Gains in Nature Conservation based on Compensatory Reforestation in the Atlantic Forest, Brazil

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ABSTRACT. The Atlantic Forest biome is considered a world biodiversity hotspot that originally covered 15% of the territory of Brazil, or 1,306,421 km^2. Spread out along the Atlantic coast of Brazil, it includes a wide range of ecosystems, such as mangroves, *restinga* vegetation, lowland and upland forests, Araucaria forest and *campos de altitude* (Brazilian highaltitude grasslands). Currently, the Atlantic Forest has been reduced to a mere 7.84% of its original size and now covers some 102,000 km^2. Studies indicate deforestation amounting 18,433 hectares (184 km^2) of the remaining forest in the period 2014-2015. Due to the high fragmentation of forests, restoration projects are important and may incorporate actions that benefit the conservation of the biome. Infrastructure projects, such as the construction or expansion of highways, can bring significant impacts to biodiversity, such as through the removal of native vegetation. To make up for such impacts, Brazilian environmental agencies follow the rule of demanding offset measures. Such measures result, for the most part, in the planting of trees in an amount arrived at by multiplying the number of organisms lost. When companies are involved in activities that benefit biodiversity conservation, its offset measures required by environmental agencies could be targeted at more consistent outcomes in favour of the natural heritage, such as environmental restoration and synergies with the management of protected areas. Against this background, a partnership was established between a company in the infrastructure sector and an institution working for nature conservation. The aim was to direct offset measures for restoration of endangered ecosystems in protected areas of the Atlantic Forest. In addition to the environmental outcomes, this initiative is a model for future activities involving environmental offset measures in Brazil.

DES GAINS POUR LA CONSERVATION DE LA NATURE BASÉS SUR DES PLANTATIONS COMPENSATOIRES DANS LA FORÊT ATLANTIQUE, BRÉSIL

RÉSUMÉ. Le biome 'Forêt Atlantique' est considéré comme un *hospot* mondial de la biodiversité qui couvrait à l'origine 15% du territoire brésilien, soit 1.306.421 km^2. Étendu le long de la côte atlantique du Brésil, il comprend un large éventail d'écosystèmes, tels que les mangroves, la végétation de *restinga* (végétation côtière), les forêts de plaine et de montagne (versants de la « Serra do Mar »), la forêt d'Araucaria et les champs d'altitude (prairies brésiliennes de haute altitude). Actuellement, la forêt atlantique a été réduite à seulement 7,84% de sa taille originale et couvre maintenant quelque 102 000 km^2. Des études indiquent un déboisement de 18 433 hectares (184 km^2) de la forêt

restante pour la période de 2014 à 2015. En raison de la forte fragmentation des forêts, les projets de restauration sont importants et peuvent intégrer des actions qui favorisent la conservation du biome. Les projets d'infrastructure comme la construction ou l'élargissement des autoroutes peuvent avoir des répercussions importantes sur la biodiversité, par exemple en supprimant la végétation indigène. Pour compenser ces impacts, les agences environnementales brésiliennes appliquent la règle des mesures de compensation. Ces mesures se traduisent, dans la plupart des cas, dans la plantation d'un nombre d'arbres calculé sur base du nombre d'arbres perdus. Lorsque les entreprises participent à des activités qui favorisent la conservation de la biodiversité, les mesures d'atténuation requises par les institutions environnementales pourraient viser des résultats plus concrets en faveur du patrimoine naturel, comme la restauration écologique et les synergies avec la gestion des aires protégées. Dans ce contexte, un partenariat est établi entre une entreprise du secteur des infrastructures et une institution travaillant pour la conservation de la nature, son objectif étant d'orienter les mesures de compensation pour la restauration des écosystèmes menacés situés dans les zones protégées de la forêt atlantique. En plus des résultats environnementaux qu'elle réalise, cette démarche représente un modèle à suivre pour d'autres actions futures de compensation écologique au Brésil.

BENEFICIOS EN LA CONSERVACIÓN DE LA NATURALEZA BASADOS EN REFORESTACIONES COMPENSATORIAS EN EL BOSQUE ATLÁNTICO, BRASIL

RESUMEN. El Bosque Atlántico es considerado un hotspot global que originalmente cubrió el 15% del territorio brasileño, equivalente a 1.306.421 Km^2. Distribuidos a lo largo de la costa atlántica está formado por un conjunto de ecosistemas: manglares, marismas, bosques de tierras bajas y cuestas de la Sierra del Mar, Bosque de Araucaria y los *campos de altitude*. El área original del Bosque Atlántico ha sido reducida a 7,84%, con cerca de 102.000 Km^2. Los estudios indican claramente la deforestación de 18.433 hectáreas, o 184 Km^2 de bosques remanecientes en el periodo comprendido entre 2014 y 2015. Debido a la fragmentación de los bosques, los proyectos de restauración son importantes y pueden integrar acciones para la conservación del bioma. Proyectos de infraestructura, como la construcción o ampliación de carreteras, pueden traer impactos significativos para la biodiversidad - tales como la eliminación de la vegetación nativa. Para compensar este impacto es la regla en Brasil que agencias ambientales soliciten medidas compensatorias. Estas medidas se reflejan, en su mayor parte, en un número de árboles plantados a partir de un recuento de multiplicación del número de individuos suprimidos. Al involucrar las empresas en acciones que vengan a favorecer la conservación de la biodiversidad, las medidas de compensación requeridas por las agencias ambientales pueden ser dirigidas a generar resultados más consistentes en favor del patrimonio natural, como la restauración ecológica y las sinergias con trabajos de gestión de las áreas protegidas. Con base en este contexto, se estableció una cooperación técnica entre una empresa del sector de la infraestructura y una institución que trabaja para la conservación de la naturaleza. La cooperación tuvo por finalidad direccionar una solicitud de compensación ambiental para la restauración de áreas protegidas del Bosque Atlántico, en ecosistemas en peligro de extinción. Además de los resultados ambientales, esta iniciativa es un modelo para las futuras acciones de compensación ambiental en Brasil.

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I. INTRODUCTION

This article outlines the conception and results of an ecological restoration process, based on an arrangement that stipulates: (i) environmental compensation mechanisms established by the Brazilian environmental law; (ii) conservation of biodiversity in threatened ecosystems; (iii) improvements needed in the management of public and private protected areas.

Under these headings, the central argument is based on experience gained in the use of environmental compensatory measures following the loss of vegetation in the course of highway construction, one of the sectors falling under economic infrastructure. This case is presented as a model, with the recommendation that it can be replicated to other projects.

The scenario also discusses an increased number of economic-infrastructure projects in Brazil, which are of relevance to a developing country, as well as the environmental compensation mechanisms in place when certain impacts are inevitable.

The article refers to reviewed literature on the characteristics and current situation of the Atlantic Forest biome, including the particular situation of associated ecosystems, such as the Araucaria Forest in the highlands of southern Brazil and the *restinga* formation in coastal areas. These areas are the subject of this article on restoration. The scenario presented introduces the real dimension of the responsibilities of, and opportunities for, companies in addressing the demands of environmental compensatory measures that have the ability to contribute to the maintenance of natural heritage.

II. THE ATLANTIC FOREST BIOME

The Atlantic Forest is considered one of the most biodiversity-rich biomes of the planet and is amongst the 25 most important biodiversity hotspots worldwide [1].

Spread along the Brazilian Atlantic coast, the Forest originally covered 15% of Brazil––an area of 1,306,421 km^2 that comprises a wide range of ecosystems, such as mangroves, *restinga* vegetation, lowland and upland forests, Araucaria forest and *campos de altitude* (high altitude grasslands) [2] [3].

Despite the degradation indicated in studies, the Atlantic Forest biome harbours in its ecosystems around 20,000 plant species and 849 bird species, 370 amphibian species, 200 reptile species, 270 mammal species and 350 fish species. More than 530 of these species are officially endangered, some are nationally endangered, and the endemic species are globally endangered [4] [5]. Yet, 70% of the Brazilian population lives within area of the biome, which includes the such major Brazilian cities as São Paulo, Rio de Janeiro, Belo Horizonte, Salvador and Curitiba [6].

Given this wide-reaching human presense, there is a constant threat of habitat destruction to the various plant formations and associated ecosystems. Currently, the Atlantic Forest is reduced to a mere 7.84% of its original size and now covers only about 102,000 km^2. Studies indicate that 18,433 hectares (184 km^2) of the forest remnants were lost between 2014 and 2015 [7] [5].

In southern Brazil, the Araucaria Forest (figure 1) stands out among the ecosystems associated with the Atlantic Forest biome. The Araucaria Forest originally covered approximately 200,000 km^2 [8], extending mainly throughout southern Brazil, specifically the territories of the states of Paraná (40%), Santa Catarina (31%) and Rio Grande do Sul (25%) [9]. However, since

FIGURE 1 ARAUCARIA FOREST.

the 1990s, it has been reduced to only 20,000 km^2 [10]. In 2004, mapping demonstrated that in the State of Paraná, less than 0.8% of its original cover remained in an advanced stage of succession [11].

Deforestation and economic timber cycles were two of the main drivers of fragmentation and decrease of Araucaria Forest coverage, threatening the continuity of existing plant populations and in some cases meaning a risk of extinction [12].

The *restinga* vegetation as well as the Araucaria Forest has undergone severe degradation due to urban expansion and economic exploitation of the Atlantic Forest. The *restinga* formation comprises a set of coastal ecosystems with rich diversity communities, which colonize sandy soil in different environmental settings. It forms complex edaphic vegetation occupying beaches, dunes and associated depressions, sand bars, terraces and plains, which extend along the Brazilian coast [13] [14].

III. CONSTRUCTION INFRASTRUCTURE AND COMPENSATION FOR ENVIRONMENTAL IMPACTS

Brazil is among the largest countries in the world, and therefore is faced with many demands for improving the economic infrastructure throughout its territory, which covers 8.5 million km^2, including 27 states with over 205 million inhabitants and an economy with a nominal GDP of US$ 1,775 trillion in 2015 [15]. Thus, it is crucial to invest in infrastructure such as highways, railways, communication and power, among others [16] [17].

As with other sectors, Brazilian regulations for the granting of start-up and operating licences require the preparation of environmental impact studies and reports. This procedure generates documents to be analysed and reviewed by the environmental authorities with a view to approving and issuing the licences [18] [19].

Even so, in the case of projects completed in line with regulatory requirements, they often inevitably lead to negative impacts on the environment, which cause biodiversity loss. The work of regulatory bodies, civil society and the media also contributes to a monitoring system to pinpoint instances of enterprises that pose risks to the environment and the natural heritage [20].

In order to mitigate this, Brazilian law stipulates that projects with significant environmental impacts must set up or maintain officially protected public areas representing 0.5% of the project value [21].

Additionally, Brazilian regulatory agencies at the municipal, state or federal level have the legal means to require specific environmental compensation, particularly in cases of impact on permanent preservation areas [22], keeping in mind that removal of vegetation in these areas should be treated as an exception. Permanent preservation areas are defined in the Brazilian Forest Code, which laid down the obligation to maintain vegetation around waterways or hilltops [23].

Reforestation is an example of an environmental compensatory measure requested by environmental agencies. The number of trees to be planted is based on multiplying the number of individuals eliminated, with each species weighted accordingly. Furthermore, there is a set time of year and region for planting. A three-year monitoring plan is also requested. However, licensing conditions may vary case-by-case and agency-by-agency.

Based on the above-mentioned compensatory measures, there is a low potential for satisfactory results when considering the context of Brazilian biodiversity: first, because it is clear that a short monitoring period does not ensure the longevity of the results [24]; secondly, because planting a single species does not ensure the ideal species composition aimed at successional stages of vegetation in a natural environment and its ecological processes [25]; and, thirdly, the need for compensatory reforestation is debatable, given of the priorities in terms of maintaining the natural heritage, such as fighting deforestation of the last remnants in threatened ecosystems.

Southern Brazil has only 55.5% of its natural vegetation remaining due in large part to the high flux of infrastructure projects in this region (13 % in Paraná, 29.6% in Santa Catarina, and 12.9% in Rio Grande do Sul) [26]. Much of it is broken up into fragments, which are under pressure from competing activities, such as agriculture, livestock and urban development [27].

IV. INVESTMENTS OF COMPANIES IN BIODIVERSITY CONSERVATION INITIATIVES

Companies can play an important role in biodiversity conservation, with a social responsibility to protect and maintain existing natural areas, or incorporate restoration measures as part of their corporate strategy.

Moreover, natural areas are essential to maintain living conditions of society as a whole, providing ecosystem services, such as the provision of water, climate regulation and the production of food and medicine [28] [29]. The ecosystem services also allow companies to recognize the dependency its operations have on the existence of natural areas [30] [31].

Other mechanisms also encourage companies to consider the importance of biodiversity for their activities. Amongst these mechanisms, the Global Reporting Initiative developed guidelines for reporting sustainability performance indicators, including specific aspects related to biodiversity, such as habitats protected or restored and the number of endangered species affected by the operations [32]. Another mechanism is the establishment of LIFE Certification that recognizes organizations efforts towards net positive biodiversity operational strategies [33].

In order to achieve the greatest environmental gain, the main goal of the partnership between Arteris Group, a Brazilian roadconcession operator, and the Society for Wildlife Research and Environmental Education (SPVS), a non-governmental organization, was to go beyond the compensatory measures required by the environmental agencies.

These agen/cies may require environmental impact measures and authorize the continuation of a project through the legal instrument called a Vegetation Removal Authorization (ASV). Among the cases were two involving Brazilian road concession operators who were required by the environmental agencies to carry out compensatory reforestation as a measure of environmental compensation and as a condition for continuing the ASV.

In one case, based on the authorization to remove vegetation in sections where the construction consisted of forks and shoulders in the road, the environmental offset was to plant 70,373 seedlings of the species *Araucaria angustifolia* in an area of 76.57 hectares. In the other case, the ASV was for the construction of a new stretch of a highway, which gave rise to an offset measure of restoring an area of 83.26 hectares.

The partnership established, as shown in the next section, was to propose to the environmental agencies a solution focused on generating greater results in favour of biodiversity. The compensatory reforestation was required to be carried out in protected areas recognized under the Brazilian National System of Conservation Units (SNUC).

For the company, this meant meeting the requested compensatory measures for the licensing process, offsetting the environmental impact caused by its activities at a reduced cost, enhancing the results. For SPVS as a non-profit organization working for nature conservation, it meant an effective mechanism to expand results in nature conservation, which in turn relates directly to the goals established by the Convention on Biological Diversity for land restoration and ecosystem maintenance.

V. RESTORATION IN PROTECTED AREAS

Human disturbance negatively affects Brazilian biodiversity, especially in the Atlantic Forest biome that contains 70% of the population. Protected areas play a key role in preventing the disturbance of natural heritage and ensure the continuity of Brazilian biodiversity. The SNUC establishes these areas [34], proposes guidelines and defines territorial space, legally instituted by the government, aiming at protecting ecosystems [35].

Despite the pressure on ecosystems of the Atlantic Forest biome, which has been exacerbated by urban expansion and industrial farming, there are mechanisms and initiatives that promote the restoration of priority areas. The restoration in protected areas through compensatory reforestation, integrates efforts and innovative initiatives for biodiversity conservation. This integration was possible due to the partnership between SPVS and the Arteris Group through two initiatives.

The first initiative, aimed not only at meeting the offset measures requested by the Brazilian Institute of Environment and Renewable Natural Resources

(Ibama), but also to contribute to the protection of a private nature reserve (RPPN).

The compensatory measure was based on the authorization to suppress vegetation in sections where road forks and shoulders of Highway BR-116 went under construction, in the metropolitan region of Curitiba, capital of the State of Paraná. Even though the location of the project is within the Araucaria Forest domain, previous urban settlements suppressed all significant remnants. Nonetheless, to obtain a vegetation removal authorization, an environmental compensatory measure was still requested.

Based on extensive conservation needs, it is important to go above and beyond the minimum requirements designated by the governing agencies. As such, enhanced terms have been requested and agreed upon to benefit biodiversity. So to meet the request for compensatory reforestation, two measures were defined: the restoration itself and the effective protection of a remnant of this threatened ecosystem. Ecological restoration was made in 32 hectares of old pasture and another 45 hectares of forest (initial stage of regeneration). Instead of a single species, 39 species of the Araucaria Forest were selected, including rare and endangered species, thereby increasing the biological diversity.

A project worked on by SPVS since 2003 was taken into account when choosing the restoration location project. The project seeks private areas with good conservation standards and develops mechanisms to ensure their maintenance, with the eventual aim of transforming the areas into private nature reserves. Despite the pressures of deforestation, the restoration activities were developed on a property in a region that is home to significant natural remnants. Therefore, compensatory reforestation meant both the ecological restoration of a degraded land and ensured the conservation of an important natural remnant. The 77 restored hectares combined with the existing remnants come to 100 hectares in good conservation condition, totalling 513 hectares in one property.

The second initiative on compensatory measures arose from the construction of a new stretch of highway approximately 50 km long in the metropolitan region of Florianópolis, capital of the State of Santa Catarina in southern Brazil. Authorization was requested to remove vegetation for the construction of lanes, overpasses and tunnels. The compensatory measure requested by Ibama was the restoration of approximately 85 hectares. With the intention of enhancing the gains of this measure for biodiversity, an agreement with the environmental agency of the State of Santa Catarina was established. The aim was to direct the compensatory measure towards a protected area, in this case the Serra do Tabuleiro State Park, also in the metropolitan region of Florianópolis. The search for a public protected area took into account the possibility of the compensatory measure signifying empowerment in the state park management. This protected area, as well as many others in Brazil, faces challenges in restoring degraded areas, strengthening its surveillance systems and improving the environmental quality of its ecosystems (by, for example, removing alien species,).

Taking into account this scenario, the compensatory reforestation covered an area of 83.26 hectares, and incorporated management actions for invasive species on 350 hectares of protected land in the *restinga* formation (figure 2). Besides meeting the compensatory measures required by Ibama, the project generated a gain in scale of biodiversity conservation. SPVS surpassed the standards of conventional planting, which only requires a single species, and succeeded in carrying out restoration with a higher species diversity, improving and accelerating the recovery process and contributing to the management of the state park.

VI. CONCLUSION

The rich and biological diverse Brazilian ecosystems face unparalleled deforestation pressure, which should be taken into account in offset measures requested by environmental agencies. The main goal must be to obtain better results in the restoration of natural areas, their continuity and their connectivity.

The expertise of SPVS and Arteris Group show that it is possible to exceed the minimum request compensatory measures, surpassing the requirements coupled with big picture strategies and significant efforts for biodiversity. This arrangement also present to companies the opportunity for strategic positioning and proactivity facing the loss of Brazil's natural heritage, intrinsically related to the change in land use for agriculture and infrastructure, in addition to the inefficient management of public protected areas.

FIGURE 1 *RESTINGA* RESTORATION.

The ability of companies to support the maintenance of private nature reserves and public protected areas established by the Brazilian National System of Conservation Units (SNUC) and managed by the Government is extremely innovative and ensures the perpetuity and connectivity of ecosystems under pressure, such as in the case of the Atlantic Forest, which is threatened with extinction.

Ultimately, an investment in medium and long-term monitoring activities is crucial to ecological restoration processes associated with the creation of private nature reserves and contribution to the management of public protected areas. This is a key aspect to effectively measure the true results of environmental impact and that should be the compensation guidelines required of companies wishing to pursue the Vegetation Removal Authorization.

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