium producers. Consumers have been using small lithium batteries for smaller accessories such as cellphones and flashlights for decades, but recently lithium batteries have been utilized to power much larger machines, notably EVs. To put the size difference in perspective, one EV battery uses about 250 kilograms of lithium,[75] which is the equivalent of about 10,000 small lithium batteries.[76] With the environmental benefits of EVs, demand is skyrocketing. Projections show that in 2025, the global demand for lithium could reach 1.637 million metric tons, enough to make approximately 6.5 million EV batteries in 2025 *alone*.[77]

With an increase in demand comes an effort to increase supply. Lithium is extracted through two methods: brining and mining. Lithium brine extraction is a natural process of evaporation. Water from underground basins with high lithium salt concentrations, known as salars, is pumped to the surface and settled until the water has evaporated and large cones of concentrate are left. Although this process is cheap, it can take anywhere from eight to 36 months.[78] On the other hand, mining lithium requires a significant upfront investment, but once a mine begins production it is efficient and consistently economical. Thus, it is slowly becoming the preferred business choice. Lithium mining is a standard style of ore extraction; hard rock, or pegmatites, with lithium concentrates are dug out, heated and turned into a slurry, separated from excess rock, and mixed with soda ash to form lithium carbonate.[79] As of now, about 75% of lithium is accumulated from salars, but mining is beginning to balance lithium sourcing as demand grows. The environmental impacts of mining are astronomically larger than lithium brine extraction. It is therefore imperative that, as lithium mine activity grows, companies move forward with caution and implement industry best practices to mitigate harm to biodiversity and wildlife.

LEGISLATION

While corporate policies and actions are crucial to improving the lives of animals, so too are laws that establish regulations companies must observe. Due to the metals and mining sector's extreme environmental footprint, governments exercise regulatory oversight to hold companies to certain standards, and work with them to mitigate harm. Stricter legislation holds companies accountable and requires that companies meet internally set deadlines. Globally, the International Organization for Standardization's (ISO) 14000 standards guide companies in their environmental management system (EMS). More specifically, the ISO 14001 are voluntary standards that companies adhere to in their effort to reduce waste, improve resource efficiency, and measure environmental impact, ultimately mitigating their biodiversity impact and improving business •operations.[80]

United States Legislation

In 1872, President Ulysses S. Grant signed the "The Mining Law," enabling Americans to claim and extract minerals from public lands. The environment was not a concern in the 19th century, so the United States has since implemented dozens of federal environmental laws making metals and mining one of the most heavily regulated industries. Federal agencies such as the Environmental Protection Agency (EPA) and the Bureau of Land Management (BLM) are responsible for creating and enforcing legislation. Government issued permits are required for the exploration and construction of new mining operations and are only issued after compliance with environmental standards is ensured.[81] Below is an outline of key legislation in the United States.

Federal Legislation

Mine Improvement and New Emergency Response Act (MINER Act): [82] Signed by President Bush in 2006, this act amended the Federal Mine Safety & Health Act of 1977. The MINER Act requires that each mine maintain updated emergency response plans and have two nearby rescue teams. While intended to enhance working conditions and protect employees, the MINER Act indirectly helps biodiversity and wildlife habitats through stronger emergency preparedness.

Endangered Species Act (ESA):[83] Passed in 1973, the ESA provides a framework for the listing of species and subspecies as "threatened" or "endangered," providing them with a broad set of protections aimed at species recovery. The two government agencies responsible for enforcing the ESA are the United States Fish and Wildlife Service and the National Marine Fisheries Service, which determine the status of a given species. In pre-construction phases, miners must conduct surveys to evaluate and list nearby species that align with the ESAs framework.

Clean Water Act (CWA): [84] Passed in 1972, the CWA regulates the discharge of pollutants into US bodies of water without obtaining a permit. The CWA is particularly relevant to mining given the runoffs and seepages of TSFs.

Resource Conservation and Recovery Act (RCRA): Passed in 1976, this act gave the EPA the ability to prevent companies from releasing hazardous waste. Unfortunately, the regulation does not restrict the release of high volume, low hazard waste.

State Legislation

California: In 1975 the California Department of Conservation passed the Surface Mining and Reclamation Act (SMARA) to mitigate environmental impact and assure sufficient land reclamation. Article 9 of SMARA requires that sensitive species and their habitats "be conserved as prescribed by the federal Endangered Species Act of 1973."[85] In addition, impact on influenced wetland habitats must "be mitigated at a minimum of one to one ratio

for wetland habitat acreage and wetland habitats value."[86]

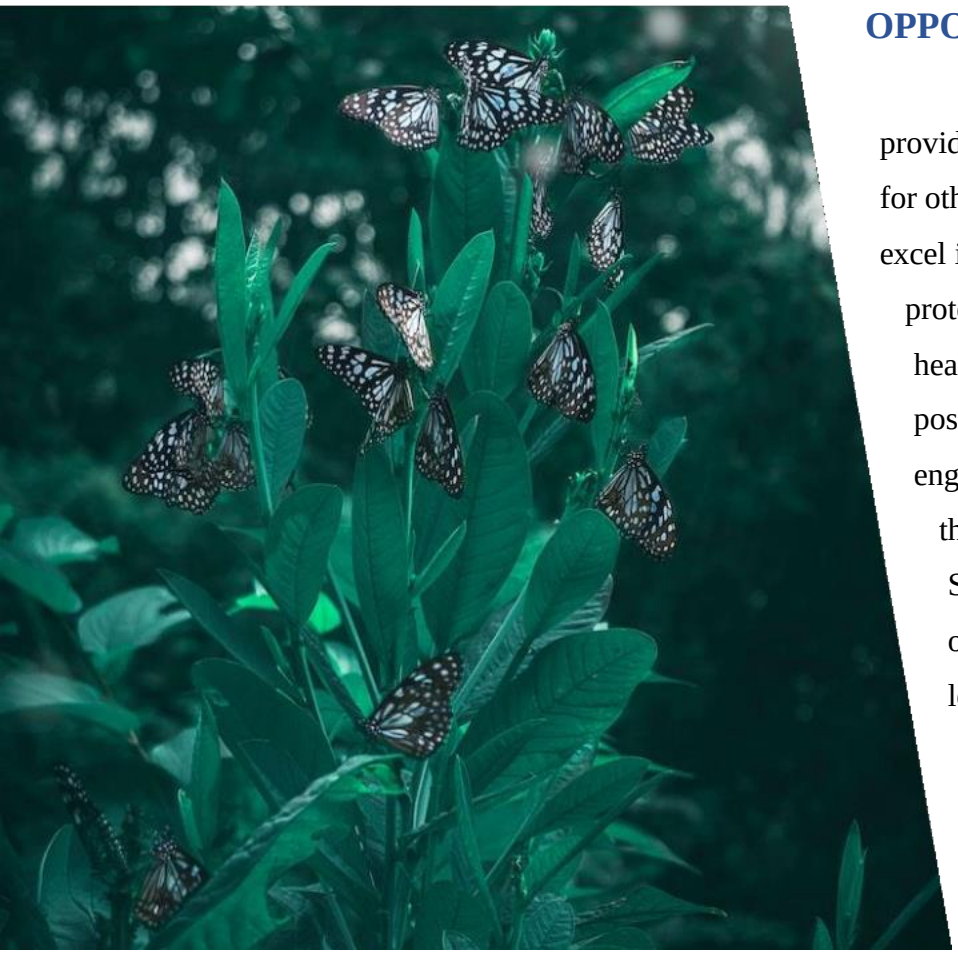
Nevada: In Nevada, "oversight and regulation of mining is shared by the Division of Minerals (DOM) and the Division of Environmental Protection (DEP) in the State Department of Conservation and Natural Resources (SDCNR). Permits for water rights associated with mining are within the purview of the Division of Water Resources in the SDCNR."[87]

European Legislation

Like the United States, the European Union (EU) has made great strides in its environmental legislation. Waste and tailings storage must be properly managed to ensure long-term stability of facilities and minimize pollution from AMD. Directive 2006/21/EC or "The Extractive Waste Directive"[88] requires that companies formulate extractive waste management plans for the European Commission's (executive branch of EU) approval that includes "the minimisation, treatment, recovery and disposal of extractive waste, taking account of the principle of sustainable development." The European Commission has established certain animal welfare standards that are consistently implemented, but these policies are primarily connected to agricultural policies and do not specifically address the influence of metals and mining on wildlife.[89]

Australian Legislation

According to the Australian Bureau of Statistics, mining was approximately the fourth largest contributor to Australia's economy and accounted for about 6% of the GDP in 2016-2017.[90] Australia operates over 350 mines for the most useful materials such as gold, iron ore, lead, and rare earth metals to name a few.[91] Australia's Work Health and Safety laws are regulated through various mine safety and health acts in each of Australia's states. For example, the Queensland Government passed the Coal Mining Safety and Health Act in 1999. In Western Australia, the Mines Safety and Inspection Act and its regulations were passed in 1994 and 1995, respectively.[92] Lastly, each of the states has implemented animal welfare acts to prevent animal cruelty, most recently Western Australia's Animal Welfare Act of 2002.[93]



Asian and African Legislation

The economic contribution of Asian and African metals and mining is massive, influencing the billions of animals that live on each continent. Unfortunately, animal welfare legislation in Asian and African nations is mostly non-existent or in the earliest stages of development.

OPPORTUNITIES FOR CHANGE

Top performing mining companies provide leadership and serve as an example for other companies in the industry to excel in the animal welfare space, protecting both animals and human health. Companies can also have a positive impact on animals through engagement with stakeholders beyond the corporations themselves. Stakeholders include government organizations, NGOs, non-profits, legislators, and interest groups. Companies can also collaborate with industry leading metals and mining companies through membership organizations that are dedicated to advancing environmental and animal welfare practices in the industry.

International Council on Mining & Metals (ICMM): Comprised of 26 of the world's leading public companies in the industry, ICMM strives to strengthen global ESG performance through implementation of its 10 ICMM principles and eight position statements.

https://www.icmm.com/

Initiative for Responsible Mining Assurance (IRMA): A group of NGOs determined to "answer to a global demand for more socially and environmentally responsible mining." https://responsiblemining.net/

Better Coal: A group of major coal buyers dedicated to ongoing improvement of the sustainability of the coal supply chain by evaluating coal mining companies on their adherence to the "Bettercoal Code." https://bettercoal.org/who-we-are/

Wildlife Conservation Society (WCS): An international NGO that engages with many companies in the industry on initiatives to save wildlife and their habitats from inevitable damage. https://www.wcs.org/

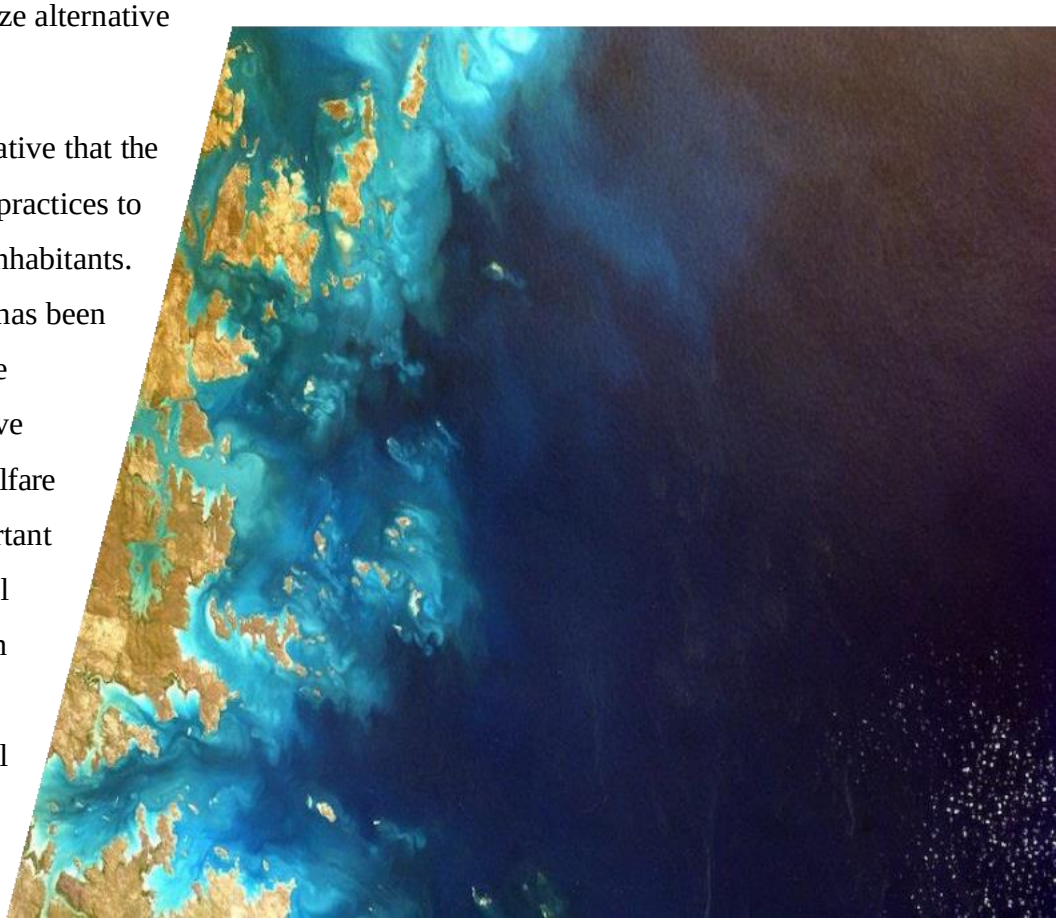
The Alliance for Responsible Mining (ARM): A global expert organization working to improve the artisanal and small-scale mining sectors in Africa, Asia, and Latin America. https://www.responsiblemines.org/en/

CONCLUSION

Ultimately, the metals and mining industry is moving in the right direction to protect the world's rapidly declining biodiversity through the implementation of best practices and serious engagement with concerned stakeholders. Karner Blue Capital (KBC) believes that investors can continue to raise the industry's standards and work to protect the health of our planet through corporate engagement and rigorously researched investments in metals and mining companies that have strong animal welfare, biodiversity, and environmental protection policies and practices. While essential to the global economy, the metals and mining industry is a persistent threat to the environment and wildlife. In the past, the environment has paid the price for all the benefits of the industry, but this no longer must be the case. Since the 1970s, the industry began to change along with the increased awareness of the grave threat that climate change poses to the health of our planet. In recent years, there has also been a drastic increase in public interest for metals and mining companies to integrate biodiversity and animal welfare considerations into their business operations. The industry has established several universal best practices regarding the aforementioned indicators, which are issues

that KBC has identified as having the most direct animal welfare impact. While KBC favors corporate engagement, KBC has decided to exclude from its portfolios those metals and mining companies that extract coal and/or generate revenue from the sale of coal, and we call upon all companies to eliminate their use of coal and invest in modern technologies that utilize alternative fuel sources.

Ultimately, it is imperative that the industry adopt best corporate practices to save our planet and all of its inhabitants. Building on the progress that has been made over the past decade, the industry is heading in a positive direction regarding animal welfare as it answers some very important questions. To what degree will companies reduce their carbon footprint? What percentage of material, waste, and water will be recycled with new technology? How will companies revamp their waste rock management and emergency preparedness protocols? Will hunting and poaching be regulated? Will decommissioned mines be abandoned or regularly monitored and rehabilitated? When will coal be fully eliminated? To what lengths will companies go to protect wildlife habitats? The answers to these questions have the potential to influence the future of the metals and mining industry in ways that will benefit all life on Earth.



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The Center for a Humane Economy is a non-profit 501(c)(3) organization that focuses on influencing the conduct of corporations to forge a humane economic order. The Center encourages corporations to honor their social responsibilities in a culture where consumers, investors, and other key stakeholders abhor cruelty and the degradation of the environment and embrace innovation as a means of eliminating both.

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