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BIODIVERSITY
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CAN WE MINE WITHOUT HARMING NATURE?

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AGE: 11

LIOR
AGE: 11

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AGE: 12

Have you heard about the environmental impacts of mining? Mining involves obtaining minerals needed for the products we use daily. To reach these minerals, forests are logged, and excavators dig large holes. In this article, we will explain how the mining industry in the Amazon basin can compensate for its impacts and help restore ecosystems and biodiversity in nearby areas. This nature-helping strategy is called the impact mitigation hierarchy. To compensate for places destroyed by mining, much larger areas should be protected and restored by planting trees and allowing nature to grow back. We found that a mining company in the eastern Amazon, Brazil, generated habitats for plants and animals outside the mining area. By doing so, the company compensated for the environmental impacts caused by their mining activities. Keep reading to learn more about how impacts can be compensated for, to produce products we need without harming nature too much!

BALANCING NATURE AND HUMAN ACTIVITIES

BIODIVERSITY

The variety of all living things—like animals, plants, fungi, and microbes—that live in ecosystems and help keep nature balanced, healthy, and full of life.

ECOSYSTEM SERVICES

The benefits nature gives us, such as clean air and water, food, medicine, and even fun places to explore—all thanks to healthy ecosystems working well.

Earth is facing some pretty big challenges. The ways we use land, the traffic we create, and the industries we run are causing serious problems for our planet and all its living things [1]. One of these challenges is related to **biodiversity**. Biodiversity is the variety of life on Earth—different genes, species, ecosystems, and how they all interact. Biodiversity is important because it provides food, energy, medicines, and materials and helps control the climate, purify water, and keep natural cycles in check. These incredible things that nature provides us with are called **ecosystem services**.

However, the ways humans are messing with nature can harm many plants and animals and put the ecosystem services we depend on—like clean air and water—at risk. To keep our planet healthy, we need to take quick action. We must find a way to carry out our activities, such as business and industry, without harming nature further [2]. Sometimes, we really *need* resources—like minerals—to make the devices and products we use every day. If we cannot recycle those materials from other sources, we might have to mine them. When that happens, we should do something good for nature in another place to make up for it. This kind of balance helps reduce or fix the damage we cause, so we can still enjoy the benefits of modern life.

Four simple rules can help us take care of nature while still building and producing the things we need (Figure 1) [3]:

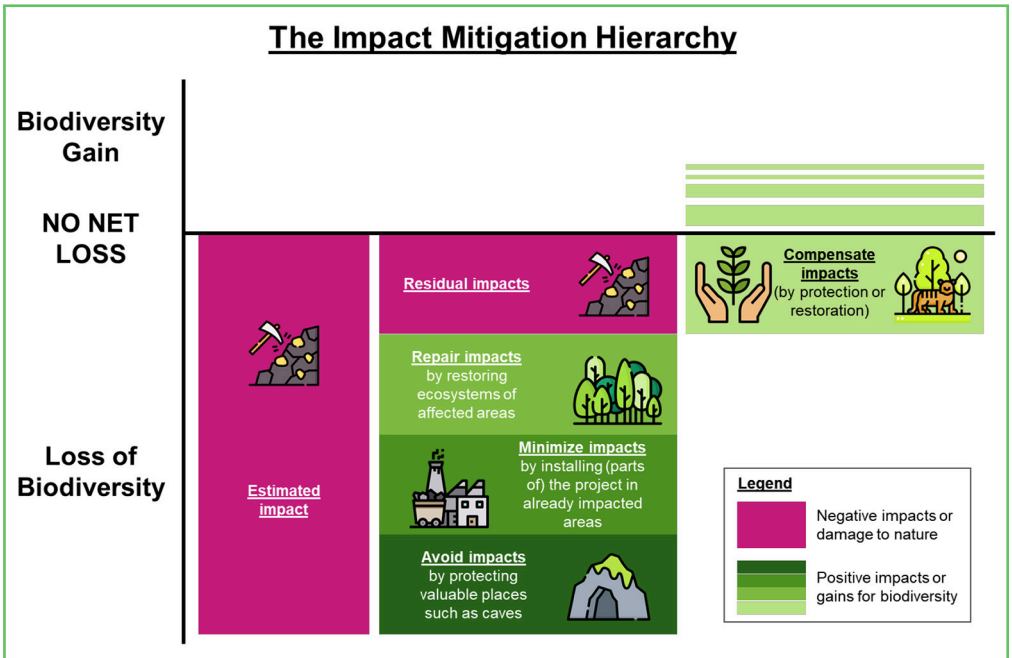

Figure 1

The impact mitigation hierarchy shows how we protect nature while doing things like mining. After estimating the overall impact, we first *avoid* harming special places with unique animals and plants, then *minimize* damage by harming nature as little as possible, and *repair* what we can. For damage we cannot avoid, minimize, or repair, we *compensate* damage by doing something good for nature somewhere else. If we compensate more than we impact, we can actually boost biodiversity and ecosystem services! (Icons from Flaticon.com).

- Avoid: when planning a road or a mine, for example, we may detect some super-special places with unique plants and animals.

We should not destroy such places—instead, we should search for alternatives.

- Minimize: we should do our best to have the smallest possible impact on nature when we build things. For example, if we need to build a road, we can also build tunnels or bridges that allow animals to cross safely without being hurt by cars.
- Repair: some of our activities, like mining, harm nature for only a short time. If we cut down trees to obtain minerals from the ground, we should help nature grow back when we are done. This means planting trees, bringing back plants and animals, and making the land healthy again. Such **restoration** is a way of giving nature a helping hand to heal. Forest restoration leads to the formation of **secondary forests**, which grow back after deforestation.
- Compensate: there are some impacts we just cannot avoid, minimize, or repair. Those are called **residual impacts**. To make up for the residual impacts of our activities, we should do something good for nature somewhere nearby.

Together, these four rules are called the **impact mitigation hierarchy** [3]. This hierarchy acts as a guide to help us balance improving our lives with keeping our planet healthy.

RESTORATION

Helping damaged land recover and return to a healthy, natural state where plants and animals can live and thrive again.

SECONDARY FORESTS

Younger forests that grow naturally after the original trees are cut down or damaged. They are still developing and changing.

RESIDUAL IMPACT

The damage to nature that remains even after we try to avoid, reduce, or fix the harm caused by activities like building roads or mining.

IMPACT MITIGATION HIERARCHY

A step-by-step way to reduce harm to nature: first avoid damage, then reduce it, fix what we can, and finally make up for what's left.

WHAT DOES THIS LOOK LIKE IN REAL LIFE?

To test this concept, let us look at a large iron mining project occurring in the Amazon rainforest in Brazil, which is called the S11D Elizier Batista iron mining complex. Iron mining in this region is especially important, as it helps create new jobs and brings in money through taxes. We wanted to see if the mine managers followed the impact mitigation hierarchy to ensure that they were not hurting nature too much.

To *avoid impacts*, the mine maintains a safe space around areas that are highly important for rare and endangered species, such as caves, lakes, and wetlands. To *minimize losses*, ore processing is set up in places that are already being used for farming. Although this requires a 9 km-long conveyor belt to move the ore from the mine to the processing plant, this minimizes impacts because fewer trees and natural areas need to be cut down! To *repair* damage, after mining is finished the company plans to restore the land by planting trees in the affected area. Finally, the company is also making efforts to *compensate* for the damage it is causing. Although mine pits are restored after exploitation, there are still some residual impacts that cannot be repaired, even with careful planning. So, mining companies are involved in large forest restoration projects, planting millions of native trees near mines trying to restore the area's original biodiversity [4].

Sounds pretty awesome, right? However, we wondered whether these factors were enough to make up for all the impacts on biodiversity caused by the S11D mining project. To answer this question, we developed a method to measure the impacts on biodiversity.

THE BIODIVERSITY VALUE

Typically, a landscape is composed of several habitat types, such as forests, meadows, fields, rivers, or lakes. Some places have many special plants and animals, while others have fewer. How can we measure how important each habitat is for nature? One approach is to check how many species the habitats contain [5], but this does not consider that habitats with many rare species, or those that are more difficult to restore, should receive higher scores than others.

BIODIVERSITY VALUE

The importance of nature's variety—for our health, survival, culture, and future—including rare species, wild places, and the jobs ecosystems do for us.

OLD-GROWTH FORESTS

Untouched forests with large ancient trees, many plants and animals, and a balanced, natural environment.

This is why we created a measure called the **biodiversity value**. It works in two steps. First, we ask how important the habitat is. We check if it is natural, if it has rare species, and how long it takes to recover (Figure 2). VIP areas such as **old-growth forests** receive more points because they are rarer, more natural, or need more time to recover than other places, such as pastures or mine lands. Second, we ask about the actual conditions of the habitat, or how healthy it is. We look for species, ecosystem services, and healthy soil. We found that a secondary forest, for example, has ~70% of the biodiversity, carbon, and soil health of an old-growth forest. Therefore, we say that its condition is 0.7.

We multiply the importance number by the condition number to obtain the biodiversity value. For example, secondary forests are somewhat natural and have some rare species but not as many as old forests (seven out of 12 possible points, Figure 2). Since they recover faster and have only about 60% of the species and services of a natural forest, their biodiversity value is ~40%. This means that we need 2.5 times more secondary forest to compensate for the loss of an untouched ecosystem. Mining areas have no biodiversity, so their biodiversity value is 0.

THE BIODIVERSITY BALANCE OF THE S11D MINING COMPLEX

To understand how the S11D iron mining complex affected nature, we investigated how habitats changed during the mining project (Figure 3). We used a tool called MapBiomas, which is like a giant map showing how the surface of Brazil changes from year to year (you can have a look at it here, but the English version is not complete). Specifically, we checked how the habitats changed from the beginning of the planning phase in 2008 until 2021 (the last year with MapBiomas mapping available when we started this project).

Figure 2

We can calculate habitat importance based on three criteria: naturalness, recovery time, and rarity. After each habitat is evaluated, the scores are summed and divided by twelve (the maximal score a habitat can achieve) so that the importance varies between 0 and 1. Secondary forests, for example, are considered near-natural habitats (Score 3), need 3–30 years to recover (Score 1), and may harbor endangered species such as Brazilian Nut and others (Score 3), summing up to an overall score of 7 and an importance value of 0.583.

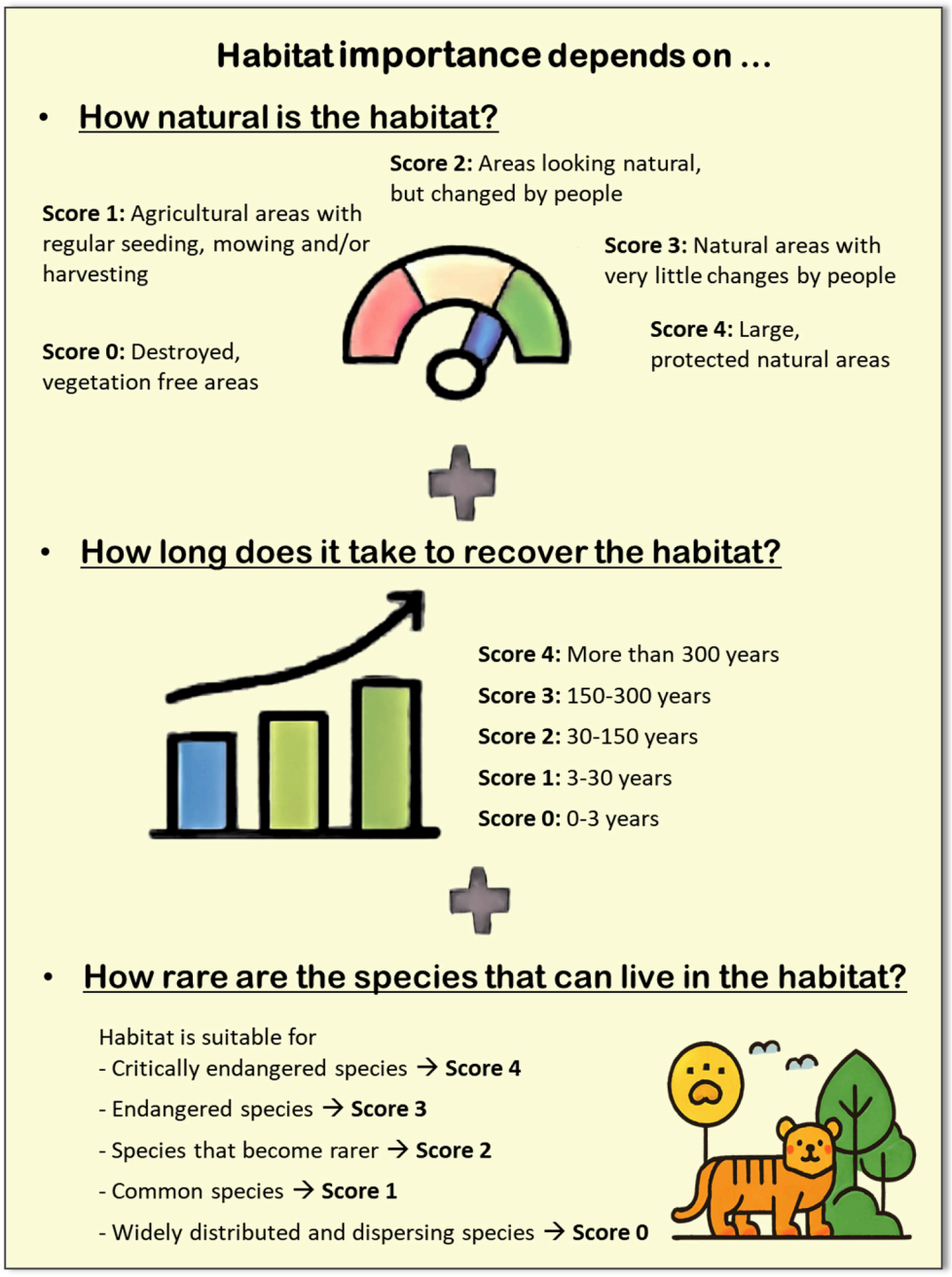

Figure 2

When the S11D Eliezer Batista iron mining complex was built, the company put a giant hole in the ground for mining and a super long conveyor belt to carry the ore to the processing plant, where iron is separated from other valuable substances. To do so, they cut down nearly 1,200 times the area of a soccer field.

However, the processing plant was built on already deforested farmlands to lessen the impact on nature. Additionally, the company did other things to balance their impacts. They bought more farmland than they needed for the processing plant and planted seedlings, so

Figure 3

Ecosystems from the neighborhood of the S11D mine. Species-rich, natural ecosystems such as old-growth forests and cangas (rocky grasslands and shrubs that grow on iron-rich hilltops) have high biodiversity value. Secondary forests are planted to compensate for mining impacts and have lower biodiversity, as they have fewer and smaller trees than old-growth forests do. Pastures used for raising cattle have a low biodiversity value, and mining areas without plants and animals have no biodiversity value.

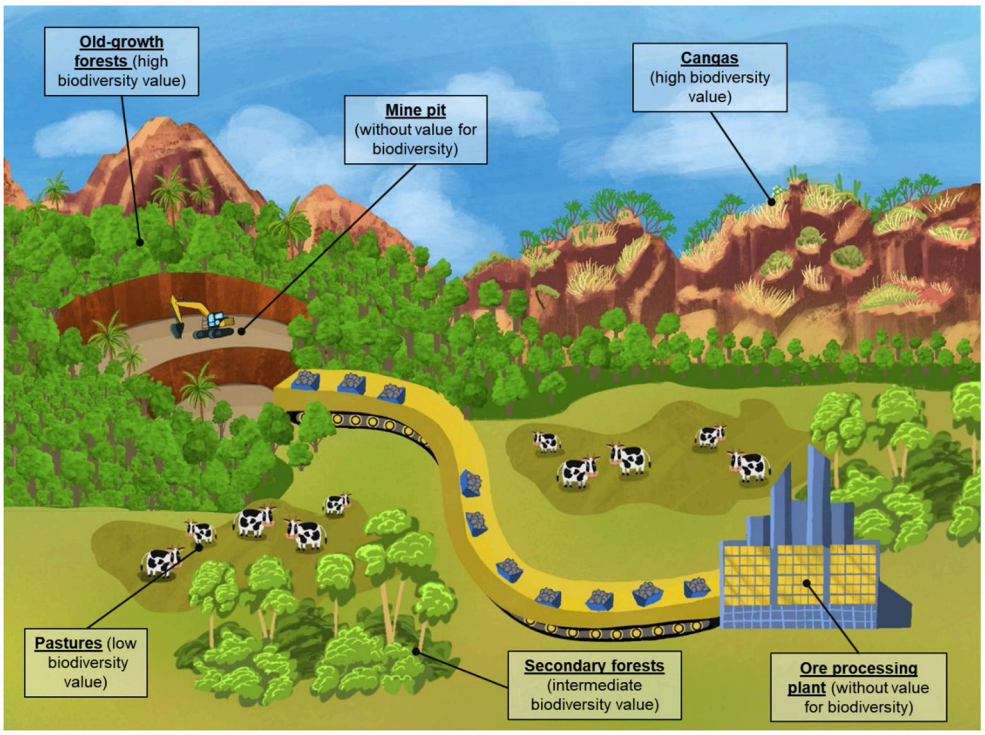

Figure 3

that nature could grow back in an area of 3,400 soccer fields. In these areas, nature was clearly the winner! As the planted area is nearly three times greater than the area of highly valuable natural ecosystems that was impacted (old-growth forests and cangas), the overall biodiversity of the area *increased* during the project! This tells us that mining impacts in tropical landscapes can be mitigated!

Although we expect further biodiversity gains as secondary forests become older and when mine pits are restored after extraction of all iron, there are some further challenges. Currently, there is no way to restore canga ecosystems. Further plans are needed to protect these ecosystem and their special plants and animals. Importantly, impact on animals was not (yet) examined in this study. While we observed positive changes in plants, a careful examination of animal diversity is necessary to understand the full impact of the mining project. For example, jaguars, the top predators of the region, have already been seen in the area, which is a good sign for wildlife, but we need to look closer to ensure that all the different kinds of animals are preserved in the new areas.

GETTING MINES TO COOPERATE WITH NATURE

We discovered that using the impact mitigation hierarchy compensates for the impact of mining on nature, although we still need to know

more about the return of animals to secondary forests. By using the mitigation hierarchy some impacts are avoided, others are minimized or repaired, and residual impacts are compensated, in our study area by planting trees in areas that are nearly three times larger than the mine itself. Our results therefore show that a responsible mining industry can combine economic development and nature conservation. Although secondary forests can make up for mining impacts, they have lower biodiversity values than the original ecosystems. Therefore, we should reduce opening new mines and a simple way to do this is to recycle things we already use, like soda cans, old electronics, and even cars. Recycling helps us avoid extracting more resources from the Earth, thereby protecting the environment we all cherish and rely on.

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ORIGINAL SOURCE ARTICLE

Gastauer, M., Pinheiro, T., Caldeira, C. F., Ramos, S. J., Coelho, R. R., Fonseca, D. S., et al. 2024. Large-scale forest restoration generates comprehensive biodiversity gains in an Amazonian mining site. *J. Clean. Prod*. 443:140959. doi: 10.1016/j.jclepro.2024.140959

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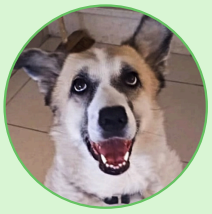
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

DANIEL, AGE: 11
I am into the horror game Five Nights At Freddy's (FNAF). I like dogs and would like to visit places such as Paris, Rome, Amsterdam, Venice, and Manchester. I enjoy playing Minecraft and love eating Italian food.



LIOR, AGE: 11
I like Harry Potter, and I finished the series multiple times.

RICCARDO, AGE: 12
My name is Riccardo. I like art, nature, and animals. I am a lively person, who loves playing outdoor with friends. I play volleyball, go canoeing and like playing football with my friends.

AUTHORS

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Priscila Sanjuan is a biologist. For almost 20 years, she has had fun studying the Brazilian Amazon rainforest. In her work, she investigates how nature recovers after damage caused by humans. Her work sought to develop strategies to assist nature in this recovery process.

TAISE RABELO
Taise Rabelo is a biologist who has been using a special pair of glasses to track forest loss in the Brazil Biomes. She is very proud to have helped protect nature for the last 20 years.

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Silvio Ramos is an agronomist who loves to study soil attributes, especially around mining areas. Environmental rehabilitation is a challenge, but at the same time, revealing the return of soil quality, as well as the increase in the diversity of plants and animals is important.

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Cecílio Frois Caldeira, an agronomist, specializes in studying plant growth and adaptation to various environmental conditions, particularly those threatened by environmental changes. He takes pride in his work with plants facing unique challenges and aims to contribute to their conservation and sustainable management.

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