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Editorial

Deadly conflicts: Mining, people, and conservation

On the reverberation of the impacts of mining operations on conservation

Although mining has undeniable importance to the Brazilian economy, the environmental degradation it causes can generate profound impacts on ecosystems and landscapes. Contrary to some expectations (or intentional advertising), that they are only related to pitches and their immediate surroundings, mining impacts indeed reach much further (e.g., Fernandes et al., 2014; Ross et al., 2016; Santos and Milanez, 2017). The impacts of mining on ecosystems and conservation are global and of major concern because of their synergy with other drivers of ecosystem changes.

Areas degraded by mining result from a wide range of drivers that, acting alone or in synergy, impact the environment. Perhaps most striking is the removal vegetation cover due to the modification of the soil structure. These processes, in turn, generate a cascade of consequences for fauna, ecosystem functioning, damage response capacity, and the provisioning of ecosystem services (e.g., Cardiff et al., 2012; Durán et al., 2013; Murguía et al., 2016). Areas degraded by mining combine vegetation suppression, habitat fragmentation, compaction of exposed material, low infiltration rates and water storage capacity, groundwater retraction, soil nutrient leaching, disruption of nutrient cycling, erosion, pollution of soil and water resources (with solvents, oils, greases and heavy metals), increased air and water particles, oxygen deficiency in water bodies, light and noise pollution, intentional introduction of non-native species during restoration, landscape alterations, and the destruction of local communities (e.g., Selinus et al., 2013; Murguía et al., 2016; Parise, 2016; Costa-Milanez et al., 2017).

The direct effects of mining on biodiversity and ecosystem services are amplified several times when the effects of research, drilling, urban development and the creation of roads and other logistic infrastructure inherent to operations of mineral extraction are considered. Since accidents do occur, the lack of established mitigation strategies for each type of ecosystem make the impacts even worse. All these types of impacts have resulted in the loss of biodiversity, especially of rare species and those restricted to particular habitat types, population fragmentation, genetic bottlenecks, increased vulnerability to disease, chasing away animal species, among many others (Cardiff et al., 2012; Durán et al., 2013; Murguía et al., 2016). A major concern today is the intentional use of exotic species in the restoration of degraded areas. This practice has resulted in further environmental degradation by facilitating additional invasions, hindering natural regeneration, and negatively impacting hydrological and fire regimes, landscape quality and restoration processes (e.g., Hilario et al., 2011; Fernandes et al., 2016a).

Beyond the pitch and governance

While what occurs within mining pitches themselves is more or less controlled, environmental problems are largely observed beyond them. One major problem is that of barren and tailings, which are mining wastes common to almost all types of mining and generally pose a great risk to the environment and public health when there is no environmentally sound management (e.g., Selinus et al., 2013; Murguía et al., 2016). These materials frequently account for up to 90% of the ore exploited (e.g., 98.7% for copper, 97.9% for niobium, 96.6% for nickel, 98.6% for cobalt and almost 100% for the gold). The generation of this mining waste is generally very high, and thus its destination or reuse is complex and requires great investment and intelligence in its handling. Tailing dams are structures used to dispose of unused material resulting from processes of beneficiation and construction. The quality of these structures needs to be ensured, beginning with site selection and continuing through the management of structures to their closure, following environmental norms, geotechnical and structural parameters, social, and safety and risk factors (see Kalsnes et al., 2017). However, since waste disposal and investment in its improvement do not seem to bring any direct financial return, entrepreneurs often build simpler, less-expensive, and thus less reliable, structures; this has been a principal factor behind the majority of accidents reported in the literature. Bowker and Chambers (2016), concluded that "...*the deviations from best available technology and best applicable practices at the mine level are conscious choices driven by economics and that without a reframing of the professional, regulatory, and legal frameworks for mining these choices will continue to be made even where proven technology and new promising technology are available and better suited to a given mining asset*". Thus, planning is the key to enabling government policies and actions to be implemented in order to improve management systems of not only these structures, but of the entire mining process. However, this control requires strong policies that promote institutional strengthening.

A tragic mining disaster

While this special feature focus on the impacts of mining on the environment, people, conservation, and policy, we argue that

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the case of the rupture of the Fundão dam in the municipality of Mariana (Brazil) figure out as a classical example on how wrong and careless maintenance and management of a huge deposit of toxic sludge lead to environmental and socioeconomic disasters that may reverberate through time (see Fernandes et al., 2016b; Segura et al., 2016). As a result of the magnitude of the social and environmental impacts, the foot-prints are now much clearer and thoroughly evaluated by economists, engineers, geologists, lawyers and environmentalists (e.g., Agurto-Detzel et al., 2016; Espindola et al., 2016; Fernandes et al., 2016b; Fonseca and Ávila Filho, 2017; Marta-Almeida et al., 2016; Miranda and Marques, 2016; Neves et al., 2016; Kalsnes et al., 2017). Although a pact was, somewhat, made to restore the river basin, the foot-prints shall go deeper into the socio-environmental mud generated.

For instance, although ecological restoration of the impacted area is mandatory and was initiated in the region, there are many key aspects of ecological restoration (e.g., functional recovery of the ecosystems, return of biodiversity, ecosystem function and services, etc.) that must be addressed (e.g., Brookes and Shields, 1996; SER, 2004; Kollmann et al., 2016). On the other hand, the practice of spreading a combination of exotic species (Fig. 1) on the mud banks along the remnants of Atlantic Forest and rivers are likely to cause more damage to the moribund Doce river watershed. These species may grow uncontrolled and prevent the proper restoration of the river-bank ecosystem by outcompeting and suffocating native species, perhaps preventing natural succession (D'Antonio and Meyrson, 2002; Fernandes et al., 2015).

Disasters caused by mining occur throughout the world, and most of them have human fingerprints. In this special feature of Perspectives in Ecology and Conservation, we intended to bring forward examples from many areas and of different events where and when mining has impacted society, and recent developments on how to deal with environmental and societal problems in mining regions. Clearly, there are dozens of types of mining industries and their impacts are dependent on a multitude of actors including government policies, resilience of the ecosystem(s) impacted and community-based knowledge and resilience. But to us what is needed most is more science and less flimsy politics on behalf of all involved.

This special feature on mining

Major and global problems related to the mining industry around the world are that of the quality of the environmental impact assessment, society sectors engagement in provoking discussion and presenting solutions, mining industry willingness to adopt more sustainable strategies and standards, governance and sound policies. If not properly built, conducted and evaluated by professionals, the impacts of mining on the environment may be scaled up several times as discussed by Dias et al., 2017. Carmo et al., 2017 specifically address the Fundão dam tragedy by Samarco and points that law relaxation, decrease of resources for regulatory agencies and the absence of effective measures for environmental recovery hampers the mitigation of the impacts. They advocate for urgent reviews on how large-scale extraction of minerals is carried out, increased technical and environmental standards, and monitoring of associated structures in the mining industry. Meira-Neto and Neri, 2017 propose actions to restore the ecosystems of the Doce river basin based on maps of plant taxonomic, functional and phylogenetic diversity as potential providers of ecosystem services. They also propose the constructions of a map of biodiversity potential for ecological restoration and for conservation of ecosystem functions and services to guarantee full ecosystem recovery. Pires et al., 2017 also focus on the Samarco disaster and argue that the impacts caused on the environment could be significantly mitigated if compliance to the new Brazilian Native Vegetation Protection Law is ensured. They argue that the percentage of forest kept in areas of permanent preservation drives the overall resilience and resistance of the entire Doce river basin by using water quality as a proxy for watershed resilience and resistance, and ultimately to improve local adaptation and sustainable development.

The mining industry is dispersed in the planet, is diverse in policies, minerals exploited and technologies employed. Hence, while there are many general conducts there are also many specificities to be observed. Pena et al. (2017) model the impacts mining might has on endemic and endangered birds and amphibians in one of the most diverse mountain regions of the world, the Espinhaço mountains. They focus on the direct and indirect effects of mining on the potential geographic range of 32 anuran and 8 bird species endemic to the eastern Brazil mountaintops and show that the potential distribution of the anuran and bird species is affected directly or indirectly by mining. They discuss the aspects related to the loss of potential habitat for these species, and call for management strategies to avert the ongoing wave of mining impacts. Rocha-Nicoleite et al., 2017 focus on the abandoned degraded areas of coal mines in the Brazilian state of Santa Catarina. Authors propose that development of specific restoration actions and measures to achieve effective restoration of coal degraded land, and reinforce the need of long-term monitoring, control of invasive grasses, and society participation for the success of restoration. Pena et al. (2017-b) presented an interesting experience in a participatory review of a city master plan where the academic participation revealed to be of great importance. A deeper participation of the academia may ensure an equitable

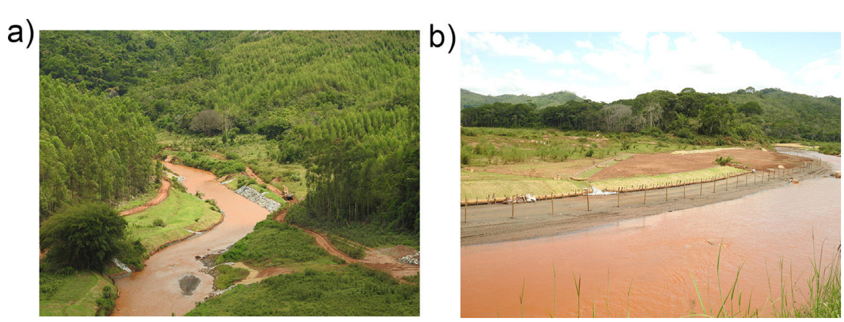

Fig. 1. (A) Under increasing pressure of habitat fragmentation, suppression, and exotic tree plantations, the moribund Atlantic forest of the Doce watershed has now to cope with a dead river and threats imposed by biological invasions caused by intentional use of exotic species in restoration of the biodiversity hotspot. (B) Attempt to seal-off the potentially toxic material with a combination of exotic species along the river channel.

balance of interests between the mining sector and society, and aid in the pursuit of quality of life improvement and natural resources preservation.

Mining also impact people and their values. MacInnes et al., 2017 address the devastating consequences of mining might have on indigenous people. Focus is given on the mining responsibility to respect indigenous peoples' right to decide about the extractive industry projects in their territories. They highlight the emergence of initiatives that have obliged the mining industry to recognize indigenous peoples' right to give or withhold their consent to operations that may affect their customary lands. In their own words, "...it distils good practice on indigenous consultation and the principle of native title from evolving national and international law...." Their article concludes that the mining industry must recognize and protect indigenous' peoples' rights as a preeminent principle of responsible mining good practices. Lewis and Lewis, 2017 address a case in the Australian continent where the indigenous people complex cultural, economic and social systems reported by myths and songlines was shattered by the British invasion and settlement. In the remote Western Australia Pilbara region on the Dampier Archipelago (Burrup Península) this violation has been perpetuated through the destructive practices of mining. This area hosts one of the world's most extensive and significant indigenous Paleolithic art galleries which conflicts with the world's most extensive and richest iron ore deposits, as well as a vast array of other minerals and fuels. The paper examines the conflict, complex politics of conservation to protect the heritage of the area from further destruction. Caldeira et al., 2017 bring a case of native Amazonian population that collect leaves of the plant genus *Pilocarpus* (jaborandi) to synthesize pilocarpine, an imidazole alkaloid largely employed in glaucoma and xerostomia treatments. Intensive extractivism and deforestation over recent decades have led to substantial declines in yields, plant populations and genetic diversity. Conservation programs and sustainable management involving the local communities and mining companies represent an important step in the conservation of *Pilocarpus* and its ecosystem services.

This special feature will not solve the problem of mining impact on ecosystems and people, and the novel ecosystems being created by the people involved in post-disasters, but it does serve to bring new scientific and political facts about mining operations around the world into light. Scientists have been mostly absent from such problems for too long. We have reached a point where to save and preserve life we have to abandon our labs and comfort zones to express sound scientifically-based opinions on the lives of people and environment.

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