Vale & Nature 2024

Photograph: Ricardo Teles

Photograph: Emiliano Capozoli

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Introduction

Vale understands that mining activities are indispensable to society and recognizes its responsibility in the search for practices that both minimize the negative impacts they have on the environment and generate positive results for nature and the community. In pursuit of this, the company always uses the best market methods, advanced technologies and responsible actions that allow for as little interference in natural resources as possible. The company aims to establish itself as a global benchmark in sustainable practices in the mining sector, focusing on operations that are increasingly more aligned with the international conservation agendas and targets.

Nature provides and maintains ecosystemic services that are important to the continuity of our operations, including the provision of water and regulation of the climate. And our operations have an impact on these services, beginning with the alteration of soil use and the composition of vegetation, as well as interference in natural watercourses, amongst others. As such, recognizing our business as being a part of nature, and integrating our actions into the different components of nature (biodiversity, water, climate and communities) is essential for the long-term continuity of our business. With the intention of avoiding and managing our impacts, we invest in research and the generation of knowledge that form the basis for measures aimed at prevention, control and mitigation, recovery, restoration and offsetting. These measures are not restricted solely to our legal obligations, since they also seek to implement additional actions focused on conservation. We have adopted the approach of an impact mitigation hierarchy as we strive for 'No Net Loss', focusing on minimizing and neutralizing impacts in areas that are highly valuable in terms of biodiversity.

We wish to implement practices that are both strong and well-suited to the management of our impacts, generating knowledge and results that can be a benchmark for the entire mining sector as well as other businesses. We hope that the results of our actions will address not only the effective management of our negative impacts, but also generate positive results for nature. We recognize the need to analyze and manage the impacts, premises, risks and opportunities involved in our operations and projects, as well as in the links of our value chain, allowing for integration with other thematic components of nature. Strengthening conscientious management and governance, making transparent disclosures and positioning ourselves before the public.

It is essential that our work is not restricted to our actions or regions, rather it is vital that our partnerships and engagement can move these positive results beyond our boundaries. Through restoration and conservation, we aim to strengthen and boost positive results for biodiversity, the climate, water and people, based upon the engagement and strengthening of local communities, and partnerships with academic institutions, organized civil society and different business sectors.

We seek innovation, with a focus on nature-based solutions and the production of scientific knowledge, creating partnerships designed to encourage sharing and exchange both within the company and in society as a whole.

In this report, we share a wide range of practical examples of this approach along with the results of our nature-focused activities in the regions in which we operate.

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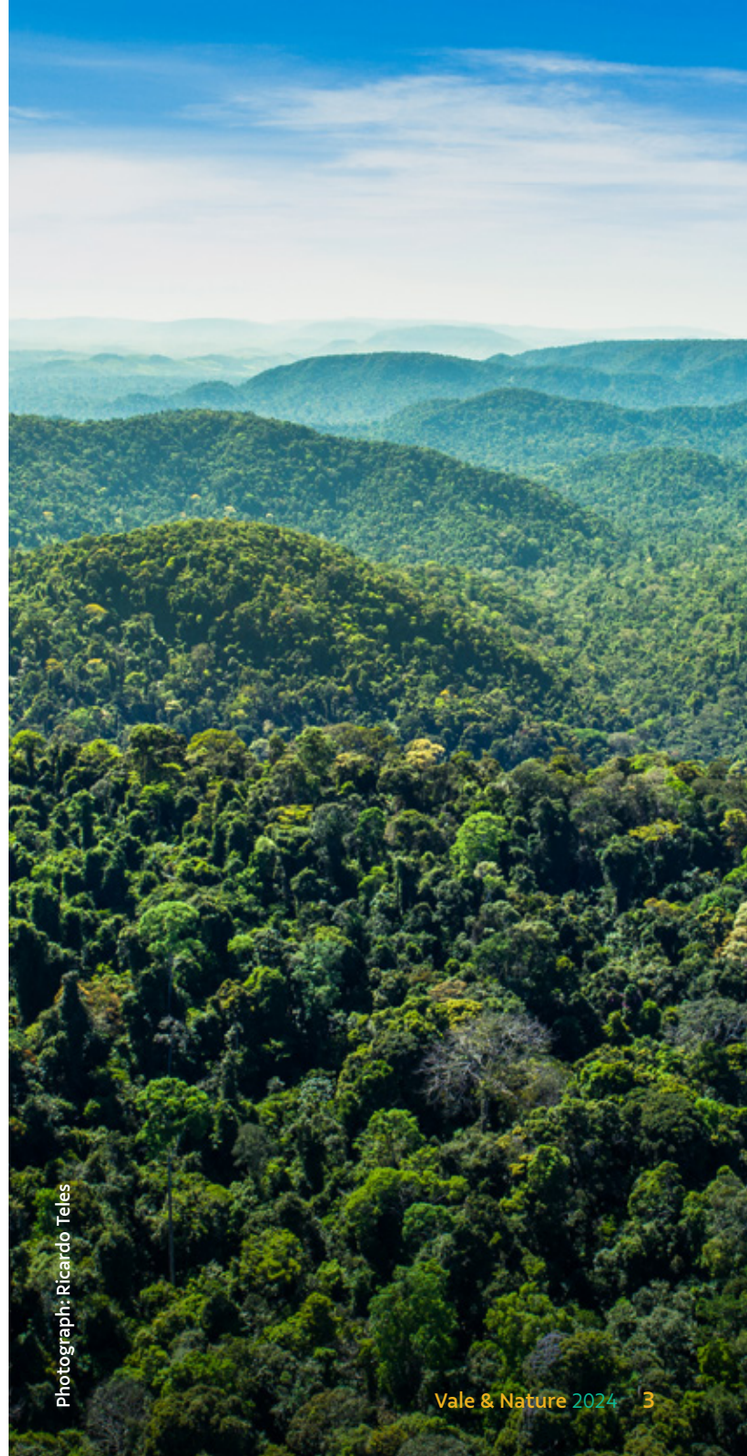

Photograph: Ricardo Teles

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Photograph: Anderson Souza

Ecological corridors in the south of the Carajás National Forest

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Introduction

The Ecological Corridors Program forms part of the Carajás Biodiversity Management Plan and involves the creation of connections between forest fragments that had previously been separated by damaged areas, thereby supporting the formation and consolidation of a forest matrix. Vale has acquired farms neighboring the S11D Complex in Canaã dos Carajás (PA), in order to restore them as part of the environmental offsetting actions. The project, however, goes way beyond compliance with the legal requirements, with the further expansion of the restored area.

Methodology

The actions began in 2016. Traditional restoration techniques were employed, including inducing natural regeneration and planting saplings (Image 1). The work begins with choosing the correct seeds, taking into consideration the regeneration capacity, the declivity of the land and the use of rare species that are of interest to conservation, such as the Brazil nut (*Bertholletia excelsa*) and Panama (*Sterculia apetala*) trees. The program also involves techniques such as the creation of habitats that attract species of fauna which can play an important role in distributing the seeds. This type of intervention plays a part in speeding up the natural succession, allowing the local biodiversity to expand, and encouraging the stability of ecological processes.

The areas are monitored, especially the saplings through until they become adult trees. Furthermore, fauna monitoring actions are developed in order to observe the return of wildlife to the region. As a means of registering the animals, night cameras have been Installed in trees, mostly close to streams and rivers, along paths, or in fruit trees, which increases the chances of recording the wildlife (Images 2 and 3).

Image 1. Traditional restoration techniques – planting of saplings.

Image 2. Monitoring fauna by means of hidden cameras. Recording of a Brazilian tapir (*Tapirus terrestris*).

Image 3. Monitoring fauna by means of hidden cameras. Recording of a puma (*Puma concolor*).

Results

It has been almost seven years since the Program was implemented, and since then, approximately one million saplings of 134 species of flora native to the Amazon biome, including species threatened with extinction and of great importance to conservation, have been planted across an area covering five thousand hectares. The monitoring has highlighted the fact that the forest covering 70% of this area is already in an advanced state of regeneration, with species already producing seeds and contributing to the process of natural regeneration.

The reestablishment of the forest in these areas has contributed to the increased permeability of the landscape, to the connection between different fragments and the Carajás National Forest, as well as to the restoration of important ecosystemic services, such as the control of erosion and regulation of the climate, based upon carbon sequestration, and to the maintenance of the populations of pollinating species.

We have been monitoring the fauna for around two years, with 60 photographic records being made of a variety of species, including big cats from the top of the food chain, such as pumas (*Panthera onca*) and ocelots (*Leopardus pardalis*), demonstrating that fauna has returned and has regularly been using the restored regions.

Strategic Alignments

This Program demonstrates compliance with SDG 13 (Action to combat climate change) and SDG 15 (Life on land). It also supports Target 2, related to restoration, of the Global Biodiversity Framework, established by the CDB.

The reestablishment of the forest in these areas has contributed to the increased permeability of the landscape, to the connection between different fragments and the Carajás National Forest, as well as to the restoration of important ecosystemic services, such as the control of erosion and regulation of the climate.

Photograph: Ricardo Teles

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Management of Vale Indonesia Biodiversity

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Introduction

The commitment made by Vale Indonesia to protecting and preserving biodiversity takes shape through the application of *ex situ* and *in situ* conservation methods. In July 2019, the Himalayan Arboretum (31.08 hectares) and the Arboretum Nursery (10.16 hectares) were designated as biodiversity conservation areas. The Arboretum's nursery was built on the same grounds as the PTVI nursery. This nursery produces 700,000 seeds every year, using generative and vegetative methods of propagation, whilst also propagating plants using vegetative methods involving saplings.

In addition to the biodiversity park, the PT Vale Indonesia also has installations for the captivity facilities of Javan rusa or Sunda sambar (Rusa timorensis), one of the animals that is most protected by the Environment and Forests Ministry's Regulation 106, dated 2018, having been awarded the status of threatened with extinction by the IUCN.

Methodology

Efforts to protect and conserve the biodiversity, using the *ex situ* flora and fauna conservation method for endemic and protected species, are undertaken to preserve the rich variety of natural biological resources.

PT Vale Indonesia supports the global target of "halting and reversing land biodiversity loss", by collecting seeds in suppressed areas before mining activities begin. Following this, the plants are propagated using generative and vegetative methods, with the seeds being used in programs designed to recover the damaged areas.

The *ex situ* Javan rusa conservation program, implemented at the Sawerigading Wallacea Conservation Park, covers an area of five hectares, including the nursery and the arboretum. The aim of the conservation effort is to preserve and protect, as well as serve as a means of environmental education for the community in relation to the biodiversity of endemic and protected species in the area covered by the operations of PT Vale Indonesia.

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Image 1.
Himalayan Arboretum

Image 2.
Arboretum Nursery

Results

The PT Vale Indonesia Arboretum (Nursery and Himalaya) preserves more than 74 native species of flora. This collection of plants operates as a source for seeds, along both generational and vegetative lines. The total conserved area covers 75 hectares and includes an arboretum, a nursery, captive Javan rusa installations, a butterfly house and natural forests.

Efforts are made to conserve the rich variety of plant species, especially those that are endemic and protected. The saplings that are cultivated at the nursery are later replanted in previously mined areas in order to allow the endemic and protected native species to return and grow, forming forest populations close to the conditions that had existed prior to the forest suppression and the mining activities. In the long-term, it is expected that the natural forest succession will form an ecosystem that supports the survival of the fauna.

As well as meeting the recovery needs of the damaged areas, the PTVI nursery also regularly distributes saplings amongst the community and government programs. The nursery has already cultivated more than 60 types of seeds. The nursery has the capacity to produce up to three cycles of fast-growing saplings over the course of a year, and two cycles of slow-growing saplings.

The PTVI began the Javan rusa reproduction program in 2008, with a total of six animals – two males and four females. Between 2008 and 2024, 47 animals were bred in captivity, 18 of which died. So far, 13 deer bred by the PTVI have been handed over to the government to be returned to nature or sent to other conservation institutions. Currently, in September 2024, there are 21 deer at the PTVI, 14 of which are male and seven female.

The founding of the Sawerigading Wallacea Biodiversity Park supports Vale's commitment to 'No Net Loss' and to global targets such as the SDG 15.

Image 3.
Javan rusa (*Rusa timorensis*).

So far, 13 deer bred by the PTVI have been handed over to the government to be returned to nature.

3

Partnerships for education on behalf of nature

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Introduction

Educational activities and collaborative actions are important tools in raising awareness and developing actions in support of nature. Working with these tools in partnership with the communities was the main aim of this project, which makes use of special environmental commemorative dates as the focus of the awareness-raising and actions. The activities take place in regions where traditional fishing or quilombola communities exist, in the municipality of Mangaratiba (RJ), where Vale operates the Ilha Guaíba Terminal (TIG). Vale has a relationship plan, which includes the provision of specific and immediate support and voluntary actions, and always involves actively listening to the community's needs. As well as working with education in support of conservation, providing people with active roles and ensuring they are part of nature, the initiatives also allow the company to get closer to its neighboring communities and people.

Methodology

In 2022, an activity was hosted on International Day for the Conservation of the Mangrove Ecosystem, called '***Limpa Manguezal***' ('Clean Mangrove Swamps'). The action took place on the Ilha de Itacuruçá, where the Paulo Scofano School is located, as well as the Gamboa Mariculture Association of Crab Collectors and Fishermen (Assomar). In 2023, in commemoration of World Water Day, an action took place on Ilha de Jaguanum and at the Santa Justina/Santa Izabel Quilombo. Environmental education actions were planned in partnership with and for the Fazenda Santa Justina quilombola community, being coordinated together with the Santa Justina Farm Residents' Friendly Association. Also in 2023, as another means of commemorating International Day for the Conservation of the Mangrove Ecosystem, the '***Limpa Manguezal***' was staged in Sahy, in partnership with the Sahy Association of Fishermen, Shellfish Farmers and Leisure (Assopesca), and at the Santa Justina/Santa Izabel Quilombo. Environmental education actions were planned at the school and a collective clean-up of the mangrove swamps took place at two different locations in Marangatiba: at the Santa Justina/Santa Izabel quilombola and in Sahy, with support from the local leaders and participation of the residents, traditional fishermen and quilombolas. The decision to organize the clean-up arose from a request made by a local resident, who at the time was a member of the association, for the younger members of the community to start taking greater care of the mangueira ecosystem. The actions were planned in partnership with the community and the director and chairperson of the shellfish collectors association, and with support from teams of Vale employees who provided safe conditions for the activity.

Image 1.
The collective clean-up that took place on International Day for the Conservation of the Mangrove Ecosystem.

Results

The mangrove ecosystems are unique and extremely rich in biodiversity, and, when managed sustainably, can play an important role in the mitigation of climate change and protection of coastal regions, whilst providing millions of people with a means of supporting themselves and their families. The environmental education action conducted in 2022, on International Day for the Conservation of the Mangrove Ecosystem, at the Paolo Scofano Municipal School, involved the participation of 60 pupils studying in Secondary Education levels I and II. Members of the community were invited to share their experiences as part of other actions held in the mangrove swamps: fishermen who have worked collecting solid waste in the mangrove swamps in the Itaguaí region spoke about the work they have performed. These talks, based upon the individuals' local and real experiences, led to discussions and work on the theme of garbage recycling. The mangrove swamp collective clean-up conducted in Mangaratiba involved the participation of pupils in their final school year and around 20 volunteers from Vale, who together collected roughly 80 kg of solid waste from the mangrove swamps (Images 1 and 2). An ecological walk was arranged to better understand the water sources that are important to the community and the municipality as a whole, aiming to raise awareness about the importance of conserving these streams. 25 quilombola residents took part in the ecological walk (Image 3).

Strategic Alignments

The initiative is aligned with Sustainable Development Goals 6, 11, 13 and 14, with the aim of consolidating the conservation of the natural heritage, raising awareness, and educating, thus empowering the communities to improve the conservation and management of the waters and reduce pollution

The mangrove swamp collective clean-up conducted in Mangaratiba involved the participation of pupils in their final school year and around 20 volunteers from Vale, who together collected roughly 80 kg of solid waste from the mangrove swamps (Images 1 and 2).

Image 2. Volunteers collecting trash during the collective clean-up that took place on International Day for the Conservation of the Mangrove Ecosystem.

Image 3. An ecological walk to better understand the water sources that are important to the community and the municipality as a whole, thus raising awareness of their importance.

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Photographs: Breno Pompeu & Jeferson Abreu

Perception of nature's contributions to people in rural communities in the Eastern Amazon region

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Introduction

Nature's contributions to people ('People–Nature–Culture' – PNC) are being taken more into account in the decisions of those responsible for making public policies due to the weight they carry for people's wellbeing. Understanding the value of nature through the perception of the communities can help to define priorities and guide the development of public policies in support of environmental conservation. The aim of this study has been to analyze the perception of the importance, benefits and problems involved in PNC amongst the residents of five rural communities and their opinions concerning the protected areas lying within the municipality, considering their socioeconomic characteristics.

Methodology

The method employed involved in–person, semi–structured interviews, based upon questionnaires applied to a sample of 214 homes selected randomly in five rural communities in Parauapebas (Pará, Eastern Amazon region). We used statistical tests applicable to the analysis of data.

Results

The principal results demonstrate that the communities are extremely homogeneous and 52% of the families live on a low income (lower than the basic–wage of US$ 250 per month).

A large portion of those interviewed place a great deal of importance on all the categories of PNC (2/3 of those interviewed placing importance on material issues, 3/4 on non–material issues and 4/5 on regulation of PNC). The most commonly mentioned benefits of the PNCs referred to subsistence, means of living and quality of life (40% of the total citations). The most commonly mentioned problems involved environmental damage (38% of the total). Virtually all of those interviewed confirmed that they had a positive opinion of the municipality's protected areas, despite not making full use of them. This is an important study since it is the first time that the perceptions of the residents of rural communities in the Eastern Amazon region have been studied in relation to PNC, which is an essential aspect in decision–making and the development of public policies.

Strategic Alignments

The initiative is aligned with Vale's poverty targets and with SDG 11.

The most commonly mentioned benefits of the PNCs referred to subsistence, means of living and quality of life (40% of the total citations). The most commonly mentioned problems involved environmental damage (38% of the total).

Photograph: Salviano Machado

5

Northern Corridor and Base Metals Environmental Control Centers: innovation and technology providing support for environmental management

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Institutions Involved:

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Introduction

The Northern Corridor and Base Metals Environmental Control Centers (CCAs) are voluntary initiatives, recommended in the Ferrous Metals Environmental Master Plan (PDAF) and in the environmental planning of Base Metals, which aim to establish the monitoring of environmental guidelines for the operational processes involved in the mining, processing, transportation and shipping of iron ore. The centers use online instruments and remote communication equipment/sensors, establish warning limits, and implement the flow of information to the operational areas, allowing the condition (normal or abnormal) of the environmental conditions to be identified, based upon the Vale management model (VPS). They use science and data engineering in the construction of predictive models, based upon data storage (guidelines/variables), with the aim of improving the management of the Business' Socio-environmental Risks (GRN) and the consequent compliance with legal requirements, regulatory issues and adherence to ESG.

Methodology

The CCAs monitor the environment and weather using automatic stations, cameras, radars and other devices that can assist in the monitoring of environmental aspects in real time (Image 1).

The environmental monitoring is divided into four sections: water resources; air quality, forest and industrial fires; and noise and vibrations. All the equipment contains online communication facilities, with a control booth and monitoring 24-hours per day, seven days per week. The field equipment involves a sampling grid that covers the entire operational area and surrounding regions, also involving areas of the community. The control center receives the information and, in the event there is any sort of abnormality, the communication flow with the operational areas is activated, advising them to swiftly implement the due mitigation procedures.

The main tool used by the meteorological booth is the Vale weather radar installed at the Carajás Urban Center, this being designed to monitor the weather conditions in the region and perform what is called 'nowcasting' (extremely short-term weather forecasting). It is also supported by satellite images, weather stations and cameras that have been installed in the operational areas and which issue alerts on rainfall, atmospheric discharges and/or wind. During the dry season (summer in the Amazon region) the booth assists with the monitoring of warnings, especially those regarding wildfires. Numerical models and the knowledge of meteorologists are used to put together the daily weather bulletins (operational and town-specific).

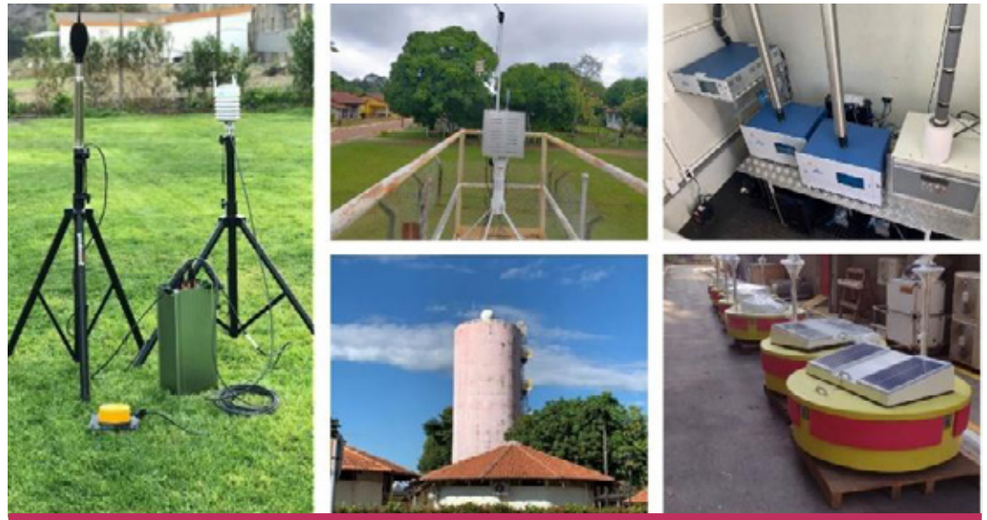

Image 1.
Environmental and weather monitoring by means of automatic stations, cameras, radars and other devices.

The CCAs monitor the environment and meteorological variations using automatic stations, cameras, radars and other devices that can assist in the monitoring of environmental aspects in real time

Results

As a result of the implementation of the centers, the environmental management of our units has been greatly improved. Advanced technologies have been introduced which mean that the trends and alerts concerning environmental indicators can be monitored in real time during the activities, allowing for a swifter response in terms of taking preventive and corrective measures, thereby minimizing or entirely avoiding negative impacts on the environment. The results of the actions of the CCAs can be monitored by means of their management panels, which display all the actions taken and the handling of the operations, as well as any pending issues. The principal results were: Optimization of the time taken to respond to environmental irregularities and the total warning time; mitigation of environmental risks; collection of data for the creation of forecasts; improvement of environmental controls; increased precision in the weather alerts; improvements to the existing weather reports and creation of daily reports for the operational areas; and a strengthening of Vale's socio-environmental commitment.

Strategic Alignments

The initiative has contributed to the following Sustainable Development Goals: SDG 6 – Clean water and sanitation; SDG 9 – Industry, innovation and infrastructure; SDG 12 – Responsible consumption and production; SDG 13 – Action against global climate change; SDG 14 – Life below water; SDG 15 – Life on land; and SDG 17 – Partnerships and means of implementation.

Image 2.
Monitoring of environmental aspects in real time.

Image 3.
Information control center.

The principal results were: Optimization of the time taken to respond to environmental irregularities and the total warning time; mitigation of environmental risks; collection of data for the creation of forecasts; improvement of environmental controls; increased precision in the weather alerts; improvements to the existing weather reports and creation of daily reports for the operational areas; and a strengthening of Vale's socio-environmental commitment.

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A sustainable system for forest management

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Introduction

The forest performs an essential role in the supply of water, providing a means of subsistence for the public and mitigating the effects of climate change. The sustainable forest management performed in mining areas represents a good option for the conservation of the forests, since it increases the number of habitats contained within the regions, as well as the biodiversity and variety of different species. The sustainable management using this scientific approach is performed by PT Sumbawa Timur Mining (STM).

The approach and methodologies applied by STM during the prospecting and viability study stages establish a solid base and a strategy for minimizing the impacts on the forest areas during the development of a mining operation.

STM's principal operating licenses are applicable to regions located in protected forest areas in Dompu Regency, West Nusa Tenggara. The implementation of a sustainable forest management system involves a systematic and integrated approach that includes ecological, economic and social aspects. The sustainable forest management is implemented by means of systematic activities that begin with stages of forest suppression in the areas that are to be mined, running through until the period following the termination of the mining activities, and taking the form of recovery and rehabilitation within the protected forest area managed by STM.

Methodology

STM, together with third parties, has performed field studies to collect data on the fauna, environment and vegetation, in line with Regulation nº P.1/PKTL/IPSDH/PLA.1/1/2017 published by the General Board of Forestry and Environmental Planning (Perdirjen PKTL), under the Technical Guidelines for Forest Inventories at Protected Management Units (KPHL) and Forest Management Production Units (KPHP), with reference to SNI 7724:2011. In addition to this, as a means of preserving protected forest areas from land-squatting activities, including itinerant farming, illegal timber harvesting and forest fires, the protected efforts are performed by means of a Memorandum of Understanding (MoU) with the Forest Management Unit (BKPH), a government institution specifically authorized to preserve protected forest regions. These programs were conducted over the course of a little more than a year, from September 2022 to December 2023. The results of the MoU were therefore assessed by the intensity of the occurrence of violations in the forest region during the 14 months the MoU was in place.

Image 1.
Fighting forest wildfires performed by means of an MoU (Memorandum of Understanding) together with the Forest Management Unit

Image 2.
Sustainable forest management activities

Results

Forest protection program:

The company has implemented a forest management program in collaboration with the Forest Management Unit (BKPH) and a number of related agencies. In 2022, STM signed a memorandum of understanding regarding support for the protection of STM's PPKH forest regions with BKPH Topaso. This agreement is related to the means of protection and security of forest areas included in the scope of the work, specifically:

1. Support for the Forest Entrance patrol and guard for the STM Forest Region Permission for Use (PPKH);
2. Support for the publication of forest regulations;
3. Support for the prevention of forest wildfires;
4. Support for the Green West Nusa Tenggara;
5. Support for the development of beekeeping in the forest;
6. Support for the Pajo Resort Base Camp guard;
7. Support for the installation of forest information panels; and
8. Support for a permanent nursery.

Based upon the results of the monitoring of the BKPH Topaso, in August 2023 a forest fire was swiftly brought under control by the Emergency Response Team (ERT) and the BKPH team. The illegal farming of timber and the occupation of the forest areas has been reduced in the last eight months. Between May and October 2023 there were no break-ins to the forest area. However, STM still faces significant challenges in maintaining the community's full understanding. This led the environmental education activities within the community to improve its understanding of the importance of forest protection.

Evaluation of fauna and flora

STM has performed scientific studies and formed a partnership with PT Gaia Eko Daya Buana for the implementation of the evaluation report on the flora and fauna in the STM forest region. Between 2017 and 2022, there were a registered total of 150 species and 67 families of species of fauna registered in the STM area, with these being divided into four categories. The category of birds contained the highest number of species, with 103 species and 43 families, followed by that of reptiles, with 23 species and ten families. The categories of amphibians and mammals contained 12 species each, but with different numbers of families – five and nine respectively. The species of fauna classified as insectivores are the most abundant in the PT STM region, with a total of 64 species. The STM region is predominantly inhabited by species of fauna that are unprotected according to Regulation P.106, dated 2018, with a total of 123 species. However, there are 27 species classified as protected.

The primary distribution of important habitats can be found in the central region of the area operated by STM, in the form of interconnected corridors, including the regions of Saridi, Mboko Oi Wou and Doro Hu'u. The habitats that are potentially critical for fauna are concentrated in two areas – the north and south. The northern portion is predominantly influenced by land conversion activities, such as community farming, whilst the southern portion is significantly affected by exploration activities. The forest area is dominated by the *Syzygium racemosum* (Bl.) DC, an "average-sized canopy tree" or "undergrowth tree" – *Schoutenia ovata Korth* and *Lagerstroemia speciosa* (L.) Pers.

The *Syzygium racemosum* (Bl.) DC performs an important role in controlling the ecosystem, not only amongst mature trees, but also at all stages of growth. At the sapling, supported and seedling stages, the presence of *Syzygium racemosum* (Bl.) DC contributes significantly to the development of the vegetation. The notable predominance of the *Syzygium racemosum* (Bl.) DC over other species demonstrates that the forest in the region under study is actively maintaining its ecological balance to achieve a stable situation.

Image 3.
A species of bird noted during the fauna evaluations

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Photograph: Eny Miranda / Cia da Foto

Program for Indigenous Permanence and Opportunities at University

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Introduction

An initiative developed by Vale and the Society, Population and Nature Institute (ISPN), 'Pipou' – the Program for Indigenous Permanence and Opportunities at University – has contributed to the continuity of indigenous people in higher education through the provision of financial support and pedagogical monitoring. With the sanctioning of the quotas law in 2012, more indigenous people have been attending universities, but these institutions do not generally promote measures designed to complement the affirmative actions (Santos, 2023; GEMAA, 2022). By working within this shortcoming in society, Pipou is improving the conditions of permanence in education and contributing to increasing the representativeness of indigenous people in society. This is a structuring action in support of the public policy offering access to rights and their defense.

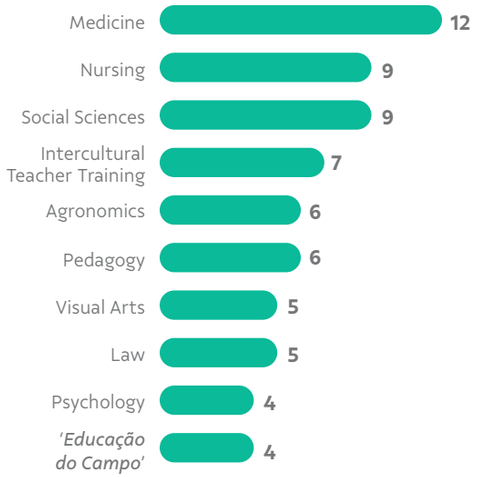
Methodology

In 2021, the first public notice for selection was published, offering 50 places for Indigenous Peoples Related to Vale. The pedagogical monitoring was formalized in 2022, with theme-based workshops and individual and group tutorials being offered. In 2023, with the publication of the second public notice aimed at Brazil as a whole, the number of scholarship students doubled, and, in 2024, following the publication of the third edition of the selection process, there were a total of 140 students involved in the program. Discussion groups, involving specialists and leaders, take place each month with the aim of forming policies on indigenous rights. Specialists (indigenous and non-indigenous) in indigenous higher education participate in the collegiate body to ensure a plurality of decisions within the program. The criteria for entering and remaining in Pipou are duly evaluated by a technical team. Students enrolled in in-person undergraduate courses are entitled to participate. They should all present good academic grades and participate in the educational activities. They receive a monthly scholarship of R$ 1,200.00 and a laptop computer.

In 2023, with the publication of the second public notice aimed at Brazil as a whole, the number of scholarship students doubled and, in 2024, following the publication of the third edition of the selection process, there were a total of 140 students involved in the program.

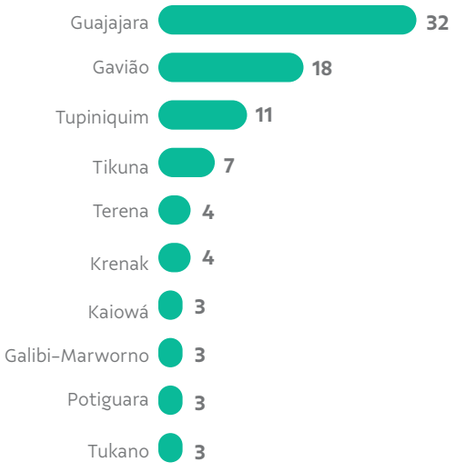
[1] At the time of going to press, the selection process as part of the third public notice was under way. As such, the information covers the consolidated data through to the second public notice, with 100 students.

Ranking of the leading courses



Distribution by peoples

(higher number of participating students)



Results

There are currently 140 scholarship students[1]. A total of 14 students have graduated since 2021. Through until the second public notice, the students came from 32 Indigenous Peoples and 40 Indigenous Lands, with 65.5% being women and 34.5% men. Of this total, 81% are in public institutions and 19% in private institutions. The three universities with the most scholarship students are the University of the State of Maranhão, the Federal University of the South and Southeast of Pará, and the University of Brasília. Up until now, 11 students have graduated. The courses with the most scholarship students are in the areas of Healthcare and Education, whilst most of the students are members of the Guajajara, Gavião and Tupiniquim Peoples.

Strategic Alignments

Through Pipou, Vale has been able to provide formal support for the university intake of indigenous peoples, thereby expanding their diversity and inclusion, and highlighting the plurality of the indigenous peoples and the preservation of the culture. The professional qualification allows the indigenous people to lead the way in finding solutions for their communities and for society as a whole in the search for improved wellbeing. For the United Nations Organization, in the sphere of the Sustainable Development Goals, Pipou contributes to Quality Education, ensuring better conditions for people to access and remain in vocational and higher education.

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Image 1.
UNIFESSPA Collective Healthcare graduate student

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Photograph: Adobe Stock

Projeto Inova UP

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Partners:

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Institutions Involved:

Vale Foundation

Introduction

The Inova UP Program is an initiative developed by the Vale Foundation, designed with the idea of boosting the ecosystem of sustainable entrepreneurship amongst young people in the state of Pará. Under the program, Inova UP has sought mainly to educate and support young entrepreneurs from the state, focusing on addressing local needs and guiding young people towards opening their own companies, whilst monitoring and assisting them in different aspects of their businesses or startups. The aim of the program is to identify people with innovative ideas who are looking to train themselves and use innovative methods to develop solutions and alternatives to the different challenges being faced in the Amazon region.

Methodology

The methodology used by the program is based, principally, on the pre-incubation, incubation and acceleration of startups and sustainable businesses, by offering technical assistance, mentoring, direct investment (seed money), and monitoring of the entrepreneurs and their businesses in four main areas (administrative-financial, production, suppliers, and opening and access to markets), always with the intention of seeking to plan, apply and promote innovative solutions. Along these lines, Inova UP looks to contribute to the socioeconomic development of the Carajás region (including the municipalities of Parauapebas, Canaã dos Carajás e Marabá), by boosting local potential and the qualified productive inclusion of young people. Over the course of its life cycle, Inova UP offers six key stages, namely: i) prospecting; (ii) basic entrepreneur training workshops – Evoking; (iii) advanced entrepreneur training workshops – Ideation; (iv) pre-acceleration workshops for business/startup ideas; (v) acceleration of the business models; and (vi) monitoring or the businesses/startups founded.

Results

Investing in the entrepreneurial skills of young people is generally an approach that offers long-term results. However, with Inova UP, we have already seen positive return and transformations in the entrepreneurial ecosystems of the municipalities where it has been implemented (Marabá, Canaã dos Carajás and Parauapebas). The economic diversification of these municipalities is necessary for the sustainability and resilience of the region. As such, the income generation brought about by entrepreneurship, especially when it is supported by programs such as Inova UP, performs a transformative role in the diversification of the local economy. By training and supporting young entrepreneurs in the founding and development of their own companies, Inova UP is contributing to the creation of more extensive and dynamic economic sectors in the region.

Through the promotion of sustainable startups/businesses, the southeastern region of Pará can explore new economic opportunities that are in line with the natural riches and local cultures. This includes an appreciation for the biodiversity of the Amazon region, promotion of sustainable tourism, the development of innovative products and services, and the creation of production chains that not only generate income, but also preserve natural resources. When the Inova UP Program came to an end, nine sustainable startups/businesses had been founded and accelerated by the initiative, benefiting more than 20 local entrepreneurs in the municipalities of Canaã dos Carajás, Marabá and Parauapebas, generating income and local jobs, as well as structuring and strengthening the region's entrepreneur ecosystem as a whole.

Strategic Alignments

This initiative was planned with the intention of focusing on SDGs: 1, 8, 10, 11, 12 and 17.

Photograph: Christian Knepper

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Photograph: Emiliano Capozoli

Spatial understanding to recognize the change in the carbon stock present in Vale's regions and at the conservation units that it helps to conserve

Authors:

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Introduction

The greenhouse gas (GHG) emissions caused by human activities have warmed the Earth's atmosphere, resulting in more frequent and more serious climate events. To mitigate these impacts, the public and private sectors have entered into agreements and defined targets to reduce emissions and increase the removal of GHGs, principally carbon gas (CO_2), that are the leading cause of global warming. In line with these objectives, Vale has defined an absolute reductions target of 33% of Scope 1 (direct emissions, generated by the operation) and Scope 2 (indirect emissions, owing to the consumption of electricity or thermal energy) emissions by 2030, and a plan to be carbon neutral (balancing emissions and GHG elimination) by 2050. Investments in decarbonization technologies, understanding the emissions and reductions, as well as the internal pricing of carbon are some of the strategies that the company has adopted. Considering this context, a project has been developed at the Vale Institute of Technology (ITV) to improve the analysis of the carbon emissions and reductions due to the changes in land use and cover in all the areas involved in Vale's Scope 1 emissions, providing focused information for the decision-making and establishment of nature-based solutions. The sectors involved in land change and use are currently responsible for some of the world's highest levels of GHG emissions, as well as being those mostly responsible for making Brazil the world's sixth biggest emitter. On the other hand, the sectors could become a great ally in the mitigation of emissions, due to their potential for storing carbon in living vegetation and in the earth.

Methodology

The methodology adopted is based upon the principles of spatial intelligence, in which the location of data, tools, analysis and visualization are used to support the decision-making. Land use and cover maps that have been produced annually since 1985 are used to evaluate the changes experienced on more than 4,000 km² of land either owned by the company or under its operational control, as well as the almost 10,000 km² that it helps to protect. A database of the carbon stock for different types of land use and vegetation has been developed, based upon scientific studies, and broken down by each Brazilian state and by country. In Pará, forest inventory data provided by Vale and ITV as well as an allometric equation of tropical regions were used to estimate the carbon stock. With regard to secondary vegetation (that which grows following deforestation), we calculate the increase in the carbon stock due to the age of the vegetation. There is a form of software, developed by ITV and registered with the INPI by Vale, that automatically creates annual maps of the stock (the carbon contained in the biomass of the vegetation), removal (carbon sequestration achieved via the growth of the vegetation) and carbon emissions (loss of stock due to the suppression of the vegetation (Image 1).

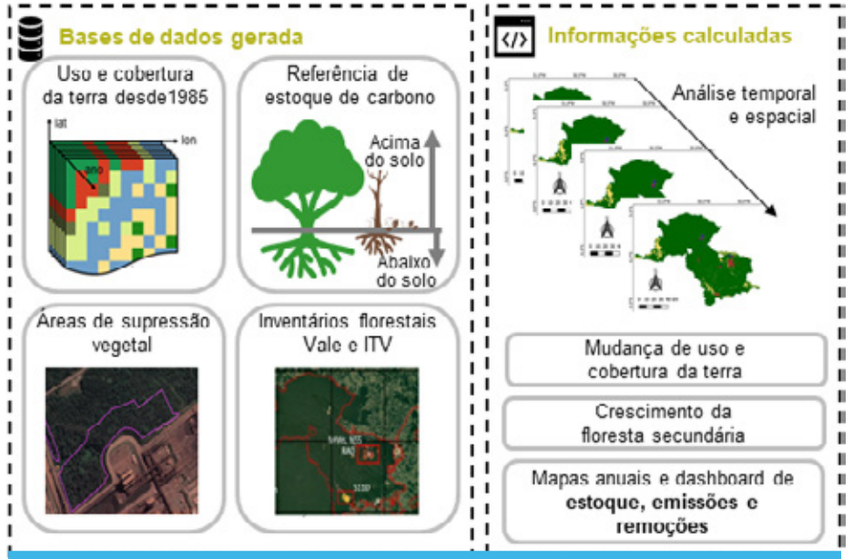

Image 1.
The methodology used to calculate the emissions and removals due to the use, and changes in use and cover of the land operated by Vale, developed using spatial intelligence.

In line with these objectives, Vale has defined an absolute reductions target of 33% of Scope 1 (direct emissions, generated by the operation) and Scope 2 (indirect emissions, owing to the consumption of electricity or thermal energy) emissions by 2030, and a plan to be carbon neutral (balancing emissions and GHG elimination) by 2050.

Results

The maps created show where the largest stocks of carbon are located and the areas with the greatest potential for removal, thus allowing coordination of the respective preservation and mitigation actions. In 2023, Vale's own lands, together with those it manages, held a stock of more than 70 Mt CO_2eq (megatons of carbon dioxide equivalent) in the vegetation, including tree canopies, roots, leaf litter and dead matter. Of this total, around 40% is located in the state of Pará. Another highlight is the Vale Natural Reserve, in Espírito Santo, which holds a stock of 11 Mt CO_2eq across its 23,000 hectares of conservation area. The reductions in the carbon stocks take place mainly due to the suppression of the vegetation, but the stock has varied very little over the years. These emissions due to the change in land use represent roughly 5.8% of Vale's total emissions (2023 data), emphasizing the importance of the voluntary reporting to provide support and transparency for the planning being made to achieve future neutrality. In relation to the removal of carbon, the areas mapped as secondary forests on Vale's land can remove around 0.6 MtCO_2eq from the atmosphere per year, which contributes to offsetting a portion of the emissions. This sum is equivalent to the GHG emissions prevented through the use of energy produced by about 155 wind turbines in one year.

We also provide management of this information for the conservation units that Vale helps to protect, in order to analyze the state of the development of the vegetation and recognize the ecosystemic service of carbon storage provided by these areas. In these protected areas, we have gauged that there is around 550 Mt CO_2eq stored in the vegetation, most of which is held in the Carajás conservation units (Image 2). This amount rises to approximately 700 Mt when we include the carbon in the soil, which further highlights the importance of protecting these areas.

The methodology used allows the company to analyze the history, meaning we can transparently and confidently monitor and report the implementation of strategies designed to reduce the carbon emissions related to the changes in land use. Methodologies for estimating the carbon stocks in the soil and the GHG emissions caused by fires have also been analyzed. The results show that they are significant and should be further analyzed to identify the opportunities and challenges involved in achieving the climate change mitigation objectives.

Strategic Alignments

This project is aligned with international initiatives aimed at tackling climate change, such as SDG 13 and the Paris Agreement, as part of which Brazil has committed itself to reducing its emissions by 37% by 2025 and 43% by 2030, in relation to the levels recorded in 2005.

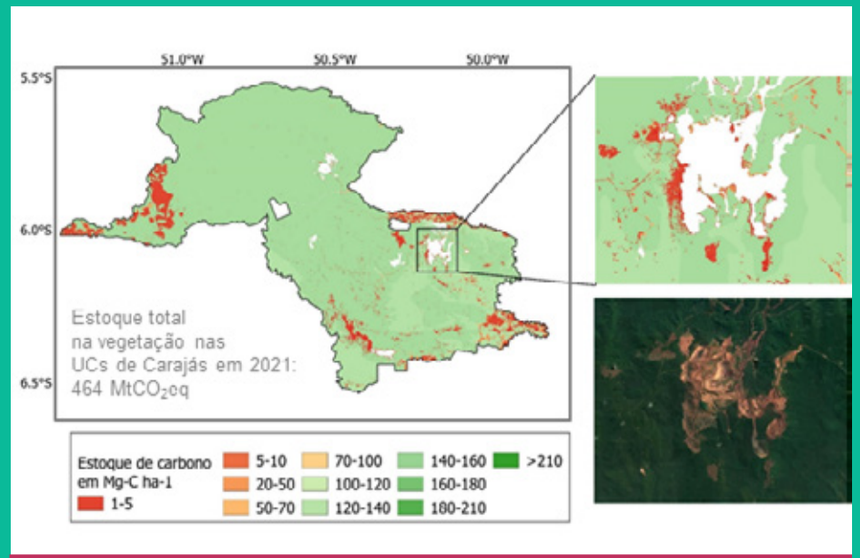

Image 2.
Map of the carbon stock in the vegetation at the Carajás conservation units.

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Photograph: Ana Caroline Galindo da Costa

MapRios: mapping the cumulative use of soil along the rivers of Brazil

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Introduction

The aquatic ecosystems are essential for millions of river-dwelling people, providing services such as drinking water for humans and animals, food (fish), recreation and maintenance of biodiversity. Rivers, despite constituting around just 0.001% of the Earth's water, are vital to maintaining the aquatic biodiversity of fresh water, which is home to approximately 10% of the species of fauna on the planet[3], with a high level of fragmentation and endemism. This biodiversity is, however, in sharp decline due to changes in land use, climate change, a reduction in the amount of wetlands, and high levels of damming and pollution. The impacts on the aquatic ecosystems are not isolated, since on its journey to the rivers, rainwater interacts with the landscape and a variety of different soil uses. As a result, the levels and quality of the water in rivers have been affected by changes in the use of the soil found throughout their upstream drainage areas, regardless of political borders. In the Amazon region, the direct changes (agricultural expansion) and those that are indirectly related to deforestation (climate change, illegal activities, an uncontrolled rise in the population, and a lack of governance) are threatening the role of this region in relation to the climate and biodiversity. Despite the existence of important initiatives such as '*Áreas Protegidas*' ('Protected Areas'), it is uncommon for them to involve the protection of aquatic ecosystems and they do not respect the upstream limits, meaning the rivers can run through protected regions that have already been greatly impacted. Although the local data on land use and occupation do help in making decisions on conservation, these data are normally provided in pixel form or gathered by federative units (municipalities or states), and do not take into consideration the limits of drainage basins, which is essential information in this type of analysis. As such, understanding how the soil is being used over the course of the entire drainage network can help to understand any hotspots that are important to the management of water resources and conservation of the aquatic ecosystem, which often remain unseen without an integrated evaluation of the combined uses that exist in the drainage basin. The 'MapRios' initiative therefore provides new insights into the status of the conservation that exists in relation to the water resources in Brazil's rivers, initially focusing on the rivers of the Amazon region.

Methodology

The methodology uses two guiding concepts: the river basin as a water resources planning unit, and spatial intelligence. We use classification of soil use and topographic information to collect these uses along the courses taken by the rivers of Brazil and the Pan-Amazon region. First, the percentage of the upstream deforested area was analyzed, as was the percentage of the mined areas in the Amazon region, highlighting the rivers lying within the protected areas. We are aiming to identify which of the protected areas in the Amazon region are in better or worse situations in terms of conservation of the aquatic ecosystems. We have also focused the evaluation on the Itacaiúnas River Basin, in the southeast of Pará, where Vale's operational areas in the North of Brazil are located. To do so, we use the global databases concerning protected areas and drainage, as well as spatial information on the landscape (deforestation and mining) to aggregate accumulated landscape measurements along rivers. We initially focused on the Amazon region (the basins of the Amazon River and Tocantins River), generating the anthropogenic signature of deforestation, mining and protected areas relating to roughly 1.5 million kilometers of rivers on a spatial scale of 500m.

Image 1. Illustrative photo of pasture land and forest in the Itacaiúnas River drainage basin.

Image 2. Illustrative photo of pasture land and forest in the Itacaiúnas River drainage basin

Results

Maps have been created that show how much of the upstream area of the river has been deforested, mined or protected at each point along its course, providing an understanding of the accumulated uses throughout the aquatic ecosystems. It is understood that, in 2020, around 40% of the Amazon and Tocantins river basins were either protected or in the process of receiving protection,15% had been mapped as deforested areas and 0.03% had been mapped as mining areas. However, the rest of the results provided by the study highlighted an unprecedented situation concerning the aquatic ecosystems: 50% of the drainage areas of the rivers in the Pan-Amazon region have experienced deforestation and 5% of the rivers contain upstream mining activities. However, just 40% of the region is under some form of protection, and around half of the rivers remain unprotected due to the fact that the protected areas do not include the rivers' drainage areas.

The case of the Itacaiúnas River(PA): The Itacaiúnas River drainage basin, a direct tributary of the Tocantins River, is an important case for Vale, because of the concentration of its operations. Due to the high level of deforestation observed outside the protected areas, this basin, located in the southeast region of Pará state, is home to roughly 14% of the basin's rivers, with the accumulated deforestation affecting more than 90% of its drainage areas. Despite this, the basin can also be considered protected, when we analyze the Carajás Mosaic of Protection Areas. The Itacaiúnas River has two sources with high levels of deforestation (point 1, Image 3) and forms part of the protected areas but which do not, in fact, have any protection, with 74% of its area having suffered deforestation (point 2, Image 3). Within the protected areas, just 4% has been deforested and 0.8% is related to mining, such which has been included in the management plan for the region. After traveling roughly 180km within the protected areas, the Itacaiúnas River leaves this stretch with 63% of its upstream area (13,000km^2) protected, 25% deforested (mainly due to headwaters) and just 0.3% related to mining (point 5, Image 3).

Strategic Alignments

This initiative is related to SDG 6 (clean water and sanitation) and SDG 15 (protection of land life), especially in relation to the protection of the rivers' ecosystems, which are critically threatened. By analyzing the protected areas and demonstrating that they may not be enough to protect the ecosystem, the action is directly related to the goal of COP 15 to protect 30% of the planet.

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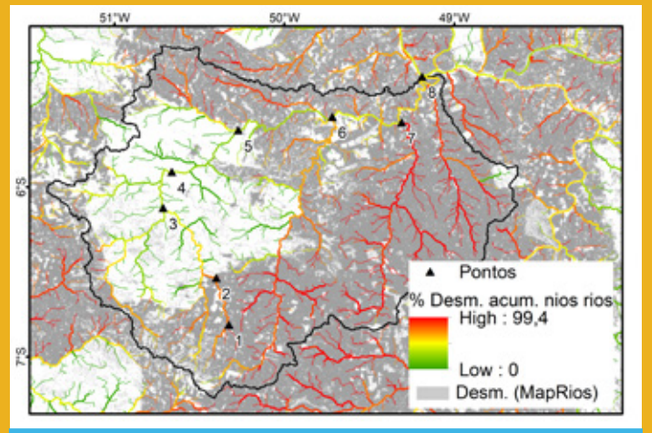

Image 3.
Deforestation and percentage of deforested areas upstream from the drainage network of the Itacaiúnas basin.

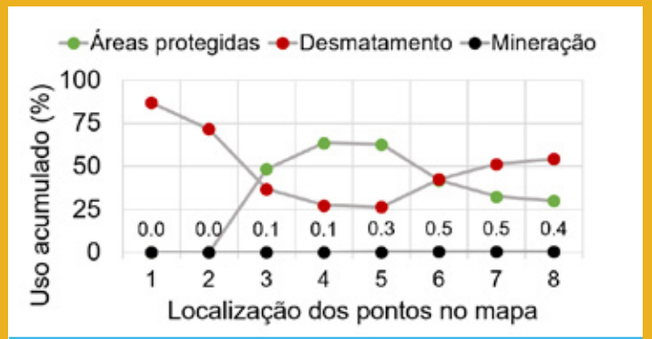

Image 4.
Profile of the accumulated upstream uses (deforestation, mining and protected area) at each point analyzed (1 to 8, upstream to downstream).

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Paths of Knowledge project – Creative Learning

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Institutions Involved:

[1]Vale S.A; [2] Faber-Castell do Brasil; Nova Lima Municipal Department of Education; Itabirito Municipal Department of Education

Introduction

Promoting social development by means of the key behavior of "Active listening and engagement with society" was the guiding premise of the Paths of Knowledge – Creative Learning Project. It was devised as a means of deploying a range of Vale's different interventions in school infrastructures in the district of São Sebastião das Águas Claras (Macacos), in Nova Lima (MG) and in four schools in Itabirito (MG). The main objective has been to provide the community with a learning environment that goes beyond a cutting-edge infrastructure to guarantee quality and transformative teaching for the children's future. As an innovative methodology for public-private partnerships, the project is aligned with the United Nations' (UN) education pillars (Learning to know; Learning to do; Learning to live together; and Learning to be) and the five most important skills for professionals of the future, according to the World Economic Forum – Analytical Thinking and Innovation; Active Learning; Complex Problem Solving; Critical Thinking and Analysis; and Creativity.

Methodology

Throughout the world, including Brazil, many professionals work with Creative Learning in one-off or occasional jobs. This is a valuable area, but specialists have a great many doubts concerning how to practically adopt it in a way that is relevant in a classroom context. The Creative Learning set forth by Faber-Castell Brasil is anchored in the Common National Curriculum Base (BNCC), cutting across the entire program content, and constituting an educational philosophy that promotes the development of individuals who think and act creatively, collaboratively and systematically, concentrating on the construction of learning environments based upon four pillars: Projects, Passion, Peers and Play. In this sense, the methodology is a well-structured proposal for how to develop this work in schools, with examples of activities and support materials that serve as a reference. The traditional classroom space is transformed into something new, a fantastic mini-world and a creative journey, in which the educational context becomes visible, providing students with a truly immersive experience in the theme of the class. Taking an innovative approach, it introduces new tools into the schools such as playing and free exploration, reducing the pressure to take the "right path", and showing that "making mistakes" is not wrong, but rather it is part of the process. Exploring alternative paths allows for the discovery of different options, which are often better than those that already exist, and this is creativity.

The main objective is to provide the community with a learning environment that goes beyond a cutting-edge infrastructure to guarantee quality and transformative teaching for the children's future. As an innovative methodology for public-private partnerships, the project is aligned with the UN's education pillars.

Image 1.
"Time Travel" – Developed by 6th and 7th grade Primary School students

Image 2.
A training session for Primary School I teachers from the Itabirito (MG) Municipal Education System.

Results

The project, which is being developed through until 2024, has been implemented in five schools – one in Nova Lima (MG) and four in Itabirito (MG) – annually involving 650 students and training 40 professionals, including teachers, principals, and pedagogical coordinators and supervisors.

The principal results in the qualitative sphere concern the perceptions of teachers and the students' parents (the community) regarding the advances in the students' learning and the way in which they have been developing socio-emotional skills.

"This project was one of the best in terms of helping children and parents to take part together. We have been able to come even closer together and provide both the children and the parents with skills." – Coordinator

"We have been able to use what we have learned in the Creative Learning to create our own business." – Student

"Let me tell you something – I've been at this school for more than 30 years, but I've had to learn to work with the kids (...), I've had to think, study to see which way I should be doing things, and this was a project that has helped me grow together with them. (...) The best thing was them realizing that, although this is a rural region, we can go great places when and if they want to. I think they understand that everything depends on the strength of their own imagination and the work they put in. (...) it is a project that made me stop and think, so it's different to all the others I've done (...). – Teacher MH, 62

Strategic Alignments

The Paths of Knowledge – Creative Learning project directly contributes to SDG 4 (Quality Education) and SDG 17 (Partnerships and means of implementation), through its mini-worlds.

"This project was one of the best in terms of helping children and parents participate together. We have been able to come even closer together and provided both the children and the parents with skills." – Coordinator

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Photograph: Felipe Borges

Analysis of the conservation of the native vegetation that exists in protected areas and on private properties

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Institutions Involved:

Vale Institute of Technology (ITV); Belterra; Mercado Agro

Introduction

In 2019, Vale made a voluntary commitment to recovering 100,000 hectares of forest and protecting another 400,000 by 2030, as part of its strategy to balance the environmental impacts and create socioeconomic opportunities. This initiative is aligned with Brazil's commitment to recovering 12 million hectares of native vegetation, as was announced at the signing of the Paris Agreement. The "Analysis of the conservation of the native vegetation that exists in protected areas and on private properties" project has been developed to help achieve these targets by addressing three topics: (i) analyzing the environmental adaptation of the rural properties located in the drainage basin of the Itacaiúnas River (BHRI); (ii) understanding how the secondary vegetation is regenerating in the BHRI; and (iii) evaluating the performance of seven agroforestry systems that have been implemented in the municipalities of Canaã dos Carajás and Parauapebas. These three objectives contribute to the mitigation of climate effects, recovery of biodiversity, provision of ecosystemic services, and generation of income for the local communities.

Methodology

Environmental adaptation: We analyze the situation of the legal reserves (LR) and Permanent Conservation Areas (PCA) on the rural properties and settlements in the BHRI (41,300 km²), located in the southeast of the state of Pará. We identify areas that need to be restored, consolidated areas and surplus forests, according to the Native Vegetation Protection Law (LPVN). Secondary vegetation: We evaluate the development of secondary vegetation (that which naturally regenerates following deforestation) in the BHRI. To achieve this, we create maps that calculate the age of this vegetation and the area that has been deforested over the course of 35 years, based upon maps of the cover and land use provided by MapBiomas (1986 to 2020). Agroforestry Systems (AFS): We analyze the development of seven AFS, each measuring half a hectare, located in the BHRI. Here, we estimate the agroforestry performance rate to evaluate the performance of the systems once they have been implemented.

Results

By analyzing the environmental adaptation of 6,352 properties, we have identified liabilities involving 4,321 km² of legal reserve (LR). The majority of this can be resolved through compensation in other properties (55% or 2,399km²), whilst the forest surplus in the BHRI (3,721 km²) is enough to cover the entire liability requiring compensation in the basin (Image 1). However, 1,922 km² requires restoration in the deforestation region. Half of the LR liability should have been resolved in 2021, in line with the LPVN. This means the recovery or compensation of 1,496 km² of damaged areas. However, only half of this area was recovered, that is, just 24% of the expected total. In relation to PPAs, 762 km² do not require restoration due to legal pardons. However, around 1,316 km² of PPAs do require restoration. The Environmental Regulation Program of Pará established a period of nine years for completion of the restoration of all the PPA liabilities as of its publication. However, only ¼ of the liabilities were effectively restored (347 km²). A large part of the preserved PPAs lies within protected areas. Relaxation of the legal regulations governing restoration suggests that the environmental laws alone are not sufficient under the current inspection system, and there is a need for the use of incentives to promote environmental adjustment.

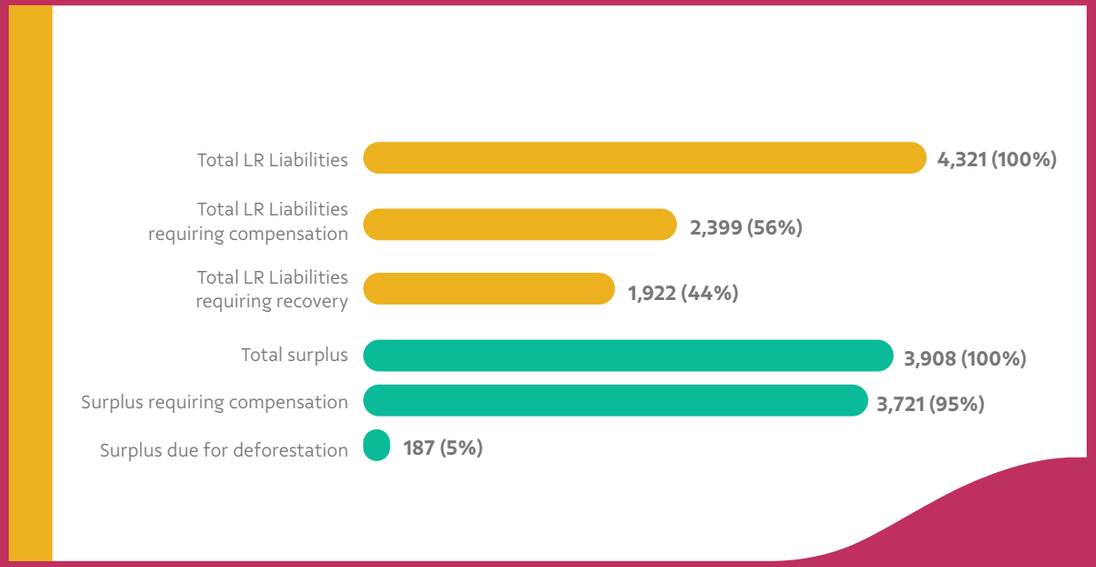

Image 1.
Estimate of the Legal Reserve liabilities and surpluses on properties registered with the Rural Environmental Register (CAR) and Incra settlements, according to the Native Vegetation Protection Law, in the Itacaiúnas River drainage basin. The percentage relates to the total liabilities/surplus in the basin.

In the BHRI, we mapped 266,000 hectares of secondary vegetation in 2020 (11.7% of the deforested area). However, the majority (69%) of this vegetation is less than five years old, having frequently suffered deforestation during this period, whilst just 16% has been in place for 16 years or more. The deforestation of this vegetation is a problem, since it provides important ecosystemic services, such as the capture and stocking of carbon from the atmosphere, and reduction of the areas of liability and the pressure due to deforestation in primary forest areas.

Through the evaluation of the agroforestry systems, we have noted variations in performance due to different factors, including the diversity of species, the quality of the soil and the death of plants (Table 1 and Image 3). The AFSs upon which there is no irrigation face greater rates of mortality during the dry season. Over time, we hope to see improvements in the performance of the AFSs, to the extent that the vegetation will mature and become more resistant to pests, diseases and droughts, since the farmers will be adopting the correct management techniques and taking care of the structure of the systems. The AFSs could potentially offer environmental benefits, such as efficient use of the land, improved quality of the soil, increased storage of carbon, and improved levels of connectivity, compared to pastureland areas. Furthermore, the systems can be implemented in family farming situations, thereby contributing to a healthier diet and generating income. It is therefore essential that the AFSs are monitored using quantitative and qualitative indicators to be able to understand how they evolve and have an impact on ecological, economic and cultural aspects. This will help us to understand the complexity of these systems.

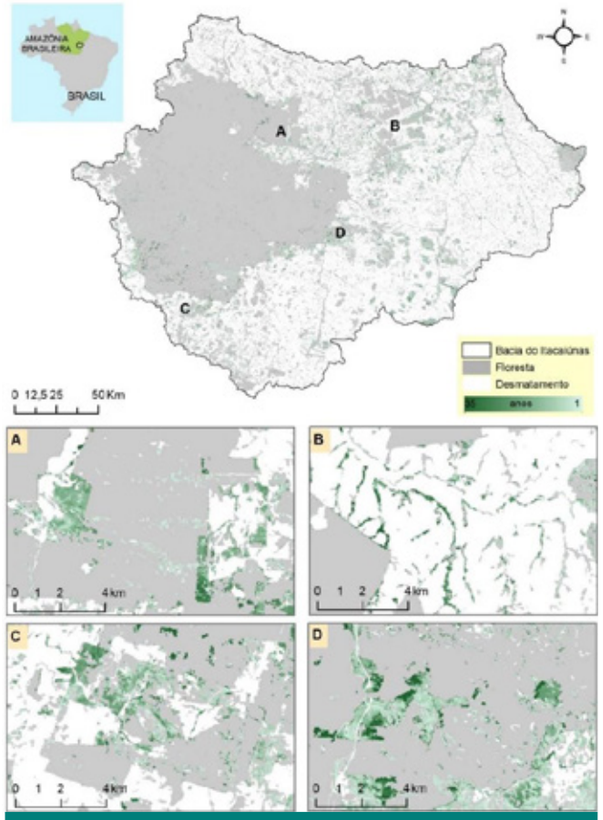

Image 2.
Distribution of the secondary vegetation in the drainage basin of the Itacaiúnas River, Pará, in 2020. **The panels containing close-ups show different stages of regeneration of the vegetation in pasture and agricultural lands (A, C and D) and permanent preservation areas (B).**

Strategic Alignments

This initiative is aligned with Vale's 2030 Agenda, supporting the strategy designed to achieve the Forest Target and the Climate Change Targets. It is also aligned with international climate change policies, such as the Bonn Challenge, the Paris Agreement and the Kunming-Montreal Global Biodiversity Framework.

Image 3. Agroforestry system with the highest score according to the agroforestry performance rate.

Indicator	AFS B	AFS C	AFS D	AFS E	AFS F
Biological diversity	4	3	3	3	3
Diversity of functional niches	3	3	3	3	3
Occupation of the area	1	1	1	2	1
Challenges encountered	2	3	3	4	4
Mortality	5	3	3	3	2
Reproducibility	4	3	4	3	4
IPA	21	19	21	21	20

Table 1. Performance of the agroforestry systems (AFS) by agroforestry performance rate (IPA) by AFSs.

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Photograph: Washington Alves

CACAO: pollination, fermentation and the bioeconomy

Authors:

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Institutions Involved:

[1]Vale Institute of Technology; Federal University of Goiás; [3]Vale S.A.; Vale Fund

Introduction

The gaps in information concerning cacao production in the Northern Region of Brazil must be urgently filled, especially given the crop's economic importance. Addressing these gaps is particularly important for agroforestry system (AFS) projects, which aim to strike a balance between environmental conservation and the generation of income, an important example of a proposal for sustainable development. As such, the central objective of this study lies in addressing the gaps in knowledge that exist concerning cacao production and its related bioeconomy, with the aim of suggesting best production practices, especially in agroforestry systems. The project covers three main themes: pollination, fermentation of seeds and the bioeconomy.

Methodology

The pollination experiment was performed on a cacao AFS, in the municipality of Medicilândia (PA) (Image 1). A number or reproductive biology treatments were performed to identify the effective pollinators of the cacao and all the insects that visited the flowers were collected. The species are still being identified by taxonomists and their DNA bar codes will be included in a public library. For analysis of the microorganisms and molecular functions involved in the fermentation of the cacao beans (Image 2), we evaluated the microbial and biochemical composition over a period of seven days of fermentation. The DNA of fungi and bacteria was sequenced to be able to identify the organisms, and the proteins were analyzed using mass spectrometry to identify the biochemical functions related to the production of flavors.

The socioeconomic, productive and land study involved a sample of 360 rural properties, distributed along 22 routes running beside the BR-230 ('Trans-amazon') highway and entering the rural region of the Medicilândia municipality (PA) (Image 2). Semi-structured questionnaires were used as research tools, containing 104 questions divided into three sections.

Consolidation

During the data collection periods, visits were observed to 90 flowers forming part of the floral biology experiment (30 in each location) (Image 1). The most important visitors to the flowers were insects belonging to the *Thysanoptera* (thrips), *Hymenoptera* (wasps and ants) and *Diptera* (flies) species. Despite watching the visitors actually making contact with the reproductive parts of the cacao flowers, no formation of the fruit was observed in any of the flowers. One of the reasons for this could have been a small amount of pollen grains deposited on the stigma of the cacao flower during a single visit. Also notable was the low rate of fructification, even in treatments where the flowers always remained open and in manually-conducted pollination treatments, which could have been related to the high miscarriage rates that occur naturally in this species. As such, new field collections will be necessary to investigate these interactions.

Image 1. The pollination experiment was performed on a cacao AFS, in the municipality of Medicilândia (PA).

Image 2. Fermentation of the cacao beans on the rural properties.

The *Saccharomyces*, *Torulaspora*, *Weissella*, *Lactobacillus* and *Acetobacter* genera were noted as being the most abundant over the course of the fermenting process. It was, however, possible to clearly observe the dominance of yeasts in the four days of fermentation, whilst the bacterias take over and dominate the area as of the fifth day. The alteration of the microbial community is clearly associated with the production of phenolic and other aromatic compounds, and this could explain the specific characteristics of different regions. Different regions or different production methods could privilege different microorganisms and this could be monitored by means of these molecular techniques. The report on the socioeconomic reality sheds light on the development of cacao farming in the state of Pará, as well as the difficulties involved in the production process. Amongst the aspects noted, that of most concern regards the aging of the population, which, on the one hand is positive, as it suggests longevity, but on the other, the lack of successors in the area of cacao farming reveals the increased number of sharecroppers as the main form of labor available to work on the plantations. The contractual relationship between the land owners and the sharecroppers could eventually lead to potential weaknesses in the social structure, such as in relation to the legality of the ownership of rural properties, since the trend towards the sharecroppers taking "ownership" of the land is quite plausible. That said, the soil and climate conditions historically associated with the production of the cacao crop in this municipality serve as an indication of the potential for production that could still be developed. There is a great deal of potential in the family farming system, but it still requires a great deal of intervention in the form of public policies focused on improvements to the infrastructure, as well as technical support for the improvement and transfer of technologies adapted and/or developed as a means of improving the cacao farming in Medicilândia.

Strategic Alignments

The work addresses the following SDGs: SDG 1: Eradication of poverty; SDG 2: End hunger; SDG 6: Clean drinking water; SDG 13: Action against global climate change; SDG 15: Land life. Support for Target 11 of the CDB's Global Biodiversity Framework.

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Photograph: Washington Alves

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Photograph: Washington Alves

Natural Capital of the Forests of Carajás

Authors:

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Institutions Involved:

[1]Vale Institute of Technology; [2]Emílio Goeldi Museum of Pará; [3]Vale S.A.

Introduction

Analyzing biodiversity is no easy task due to its complexity, evolution and the interactions between the many components. However, the loss of biodiversity and average global temperature are both increasing rapidly, making evaluations of biodiversity that much more urgent. Biodiversity is a key-characteristic of natural capital, defined as the sum of all the benefits that balanced ecosystems provide to humankind, such as drinking water, food and wood. These benefits are also called ecosystemic services. The tropical forests are of particular interest to the economy of biodiversity, since they are home to almost half the Earth's plants and animals. This debate has a direct implication on the robustness of sustainability strategies, since it is not always possible to replace natural capital with other forms of capital. The main objective of this study has been to develop a framework that can connect numerous different perspectives in order to evaluate the natural capital of a tropical forest, by means of a case study conducted in the Carajás National Forest.

Methodology

We divided the components of the natural capital into two categories (Image 1). The ecosystemic functions are defined as intrinsic characteristics of the ecosystem and represent the set of ecological processes by means of which the ecosystem manages to maintain its integrity. They were used to connect the processes that we consider to be associated with the ability of nature to continue as a standing forest. The ecosystemic services are, in turn, related to nature's contribution to people. We use 14 sample points within the Carajás National Forest (PA) (Image 2). The sample points were located at least 1.5 km from each other. Different sampling methods were employed to collect bees, butterflies, birds (identified by means of their song), plant species (that were also used to calculate the carbon stock) and soil (evaluating proteomics, metagenomics and stored carbon analyses). The species identified were also analyzed with regard to functional diversity. Using forest loss, and climate and hydrological modeling simulations, we were able to establish the role of the forest in regulating the local climate and protecting the water resources, respectively. The role of pollination in farming production was also estimated through studies of the bee species collected. Finally, analysis was performed regarding which of the plant species found had previously been cited as being important in terms of their use (15 evaluated uses) by traditional communities.

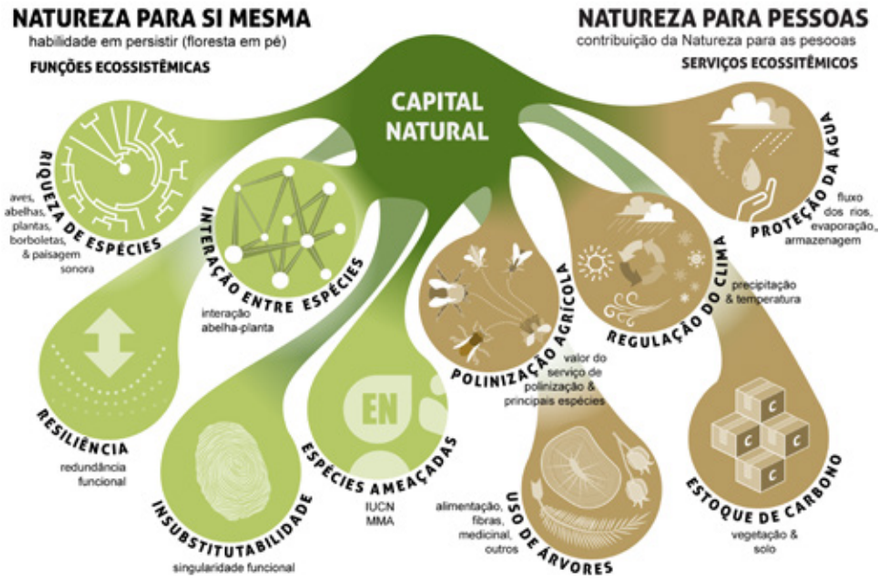

Image 1.
Division of the components of the natural capital

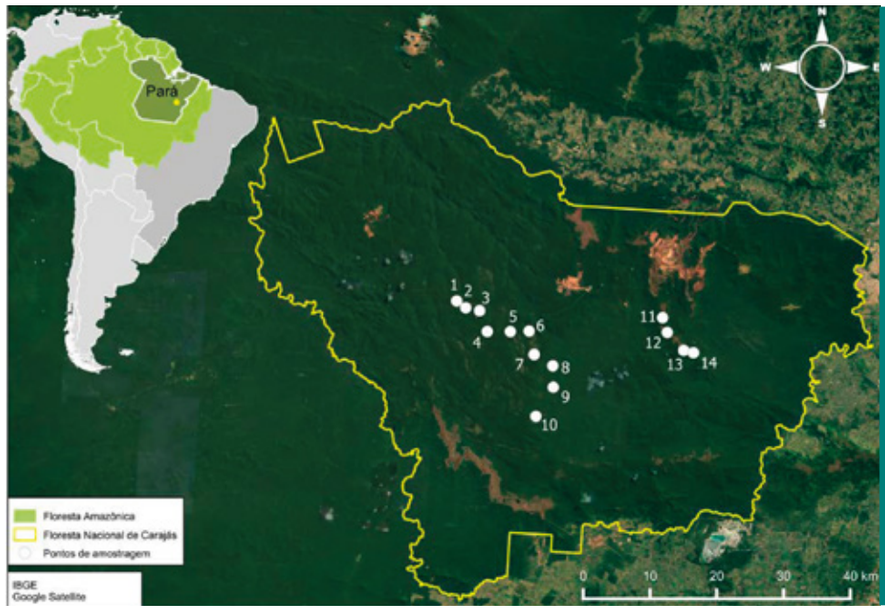

Image 2.
Sample points within the Carajás National Forest (PA).

Results

The total diversity of species that we found in the sampled areas in the Carajás forests included 122 bees (1,581 specimens), 292 birds (in 7,000 minutes of recordings), 53 frugivore butterflies (176 specimens) and 418 plant taxons (290 species identified and 2,278 specimens). We also detected 480 bee-plant interactions, involving 57 species of bees and 73 plants. The average diversity of interactions between partners was 2.8 (ranging from 1.9 to 3.6). In relation to resilience, the evaluation showed that at least 83% of the species are responsible for maintenance of the forest's functional diversity (functional redundancy) and 60% of this diversity is supported by irreplaceable species (functional singularity). With regard to threatened species, 9% of the plant species and 11% of the bird species were reported as facing some level of threat. The climate modeling resulted in a temperature increase of up to 0.3°C. The modeling also demonstrated changes in rainfall (an increase of 2mm/day). In relation to water protection, the amount of water that returns to the atmosphere by means of evapotranspiration is 1,277 mm/year (72% of the annual rainfall) in forested areas, a sum which is 272 mm/year more than the evapotranspiration in deforested areas (1,005 mm/year). Around 15 km^3 of water is transferred to the atmosphere each year by means of evapotranspiration due to the forests. With regard to the carbon stocks, the average stock was 41.6 Mg ha-1 in the soil, whilst the average amount found in the trees was 173 MgC ha-1. Considering the use of trees by the traditional peoples, we noted that, of the 266 fully-identified species, 42% were cited as being used for at least one purpose. As for the pollination of crops, amongst the 122 species of bees identified, 28 were cited as pollinators of agricultural crops. In 2021, the service of animal pollination represented approximately US$ 4.5 million in these municipalities, demonstrating the importance of the pollinators to agriculture and the local economy.

Strategic Alignments

The work addresses the following SDGs: SDG 1: Eradication of poverty; SDG 2: Ending hunger; SDG 6: Clean drinking water; SDG 13: Action against global climate change; SDG 15: Land life. Support for Target 11 of the CDB's Global Biodiversity Framework.

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Photograph: Beto Felício

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Photograph: Irisvelton Silva

Agroforestry systems in the Amazon region of Brazil: usage trends and appreciation for pollination services

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Partners:

Federal University of Goias

Institutions Involved:

[1]Vale Institute of Technology

Introduction

The development of synergies between conservation and agricultural production is crucial at a global level and even more so in the Brazilian Amazon region, where the conservation of forests is necessary to ensure the continuity of essential products and services. Agroforestry systems (AFS) are a traditional practice that involves growing native trees together with crops and/or livestock farming as a means of increasing productivity, conserving the soil and recycling nutrients (Image 1). The AFSs can align the conservation of biodiversity with income generation and are a strategically beneficial form of land use in rural planning, whilst they can also increase biodiversity and the provision of ecosystemic services in relation to conventional agriculture. In tropical forests, pollination of the crops plays a fundamental role in food production, and is a critical ecosystemic service for food security. Pollinators are threatened all over the world and the reduction in their numbers could lead to important economic losses, but the AFSs can provide the habitat that is necessary and support the pollination services, adding diversity to agricultural areas. The aim of this study has been to understand the panorama of the AFSs in the Brazilian Amazon region and evaluate the crop pollination services in Amazon forest regions.

Methodology

The study was focused on agroforestry systems in the Brazilian Legal Amazon region, using data from the IBGE agroforestry censuses from 2006 and 2017. The data provide information on the number of AFSs and their respective land areas, the crops developed and the economic value of the agricultural production in forested areas. Research was performed in the relevant literature to find the dependency values of pollination for each crop, based upon the fruit growth rates and/or seeds with and without pollinators. The agricultural production values are multiplied by the dependency of each plant species on the pollinators to establish the value of the pollination services for each crop analyzed. The literature on the pollinator species associated with the plants present in the IBGE list was reviewed and only the effective pollinators were considered to be directly connected to the value of the pollination service.

Consolidation

The use of AFSs increased in the Brazilian Legal Amazon region between 2006 and 2017, with a 23.18% increase in the area and a 3.27% increase in the number of AFSs established. The state of Pará contained the highest number of AFS, but the greatest increase in number was observed in the state of Amapá. Socioeconomic variables (land ownership, funding options, access to information and technical support) and agronomic variables (availability of water resources and soil quality) are probably influencing the adoption of AFSs in different regions. Globally, AFSs have attracted a great deal of attention in the majority of developing countries due to the potential they offer in mitigating climate change and increasing the sequestration of carbon from the atmosphere.

Image 1.
Agroforestry systems (AFS) are a traditional practice that involves growing native trees together with crops and/or livestock farming as a means of increasing productivity, conserving the soil and recycling nutrients (Image 1).

Agroforestry systems (AFS) are a traditional practice that involves growing native trees together with crops and/or livestock farming as a means of increasing productivity, conserving the soil and recycling nutrients.

The total value of the agricultural production in the forest areas increased by 45.61%, rising from US$ 167.3 million (2006) to US$ 243.5 million (2017). The five principal crops in 2017, in terms of value of agricultural production, were açai, Brazil nuts, babassu coconut, babassu almonds and hearts-of-palm. Of the 33 crops analyzed, 24 showed some form of dependence on pollinators. Our results demonstrated the importance of this ecosystemic service to the agricultural sector. When estimating the value of the pollination service for these crops, the value increased from US$ 73.3 million in 2006 (44% of the production that year) to US$ 156.7 million (64.36% of the production) in 2017. Of the 20 municipalities with the highest production and pollination values, 17 were in the state of Pará. The result was closely related to the açaí crop, but also marginally related to other important products grown in the state, such as Brazil nuts and cacao. Insects were the main pollinators cited, responsible for 84% of the total number of species evaluated as effective pollinators, followed by birds (12%) and bats (4%). Bees were the main pollinators, accounting for 43% of the total number of crop pollinating species, followed by beetles (15%). This prevalence was to be expected, since bees are the biggest group of pollinators of crops associated with food production, not only in tropical regions, but also globally. Public policies are urgently needed for this group in order to ensure maintenance of the biodiversity and services that these organisms provide. Studies on the value attributed to important ecosystemic services such as pollination are still rare. This information is basic to the planning of better directed actions by decision makers and farmers. Furthermore, specific studies on pollination within AFSs are urgent, considering the importance of protecting the pollinator species and their habitats. (article available at https://doi.org/10.1016/j.agee.2022.108012)

Strategic Alignments

The work addresses the following SDGs: SDG 1: Eradication of poverty; SDG 2: Ending hunger; SDG 6: Clean drinking water; SDG 13: Action against global climate change; SDG 15: Land life. Support for Target 11 of the CDB's Global Biodiversity Framework.

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Photograph: Ricardo Teles

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Photograph: Ricardo Teles

The contribution of the Vale Amazônia BioPark to the conservation of the Amazon region's fauna under threat of extinction.

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Introduction

The Vale Amazônia BioPark (BVA) was inaugurated in 1985, the same year that operations began at the Carajás Mine and along the Carajás Railroad (EFC). Since then, it has established itself as one of the most important biodiversity research, conservation and education centers in Brazil. Located in the Carajás National Forest, the center occupies an area covering 30 hectares, of which roughly 70% is native forest, divided into 29 enclosures, providing a home to more than 360 animals representing 70 species native to the Amazon biome. The main commitment of the BioPark is to contribute to the conservation of the various species, serving as a genetic stock and training specialist professionals to work on behalf of the conservation of Brazilian fauna, by means of its Reproductive Management Program for the Conservation of Species that are Endangered and of Biological Importance. The BVA forms part of the program developed by the Brazilian Association of Zoos and Aquariums (Azab) focused on ***ex situ*** conservation. The management and reproduction work conducted by humans and shared amongst the institutions is extremely important in supporting the conservation of species threatened with extinction.

Methodology

The BioPark is a member of the Brazilian Association of Zoos and Aquariums (Azab) and as such forms part of the Technical Cooperation Agreement (nº 3202386), entered into between the ICMBio and the MMA (process nº 02070.003869/2018-45), for the ***ex situ*** management of 25 species of Brazilian fauna threatened with extinction. Amongst these species, the BioPark has declared its responsibility and institutional commitment to the ***ex situ*** establishment and safe and secure management of representatives of the following species: *Amazona farinosa* (mealy Amazon parrot); *Guaruba guarouba* (golden conure) (Image 1); *Harpia harpyja* (harpy eagle) (Image 2); *Panthera onca* (jaguar) (Image 3); *Saguinus bicolor* (Brazilian bare-faced tamarin); *Speothos venaticus* (bush dog); *Ateles marginatus* (white-cheeked spider monkey); and *Pteronura brasiliensis* (giant Brazilian otter), with long-term genetic and demographic viability for conservation purposes. Another of the principal intentions of the conservation work, which falls into line with fulfilling the agreement, BioParque meets the criteria for the best final habitat for the animal, considering the priority recommendations for management published by Studbook Keepers and the capacity of different institutions to receive, uphold and apply these recommendations.

Located in the Carajás National Forest, the center occupies an area covering 30 hectares, of which roughly 70% is native forest, divided into 29 enclosures, providing a home to more than 360 animals representing 70 species native to the Amazon biome.

Image 1.
Golden conures *(Guaruba guarouba).*

Image 2.
Harpy eagle*(Harpia harpyja).*

Image 3.
Jaguar (Panthera onca)

Results

Amongst its stock of species, the BioPark has 18 adult *Guaruba guarouba* (golden conures) and, following the pairing of couples and management of reproduction, three chicks were born, which were sent to the Utinga State Park in Belém in 2019 (as part of a program to reintroduce them into nature), whilst there are three more chicks, which were also born at the BioPark, awaiting recommendation from the Studbook Keeper specialists.

There are also eight adult, and one youth, specimens of the *Panthera onca* (jaguar) that were born at the BioPark, including five females and three males, with the youth specimen being female. The successful reproduction of the jaguars at the BioPark demonstrates the important role the institution plays in the reproductive management of threatened species. Over the last ten years, there have been six births, the highlights being the most recent ones that were sent to new homes in line with recommendations from the Studbook Keepers: one female black jaguar that was sent to the Gramado Zoo (RS) in August 2021, and one male jaguar that was born at the BioPark and sent to the Animalia Park in São Paulo in January 2023.

Amongst the species at the BioPark are two male bush dogs (*Speothos venaticus*) , four adult mealy Amazon parrots (*Amazona farinosa*), currently in the reproduction center, a pair of Brazilian bare-faced tamarins (*Saguinus bicolor*) on display, a pair of harpy eagles (*Harpia harpyja*) also on display, and one female in the 'extra' sector, and four adult white-cheeked spider monkeys (*Ateles marginatus*) (three females and one male).

Stressing the importance for the ***ex situ*** conservation and management programs, in 2019, Naturatins (the Tocantins state environmental organ) presented the BioPark with a three-week-old giant Brazilian otter (*Pteronura brasiliensis*), which remained under the parental care of the BioPark following recommendation from the Studbook Keepers. In October 2022, the otter was sent to the São Paulo Aquarium to mate with a female.

The ***ex situ*** management focused on reproduction and breeding, principally of species that appear on threatened lists, should be the most important commitment of institutions such as bioparks and zoos, since by doing so, we can form safe communities and gene banks for these species.

Strategic Alignments

In line with the principles of the Convention on Biological Diversity and the UN's Global Compact, contributing to SDG 15 (Life on land) and priority action 16. Forest policy, control of deforestation and corridors of biodiversity of Agenda 21.

Photograph: Ricardo Teles

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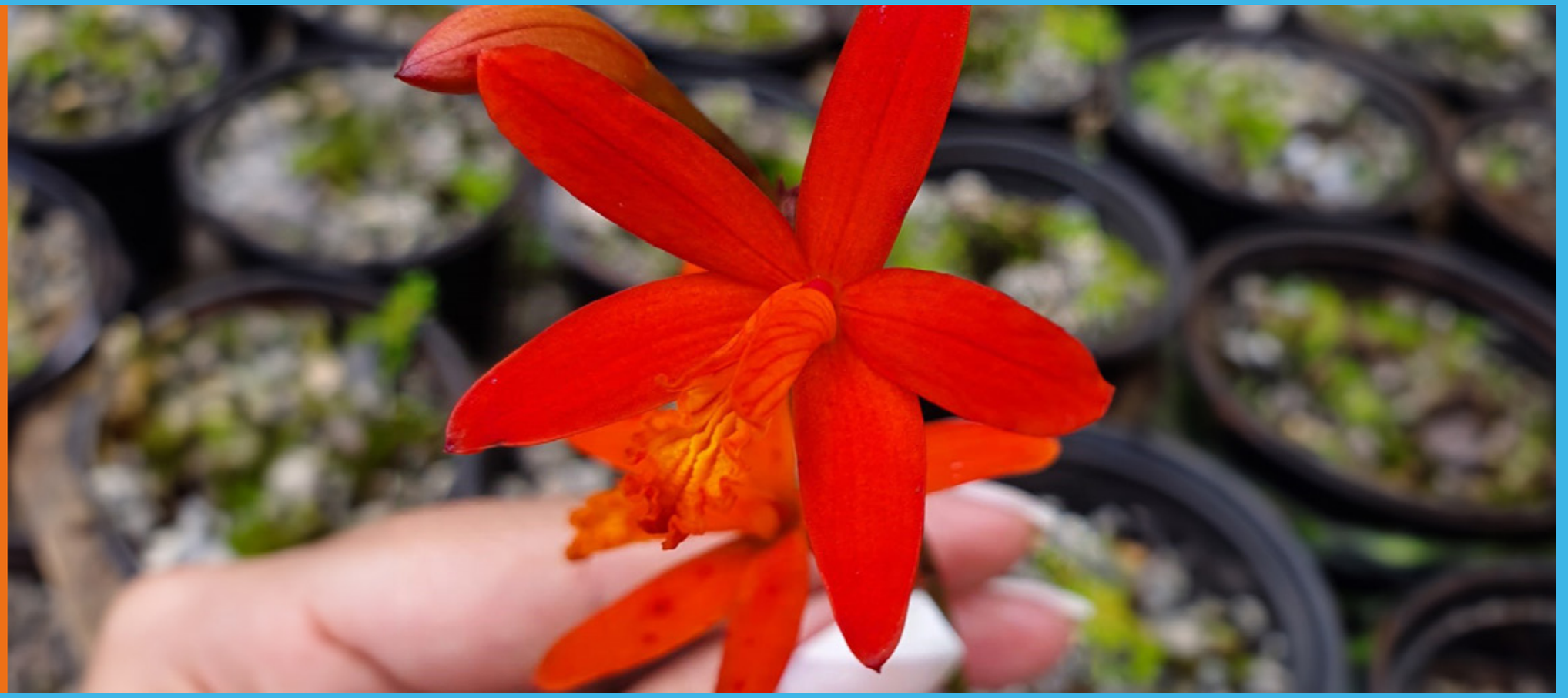

Micropropogation protocol relating to the *Cattleya milleri*, a critically endangered species endemic to the Quadrilátero Ferrífero

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Institutions Involved:

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Introduction

The *Cattleya milleri* is a species of orchid found in the Ferruginous Rocky Fields of the Quadrilátero Ferrífero region of Minas Gerais. The species is currently classified as critically threatened with extinction, above all due to the limited geographical region in which it is found, the damage that its natural habitat has experienced, and the reduced number of natural populations. The establishment of propagation and growing methods that allow the species to multiply on a large scale is a crucial stage in its ***ex situ*** conservation, its flowering in natural areas, and the continuity of the species in its natural habitat. Despite not being associated with any conditions imposed by the environmental organs in relation to activities developed by the company, through the Ferrosos Technology Center (CTF), Vale has worked to develop a methodology that allows for the generation of new *C. milleri* plants for studies on the natural population enrichment adaptation as a means of voluntarily contributing to the conservation of the species.

Methodology

The *Cattleya milleri* micro-propagation protocol was developed at Vale's Bio-factory, located at the CTF/Nova Lima. Specimens of *C. milleri*, collected from the region in which the species grows naturally, in the municipality of Itabirito (MG) were grown in a greenhouse at Vale's Native Species Saplings Production Center in Nova Lima to obtain workable seedlings. These plants are kept as seed trees, being further cultivated to obtain seeds and develop saplings. Based upon the seeds produced at the greenhouse, an in vitro propagation protocol was developed in accordance with the following stages: disinfection of plant matter, definition and preparation of the culture medium for orchids, inoculation of the seeds, and transfer to the growing room. Following the replanting cycles, performed by means of the picking out that follows the growth of the seedlings and consumption of the medium and nutrients, those seedlings that reach the ideal size were transferred to acclimatization areas in an external environment (Image 2). At this stage, the plants were exposed to fluctuating atmospheric conditions and planted in a substratum that allows for the roots to further develop. Saplings that grow satisfactorily, developing new roots and leaves, are then prepared for their definitive planting in their natural habitat. This reintroduction is performed in previously selected locations which offer the best conditions for adaptation of the species or in areas where the species occurs naturally but where there is a need for development of the natural populations (Image 3). Regular visits are made to the areas where the plants have been reintroduced to verify their survival and recruit new specimens.

Image 1.
Cattleya milleri
saplings cultivated in the laboratory.

Image 2.
Cattleya milleri
saplings undergoing acclimatization.

Image 3.
Cattleya milleri
plants having been reintroduced into nature.

Results

The in vitro germination and growing of the *C. milleri* led to the creation of a large number of workable seedlings. At this stage of the micro-propagation, through the use of the seed trees kept in the greenhouse, it has so far been possible to obtain more than 3,000 seedlings. The acclimatization process is ongoing, or in other words, as new lots of seedlings reach the ideal size for transfer, they also demonstrate good survival rates of above 90%. Of this group of plants that grew successfully during the acclimatization phase, the first lots were transferred to the field for assisted reintroduction in rocky regions. The success of this process has been demonstrated by the high survival rates of the species after having been planted in their natural habitats. The results obtained from this study are pioneering for the propagation of the *Cattleya milleri* species, providing grounds for the development of management and conservation plans for this endangered species. Furthermore, the knowledge developed over the course of the process has been incorporated into Vale's activities and can now be applied to other situations that require actions of this nature. These results have been published and are in the public domain.

Strategic Alignments

Initiatives focused on the conservation of threatened species, in the form of research as well as maintenance and restoration of the populations, are fully aligned with the global agendas regarding sustainability (SDG 15, Target 15.5) and biodiversity (Aichi Target 12), and contribute to reducing the pressure on endangered species, whilst also even providing the possibility for removing them from the extinction lists. In addition to this, they are also aligned with the targets of the Brazilian Corporate Commitment to Biodiversity, principally Target 8 (enhance conservation and recovery actions with a focus on seeking a net positive impact).

The success of this process has been demonstrated by the high survival rates of the species after having been planted in their natural habitats. The results obtained in this study are pioneering for the propagation of the *Cattleya milleri* species.

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Photograph: Adobe Stock

Reuse of organic waste in the recovery of damaged areas and in agriculture

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Introduction

Around 79 million tons of municipal solid waste (MSW) is generated in Brazil each year, with organic waste representing more than 45% of the total. Most of this organic waste is disposed of in sanitary landfills or in irregular waste sites, demonstrating a significant demand for new landfills and being one of the causes that make universalization of solid waste management so difficult. Due to these challenges and considering the targets established in public policies relating to the Sustainable Development Goals (SDGs) set forth in the UN's 2030 Agenda, a proposal was developed to reuse organic waste in the form of projects that pursue three different technological paths: the employment of biosolids produced from the sludge arising from wastewater treatment stations (WTSs), the anaerobic biodigestion of organic waste, and the composting of organic waste by means of the passive aeration method.

The biosolids, the digestate of the biodigestion and the products arising from composting, all rich in organic materials and micronutrients, can be applied in the recovery of damaged areas (SDA) and on farmland, being reintroduced into the production chain as part of a circular economy. The reuse of waste as bio-fertilizers can also support the local economy in the productive activities of communities where agriculture is the leading source of income.

Methodology

Different methodologies were applied using three technological approaches for the management of Organic Solid Waste (OSW).

- **Utilization of WTS sludge biosolids** The wastewater treatment centers serving the Metropolitan region of Belo Horizonte produced roughly 700 t/year of sludge. This product, when properly treated, possesses enormous potential for reuse due to the richness of its macro and micro-nutrients and organic matter. This project aims to provide a sustainable and innovative solution focused on the combined demand for waste management and the need to recover damaged areas.

  Agronomic and Environmental Aspects: profiling of organic fertilizers and soils; selection of sanitary wastewater sludge; definition and application of portions of sludge; sampling and evaluation of the soils; analysis of the leachate and mapping of areas that are environmentally suitable for application of the sludge.

  Economic Aspects: Development of an economic network of supply and demand and evaluation of the lowest cost form of fertilization.

- **Anaerobic treatment of organic waste with production of biogas:** a centralized OSW treatment unit was proposed, involving the following processing stages: waste collection logistics; treatment of the waste by means of anaerobic biodigestion; generation of energy from biogas; and application of digestion on SDAs.

- **Composting of organic waste in passive aeration compost piles:** This project was developed in partnership with the Recycled Waste Collectors' Association, including: development of an economically viable technical project and business model for composting in Compost Piles with Architecture Designed for Aeration; mapping of the origins of organic waste, with such arising either from Vale's own areas or from local vegetable producers; implementation of a composting patio; monitoring of the operation by controlling variables such as temperature and the quality of the compost generated; and economic and viability analyses of the project for production of 20 t/month of organic compost based upon 110 t/month of OSW.


Photograph: Adobe Stock


Photograph: Leonardo Silva Tavares

Results

- The content of organic matter, fertility of the soil and other indicators analyzed increased significantly following the application of the bio-solid;
- Bio-fertilizers have lower rates of leaching compared to organic mineral fertilizers, thus making them environmentally much safer;
- GHG reduction: for every 3 tons of organic waste that is not sent to sanitary landfills, there is a reduction in emissions of around 1.8 tCO_2eq.
- Energy generation: the anaerobic digestion of one ton of organic waste produces approximately $3m^3$ of biogas, which can be converted into electricity.

The use of bio-fertilizers resulting from the treatment of organic waste plays an important role in the advancement of the circular economy. The recycling of organic matter and nutrients benefits improvements in the quality of the soils and reduces the dependence on non-renewable fertilizers, since it contributes to greater longevity of deposits of minerals such as phosphorous, an essential resource in the production of nutrients. There are also positive effects that take place in the preservation and recovery of areas due to the reduction of negative impacts in different environments.

The bio-fertilizers perform a crucial role in the decarbonization process and in the reduction in the greenhouse gas emissions, since they reduce emissions from landfills as well as the need for conventional fertilizers that involve intensive energy consumption and CO_2 emissions.

This project offers enormous potential for replication due to the convenience of the solutions and the broad range of needs requiring proper OSW management. The products are employed in both the recovery of damaged areas and in agriculture. Similar projects can be replicated for the development of the communities neighboring Vale's operations, due to the prevalence of agricultural activities in these regions.

Strategic Alignments

The results of this type of reuse activity are related to SDG 1: eradication of poverty; SDG 2: zero hunger and sustainable farming; SDG 8: Decent work and economic growth; and SDG 12: sustainable consumption and production.

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This project offers enormous potential for replication due to the convenience of the solutions and the broad range of needs requiring proper OSW management The products are employed in both the recovery of damaged areas and in agriculture. Similar projects can be replicated for the development of the communities neighboring Vale's operations, due to the prevalence of agricultural activities in these regions.

Photograph: Isaque Junior

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Photograph: Isaque Junior

Literacy Trails

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Introduction

The 'Literacy Trails' is a project developed by the Vale Foundation, in partnership with the FGV, that aims to contribute to the improvement of children's learning, with a special focus on the literacy cycle. To achieve the results hoped for, we believe that a social mobilization process is required that involves the schools, the families and the community, strengthening social ties and creating spaces in which knowledge can be recognized.

Methodology

The Literacy Trails methodology is founded on the hypothesis that, for the literacy processes to be more successful, it is essential that the knowledge in the community be shared by the school. To achieve this, the strategies of the project that most support this methodology are as follows:

School Territorial Movement – This involves the activities by means of which the knowledge that the students produce is shared across the community. Everyone is involved in these actions, which strengthen social ties, creating opportunities to recognize intelligence and talent. Artistic and cultural groups as well as local entrepreneurs play an important part in our activities. Every year, two socializing activities take place (one each semester), that can take the form of cultural or scientific exhibitions, sustainable development fairs, forums or thematic days, amongst others. Each of these activities are organically tied in with the skills that are being developed in the literacy process, in line with the National Standard Curriculum Base (BNCC).

Identity and Culture – A multimedia web environment dedicated to the presentation and sharing of cultural expressions and dynamics within the operational sphere of the project. These dynamics include cultural practices, traditions, methods, vocabularies, rhythms, shared memories, different languages and the whole range of cultural experience that each of the students and teachers discovers, perceives, invents and shares.

***'Falares'* (Expression)** – This activity aims to provide support for the literacy work, not only identifying the meanings of regional words and expressions, but also understanding the contexts in which they are used. Within this context, it is necessary to establish what the student brings to the classroom from their native language and the expressions common to the region, in order to share this rich linguistic heritage, creating a memory of words that express the way of being, and the feelings and customs rooted in their state and people.

Literary Circuits – These activities are designed to share the texts created in the classrooms. In each municipality, there is a space for the exhibition of the individual and collective work developed by the students and teachers, with talks and presentations by local writers, as well as awards.

Image 1.
Students supported by the Literacy Trails project.

The Literacy Trails methodology is founded on the hypothesis that, for the literacy processes to be more successful, it is essential that the knowledge in the community be shared by the school.

Taking Care of Myself, Taking Care of my Land – This involves activities that involve the multi-dimensional nature of environmental education, encouraging the children to understand the relationship between taking care of themselves and others as well as the planet (BNCC).

Results

In Pará, during the first quarter of 2023, around 32,600 students, attending 262 schools, benefited from the Literacy Trails program. In Maranhão, in 2022, around 18,000 students, attending 315 schools spread across the 24 municipalities located along the Carajás Railroad, benefited from the Literacy Trails. In the first quarter of 2023, 59,000 students attending 1,143 municipal schools, benefited from the Trails program. In Maranhão, where the Trails project has been under way for longer, proven results have been observed in the children's learning. The results of the Reading Fluency evaluation, applied to children in the 2nd grade of primary school, showed that the municipalities implementing the Trails had a higher percentage of "fluent readers", when compared to the total across Maranhão and with municipalities that have not implemented the Trilhas project.

Strategic Alignments

The Literacy Trails project is aligned with the 2030 Agenda, due to its further development of strategies designed to bring about Vale's social goal of being a partner company in the development of independent communities, whilst also being aligned with SDGs 4 and 17.

Image 2.
Students supported by the Literacy Trails Project.

In Pará, during the first quarter of 2023, around 32,600 students, attending 262 schools, benefited from the Literacy Trails program. In Maranhão, in 2022, around 18,000 students, attending 315 schools spread across the 24 municipalities located along the Carajás Railroad, benefited from the Literacy Trails.

Image 3.
Students supported by the Literacy Trails Project.

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Photograph: Isaque Junior

'*Quebradeiras*' – Babassu coconut crushers: a multidimensional look at traditional Maranhão communities

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Introduction

The '*Quebradeiras*' project was created and developed with the aim of generating a fully-comprehensive sense of wellbeing, whilst also generating positive and long-lasting results in terms of income, education, health, nutrition and infrastructure in the numerous communities of female babassu coconut crushers. This project also contributes to the appreciation and recognition of the importance the female babassu coconut crushers in Maranhão state in the form of community entrepreneurship, the social monitoring of families, and improvement of living conditions, amongst other approaches. Organization of the bamboo crushers' movement, together with the added value of the babassu as a product of socio-biodiversity in Maranhão, arising from the traditional primary extractivism in the Amazon and Cerrado biomes, is providing these women and communities with a means of socioeconomic empowerment. Babassu collection is based upon sustainable extractivism, involving the gathering of coconuts after they have fallen, meaning the practice is in harmony with the people and the local biome (Image 1). When the activity is performed in line with the proper processes and management, it has the potential to not only preserve, but also improve the native vegetation of the Amazon and Cerrado biomes. Over the years, the babassu value chain pursued by the female coconut crushers and recognition of the rights of the local traditional communities have driven public policies and regulations for conservation of the native babassu forests, such as, for example, in the form of extractive reserves (RESEX) and free babassu laws.

Methodology

The project takes a multidimensional approach which initially aims to remove people from conditions of poverty in the long-term, taking into consideration the intrinsic complexity of the crushers, in which a variety of elements and players interact, promoting the women's autonomy by means of a bioeconomy that develops a comprehensive sense of wellbeing for families and communities, whilst also reinforcing maintenance of the local socio-biodiversity.

The first steps involved the definition of certain communities of coconut crushers in greater conditions of social vulnerability. Once this had been established, these communities were divided into two groups. The first stage of the project consisted of a diagnosis of the communities, visiting each of the coconut crusher families in order to better understand their situations. Following this process, meetings began with those participating in the project (in groups and individually) to be able to put together a family monitoring plan. This plan incorporates the Vale Foundation's strategy for operating with each family that it will be accompanying over the course of the project. This complex strategy includes the community entrepreneurship, living status, sustainable production and social empowerment.

Photograph: Isaque Junior

Image 1.
Babassu coconuts collected under the sustainable extractivism method, soon after the fruit has fallen.

Results

The principal aim of the project is to remove these families from conditions of poverty, enabling decent living conditions and supporting sustainable production as an integral part of the Amazon and Cerrado biomes, by means of the extraction and processing of the babassu coconut. The crushers work within a multidimensional methodology framework. As such, we have activities in the areas of healthcare, social welfare, housing, food security and income generation. Being a project that contributes to Vale's social ambitions, the indicators used seek to evaluate violations of rights and to what extent the family will, in the future, manage to be able to move out of its situation of poverty following participation in the project. At this initial stage, the project aims to work together with 450 families, all of which are located in the following seven municipalities along the Carajás Railroad, in Maranhão: Alto Alegre do Pindaré, Vitória do Mearim, Tufilândia, Monção, Pindaré Mirim, Santa Inês and Igarapé do Meio. In total, 16 communities are being considered for the initiative, although this number may increase over the course of the project. There are 460 families currently participating in the activities and benefiting from interventions founded on the following pillars:

Healthcare and Social Welfare: Community and individual construction of the Family Empowerment Plans, consultations and guidance for the Social Welfare System (Suas), social welfare actions, a mobile Social Welfare Referral Center (Cras) in partnership with the municipal governments, and theme-based actions (Women's Day and Pink October, amongst others).

Community entrepreneurship and food security: Exchange programs designed to understand community businesses, seed-capital, inputs and equipment, workshops and mentoring aimed at learning new practices and definition of businesses. Areas of activity defined so far:

- **Community Nursery:** two collective businesses involving 16 families (Image 2);
- **Nutrition (babassu processing and products, fruit pulp and pepper production, and a snack bar):** four businesses involving 15 families and 39 family businesses;
- **Handicrafts (involving parts of babassu and crochet):** two collective businesses involving five families;
- **Family farming (rice, multi-crop farming, horticulture, fish farming, plant seedlings and poultry farming):** two collective businesses and 35 family businesses.

Sustainable Housing 113 people have already taken part in theme-based workshops, 38 families have received sanitation kits, with another 111 kits in the process of being installed, 35 families have received means of improving the quality and supply of water, with another 114 of these systems in the process of being installed, and 149 technical visits have been made to the properties. Furthermore, a number of community chlorinating devices, safer and more sustainable stoves and community internet points have been implemented.

Strategic Alignments

This initiative was planned with the intention of focusing on SDGs: 1, 2, 3, 4, 5, 8,10, 11 and 17.

Photograph: Alexandre Rezende / Nitro

Image 2.
Implementation of community nurseries to ensure food security for the participating communities.

The principal aim of the project is to remove these families from conditions of poverty, enabling decent living conditions and supporting sustainable production as an integral part of the Amazon and Cerrado biomes, by means of the extraction and processing of the babassu coconut.

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Photograph: Isaque Junior

Women of Maranhão Network: culture and tradition as part of the generation of income in the Maranhão Amazon Region

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Institutions Involved:

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Introduction

The Women of Maranhão Network (RMM) is a form of social technology created and implemented as a social, environmental and economic project that contributes to the process of constructing alternatives for the socio-productive inclusion of women who had previously been itinerant salespersons along the Carajás Railroad and extractivist babassu coconut crushers.

The social businesses that make up the Women of Maranhão Network mostly involve women who had previously sold products to passengers through the train windows (Image 1). With the modernization of the train in 2015, the windows were sealed shut and these women lost their main source of income.

The RMM was created as a means of ensuring sustainability for 15 social businesses consisting of four groups of babassu coconut crushers, providing a solid identity structure amongst the entrepreneurs and a focus point for local cooperation. The Vale passenger train is the RMM's main partner for collective sales, boosting family income, the social development of the region, the formation of a network of social businesses, as well as the strategy of inclusion aimed at productive groups in the meso-markets and macro-markets, and in gender empowerment and sustainable extractivist practices that contribute to the socio-biodiversity of the Amazon region, preservation of the babassu coconut plantations and local cultural wisdom.

In 2022, the RMM was considered in the selection process for the Amazonia Fund's 29th public call notice for the Promotion of Ecosocial Productive Landscapes (PPP-ECOS), being represented by the "Kernels from the Babassu: promoting the way of life, income and organization of the Sumaúma crushers" project . At the end of February, in Manaus, the initiative was one of six winners in the "United Earth Amazonia" awards (considered to be the "Green Nobel"), for its emphasis on the bioeconomy of the Amazon region, contributing to social inclusion and forest preservation.

Image 1.
The Women of Maranhão Network mostly involves women who had previously sold products to passengers through the train windows on the Carajás Railroad.

Photograph: Isaque Junior

Image 2.
The Women of Maranhão Network, which creates products from the babassu coconut and other sustainable bio-products.

Methodology

Through use of the 'AGIR' program, a Vale Foundation technology designed to support social businesses, the groups were able to adapt themselves to the new scenario, get their businesses properly structured, and encouraged to develop their cooperative and associative aspects as part of a network. As a means of extending the AGIR Program, the Women of Maranhão Network has allowed the women to take back control by boosting their productive activities, bringing groups of babassu coconut crushers into the Network and accessing new markets. The businesses underwent different phases of support since their founding, including incubation and current growth.

Results

The RMM includes 16 businesses located in eight towns in Maranhão, generating income for around 154 female entrepreneurs and their families. They also directly and indirectly contribute to the turnover of the bioeconomy of the local community. Their products spread the name of the babassu coconut and the traditional culture of the state to different parts of the country and the world. The majority of the businesses use the babassu coconut as their raw-material, which is farmed by the local coconut crusher communities, which are mostly responsible for the upkeep of this species as the symbol of Maranhão and maintaining the standing forest. All of the businesses supported by the Women of Maranhão Network are acutely focused on preserving the nature that exists in the communities in which they live and work. The coconut crushers are at the forefront of the babassu preservation work being performed in the state of Maranhão. Their work encourages and collaborates with the conservation of the species, whilst respecting the ecosystem and the seasonality. The sanctioning of the Free Babassu Law is a victory for all the babassu coconut crushers throughout the state of Piauí since it prohibits the felling of babassu palms, provides the agro-extractivist communities with free access to the plantations, prohibits the use of crop dusting with pesticides, prohibits the burning of plantations and the cutting of whole coconut clusters since this hampers the reproduction and existence of the palm trees as well as the traditional sustainable ways in which the babassu coconut is used and undermines other benefits to the environment and the traditional communities. The RMM supports female economic empowerment, since the majority of the members are women and crusher communities, in which the crushing of coconuts has traditionally been a female skill and practice. It has also worked to ensure improvements in the crushers' working conditions, making suggestions for innovations in their activities and supporting diversification in the different items produced from the babassu coconut raw material. Whereas previously the crushers had worked exclusively on the extraction and crushing, they are now owners of micro-businesses producing items such as mesocarp (flour), oil and cookies, and selling them directly to end consumers and companies.

Strategic Alignments

The manner in which the 'Women of Maranhão Network' project is set up means that it is aligned with a number of the UN's SDGs: 1, 2, 3, 5, 8, 9, 10, 11, 12, 15 and 17

Photograph: Isaque Junior

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Photograph: Washington Alves

Large scale forest restoration: Planting of trees to maximize environmental gains in a manner which is socially equitable

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Introduction

Restoration of the tropical forest is necessary in order to reduce social inequalities, mitigate climate change and protect biodiversity, but the high costs involved in planting trees is an enormous obstacle to its large-scale implementation. Due to this situation, the natural regeneration of forests is a cheaper alternative, even though its success depends on the environmental, social, economic and political context. A recent study discovered that 22 Mha of damaged areas in the recognized hotspot of the Brazilian Atlantic Rainforest has the potential for self-regeneration (Crouzeilles *et al.*, 2020).

The Native Vegetation Protection Law ('LPVN', also known as the Forest Code) aims to protect ecologically sensitive regions (Permanent Preservation Areas - PPAs) and designate a specific portion within each private property for conservation of the biodiversity and provide ecosystemic services. These areas are called 'Legal Reserves' (LR). The legal reserve of the Atlantic Rainforest, for example, covers 20% of the total area occupied by medium-sized and large properties. To fulfill their ecological functions, the PPAs and LRs need to be covered by native vegetation and, in the event they be damaged, should be restored for the properties to meet certification standards.

As the potential for natural regeneration depends principally on the forest cover of the region (Crouzeilles *et al.*, 2020), it is understood that those PPAS and LRs in regions with less remaining forest cover have less chance of regenerating naturally than regions with greater forest cover. As such, natural regeneration itself would not be able to remedy all the environmental deficits that exist in Brazil. It is also expected that the potential of damaged areas to regenerate naturally is greater in areas where small farmers operate (marginal areas) than in areas that have been highly developed by large-scale producers. As such, the prioritization of natural regeneration cannot be the best strategy with which to intensify the forest restoration activities in the Atlantic Rainforest, since it could disproportionately affect small farmers and specific soil uses. Above all, the prioritization of natural regeneration could become less economically viable than alternative methods, since it only involves the evaluation of the implementation costs, without taking into account the opportunity costs, or in other words, the monetary sums that the farmer fails to earn whilst restoring a certain area.

The aim of the study was to compare the environmental and social consequences of different scenarios in order to intensify the Atlantic Rainforest restoration activities, including: (i) the sole prioritization of natural regeneration to save on costs concerning implementation; and (ii) the reduction of the environmental debt (PPAs and LRs) to maximize the environmental result. Within the latter, areas in addition to the forest restoration were selected due to the lower total cost (implementation costs plus opportunity costs). As part of this, ITV researchers, in partnership with ESALQ/USP, analyzed the soil use and cover, the boundary maps and the distribution of the areas that could, potentially, regenerate naturally. They compared the environmental performance, the future distribution of the forest cover between the municipalities, and the distribution of the restoration costs between small, medium and large scale producers using four different targets (6, 8, 15 or 22 Mha) under the two scenarios.

Methodology

To compare the two previously established scenarios, the researchers used data sources that are freely available to deduce the use and cover of the current areas (MapBiomas, Souza *et al.*, 2020) and boundary maps (Sparovek *et al*. 2019). They also use raster data offering information on the potential of forests to naturally regenerate (Crouzeilles *et al*. 2020) and information from the municipalities to map all the PPAs within the biome (Gastauer *et al*. 2021). All the maps were created at a resolution of 30 x 30 m.

The researchers performed a pixel by pixel analysis to gauge the potential for natural regeneration under different types of land use, in the damaged PPAs and under different classes of land ownership. They have estimated the opportunity costs (in US$) for the forest restoration for each pixel of the current land use based upon the gross amounts of the municipality for the farming of cattle and primary agricultural crops (2015), divided by the area of the use of the specific land within the municipality (Gastauer *et al*. 2021). Finally, the implementation costs were estimated based upon the area's regeneration potential; an area offering 0% in terms of natural regeneration bears costs of US$ 5,482 per hectare, and an area with 100% of potential would have no implementation costs. The implementation costs were divided by 20 to obtain annual costs that could be added to the annual opportunity costs to obtain the annual total restoration costs.

Photograph: Salviano Machado

Compliance with the LPNV was calculated for each property. If any deficit were detected in the legal reserve, the areas associated with the total lower costs (implementation and opportunity) were suggested for restoration of the LR, ignoring the possibility of compensation for PPAs being made on neighboring properties. Finally, the percentage of natural and restored plant cover was calculated in each municipality.

Results

A total of 15.63 Mha of PPAs in the Brazilian Atlantic Rainforest were mapped, of which 6.97 Mha have no natural vegetation cover. Together with the damaged LRs, the total environmental debt of the Atlantic Rainforest is thus estimated at 8.31 Mha, of which just 37.92% has a potential for natural regeneration (Image 1). Furthermore, the potential for the regeneration of forests is not distributed proportionally between the different classes of land use, with the greatest potential being found in the categories of Agriculture and Pastureland Mosaics, Other Temporary Crops, and Pastureland (Image 1).

As such, the prioritization of natural regeneration as a means of intensifying Brazilian commitments to the restoration of the Atlantic Rainforest (Scenario I) would disproportionately overburden small rural properties and specific types of land use, such as Agriculture and Pastureland Mosaics, typically associated with family and subsistence farming. Above all, Scenario I would result in higher annual opportunity costs per future unit of arable land for small rural properties than for medium or large properties.

As well as distributing the restoration efforts more fairly between the different classes of land ownership, Scenario II would result in forest cover that is better distributed across the biome, reducing the number of municipalities with low vegetation (20%) and very low (10%) cover compared to Scenario I. These data show that the prioritization of natural regeneration disproportionately burdens small rural properties. Scenario II, on the other hand, which balances natural regeneration and the planting of trees to fulfill environmental debts, minimizes the total restoration costs and is socially fairer. Eradicating the entire Atlantic Rainforest debt, Scenario II leads to three important benefits:

- The restoration of PPAs and LRs, mostly by means of active restoration, ensures the regularization of the properties and the owners' access to credit and domestic and international markets;
- As the PPAs and LRs are areas that are protected by law, their restoration guarantees the permanence and protection of secondary forests against future deforestation;
- As it focuses on regions and municipalities with low or very low remaining plant cover, Scenario II would better distribute the ecosystemic services across the biome.

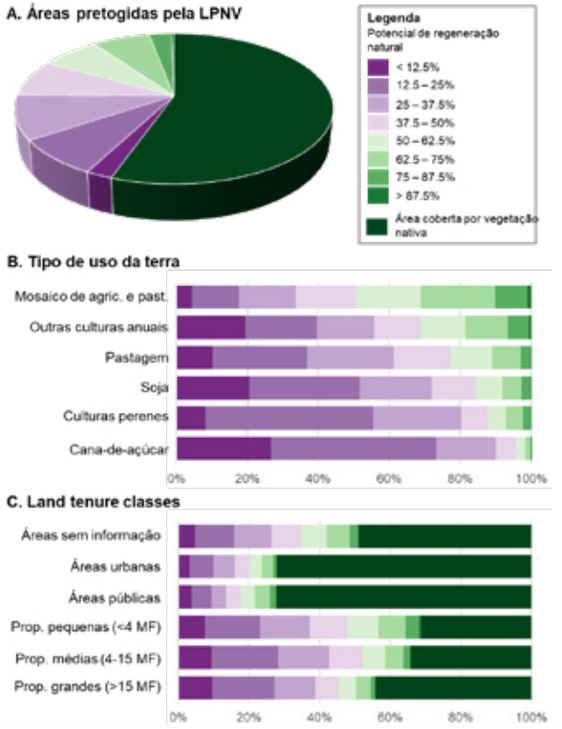

Image 1.
Potential for natural regeneration in areas protected by the LPNV (PPAs and LRs) (A); in different types of land use (B); and in different land classes (C). Adapted from Gastauer; Miazaki; *et al*. (2021).

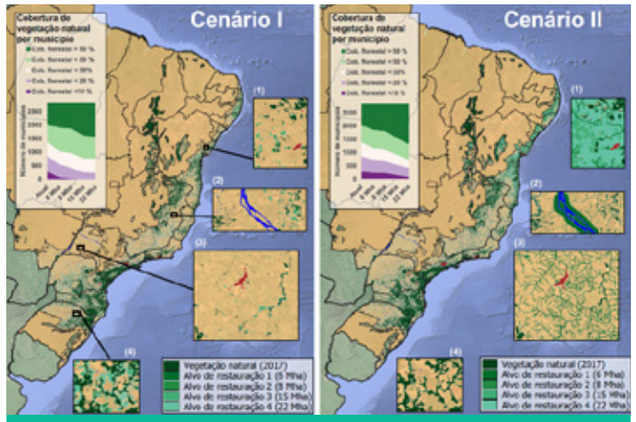

Image 2.
Spatial results of two forest restoration scenarios (see methods for details) for the Brazilian Atlantic Rainforest considering four targets that differ in the sizes of their restored areas (6, 8, 15 and 22 Mha). The maps incorporated show the differences in the results achieved between the restoration scenarios in the north of Bahia (1), the River Doce basin (2), the interior of São Paulo state (3), and the Serra Gaúcha region (4) The boxes within the images illustrate the percentage of native vegetation by municipality upon reaching different restoration targets. Adapted from Gastauer; Miazaki; *et al*. (2021).

Despite these environmental benefits, the large-scale forest restoration outlined in Scenario II is associated with lower total restoration costs that in Scenario I (Image 3). This is because the annual opportunity costs are higher than the implementation costs, meaning the selection of less productive areas in order to intensify the forest restoration makes more economic sense.

The lower environmental performance, non-compliance with the LPNV, greater burden on small farmers and higher total costs involved in the sole prioritization of natural regeneration (Scenario I) highlight the need for the specific selection of the best strategy for forest restoration to achieve the large scale restoration of the Brazilian Atlantic Rainforest. This is because the optimization of the restoration strategy (natural regeneration and planting of saplings) maximizes the environmental, social and economic results of forest restoration.

Strategic Alignments

The study is aligned with SDG 15 (Life on land) and with the Forest Targets set forth in Vale's 2030 Agenda.

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Image 3.
Costs (in US$ billions) of the forest restoration under two scenarios for the restoration of the Brazilian Atlantic Rainforest. Adapted from Gastauer; Miazaki; *et al*. (2021).

The large-scale forest restoration outlined in Scenario II is associated with lower total restoration costs than in Scenario I (Image 3).

Photograph: Ricardo Teles

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Photograph: Washington Alves

Indigenous healthcare cycle: a path towards change in the state of Maranhão

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Partners:

Healthcare Promotion Center (Cedaps)

Institutions Involved:

[1]Vale Foundation

Introduction

The Indigenous Health Cycle is a technical cooperation program created by the Vale Foundation that aims to support Indigenous Primary Healthcare in the state of Maranhão through the donation of equipment and furniture, as well as the training and monitoring of professionals at the Indigenous centers in the municipalities of Santa Inês and Zé Doca, both of which are located near the Carajás Railroad (EFC). This Vale Foundation initiative, in partnership with the Healthcare Promotion Center (Cedaps), began after the successful experience of the Health Cycle Program which, since 2014, has been operating in more than 40 municipalities in six Brazilian states.

Methodology

The program uses participative methodologies, encouraging inter-cultural dialog, the combination of knowledge for the shared construction of solutions to local challenges (needs, demands and disputes, amongst others), language and cultural translation, and the exchange of experience and knowledge in which nature is considered to be a determining social and environmental factor for healthcare. The Ka'apor, Awá Guaja and Guajajara peoples believe that they are a part of the ecosystem, and it is from the relationship with preserved nature that the necessary conditions arise for the bio-psychosocial reproduction of these societies.

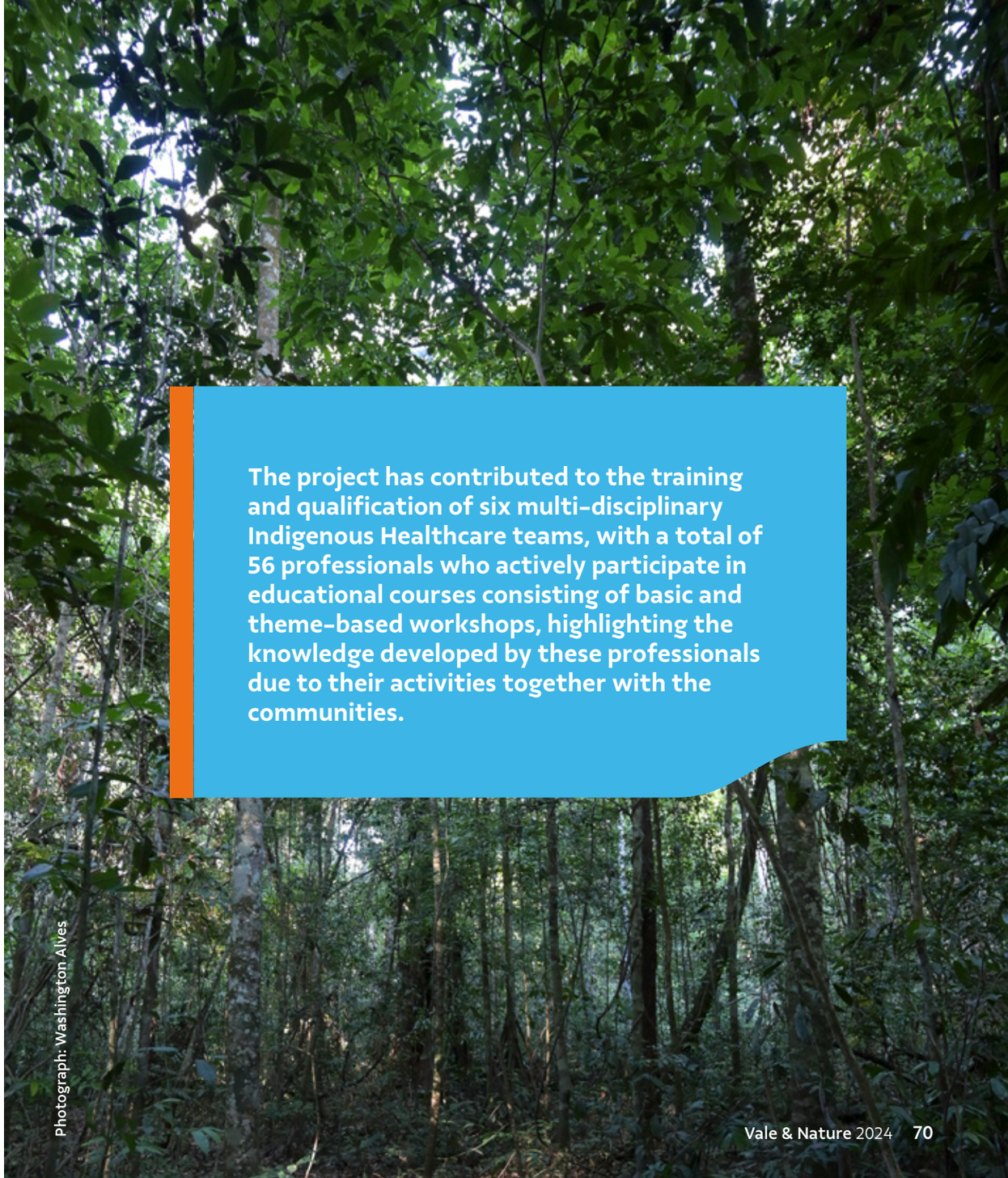
The Vale Foundation, with the support of teams from the PICT ('Vale's Indigenous Peoples and Traditional Communities), promoted the initiative as a means of increasing the actions undertaken together with the indigenous peoples with which Vale has a relationship in the state of Maranhão. Along these lines, the focus of the Indigenous Health Cycle was on strengthening the ties between the multi-disciplinary indigenous healthcare teams (EMSI) and the indigenous communities, by means of inter-cultural strategies that improve the communication, engagement and participation of the families involved. By doing so, the opportunities are increased for ensuring the right of the indigenous peoples to comprehensive healthcare that is attentive to their indigenous needs.

Results

The project has contributed to the training and qualification of six multi-disciplinary Indigenous Healthcare teams, with a total of 56 professionals who actively participate in educational courses consisting of basic and theme-based workshops, highlighting the knowledge developed by these professionals due to their activities together with the communities. Women's health, indigenous mental health, and food security are some of the themes pursued in the workshops. More than 280 pieces of equipment and furniture were also donated to eight Indigenous Basic Healthcare Units (UBSI), in support of the work of the 20 Indigenous Healthcare Workers in the area of geo-planning and the strategic use of data on the reality of the region. A number of important items were also delivered to the UBSI, including: gynecological stretchers, sonar apparatus, ophthalmoscopes, children's scales, pressure-measurement devices and vaccination kits, amongst others.

Strategic Alignments

This initiative was planned in order to focus on SDGs: 3, 10 and 17.



The project has contributed to the training and qualification of six multi-disciplinary Indigenous Healthcare teams, with a total of 56 professionals who actively participate in educational courses consisting of basic and theme-based workshops, highlighting the knowledge developed by these professionals due to their activities together with the communities.

Photograph: Washington Alves

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Photograph: Isaque Junior

Rural development center: a social technologies center of excellence in the state of Maranhão

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Partners:

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Institutions Involved:

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Introduction

The Rural Development Center (NDR) is a space created for the innovation and dissemination of rural, sustainable, social technologies that can be replicated by communities and families, with the aim of increasing access to quality food, supporting agro-ecological family farming, and productive inclusion. Along these lines, the NDRs develop a wide range of activities related to farming and the rural world, such as the management and cleaning of dams, different irrigation techniques, a seed bank and native saplings, soil preparation and bio-fertilizer tanks, jointly-operated plantations and production of bio-fortified foods, ecological sanitation, technical support and field days in service of the communities and teaching institutions, promoting the exchange of knowledge, improved production, gains in scale and strategies for commercialization and the opening up of markets.

Standing out amongst the actions developed by the NDR is the activity related to meliponiculture (the raising of stingless bees), in partnership with the State University of Maranhão (Uema) and the "***sisteminha***" ("little system"), a social technology developed in partnership with Embrapa. Under the meliponiculture initiative, the Uema researchers, together with experts from the NDR, look for alternatives to make this activity a viable and economic option that will provide families with the option to adopt it as a source of socio-productive inclusion, combining generation of income with all the environmental benefits arising from the pollination performed by the bees. In the case of the "***sisteminha***", a social technology that is also focused on family farming, the NDR experts, together with researchers from Embrapa, look for ways to ensure the families' food and nutritional safety, connecting stability and access to production with commercialization of the surplus produced, thereby facilitating the generation and increase of the family income.

Methodology

The Rural Development Center (NDR) was created to operate as a hub of excellence in social technologies focused on the primary sector, especially agro-ecological family farming. As such, all the work performed at the NDR is performed by means of the development, experimentation and implementation of low-cost, rural social technologies that can be replicated in the backyards of the families and communal areas shared by the Maranhão communities. Both the meliponiculture project (a partnership with Uema) and the "***sisteminha***" (a partnership with Embrapa) adopt a specific methodology and, as such, move through the following stages: (i) development of the social technology; (ii) tests and evaluation of the social technology with the aim of reducing production costs; (iii) tests and evaluation of the social technology with the aim of increasing its productivity and permitting economies of scale; (iv) adjustment and approval of the social technology in the field; (v) replication of the social technology by families and communities in Maranhão.

Photograph: Isaque Junior

Photograph: Isaque Junior

Results

Over recent years, the NDR has been operating on three pillars. The first involves Productive Inclusion and Innovation, offering training cycles, technical support and seed capital to more than 160 family farmers. In the pillar of Food and Nutritional Safety, the NDR has implemented more than 120 rural social technologies and supported the training of public agents working on school meals, directly impacting around 1,000 students enrolled in the municipal education system. In the pillar of Education in the Field, more than 2,200 students from state schools and federal institutes, as well as undergraduates studying at public universities, participated in Field and Technical Immersion days at the Rural Development Center. If we also take into consideration the positive impacts of the NDR's actions in the region of Arari, we can also highlight the improved food and nutritional independence of the families; the increase in the volume of sales by family farmers at the municipality's street markets; teaching practices implemented in public and private schools, institutes and universities; the advances made in studies concerning the genetics of stingless bees; and the evolution of organic production with certification seals, thereby strengthening the commitment to sustainable agriculture and agro-ecology in the state of Maranhão.

Strategic Alignments

This initiative was planned in order to focus on SDGs: 1, 2, 6, 8, 10, 11, 12 and 17.

If we take into consideration the positive impacts of the NDR's actions in the region of Arari, we can also highlight the improved food and nutritional independence of the families; the increase in the volume of sales by family farmers at the municipality's street markets; teaching practices implemented in public and private schools, institutes and universities; the advances made in studies concerning the genetics of stingless bees; and the evolution of organic production with certification seals, thereby strengthening the commitment to sustainable agriculture and agro-ecology in the state of Maranhão.

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Socioeconomic and environmental benefits obtained by means of the Shared Value Generation model, developed through the PET Project (R&D)

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Introduction

The Research and Development (R&D) project involving Vale and Ufes (Federal University of Espírito Santo) sought to create a suppressor of particulate matter using recycled PET plastic. The suppressor is obtained by means of the chemical recycling of PET plastic, transforming this post-consumption material into a biodegradable and sustainable product. This technology is currently employed in a range of different industrial-scale operations, such as iron ore stacks and wagons, as well as in unpaved access routes. In 2023, the PET-based suppressor became a reality following its commercial ratification, with the partnership formed in September 2023, between Vale and Biosolvit, a startup based in Barra Mansa (RJ), for the production of sustainable polymer, putting Porter's concept of Shared Value Generation into practice.

Vale employs the suppression of particles on a large-scale as a means of controlling the emissions involved in its processes, whilst it is also an important player in the social and environmental life of the locations where it has operations.

The suppressor is obtained by means of the chemical recycling of PET plastic, transforming this post-consumption material into a biodegradable and sustainable product.

Methodology

A number of aspects were identified including opportunities institutional cost reduction and gains; evidence of environmental gains (emissions control, sustainable disposal of waste and chemical recycling of plastic materials) and positive social impact (generation of income and opportunities for cooperatives, social engagement on the issue of waste and environmental education); and sharing of Vale's assets and expertise, in addition to the encouragement of entrepreneurship and industrial activity.

There was a need to reinforce the connection with a set of existing actions which, up until then, had been undertaken independently. An evaluation of the potential benefits of cost reduction and the increased efficiency of the particulate matter suppressor was undertaken, as well as of the opportunities for socioeconomic and environmental development that the business model offers in the regions in which Vale operates.

The starting point was the structuring of the '*Reciclo*' project, in the state of Espírito Santo (ES). The project worked to empower the cooperatives (improvements in management, manufacturing processes, certification, equipment and remodeling); environmental education (engagement and training in condominiums and companies); Vale volunteers (encouraging Vale employees to work with the organizations); training of the cooperatives in fund raising; and strengthening the local recycling ecosystem.

In Minas Gerais, meanwhile, an extensive analysis was conducted to better understand the plastics recycling ecosystem in the regions of interest, as well as the integration of Vale's waste management plan in the region (an initiative developed as part of the Environmental Management). The aim of this action is to make maximum use of the recyclable waste and ensure that it is forwarded to the cooperatives operating near Vale's operational units, thereby strengthening the cooperatives and associations, and improving their capacity to absorb recyclable materials from the neighboring mines, thereby generating social, environmental and economic impacts.

These efforts create income and opportunities for those in vulnerable situations and lead to enormous environmental gains, since they spur and strengthen public policies regarding recycling for the sustainable disposal of plastic waste, whilst also reducing the emission of particles that impact upon the communities neighboring our operations.

The partnership with Biosolvit and the sub-licensing of the technology has also allowed for the implementation of Sustainable Suppressor manufacturing plants, transforming an R&D project (Ufes) into an actual market innovation.

Results

The technical development of the use of the resin for suppression of particulate matter using PET plastic has achieved noticeable results. As well as being environmentally more sustainable, the suppressor that uses PET bottles as an ingredient (which Vale currently refers to as a 'Sustainable Suppressor') has demonstrated performance that is equal to or greater than other suppressors available on the market.

Another important result has been that the R&D project has led to the obtaining of Vale's first green patent, whilst it was also the first to sub-license a technology for use and the sharing of value. Biosolvit's first Sustainable Suppressor factory, in Cariacica, began operations in May 2024, with the aim of meeting Vale's demands in the region.

From the perspective of meeting social needs, the results obtained by the Reciclo initiative in Espírito Santo have already been made a reality. Since 2021, the '***Reciclo ES***' project has already trained, certified and increased the income of 12 waste collection associations as well as one second-level association ('***Reunes***' – '***Rede de Economia Solidária dos Catadores Unidos do Espírito Santo***'), with 580 people being directly impacted (Image 2), in six municipalities in Greater Vitória and along the Vitória Minas Railroad.

56.7% increase in the members' income

147% increase in the amount of recyclable materials commercialized

77% increase of PET handled by the associations

480+ hours of training provided

78%+ increase in the productivity of the associations (production capacity and quantity control) (Image 3)

29 public managers certified as part of the public management training

R$ 600,000 raised through call notices and partnerships

157 new recycling stations implemented

Around 60,000 people directly impacted by the new recycling stations implemented

900+ environmental education actions

In Minas Gerais:

Vale currently has a project under way, together with Boomera, providing improvements and training for eight cooperatives and associations in MG (143 cooperative members), achieving concrete results in relation to increases in the invoicing, processed volumes and average income of these institutions. This project has prepared these community enterprises to receive and process the recyclable materials arising from our operations in Minas Gerais, having a social, environmental and economic impact on the region.

There has been a study of the PET recycling chain in 22 municipalities of interest to Vale, to be able to understand the availability of the raw-material in the area covered, which involves 22 associations and cooperatives.

Strategic Alignments

As well as contributing to sustainable mining, the model in question is directly related to Vale's 2030 Agenda. The initiative is directly related to SDGs 1, 8, 9, 10, 11, 12 and 17.

Image 1. Training, certification and increased income for waste collection associations in Espírito Santo following implementation of the project.

Image 2. Waste collectors impacted by the project in the municipalities of Greater Vitória and the Vitória Minas Railroad (EFVM).

Image 3. Increased productivity amongst the associations (production capacity and quantity control) following implementation of the project.

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Photograph: Washington Alves

Bio-blankets made from the native grasses of the ferricretes of Carajás: an alternative for improving the recovery of slopes in mining areas

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Introduction

The iron ore exploration process forms cut slopes within the mines, whilst also leading to the accumulation of piles of solid waste. One way of improving the stability of the piles and slopes is to begin the recovery of these areas through revegetation. As well as the physical and chemical restrictions presented by these substrata, the incline of these areas (mainly the cut slopes) is one of the biggest challenges to native plants taking root and the consequent improvement in the environmental restrictions to recovery of the area. The technique of providing ground cover on the slopes represents a promising approach which could be used in the revegetation of mining areas. The aim of this study has been to investigate the best ways of forming biodegradable blankets, based upon the substrate arising from mining and using native species to cover the cut slopes at the mines in the Carajás Mineral Province (PMC). In this study, the *Paspalum cinerascens* species was chosen following evaluation of its potential use in the creation of biodegradable layers or blankets for application as cover for the slopes. Previous studies performed by ITVDS showed that this species grows extremely well in the remaining substrate of the Carajás mining area (following the addition of nutrients, this substrate was used to grow plants and create the base for the layers).

Methodology

The substrate produced by the mining at the PMC, following the addition of organic material and vermiculite (a mix), was used to make physical and chemical improvements, whilst the area was also treated as a means of control without the addition of these materials (Image 1).

Both the means of treatment received fertilizers (at half the amount of nitrogen, phosphorous, potassium and micro-nutrients normally applied to the areas under recovery at the PMC). Evaluation was also performed with regard to the existence of benefits arising from the consortium of *P. cinerascens* with the native liana *Dioclea apurensis*, a nitrogen fixer. The criteria used to certify the quality of the cover were also evaluated, including the capacity for fixing the carbon of the plants and the production of biomass, as well as nutritional analyses of the substrates and plants.

The technique of providing ground cover on the slopes represents a promising approach which could be used in the revegetation of mining areas.

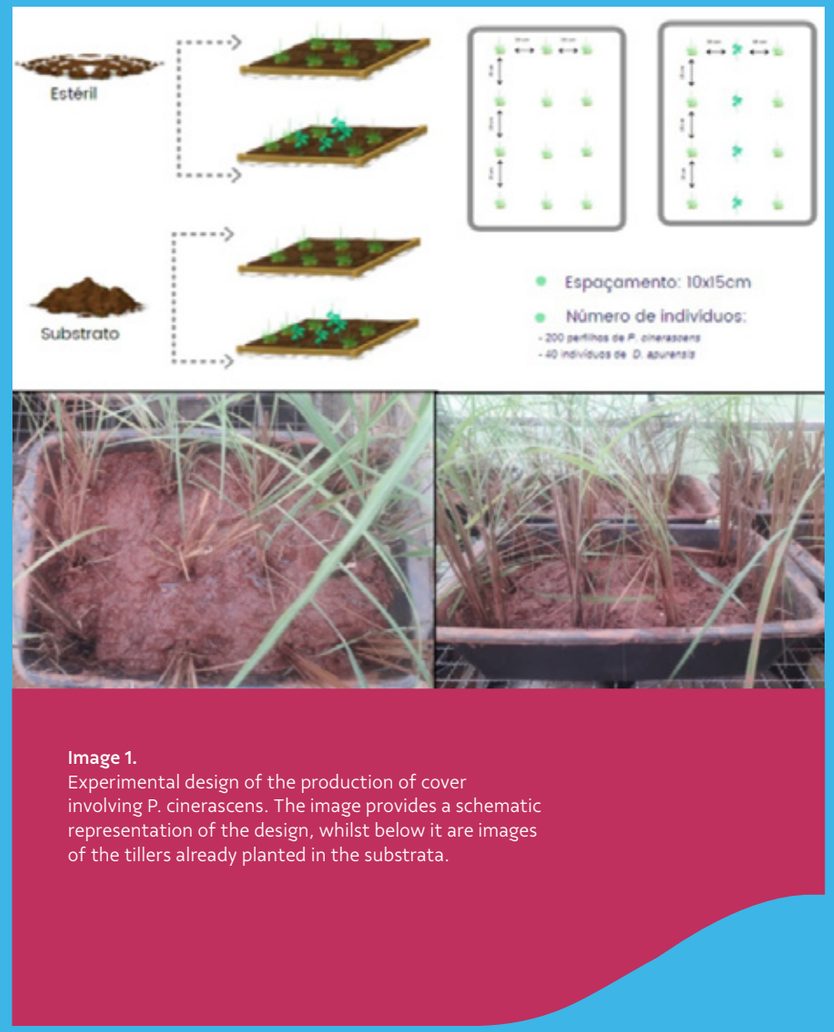

Image 1.
Experimental design of the production of cover involving P. cinerascens. The image provides a schematic representation of the design, whilst below it are images of the tillers already planted in the substrata.

Results

We have noted that the mix of substrata has increased the biomass above ground, as well as the amount and density of the roots of the cover. The consortium involving the *D. apurensis* species increased the leaf concentration of Nitrogen in *P. cinerascens* and the assimilation of carbon, but was not enough to alter the biomass. These results suggest that *P. cinerascens* is a plant offering great promise for use in the preparation of biodegradable blankets and the addition of vermiculite and organic material help the growth of this species in the substrate remaining after mining. The potential benefits of the consortium involving *D. apurensis* may not have been observed in the fertilization of the substrate (even in reduced amounts). However, the potential benefit of the inclusion of this species should be stressed, including as a means of enriching the diversity, the potential biological fixing of nitrogen, and the increase in the return of ecosystem services to damaged areas. The use of *P. cinerascens* is generally recommended for the creation of biodegradable blankets involving living plants for use in the recovery of areas damaged by mining activities in Carajás. Considering the good rates of development of this species' roots and the part growing above ground, as well as the benefits of providing immediate cover for the slopes and reducing erosive processes, these biodegradable blankets may also offer the advantage of providing environmental conditions that provide the opportunity to attract other species and accelerate the recovery process. The production of these biodegradable blankets could be an alternative to the revegetation of cut slopes at the mines and, due to the simplicity of their creation, they represent a viable alternative for implementation.

Strategic Alignments

Alignment with SDG 13 – Action against global climate change: taking urgent action to combat climate change and its impacts.

Considering the good rates of development of this species' roots and the part growing above ground, as well as the benefits of providing immediate cover for the slopes and reducing erosive processes, these biodegradable blankets may also offer the advantage of providing environmental conditions that provide the opportunity to attract other species and accelerate the recovery process.

Image 2. Demonstration of the proportion of each substrate used.

Image 3. Substrate used for creation of the cover involving *P. cinerascens* in the respective trays prior to homogenization.

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Photograph: Eduardo Perini

The importance of forest restoration in mitigation of the impacts of mining on biodiversity

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Introduction

In order to prevent losses of biodiversity and ecosystem services, the International Council on Mining and Metals (ICMM) has developed a guide to mitigating environmental impacts, called the 'Mitigate Hierarchy'. The actions are organized into four stages for the (i) Avoidance; (ii) Minimization; (iii) Restoration; and (iv) Offsetting of the impacts on the biotic environment, and should be executed in this sequence. The application of the four phases ensures the reduction and mitigation of the negative environmental impacts at all stages of the mining operation, ensuring continuity of the ecosystemic services provided by nature, as well as the roles that the different species play in the ecosystems (Image 1).

Offsetting is the final alternative to be considered, once it has been definitively recognized that it is not possible to avoid, minimize or restore the environmental damages caused or planned over the course of the project. As such, the offsetting seeks to balance only those residual environmental losses caused by the economic activity. The offsetting can be undertaken by means of recovery of the damaged areas, leading to direct gains for the biodiversity. The creation of protection and conservation programs, or the implementation of measures designed to reduce the impacts of other, similar activities, prevents any future damage to the biocenoses. The idea is that, by preventing future environmental damage, the environmental functions and services provided by the ecosystems are preserved. When the benefits generated for the biodiversity through offsetting are greater than the residual impacts, the project can lead to net gains.

The offsetting, be it by means of restoration of damages prevented, should follow the principle of ecological equivalence, or in other words, impacts should be offset by activities in the same area, during the same period and with the same biological characteristics, that is, species, habitats and/or ecosystems. This principle does, however, have limits, since no one biological community is exactly the same as any other, and some habitats require specific abiotic conditions. This means that the strict application of the principle of equivalence can be limited, especially when it concerns habitats with restricted distribution.

As such, it may be necessary to find a more flexible approach, substituting losses of certain biological elements with gains in others [Sponagel et al. (2022)], provided that the continuity of viable portions of all the different elements of biodiversity is ensured by other forms of mitigation. Or in other words, the substitution cannot be made when a project could result, for example, in the extinction of a species. In order for the substitution to be effective, it is essential that methodologies are used that can calculate the impacts caused and the results obtained with offsetting measures, in a way that is objective and can be reproduced.

In this study, we have developed a methodology to evaluate the impacts on the biodiversity and fulfillment of the 'No Net Loss' policies related to mining and large scale forest restoration in the Amazon region. Our focus was the S11D Eliezer Batista Complex, in Canaã dos Carajás, Pará, Brazil, due to its strategic importance and the socioeconomic benefits it provides for the region. As such, we gauged the alterations in the land use in the region of the spatial structure of the landscape before and after the implementation of the project. Based upon this, we calculated the biotic value to determine the gains and losses in relation to biodiversity in the region.

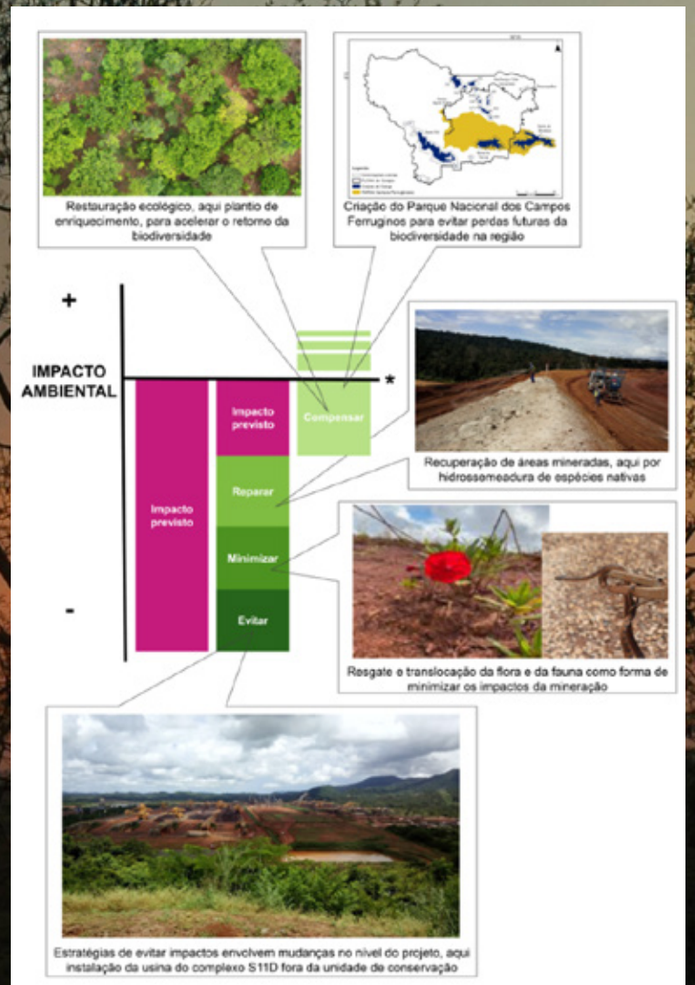

Image 1.
The principle of hierarchy of mitigation of impacts with some examples to guide the sustainable use of natural capital (Photographs: André Luiz de Rezende Cardoso, Markus Gastauer).

Photograph: Vantoen Pereira Jr.

Methodology

The area studied covered a radius of 11km around the mine and plant of the S11D Complex, including part of the Carajás National Forest. The most important native ecosystems in the region are the Ombrophilous and Iron Savannah Forests (Cangas), characterized by the highly diverse and endemic range of species that have developed above the deep laterite crusts – Giulietti *et al*. (2019). The Ferricrete regions hold deposits of iron and are the main ecosystems impacted by the iron mining, but methodologies for the restoration of these ecosystems are still not readily available [Levett *et al*. (2020)], which limits the possibilities of performing like-for-like offsetting.

In order to create the balance of gains and losses of biodiversity associated with the installation of the mining complex, the changes in soil use and cover in the area between 2008 (when the environmental impact studies began) and 2021 were detected. Following this, researchers from ITV used a recently-developed and highly innovative methodology to determine the biotic value of the different ways in which the soil had been used, an approach which summarizes the value of a specific area to the biodiversity and the ecosystemic services in a single figure, based upon its importance and conditions (Gastauer *et al*., In press). This methodology is based upon specific criteria, which include Naturalness, Rarity, Substitutability and Importance to the ecosystem structure of a specific habitat. Each criterion is evaluated independently, attributing scores varying from zero (minimum) to five (maximum) for each habitat present in the area of interest. The importance of the habitats is calculated as the sum of the scores of each criterion, divided by 20, which results in a sum which varies from zero to one.

Definition	Scoring	Ferricretes	Primary forest	Secondary forest	Livestock farming	Mined area
Naturalness – degree of human intervention in the area, or in other words, entries and extractions of energy and materials in the area, or their waste	0: Destroyed areas free of vegetation; 1: Planted areas without native vegetation; 2: Semi-natural areas such as agroforestry system or slash-and-burn agriculture; 3: Near-natural areas with altered communities; 4: Natural ecosystems with a representative composition	4	4	3	1	0
Substitutability – spatial and temporal dimension to substitute similar types of habitats in the region	Common habitats in the neighboring regions: 0: Biocenose replaceable within 1 to 3 years; 1: 3–30 years; 2: 30–150 years; 3: 150–300 years; 4: >300 years Habitats uncommon or rare in the neighboring region: 1: 1–3 years; 2: 3–30 years; 3: 30–150 years; 4: >150 years	4	4	1	0	0
Rarity/danger – spatial availability of similar habitats and their suitability for species and populations that are rare, endemic or threatened with extinction	0: widely distributed habitats and species; 1: Formations of common vegetation and species; 2: Formations of vegetation and species in decline; 3: Threatened habitats and species; 4: Large-scale remains of natural vegetation and its rare communities within the regional context	4	3	3	0	0
Importance to the structure of the ecosystem – (a) importance for migratory species and gene flow between separate populations; (b) buffering functions, for example, for conservation units; and (c) the importance to animals occupying large areas or which use different habitats or ecosystems for hiding, reproduction, feeding or hibernation	0: The area does not meet any of the three sub-criteria; 1: The area meets one of the three sub-criteria; 2: The area meets two of the three sub-criteria; 3: The area meets all of the three sub-criteria; 4: The area meets all of the sub-criteria at an above-average level	4	4	3	1	0

Table 1. Definition of the criteria used accompanied by various examples to establish the importance of habitats

As well as the importance, the methodology also considers the conditions of the habitat. To evaluate the conditions, indicators are used that are related to the structure of the vegetation, diversity of the communities (vegetation and fauna) and ecological processes (Gastauer, Sarmento, *et al*., 2021). These indicators are collected in the field and incorporated by means of a multivariate analysis of the principal coordinates. This analysis allows for the combination of all the indicators in a single measurement of environmental quality. Once the data have been ordered, the environmental quality of a specific habitat is represented by the course that has been taken, moving from the most damaged state to the benchmark natural ecosystems Gastauer *et al*. (2020) and Gastauer; Sarmento; *et al*. (2021). This approach allows for an evaluation of the current state of the habitat in relation to its recovery potential, as well as identification of the most important aspects requiring restoration or conservation.

Results

Using the methodology outlined, the researchers from the ITV conducted a landscape-scale analysis to evaluate the losses and gains of biodiversity associated with the installation of the Eliezer Batista S11D Complex in Canaã dos Carajás. Between 2008 and 2010, significant changes were observed in the land use and cover, with the suppression of approximately 700 hectares of ferricretes for the extraction of iron ore. However, the installation of the plant outside the boundaries of the conservation unit has contributed to avoiding the impacts on the natural resources. Furthermore, around 3,500 hectares of pastureland were converted into secondary forests through restoration projects. The gains in biodiversity originating from these restoration activities were greater than the losses resulting from mining, as illustrated in Image 2. These results indicate a positive balance for the biodiversity in the region studied.

Strategic Alignments

Sustainable Development Goals: SDG 15 – Life on land Global Biodiversity Framework: Target 3 and Target 11.

As well as the importance, the methodology also considers the conditions of the habitat. To evaluate the conditions, indicators are used that are related to the structure of the vegetation, diversity of the communities (vegetation and fauna) and ecological processes (Gastauer, Sarmento, *et al*., 2021).

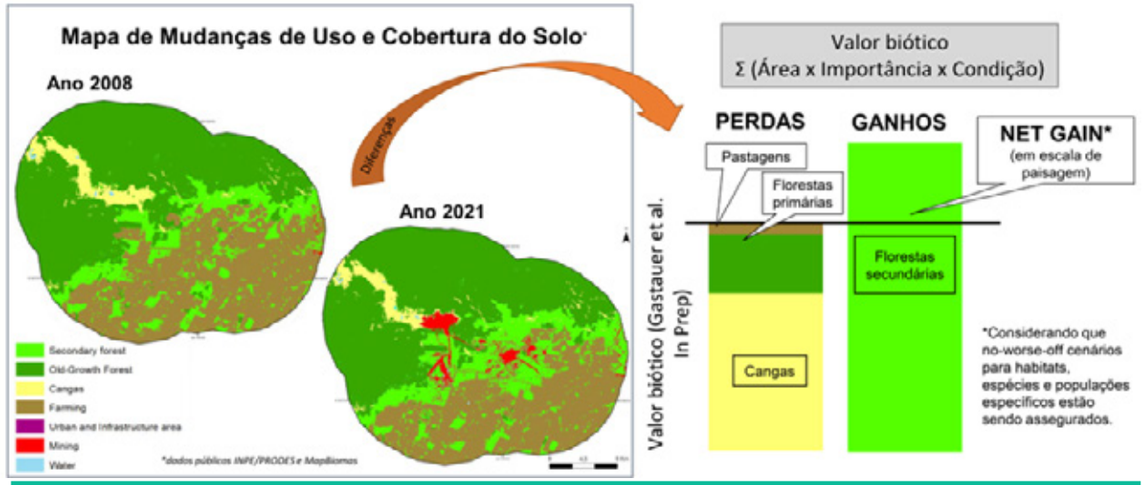

Image 2.
Methodology developed by researchers from the ITV, based upon analysis of Changes in Land Use and Cover and quantification of losses and gains for the biodiversity.

The gains in biodiversity originating from these restoration activities were greater than the losses resulting from mining, as illustrated in Image 2. These results indicate a positive balance for the biodiversity in the region studied.

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'*Mundo Meliponíneos*': Raising awareness and protection of native bees at the Vale Botanical Gardens in Vitória

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Partners:

AME (Meliponiculture Association of Espírito Santo)

Institutions Involved:

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Introduction

Located at the Tubarão Unit and associated with the operation's Green Belt, the Vale Botanical Park, in Vitória, covers a 33 hectare region of the Atlantic Rainforest. The Vale Botanical Park aims to conserve the local biodiversity and provide educational and recreational activities for the community. The space is open to the public every day, with entry free of charge. The Park area was reforested with eucalyptus trees in the 1970s (the first eucalyptus plantation in Espírito Santo to be promoted by the government) and has, for more than 20 years, been aesthetically and environmentally restored with saplings of species native to the Atlantic Rainforest, with the idea of developing an ecosystemic situation as close as possible to its original state. There are two 'meliponaries' (communities of stingless bees) in the Park, one of which is community-based, focusing on research and breeding, and another which is self-guided, allowing the visitor to discover a little more about the world of meliponiculture. We also have a 'meliponary' at the administrative center of the Tubarão Unit, allowing the employees to better understand the culture. This initiative is the result of a partnership between Vale and the Meliponiculture Association of ES (Ames). The focus of the partnership is to boost the generation of income in the local communities and the conservation of these species through sustainable management and environmental education. The members' parent colonies provide the basis for multiplication of the swarms, increasing the availability of colonies that can be multiplied in the municipalities located in Greater Vitória. The 'meliponaries' currently house 89 colonies, containing five species, amongst which two are considered to be priority in terms of breeding and associated research: the Yellow Urucu Bee (*Melipona mondury*) and the Brazilian Stingless Bee (*Melipona quadrifasciata*).

Methodology

The project began with the inauguration of the Meliponary at the Vale Botanical Park and operates on four pillars: swarm management, environmental awareness, conservation and dissemination. The first pillar focuses on management of the swarms with the main aim of multiplying the population. The management activities aim to maintain and monitor the swarms, including cleaning and caring for the hives, controlling pests and employing responsible management techniques. The most important activity undertaken within the meliponary community is breeding, which contributes to conservation, whilst also ensuring pollination of the local flora. These swarms are provided to the communities by the Meliponiculture Association, in order to encourage beekeeping in the region.

The second pillar consists of conducting activities aimed at raising the environmental awareness of the community. These activities aim to provide information on the role the bees play in maintaining the biodiversity and the impact of environmental destruction on their habitat. Through talks, visits to the meliponary and educational workshops, the visitors have the opportunity to find out more about the native bees and their importance to the environment. Providing support for these educational activities, the park has a 'honey bike', that supplies the community with a range of meliponiculture-based products, especially honey, propolis, wax, pollen and cosmetics.

The third pillar focuses on conservation of the bees and their habitat. To do so, the project has planned future studies to better understand the ecology of the bees and their role in pollination, as well as development of projects for the conservation of habitats and the creation of long-term conservation strategies. At present, the park is performing a survey of bee species to be able to implement an apiculture pasture, with the aim of adding trees that are good suppliers of nectar and pollen to the local flora. The final pillar concerns the dissemination of information on the native bees and their importance to maintaining the biodiversity. The project offers courses and talks on the subject, publishing educational materials and staging exhibitions on native bees.

The Vale Botanical Park aims to conserve the local biodiversity and provide educational and recreational activities for the community. The space is open to the public every day, with entry free of charge.

Results

This project has allowed information to be shared on the importance of native bees to both the environment and the economy. Environmental education activities were also developed for children, young people and adults in Greater Vitória, with the aim of raising their awareness of the importance of native bees to the conservation of biodiversity. These activities include talks, exhibitions, workshop and visits to the meliponary. It has also been possible to intensify the work focused on conserving and preserving the park's native bees, by means of the partnership that has been established with the Meliponiculture Association of ES, which involves the direct participation of the members in the activities. The project also contributes to the development of honey production, since it has been possible to improve the management approach taken by those involved. Finally, it provides a platform for the sharing of experiences and knowledge concerning our native bees.

The principal actions implemented by the project so far include:

- **A community meliponary** made up of the members' colonies which they are not able to keep at home. The aim is to encourage the activity of meliponiculture in the local community and provide a form of income from breeding. The project also increases environmental education, providing a means for the members of the community to learn how to manage their colonies in a way that is more sustainable.
- **Monthly meetings** with the Meliponiculture Association of ES, to address issues related to native bees.
- **Scheduled assistance for educational institutions**, as well as guided visits to the meliponary for the members of the public who visit the park.
- **Annual exhibition of stingless native bees** (Image 1): the exhibition of photographs of "Native Bees of Espírito Santo" that was staged in August 2023. In this exhibition, the photographs capture the essence of the bees in their interaction, as they perform a fundamental role in the maintenance of the biodiversity. Each image is a window on the world of bees, an opportunity to appreciate the beauty of these insects as they go about their activities. The "Native Bees of Espírito Santo" exhibition allows the visitor to discover the nuances and varieties of the species of bees that inhabit our state.
- **Fifth Espírito Santo Exhibition of Native Bees** (Image 2): This exhibition took place in August 2023 and was an event that aimed to celebrate the incredible biodiversity of the native bees of Espírito Santo. Over the two days of the exhibition, hives and some of the species of stingless native bees were displayed, and visitors could explore the individual characteristics of each of them whilst learning about their role in the pollination of plants. Workshops hosted by specialists imparted valuable knowledge about meliponiculture.

Image 1.
Launch of the photography exhibition: "Native Bees of Espírito Santo" in August 2023.

Image 2.
Fifth Espírito Santo Exhibition of Native Bees – "Pairing of honeys and cheeses" workshop

The exhibition also offered a space for the sale of apiculture and meliponiculture products, providing visitors with the opportunity to try the delicious natural products created by the bees, and different workshops including one on "Pairing honeys and cheeses"

- **Sixth Exhibition of Stingless Native Bees** (Image 3)

Image 3.
Sixth Exhibition of Stingless Native Bees.

Strategic alignments

This project contributed especially to SDGs 4, 11 and 15.

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'*Ferricretes do Araguaia*' project: Increased understanding of the rocky outcrops in the southeast of Pará state

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Institutions Involved:

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Introduction

The conservation of rare habitats containing a high level of endemic species, such as ferricretes, known in Brazil as '***cangas***', require the compilation of information to understand their spatial distribution and biological diversity. Recognizing the importance of these habitats to biodiversity, Vale has increased the studies of ferruginous outcrops beyond its boundaries. The '***Ferricretes do Araguaia***' (FA) project is made up of field activities and remote monitoring of areas located in the River Araguaia Valley, the southeast of the state of Pará, and is focused on increasing understanding of the distribution of these outcrops and their biota, as well as recognizing the different types of vegetation and evaluating their state of conservation. This case presents the most important results obtained since the project began.

Methodology

In 2021 and 2022 six field campaigns were performed, in the rainy and dry seasons, generating 3,054 exsiccatae (plant samples used in botany studies). The identification of geo-environments follows the classification put forward by Schaefer (2016), whilst the classification of vegetation follows that recommended by Mota *et al*. (2015).

The following data were included for mapping of the vegetation in ferruginous outcrops:

- Regional geological map (scale – 1: 1,000,000);
- Digital Elevation Model (Alos Palsar 12.5m, assuming a minimum elevation of 200m);
- Landsat/TM image classification (spatial resolution of 30 m), 1990, and Landsat/OLI, 2023, to detect human losses and/or alterations of the rocky outcrops.

Following this, the Normalized Difference Vegetation Index (NDVI) (Shimabukuro and Smith, 1991) was used to classify vegetation according to the vigor of the growth.

Results

278.62 km² of ferricrete environments were mapped, along with 80.53 km² of human alterations, meaning roughly 200 km² of conserved ferricretes in the Araguaia Valley. In this preliminary phase, the Open and Shrubbery Rocky Fields were differentiated from the Savannah land (Image 1). The variations in the vigor of growth of the vegetation can be noted, ranging from more densely populated areas (in green) to the more sparsely populated areas (in yellow), as well as the absence of biomass on the rocky outcrops (in red).

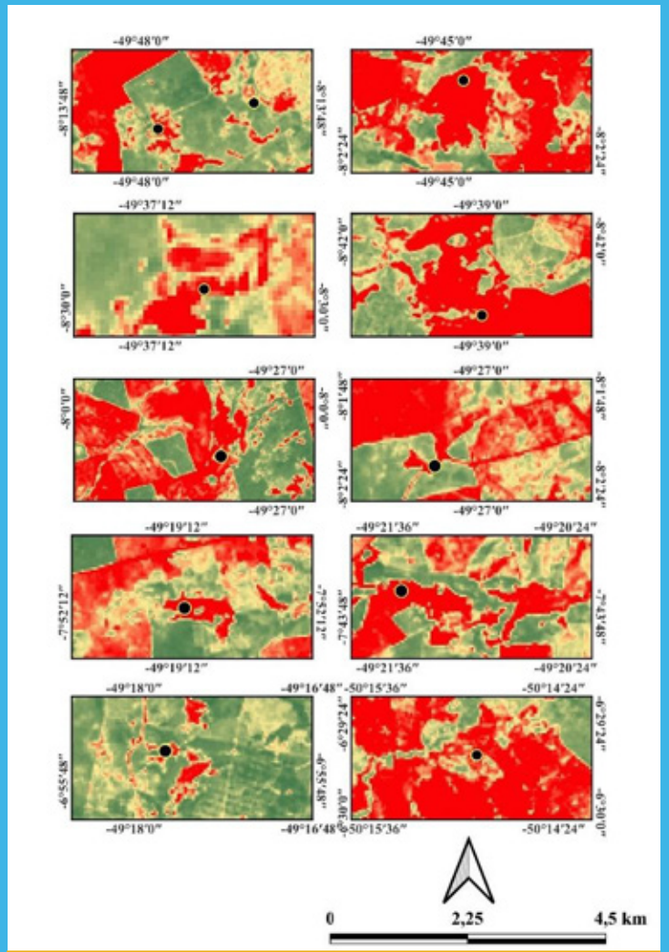

Image 1.
Classes of vegetation in a test area in the Araguaia region.

Plants which only grow in ferricrete areas, such as the *Anemopaegma carajasense*, *Buchnera carajasensis*, *Peperomia albopilosa*, *Eleocharis pedrovianae*, *Sporobolus multiramosus and Xyris brachysepala* (as well as others that have yet to be identified) were found, increasing the area of occurrence and improving the evaluation of their risk of extinction, according to the IUCN criteria (Image 2). *Buchnera carajasensis* and *Sporobolus multiramosus* were also found in other lithology studies, increasing the distribution and their association with different habitats.

The *Pseudopaludicola cangae* frog (Image 3) was observed during the field trips, which led the Reptiles and Amphibians of the Southeast of Pará project to include these areas in their searches, demonstrating a synergy between projects and a reduction of the gaps in knowledge concerning the ferricretes. Caves, etchings and archaeological sites were located, leading to the creation of the "Araguaia Speleological Prospecting of Ferricretes" project, which contributes to the better understanding of this natural and cultural heritage.

The discoveries made indicate that the southeast of Pará and the areas bordering Tocantins, Maranhão and Mato Grosso, could very possibly be home to other traces of ferruginous outcrops. As such, continuity of the prospection should be considered as a strategy for conservation of the biodiversity of the ferricretes in the region.

However, expansion of the distribution and the classification of vegetation are still challenging tasks, since the ferruginous outcrops are located on the division of the Amazon forest matrix and the vegetation of the Cerrado. This makes its demarcation less obvious, due to the mix between the Cerrado and the vegetation of the ferricretes, and thus requiring continual improvement of the methodology.

Strategic Alignments

The project is aligned with the principles of the CBD, the UN's Global Compact; SDG 15; and Objective IV, Action 16 of Agenda 21.

The discoveries made indicate that the southeast of Pará and the areas bordering Tocantins, Maranhão and Mato Grosso, could very possibly be home to other traces of ferruginous outcrops. As such, continuing with the prospection should be considered as a strategy for conservation of the biodiversity of the ferricretes in the region.

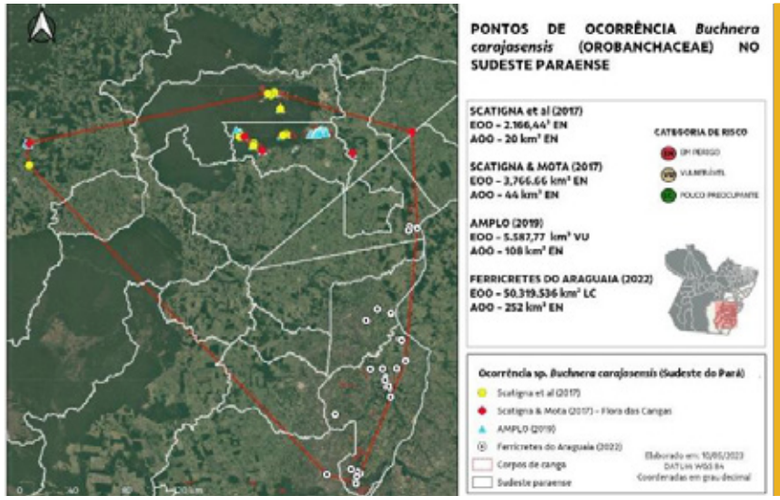

Image 2.
Increased understanding of the areas in which the *Buchnera carajasensis* occur and take root.

Image 3.
Pseudopaludicola cangae in the ferricretes.

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Photograph: Washington Alves

Exploring the biodiversity of the Amazon region: A taxonomic and genetic analysis of the reptiles and amphibians in the Southeast of Pará state

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Institutions Involved:

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Introduction

Understanding the biodiversity of a region is the first step to creating conservation programs, principally in relation to reptiles and amphibians, considering that around 4% of Brazil's amphibians and 9% of its reptiles are threatened with extinction.

The Amazon region, the world's biggest and most extensive biome, is home to around 250 species of amphibians (Frost 2009) and more than 300 species of squamata reptiles (snakes, lizards and amphisbaenians) Ávila-Pires *et al*. 2007). This diversity of species is associated with the high levels of vegetation, water and climate variation found in the Amazon region, as well as the structuring aspects of these conditions recorded in the past (Morato *et al*. 2018). The Carajás Mosaic, one of the most extensively studied locations in the region, currently contains 71 species of amphibians (66 anurans and five caecilians) (MARTINS *et al*., 2012; NECKEL-OLIVEIRA *et al*., 2012) and 120 species of squamata reptiles. The *Pseudopaludicola canga* amphibian is a species that is geographically restricted to the ferricrete areas of the Serra dos Carajás region (GIARETTA & KOKUBUM, 2003), whilst the *Gonatodes eladioi* lizard and the *Erythrolamprus carajasensis* snake are described as being endemic to the same region. Due to these characteristics, during the development of the Biodiversity Management Plan, investigation relating to conservation began to focus on these three species. Considering the importance of conserving the biodiversity of squamata reptiles and amphibians in the Amazon region, the aim of this project was to increase the understanding of these groups in rupestrian areas in the southeastern region of Pará and related forest environments, as well as to explore the knowledge of the abovementioned species, by means of surveys and taxonomic and molecular classification of the species. The use of molecular technologies, as well as the increased existence of reptiles and amphibians in museum collections, will provide for a legacy of knowledge that will certainly contribute to quicker analyses of the fauna of the region, reducing uncertainties and providing a basis for future actions regarding the management and conservation of the species.

Methodology

For this study, three areas neighboring the mosaic of protected areas within the Serra dos Carajás were selected: São Geraldo do Araguaia, Conceição do Araguaia and Ourilândia do Norte/São Félix do Xingu. These areas were prioritized due to the proximity of Carajás. The collections were performed during the rainy season (November-July, 2021-2022) and dry period (July-October, 2021-2022), involving forest and ferricrete areas, when available.

Before the prospecting work was undertaken in the field, a survey of the species contained in the Herpetology Collection of the MPEG and published in bibliographies was performed (CUNHA *et al*., 1985; NASCIMENTO *et al*., 1986; BERNARDE *et al*., 2012; PINHEIRO *et al*., 2012; NECKEL-OLIVEIRA *et al*., 2012; RIBEIRO-JÚNIOR & AMARAL, 2017; SÁ *et al*., 2020), focusing on the areas of interest. Following this, the selection of species in the selected areas took places using the visual (amphibians and reptiles) and auditory (anurans-amphibians) active search collection methods, performed during the day and at night, in different habitats and micro-habitats, capturing the animals by hand. The procedures performed following the collection of each species were: field identification, recording of geographical coordinates, photography, taking of tissue samples (liver or muscle preserved in 100% ethanol) and preservation of the specimen in 10% formalin, followed by storage in 70% ethanol. All the collection activities were legally permitted under the SISBIO #79306-2 license. All the specimens and tissue samples collected were included in the Herpetology Collection of the Emílio Goeldi Museum of Pará (MPEG), Belém, Pará, Brazil. In some cases, the term "cf." for preliminary identification of a species, "aff." for strains related to the indicated species, but which do not correspond to it, and "sp." for taxons not identified as belonging to a specific level, were used in accordance with the guidelines established by SIGOVINI *et al*. (2016).

As a means of generating genetic references, tissues collected during the three campaigns and placed in the MPEG collections, were used to collect DNA. Following this, the DNA was expanded to the regions of the Cytochrome oxidase subunit I (COI) mitochondrial gene and the 16S rDNA nuclear gene. The primer pairs used to amplify the COI and 16S region were COI-ReptBCF-COI-ReptBCR (Palumbi *et al*., 1991) and 16Sar-16Sbr (Palumbi *et al*., 1991), respectively. The sequencing was performed using the Sanger ABI 3730 DNA Analyzer platform (Thermo Fisher) and the analyses of quality and assembly of sequences/barcodes were performed by the Geneious Prime 11 v2022.2.2 (Biomatters Ltd.) software.

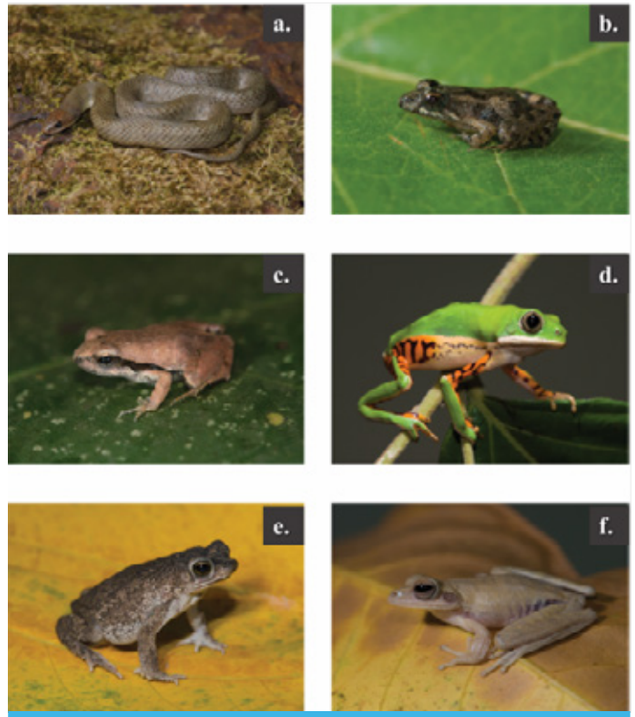

Image 1.
Some species collected in the field in the region of Conceição do Araguaia. a) *Erythrolamprus poecilogyrus*; b) *Pseudopaludicola canga*; c) *Physalaemus aff. ephippifer*; d) *Pithecopus hypochondrialis*; e) *Rhinella major*; and f) *Boana aff. raniceps*. Photographs: Adriano Maciel.

Results

During the expeditions, 103 species were registered, with the highest number of registrations at species level occurring in São Geraldo do Araguaia (61 spp.) followed by Conceição do Araguaia (48 spp.) and Ourilândia do Norte/São Félix do Xingu (36 spp.), with the proportion of amphibians and reptiles varying depending upon the area. Upon consolidating data from the MPEG collections with the field expeditions, 292 species of reptiles and amphibians were recorded in ferricrete environments in the southeast of Pará, with 58% being reptile species (106 spp. snakes, 58 spp. lizards, and eight amphisbaenians) and 42% amphibians (115 spp. anurans, 6 spp.). The largest number of species was found to be in Ourilândia do Norte/São Félix do Xingu (147 spp. of which 11 were found solely in this region and 67 were shared with Mosaico de Carajás), followed by São Geraldo do Araguaia (99/11/14) and Conceição do Araguaia (66/9/10). The comparison between the composition of species of the Carajás Mosaic and the other ferricrete environment revealed that 90 species are exclusive to this region ad just 29 spp. (17 spp. amphibians and 12 spp. reptiles) are present in all the areas. It should also be highlighted that there is a more exclusive presence of reptiles in the areas when compared to the amphibians. In terms of distribution, we established that the diversity of species found was divided up as 33.1% associated with forests; 20.4% with forests and open areas; 10.8% with open areas; 3.1% with open and perianthropic areas; 2.1% with forests and perianthropic areas; 2.1% with perianthropic areas; and 15.9% with all these habitats; whilst there was no information on 12.5%.

In extremely diverse countries such as Brazil, there exist two great impediments to effective conservation: insufficient knowledge of the country's biodiversity and the lack of complete inventories of the species and the resulting uncertainties regarding their distribution (HORTAL *et al.*, 2015). Studies based upon DNA are being increasingly adopted as a means of monitoring biodiversity (DIANA, 2022). The 'metabarcoding' DNA method, which allows for the identification of species based upon environmental samples (water, soil, etc.) is currently being widely employed in species assessment studies. However, this approach depends upon DNA barcode databases, which are short, standardized sequences of the genome, generated using specimens identified by taxonomists, to deduce the taxonomic identifications using the DNA present in the environmental sample. As well as the taxonomy survey, a DNA database of barcodes has been created as part of this project. So far, references for 112 identified species have been produced. A total of 339 barcode sequences was created for the COI gene (251 amphibian specimens, 60 lizards and 28 snakes) and 225 for the 16S gene (165 amphibian specimens, 39 lizards and 21 snakes). In relation to *Pseudopaludicola canga* and *Pseudopaludicola sp.*, 59 16S gene sequences were created and seven COI sequences, respectively. These data are to be used in more in-depth genetic studies, allowing for an understanding of the genetic diversity within the species. The same is being done for other important species in the region of Carajás, such as, for example, *Gonatodes eladioi* and *Ameerega flavopicta*. Finally, the expeditions resulted in a 70.5% increase in the taxonomy list for Conceição do Araguaia, 20.6% for São Geraldo do Araguaia, and 7.5% for Ourilândia do Norte/São Félix do Xingu. The DNA barcode references created are being used in complementary studies that employ the DNA metabarcoding technique for monitoring and surveying species of interest.

Strategic Alignments

The project is aligned with SDG 15 (Life on land), whilst also fulfilling the five strategic objectives based upon the Aichi Targets. The application of new technologies focused on the conservation of biodiversity also forms part of Target 19 of the Aichi strategic objectives.

During the expeditions, 103 species were registered, with the highest number of registrations at species level occurring in São Geraldo do Araguaia (61 spp.) followed by Conceição do Araguaia (48 spp.) and Ourilândia do Norte/São Félix do Xingu (36 spp.), with the proportion of amphibians and reptiles varying depending upon the area.

Photograph: Adobe Stock

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Photograph: Anderson Souza

Study of the Natural Background of Surface Water in the Amazon region

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Introduction

Water is a natural resource that offers countless types of use and its quality is a determining factor in allowing such use. Brazil is home to numerous different biomes with distinct water conditions, ranging from natural scarcity, to extremely high availability, as is the case in the Amazon region. Conama Resolution 357/2005 sets forth the classification of bodies of water and environmental guidelines for their classification, however, due to the combination of lithologies of the Amazon with the characteristics of the waters in the region, the benchmark standards established in Conama 357/2005 can significantly differ, since these standards are established generically (CARVALHO, 2009). These differences have yet to be included in the Amazon region water resources management programs. One of the reasons is the lack of resources available to public organs for studies in support of water resources management in the Amazon region. A 'background study' is an important means of distinguishing natural concentrations of a specific chemical element or compound resulting from human activities performed in the region in question.

Methodology

Acquisition of data: The results of laboratory tests and samples from the period of October 2020 to October 2021 were analyzed on a fortnightly basis. The choice of the parameters of interest took into consideration the geological formation, including: dissolved aluminum, dissolved copper, dissolved iron and total manganese. The surface water monitoring points, as well as the geology of the area, are presented in Image 1.

Estimates of the Quality Reference Values (QRV) (EPA, 2002, 2016):

The following steps were followed to determine the QRV:

- Statistical treatment of the natural background values
- Establishment of the QRV using the ProUCL statistical analysis software, developed by the Environmental Protection Agency (EPA);
- Establishment of the values of the simultaneous upper limit (SUL) that are used for the comparison on point-to-point individual observations and the mean values in which the mean plus twice the standard deviation was considered, producing a confidence interval of around 96% for the mean value.

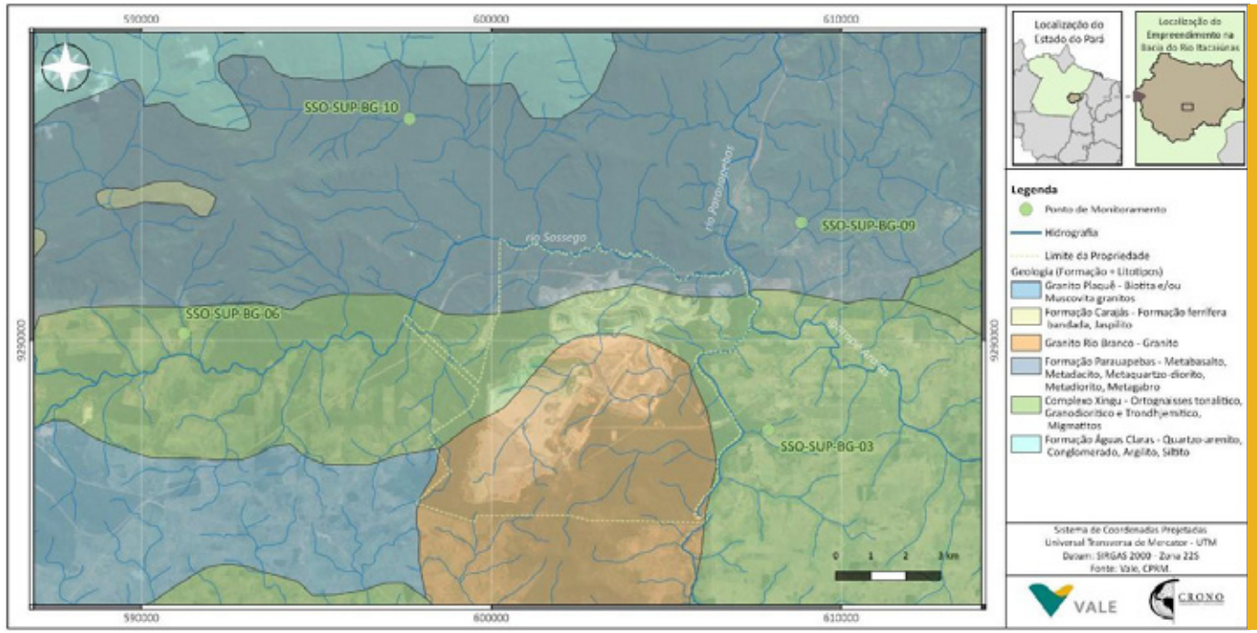

Image 1.
Surface water monitoring points, as well as the geology of the area.

Results

Natural background reference values: The natural background reference values compared to the reference values found in Conama 357 are presented in the table on the right.

As can be seen in the table, we noted higher values than the standard established for class 2 watercourses, relating to the elements evaluated, except for the mean found in the dissolved aluminum parameter, confirming that these metals are associated with the local geology and pedology. The waters in the Amazon region have specific characteristics such as an abundance of organic matter resulting from forest decomposition and high temperatures, which lead to the dissolution of these elements in the water.

In order to allow for sustainable management, it is necessary to classify the rivers in the Amazon, a move which could provide guidelines for sustainable practices that can be adopted for investments in the development of the Amazon region, since the economic vocation of the region is mostly connected to water resources, meaning it is essential that consistent management instruments are created to ensure that the water potential is pursued in a way that is sustainable.

Parameter	VR Conama 357/2005 Class II (mg/L)	SUL - Upper Limit (mg/L)	mean + 2*DP (mg/L)
Dissolved aluminum	0.1	0.21	0.09
Total manganese	0.1	0.24	0.14
Dissolved copper	0.009	0.2	0.011
Dissolved iron	0.3	1.65	0.96

Strategic Alignments

This case is directly related to Vale's water targets, whilst it is also connected to a number of the UN's SDGs, including those related to Drinking Water and Sanitation, Life below Water, Clean and Accessible Energy, and Decent Work and Economic Growth.

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Photograph: Anderson Souza

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A partnership with plant extractivism in the Carajás National Forest

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Introduction

The Carajás National Forest (Flona de Carajás) is a Conservation Unit for Sustainable Use (CU) meaning extractivist activities that do not compromise its future use are permitted. Mineral extractivism is currently performed in the CU by Vale and plant extractivism is performed by the Flona de Carajás Extractivist Cooperative (Coex). As such, the use of natural resources in the same region makes Vale and Coex close partners. With support from the ICMBio, the unit's management body, this partnership aims to contribute to the sustainable use of the region, develop courses and training for the extractivist workers, provide instruction on the sustainable exploration of the plant resources, develop techniques for sustainable management, and provide seeds for the environmental restoration and recovery of the mined areas, amongst other actions. Vale has contributed to the development of Coex for many years, creating a partnership that supports the management, conservation and strengthening of the extractivist activities within the conservation unit. This partnership began in 2009, involving traditional leaf collectors in the region, and later operating through the Conservation of the Native Jaborandi Plant Program within the Carajás National Forest, which began in 2012, involving research partnerships with the Rural Federal University of the Amazon Region (Ufra), the Vale Institute of Technology (ITV), and the Joint Socioeconomic Institute (Ises). As well as the abovementioned structured actions, Vale supports Coex in a range of different activities pursued as part of its daily operations, as outlined below.

Methodology

During the day-to-day routine of its operations within the Flona de Carajás, Vale develops activities designed to strengthen Coex, including the purchase of the seeds collected by the cooperative. For many years, the extractivism work performed by Coex solely involved collection of the leaves of the jaborandi plant. Vale's acquisition of native seeds provides the members of the cooperative with the opportunity to diversify the material with which they work and consequently increase their income. Coex processes and supplies seeds collected in the Flona de Carajás to the Vale nursery. The supply relationship established by means of this partnership generates income for the members of the cooperative, principally during the period outside the leaf collection harvest season, with the seeds being used to grow native saplings and plant species in the restoration areas implemented by the mining company. With the aim of strengthening the seed supply chain, Vale offers the members of the cooperative training sessions. These are theoretical and practical training sessions focused on the identification of trees, collection and management of seeds, processing and other actions involved in the activity. These training sessions are conducted by the Vale technical team (Carajás Biodiversity Plan – PGBio) and involve ongoing personal training and certification for the identification of trees, guaranteeing the good quality of the seeds that are delivered to the Carajás saplings nursery; compliance with legislation and legal conditions; professional qualification and evaluation of the seed collectors with the aim of identifying and registering trees; development of the skills necessary for the recognition and identification of the principal plant families in the region, especially those forest species protected by legislation, areas which could potentially be recovered, and species endemic to ferricrete environments. Other actions include the creation of a collection schedule per species and the creation of a photographic guide to the seeds.

In relation to the collection of jaborandi leaves, Vale contributes with logistical support to enable access to certain areas and assist with the production flow. The Flona de Carajás region, known as 'VP5' or 'granite central', is hard to access. With support from the forest guard, three clearings, measuring 30m x 30m each, were opened up. They were named Cocal, Michelangelo and Laje, and serve as helipads and support spaces. In these areas, Coex used the corporate aviation helicopter to transport supplies that allow the leaf gatherers to survive the harvest period, whilst the aircraft also facilitates the transportation of the leaf production. The leaf gatherers bring the harvest yield to these clearings so that, at the right moment, Vale can transport it to the 'Hangar do Carajás', a place that can be accessed by road (Image 1).

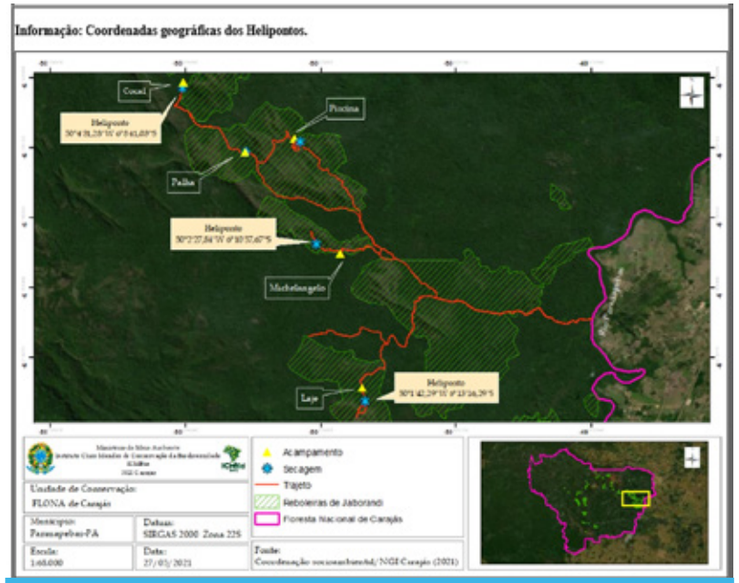

Image 1.
Location of the helipads installed to provide support for transportation of the leaves collected by Coex.

The leaf gatherers bring the harvest's yield to these clearings so that, at the right moment, Vale can transport it to the 'Hangar do Carajás', a place that can be accessed by road (Image 1).

Results

Over the last six years, more than 22 tons of seeds have been collected (Image 2) involving 120 different species, which has generated around R$ 3 million in income for the families involved (Table 1). As a result, every year, more than 200,000 saplings are produced and planted in restoration areas. Amongst the seeds collected are species such as mahogany, mimosa, açaí, Brazil nut and jaborandi.

Over the course of 2020, 2021 and 2022, the PGBio team conducted more than ten training sessions for Coex, and, in April 2023, as can be seen in the photos, a 32-hour theoretical and practical training session was offered to all the members of the cooperative (Image 3) providing updates on the new Normative Instruction (NI) nº 06/2022 and training them on identifying trees for the collection of seeds in the Flona de Carajás (Image 3). During the training sessions, a phenological calendar of the plants in the ferricrete region was distributed to the members of the cooperative along with a guide to the collection of species of seeds endemic to the soil of the Serra dos Carajás.

Since 2020, more than 52 tons of jaborando leaves have been transported by means of the Vale helicopter (Image 4).

Strategic alignments

This project is aligned with SDG 8: Decent work and economic growth; SDG 12: Responsible production and consumption; and SDG 15: Life on land

Year	Amount paid
2019	R$ 683,503.53
2020	R$ 905,376.90
2021	R$ 1,077,548.26
2022	R$ 852,386.00

Table 1. Inventory of seeds purchased by Vale from Coex – 2019 to 2022.

Image 2. Amount of native seeds supplied by Coex to Vale over the years.

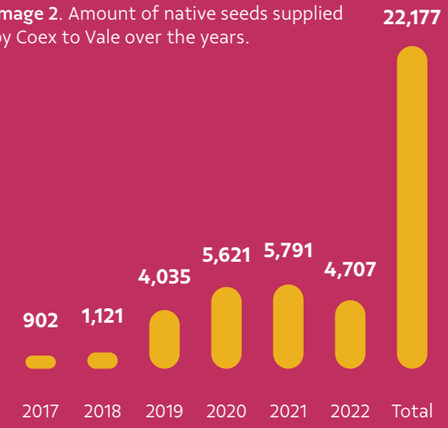

Image 3.
Practical training in the identification of trees, management of seeds and botanical identification.

Image 4.
Transportation of the jaborandi leaves collected by Coex by means of the Vale helicopter.

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33 '*Legados*' Project – Trails through the Serra da Calçada

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Introduction

Vale owns approximately 3,800 hectares of land in the Serra da Calçada, in the ecotone region between the Cerrado and Atlantic Rainforest biomes, located in the municipalities of Brumadinho and Nova Lima, in the metropolitan region of Belo Horizonte. At the beginning of the 21st century, the area was studied to gauge the viability of implementing a mining project that did not ultimately go ahead, principally due to the environmental cost and importance to the community which had always used the neighboring trails for leisure and sports (off-road vehicles, mountain biking and trekking). As well as currently housing legal reserves and Vale's environmental offsetting projects, the area forms a part of the areas of the Serra da Calçada Municipal Natural Monument (Monsac) and those making up the Listing of the State Institute of Historical and Artistic Heritage (Iepha), the National Institute of Historical and Artistic Heritage (Iphan) and the Municipal Government of Brumadinho. These protection instruments have established new restrictions on the use of the land, even though the property continues to belong to Vale, which is responsible for its upkeep. The area is in a good state of preservation, although, along some stretches, sports involving motor vehicles have led to significant levels of erosion. The project was developed within this scenario, sharing Vale's environmental assets based upon the existing trails, working to conserve the historical, cultural and environmental heritage, and providing a true legacy of our presence in the region.

Methodology

The project is based upon the idea of appreciating the presence of Vale in the region, through the recognition of our environmental assets in the form of the following lines of activity:

1 – Internal strategy: Sharing Vale's environmental assets and promoting their sustainable use as an effective form of compensating society for the development of the mining activities in the region. Free access to the Serra da Calçada has continued, with the adoption of educational approaches and development of a sense of shared ownership with the users. A number of projects focused on the environmental protection and recovery of the existing trails and water sources were developed in parallel.

2 – External relations: Effective participation in environmental forums of which we are formal members (Codemas, Tourist Boards and Drainage Basin Committees); environmental education program; formal relationship with the committees through the Community Relations teams; and a friendly approach to welcoming visitors and users to the Serra da Calçada.

3 – Protection of the area: Fencing; security provided by the Vale Business Security staff and through partnerships with the Police Force and the Municipal Guard; a forest firefighting department; creation of a network protected by the 'Protected Serra' WhatsApp group.

4 – Rehabilitation of trails and water sources (Image 1): Mapping of the existing trails and their connections; identification of the environmental liabilities (erosion, poor means of access); development of a rehabilitation project together with the BH Mountain Bike Association, the Trilhas Project and the UFMG; and implementation of phase 1 (concluded), phase 2 (under way), and phase 3 (forecast for 2023/2024).

Image 1.
Stage involving the rehabilitation of trails and water sources, mapping the existing trails and their connections, and identifying the environmental liabilities (erosion and poor mens of access).

Results

Recovery of Trails and Water Sources: The Serra da Calçada has suffered numerous impacts resulting from the incorrect use of its trails and the creation of divisions in the vegetation (Image 2). The project aimed to recover the region's trails and water sources, together with the BH Mountain Bike Association, the UFMG and the Trilhas Project. The results were only achieved due to the involvement of the community and the local authorities, creating an environment of trust and with the work being effectively completed meaning real value for all involved.

Theft of saplings: The vegetation of the Serra da Calçada is rich in species endemic to rocky environments, making it the target for theft of saplings for sale on the black market in Belo Horizonte. With increased security and the creation of the 'Protected Serra' WhatsApp group, this type of activity has been limited and the plants seized are now sent to the Vale nursery for reintroduction into conservation units (Image 3).

Forest fire prevention and fighting: Due to its location and the nature of its vegetation, forest fires are one of the biggest threats to the Serra. The communication network established makes the detection of flashpoints faster and reduces the time spent mounting a response to tackle the fires. No large-scale wildfires have been recorded in the Serra da Calçada over the last two years, compared to previous years.

Sustainable use of trails: The Serra da Calçada has been receiving increasingly more visitors, without, however, showing any signs of impacts relating to these greater numbers, such as the opening of new trails, disposal of trash, collection of plants, disturbance of the fauna, or lighting of fires. The users of the trails have begun taking greater care of the environmental and cultural heritage, reporting abuses and adopting a conservationist approach. The use of automotive vehicles has been restrained by actions developed jointly by Vale, the Police Force, NGOs and trail users. Walkers and cyclists are now the only ones permitted access to the Serra, thus preventing the development of new forms of erosion and improving the interaction and safety of the users.

Shared use: Lease agreement with a partner company for the implementation of an ecotourism support structure related to the sustainable use of the trails in the region. This model is currently being implemented, with the future possibility of being replicated in other environmental assets belonging to Vale.

Reduction of costs and generation of value: The initiatives prompted by the partnerships that have been created and by the establishment of a sense of ownership amongst the stakeholders have made the environmental protection actions that much more effective and consequently reduced maintenance costs. The Serra da Calçada is now a benchmark for the sustainable use of trails for mountain biking and trekking, and Vale has been increasingly recognized as an important partner in improving the quality of life in the region.

Image 2.
Impacts arising from the incorrect use of the trails in the Serra da Calçada.

Image 3.
Increased security and creation of the 'Protected Serra' WhatsApp group to prevent the theft of saplings.

The preservation and availability of the Vale asset in which the Serra da Calçada Natural Monument is located is an important element in the company's ambition to be a leader in sustainable mining, making the company a good neighbor, despite the asset being used not only by the nearby residents and communities, but also by the general public visiting from elsewhere. The preservation and opening of this asset to the public has also been discussed by the Jardim Canadá Social Committee, which has identified possibilities for the development of business with a social impact connected to ecotourism, which can also involve the inclusion of those with mobility issues. Social projects in the region are also developing activities connected to the Serra da Calçada, such as mountain bike lessons. In the Vale do Sol district, efforts are gaining force to organize the tourism that is growing as a result of the access provided to the Serra da Calçada and other environmental reserves in the region, in the form of a project that combines gastronomy, art and ecotourism, whilst also taking into consideration the inclusion of people with walking difficulties. The intention is to optimize these important attractions as a means of developing the region.

Strategic Alignments

The case is aligned with Vale's new strategic pillars as part of its renewed commitment to society. The pillars aim to create a better company, one that goes beyond providing reparation by transforming the way of working and having a positive impact on the communities where it has operations.

In the Vale do Sol district, efforts are gaining force to organize the tourism that is growing as a result of the access provided to the Serra da Calçada and other environmental reserves in the region, in the form of a project that combines gastronomy, art and ecotourism, whilst also taking into consideration the inclusion of people with mobility issues. The intention is to optimize these important attractions as a means of developing the region.

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Case-by-case: overcoming challenges through demographic studies of rare and endemic plants

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Institutions Involved:

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Introduction

Advances of human occupation and the changes in land use are amongst the greatest threats to biodiversity. Within this context, mining activities, although essential to economic development, are amongst the actions performed by humans that cause the fragmentation and destruction of natural habitats. Understanding what these alterations mean in terms of the increased risk of extinction for certain species is, however, recognized as a great challenge in ecological studies (Sonter *et al*. 2018). Given the scenario in which we live, with an intensification of human activities and climate change, this work is increasingly urgent, principally for rare and endemic species, since these are at most risk from the fragmentation, destruction and loss of habitats. As such, population viability analyses (PVA) are recognized as important tools and their results have been employed in programs focused on the conservation of threatened species. However, the robustness and reliability of the results of the PVAs depend upon the quality of the data relating to the distribution and demography of the species. As such, the first, and essential, step for studies on the risk of extinction using PVAs is to define the methodology to be used for the monitoring and collection of demographic data on the species in question. Based upon the satisfactory demographic data we can gauge the combined effect of survival, growth and reproduction on the long-term population viability of the species. However, as mentioned above, the different characteristics of each species mean there exist specific challenges, principally for those rare and endemic species that inhabit restrictive environments, such as the ferricrete regions of the Amazon. These challenges are specifically related to the lack of information that exists on the biology and population dynamics of the species. Our aim is to develop specific methods and protocols for the collection of demographic data on four rare, endemic and threatened species inhabiting the Carajás National Forest (Flona), with the intention of applying these data to PVAs and estimates of these species' risk of extinction.

Methodology

This project involves the evaluation of different populations of the species *Carajasia cangae (Rubiaceae), Daphnopsis filipedunculata (Thymelaeaceae), Ipomoea cavalcantei (Convolvulaceae)* and *Parapiqueria cavalcantei (Asteraceae)*. These are amongst the 38 rare and endemic species found in the Carajás Flonas that have so far been identified. In order to deal with the different biological characteristics of each species, we have developed specific protocols for the collection of data which obey the following steps: (i) review of the distribution and population data; (ii) review of the literature and field analysis (Image 1) of the biology and population structures; (iii) participation in an international course on demographic data analysis; (iv) meeting with widely respected researchers in the area of demographic studies; (v) establishment of plots and identification of young and adult specimens within different populations; (vi) collection of data on the recruitment, survival, growth and reproduction of the specimens; (vii) analysis of the quality of the data collected

Image 1.
Investigation of the demographic and biological structure of different populations of the *Carajasia cangae* (a) *Daphnopsis filipedunculata* (b), *Ipomoea cavalcantei* (c) and *Parapiqueria cavalcantei* (d), implementation of the plots, identification of individuals and collection of recruitment, survival, growth and reproduction data on each species, in the Carajás Flona, PA, Brazil.

during the first year of the study. With the aim of making the best use of the financial resources and the time used to collect the data, we adapt the frequency of the field work to fit the biological characteristics of each species.

Results

We performed 12 field trips between February 2022 and May 2024 (Image 1). During this period, we monitored two populations of each species studied and collected detailed information on their biology, population dynamics and life cycles. As such, we were able to develop the following protocols and data collection methods for each species.

***Carajasia cangae* (Rubiaceae):** Monitoring of all the specimens of the species in ten plots measuring 1m², divided into four quadrants of 50cm x 50cm, and distributed equally across a rocky area of land in the Southern Serra of the Carajás Flona. The size of each specimen was calculated as the area of an ellipse via the diameter measurements in centimeters, taking the measurements of the polar and equatorial radius. As such, in order to perform the long-term monitoring of the specimens, we adapted the method developed at the start, dividing the plots into quadrants of 50cm x 50cm (Image 2a) and subdividing these quadrants into 25 squares of 10cm x 10cm (Image 2b). In each square, the specimens were mapped, managing to refine the positioning of each individual within the plots. A total of 1,020 specimens are being monitored.

***Daphnopsis filipedunculata* (Thymelaeaceae):** Assignment of ten 25m² plots (image 2c) equally distributed across the areas of Lagoa da Mata and N1, in the Northern Serra of the Carajás Flona. In each plot, all the specimens of the species were identified with aluminum plates and, for each specimen, data was collected regarding their height, reproductive stage and stage of life (recruit, youth or adult). In each area, data was gathered on 100 identified and sampled specimens, and analysis of the distribution of the individuals amongst the classes revealed that our samples matched the distribution patterns of neo-tropical tree and shrubbery species. As the species includes specimens with different sexual characteristics (Images 2c and 2d), presenting only specimens with staminate or pistillate flowers, we have, whenever possible, recorded the sex of each specimen and the structural characteristics of their flowers. The species shows clonal growth, which is why we consider a specimen to be each shoot that emerges from the ground, whilst not considering the layer of forest floor detritus.

***Ipomoea cavalcantei* (Convolvulaceae):** Since the density of specimens of the species differs across different geological surfaces, we established five plots, each measuring 25m², on a rocky outcrop, and six plots on open rocky vegetation. All the specimens, including seedlings (Image 3a), were identified with a metal plate (Image 3b) and measured. At the start of the monitoring process, we identified and noted the data on 179 specimens in the rocky outcrop area and 121 specimens in the open rocky vegetation area.

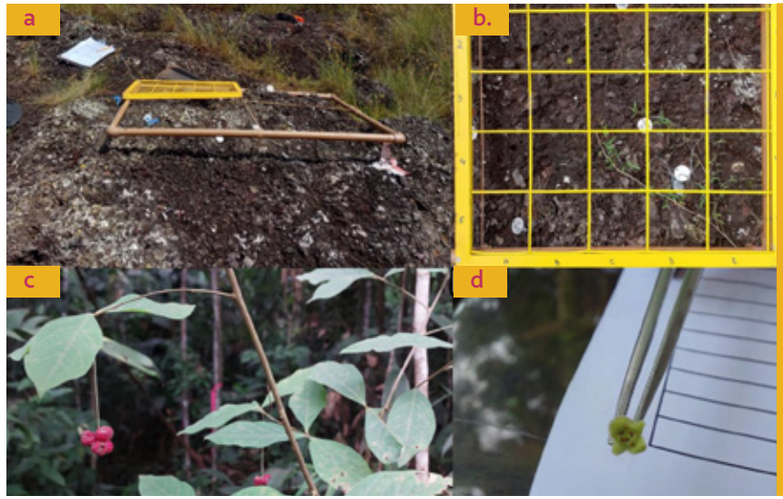

Image 2.
Establishment of a 1m x 1m plot (a) and a quadrant of 50cm x 50cm, subdivided into squares of 10cm x 10cm (b) for the collection of demographic data and monitoring of the populations of *Carajasia cangae*, in the Southern Serra of the Flona de Carajás (PA). Detail of the fruit of a female specimen (c) and the functionally staminate flower of the *Daphnopsis filipedunculata* in the Southern Serra of the Flona de Carajás.

Image 3.
Detail of the seedling (a) and specimens with permanent metal identification plaques (b) of the *Ipomoea cavalcantei*, in the Southern Serra of the Flona de Carajás (PA). Detail of a *Parapiqueria cavalcantei* specimen (c) and establishment of a 25cm x 25cm plot for samples of the populations of this species in the Southern Serra of the Flona de Carajás

For each specimen, the measurements taken related to the number of shoots (vegetative or reproductive), length of the longest shoot and stage of life, in which we considered specimens as being seedlings (with the presence of cotyledons), non-reproductive (without flowers or fruit) and reproductive (with flowers and/or fruit). The data collection was performed once a year, ideally at the peak of the species' flowering (March or April), and, once a year, the new recruits (seedlings) were incorporated in the monitoring.

***Parapiqueria cavalcantei* (Asteraceae):** A total of 20 plots (25cm x 25cm) were established along two water courses in the Southern Serra – the S11B and S11C of the Carajás Flona (ten plots/stream). The plots were subdivided into 25 squares of 5cm x 5cm to facilitate counting and identification of the sparsely and densely populated specimens (Images 3c and 3d). In order to understand the biology of the species, we took four samples from the plots, collecting data on around 1,500 specimens. The samples were taken from the plots three times over the course of the year, such being at the recruitment of the specimens, at the time the specimens established themselves, and at the peak of their reproductive lives. This planning of samples is based upon the need to understand the fast-moving population dynamics of annual species.

The population viability analyses (PVAs) can be seen as important tools for evaluating the risk of extinction of threatened species in relation to the different scenarios of loss of habitat. However, the robustness and reliability of the results of the PVAs depend upon the quality of the data relating to the distribution, abundance and demography of the species. The Carajás Serra is home to a great many endemic species and, therefore, is of great conservation interest. However, the singular characteristics of these species make the task of collecting demographic data extremely hard. As such, the protocol established for the collection of the demographic data concerning these four species endemic to the Carajás Serra will assist in standardizing the collection of data in the long-term, and can be replicated for use with other populations and other species with similar ecological characteristics and life cycles. The data obtained in the long-term through the application of these collection protocols will substitute studies concerning the potential vulnerabilities of the populations of rare and endemic species and facilitate sets of data which can be applied to models addressing risks of extinction, thereby contributing to the management and conservation plans in mining-related areas.

Strategic Alignments

The project is aligned with SDG 15 (Life on land).

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The data obtained in the long-term through the application of these collection protocols will substitute studies concerning the potential vulnerabilities of the populations of rare and endemic species and facilitate sets of data which can be applied to models addressing risks of extinction, thereby contributing to the management and conservation plans in mining-related areas.

Photograph: Irisvelton Silva

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Photograph: Gustavo Baxter

Forest target – A commitment to recovery

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Institutions Involved:

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Introduction

Vale is voluntarily committed to protecting and recovering 500,000 hectares of land lying beyond the company's property boundaries in Brazil, by 2030. Of these 500,000 hectares, 100,000 are in the recovery stage as part of different strategies and models. Located within them are businesses with a positive socio-environmental impact. The Vale Fund is responsible for the ideation and coordination of the implementation of the Forest Target on recovery, having been in operation since 2019, creating new partnerships and innovation, testing models, and providing training as a means of scaling these businesses. Part of the approach to achieving the recovery of the 100,000 hectares of forest has involved the promotion, acceleration and support of businesses and startups focused on sustainable systems, especially those working with Agroforestry Systems (AFS). As there are a limited number of such businesses with a history of large-scale operations in Brazil, the work focused on environmental recovery has been based upon the premise of generating income and employment, promoting sustainable production chains over the course of the process involved in the recovery of the biomes and ecosystemic services, and permitting the sequestration of carbon from the atmosphere. There are not currently any businesses with a history of large-scale operations in the country.

As well as the businesses supported, we have promoted the testing of sustainable models that manage to achieve scale in terms of hectares, financial return and a socio-environmental impact, whilst we have also been reinforcing the ecosystem of agroforestry businesses to create an environment which allows new companies to grow, thus leaving behind a positive socio-environmental legacy.

Methodology

The Vale Fund has assumed the challenge of developing an alternative approach to achieving this target, through the implementation of innovative commercial initiatives that offer positive impacts related to land use, whilst also offering an attractive balance between risk, return and socio-environmental benefit. To achieve these objectives, the methodology adopted by the Vale Fund involves three main strategies: 1) Mapping, selection and support for businesses that have an impact in order to increase the efficiency of the generation of a pipeline for investment and optimization of its portfolio, including: the challenge of Agroforestry and Mapping of Agroforestry Businesses (59 evaluations); 2) Coordination with investors to allow 'blended finance' operations, reducing the risk of investments through the combination of philanthropy and impact investment; and 3) Coordination with 'off takers' to allow for strategic agreements based upon the value chain (guaranteed purchase of products, early receipt of yield, etc.). Based upon these strategies, the Fund aims to achieve the positive results and impacts in the area of recovery outlined in the Forest Target's Theory of Change.

As well as financial support, the Vale Fund also works together with different institutional partners which provide support for the businesses throughout the entire process involved in implementing the areas, principally in relation to the management of environmental safeguards, the management and gauging of the impact generated by the initiatives' operational processes at the proposed scale, and in the acceleration and strengthening of the businesses. This assistance takes the form of non-financial support and is offered to the businesses whilst the land is being recovered, with the aim of improving the businesses' efficiency and processes.

In 2023, proofs of concept were undertaken with those impact projects with the potential to contribute to the recovery of the regions. This initiative sought to create knowledge products, tests on productive arrangements, and financial and impact management models, and was conducted together with four partners: Camta, Courageous Land, Futuro Agroflorestal and Radix.

Vale is voluntarily committed to protecting and recovering 500,000 hectares of land lying beyond the company's property boundaries in Brazil, by 2030. Of these 500,000 hectares, 100,000 are in the recovery stage as part of different strategies and models. Amongst them are businesses with a positive socio-environmental impact. The Vale Fund is responsible for the ideation and coordination of the implementation of the Forest Target and has been working with recovery of the areas since 2019.

Photograph: Leo Drumond / Nitro Agency

Results

The Forest Target worked on the recovery of more than 12,615 hectares between 2022 and 2023. The recovery work was conducted on more than 110 rural properties through the activities of socio-environmental impact businesses. The total areas are distributed across nine Brazilian states: BA (24.1%), MG (12.2%), MS (16.1%), MT (7.8%), PA (9.4%), RO (2.8%), RR (5.9%), SP (4.1%) and TO (17.6%), with 43% of the recovered land located in the Amazon region, 30.4% in the Cerrado, 18.1% in the Caatinga, and 8.5% in the Atlantic Rainforest. An average of 400 jobs (fixed and temporary) are created each year for development of the productive activities. The areas being recovered received 49 plant species in 2023, meaning a total of 66 different species have been used in the recovery of the areas since 2020, 58% of which are native to Brazil.

The six businesses supported in 2023 received R$ 50 million, with R$ 40 million in the form of direct investment and R$ 10 million being provided in the form of non-financial support. In 2023, this meant support for the management and implementation of the areas, administration of the impact and evaluation of the socio-environmental safeguards.

A number of products were developed during the execution of the Proofs of Concept (PoCs), including: the offer of crowdfunding as a means of raising funds, development of the Theory of Change and an impact plan, analysis of the carbon stocks in the productive systems, a development plan for a mechanized guard patrol, and a technical study to evaluate the viability of recovery of the legal reserve (LR) in the Atlantic Rainforest by means of sustainable systems.

Strategic Alignments

This case contributes to fulfillment of SDGs 2, 12, 13, 15 and 17.

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Photograph: Luis Veiga

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Forest target – Paths towards conservation

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Introduction

Vale is voluntarily committed to protecting and recovering 500,000 hectares of land lying beyond the company's property boundaries in Brazil, by 2030. Of this area, 100,000 hectares involve recovery work. The other 400,000 hectares consist of forest lands protected by means of partnerships with Conservation Units, the purchase and creation of high integrity forest carbon credits, as well as partnerships with other public or private players for the leveraging of nature-based solutions.

In 2022, the component of carbon was included in this account as a strategy approved by specialists for fulfillment of the company's target. This concept goes beyond the removal or emission of greenhouse gases (GHG), incorporating the results of an investment that triggers local socioeconomic and environmental development, with a view to the equitable, equal and fair generation and distribution of benefits.

Methodology

IN 2021, a REDD+ Business Plan was created, which analyzed more than 60 opportunities using a rigorous methodology that combines the positive socio-environmental impact with business strategies, looking at Vale's objectives, and resulting in a final list of projects totaling more than 900,000 hectares with an aggregate potential of 2,500,000 credits/year in the states of Rondônia, Acre, Pará and Amazonas, called the "green portfolio".

Based upon the green portfolio, an operating plan was created to structure the acquisition of carbon credits arising from these projects.

In 2022, the protection of 50,000 hectares of forest by means of the purchase of REDD+ credits in partnership with the Algar Group was selected as a pilot project. The advances on this front, made by the Vale Carbon Hub, a vehicle founded and nurtured by the Vale Fund to create, develop and manage carbon projects and environmental assets, aims to promote and expand the voluntary carbon market in Brazil through nature-based solutions.

Results

The Algar Group's Pacajá Farm hosts one of the most important forest management projects in the Brazilian Amazon, having been certified by CERFLOR (Brazilian Forest Certification Program, which is recognized internationally by the Programme for the Endorsement of Forest Certification – PEFC). It is one of the most extensive areas of sustainable forest management in the country. Located in the municipality of Portel, in the north of the state of Pará, it meets the legal requirements of sustainable management as an instrument of conservation and preservation of native forests. All the property's trees located within the respective Annual Production Unit (APU) are inventoried and georeferenced (Image 1 and Image 2). Following the forest collection, the products receive a QR Code, allowing identification of the species and its respective

Image 1.
Trees on the Pacajá Farm, located within the Annual Production Unit (APU), being inventoried and georeferenced.

Image 2.
Conducting the inventory of the trees on the Pacajá Farm, located within the Annual Production Unit (APU).

location, whilst also ensuring traceability and transparency of the forest management. The work is based upon a low-impact forest harvest, in proportion to the rate of forest regeneration, with minimal impact on the ecosystem. As well as contributing to the sustainable use of the forest and keeping it standing, socio-environmental actions are developed with five local communities. The Pacajá Farm has been developing the Socio-environmental Responsibility Program since 2017 (Image 3 and Image 4), implementing actions in support of the autonomy of the communities and mitigating problems by means of investments in education, the generation of alternative sources of income (training the communities in the development of production systems in the areas of fishing, poultry breeding and agroforestry production), the environment, sports and infrastructure.

As well as purchasing forest carbon credits, Vale's partnership with the Algar Group can be expanded to include the recovery of damaged areas in the region based upon agroforestry systems, involving the work of the Pàcajá Farm with the communities in the region where it operates. The Algar Group's REDD+ project involves the future monitoring of biodiversity in the region covered, preventing deforestation, increasing the independence of the communities located within the area of the project, as well as providing encouragement, monitoring and investment in the economic, social and environmental areas together with the communities. In total, it is estimated that the project has prevented the deforestation of 82,994.27 hectares of land over its 30 years in existence, the equivalent of reducing emissions by 40,222,208 tCO^2.

Strategic Alignments

The conservation of more than 400,000 hectares of forest by the company has contributed to maintaining the biological diversity of the region and to the sequestration of carbon, in line with global agreements on climate and biodiversity, and with the Sustainable Development Goals contained in the 2030 Agenda, with the expectation of generating carbon credits and boosting the voluntary market in the country through what the Vale Fund defines as carbon impact.

The Pacajá Farm has been developing the Socio-environmental Responsibility Program since 2017 (Image 3 and Image 4), implementing actions in support of the autonomy of the communities and mitigating problems by means of investments in education, the generation of alternative sources of income (training the communities in the development of production systems in the areas of fishing, poultry breeding and agroforestry production), the environment, sports and infrastructure.

Image 3.
Socio-environmental Responsibility Program developed on the Pacajá Farm.

Image 4.
Social actions developed by the project.

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