



Atlantic Forest and Ferruginous Rocky Grasslands Environmental Offsetting in Minas Gerais, Southeastern Brazil – Between Legalism and Ecological Ineffectiveness

Compensação ambiental da Mata Atlântica e dos Campos Rupestres Ferruginosos em Minas Gerais, sudeste do Brasil – entre o legalismo e a ineficácia ecológica

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ABSTRACT The Atlantic Forest (AF) is one of the world's most threatened biodiversity hotspots and the only Brazilian biome ruled by a specific conservation law. The present study is an investigation about AF environmental offsetting (EO) in Minas Gerais State (MG), as provided for by the Brazilian environmental legislation. Minas Gerais State exceeds the provisions in the AF law and requires the compensate area to be twice as large as the cleared area. Although these instruments have the potential to help the biome's ecological restoration, MG is always among the Brazilian states accounting for deforesting the AF the most. Data about 128 legal suits processed by MG's environmental agency between 2020 and 2023 were analyzed. Most EO cases in MG regarded the tenure regularization of legally protected land. Only 19% cases regarded ecological restoration. The EO approach in MG is ineffective and disconnected from the best scientific practices and it leads to net biodiversity loss, mainly in ferruginous rupestrian fields or *canga* areas. Recommendations include adopting integrated or cumulative environmental assessment, and prioritizing ecological restoration to achieve strategic biodiversity gains or, at least, no biodiversity loss in AF territories.

Keywords: biodiversity offsetting; ecological restoration; land tenure regularization; protected areas.

RESUMO

A Mata Atlântica (MA) é um dos mais ameaçados hotspots de biodiversidade mundial e o único bioma brasileiro que tem uma lei específica para sua conservação. Este estudo investigou a compensação ambiental (CA) da MA no estado de Minas Gerais (MG), conforme previsto pela legislação ambiental brasileira. Neste sentido, o estado mineiro vai além do previsto na Lei da MA e exige que a área compensada seja o dobro da suprimida. Embora esses instrumentos tenham potencial de contribuir para a restauração ecológica do bioma, MG figura recorrentemente entre os estados brasileiros que mais desmatam a MA. A pesquisa se valeu dos dados disponíveis nos processos que tramitaram para a aprovação do órgão ambiental estadual em sua Câmara de Proteção à Biodiversidade e Áreas Protegidas do Conselho Estadual de Política Ambiental (CPB-COPAM) entre os anos de 2020 a 2023. Foram coletados dados de todos os 128 processos que tramitaram na CPB-COPAM nos quatro anos analisados. Os resultados obtidos indicam que a CA da MA na proporção de 2:1 em MG causa uma impressão positiva que é incorreta, uma vez que a compensação se dá na grande maioria das vezes através da regularização fundiária de terras já legalmente protegidas, e em apenas cerca 19% dos casos por restauração ecológica. Reforça-se o entendimento de que a CA da MA em MG é ineficaz, desconexa do melhor conhecimento científico, e tem levado à perda líquida de biodiversidade, especialmente dos campos rupestres ferruginosos ou cangas. O estudo propõe algumas recomendações para melhorias na CA da MA em MG, que também são úteis para outros territórios e contextos, como a adoção de uma avaliação ambiental integrada ou cumulativa e que se priorize o estímulo à restauração ecológica, visando ganho líquido ou pelo menos nenhuma perda de biodiversidade nos territórios.

Palavras-chave: compensação da biodiversidade; restauração ecológica; regularização fundiária; unidades de conservação.

1. Introduction

The Atlantic Forest (AF) is the tropical forest accounting for the largest tree diversity per hectare in the world, despite its high biodiversity, and fauna and other taxonomic groups' endemism levels. Its biome is one of the five main global conservation hotspots. Atlantic Forest (AF) history of pressure dates back to the Brazilian colonization time, since Brazil holds more than 90% of its area. The Atlantic Forest accounts for 80% of Brazilian population's economy and is home to almost 70% of it (Pinto & Hirota, 2022). The AF biome is the only one in the country ruled by a federal law focused on its protection, namely: law n. 11.428, from 2006. In other words, whenever allowed, its

suppression requires environmental offsetting measures (Brasil, 2006).

Environmental Offsetting (EO) can be understood as the fourth stage of the so-called hierarchy of environmental impact mitigation, according to which, ecological damage is initially avoided; then, it is minimized; subsequently, it is locally restored; and, finally, it is compensated (Moilanen & Kotiahoc, 2018). In practical and legal terms, EO can be carried out through different mechanisms provided for in laws and regulations in force in each State or territory.

The current research specifically addresses the offsetting provided for in the Atlantic Forest law, in articles 17 and 32 of Brazilian federal law n. 11.428, from 2006, which rules Minas Gerais State's (MG) environmental agency, by

its Chamber for Protection of Biodiversity and Protected Areas (CPB) of the State Council for Environmental Policy (COPAM). The Atlantic Forest offsetting must be approved before the suppression of the native vegetation cover intended by the project to seek license. Minas Gerais State exceeds provision in the AF law and requires the compensate area to be twice as big as the suppressed one, as provided for in articles 48 and 49 of State Decree n. 47.749, from 2019 (Minas Gerais, 2019). However, according to yearly reports by SOS Mata Atlântica and INPE (National Institute for Space Research) (2020; 2021; 2022), MG is always among the states known for deforesting the AF the most and for losing the largest amounts of its native vegetation cover in the country. It is also noteworthy that deforestation in MG increased by 88% between 2020 and 2021, by 7% between 2021 and 2022, and by 48% between 2022 and 2023, according to the Yearly Reports on Deforestation in Brazil, also known as RAD (MapBiomass, 2024).

Ferruginous rocky fields are a particular feature of environmental offsetting (EO) and Atlantic Forest (MA) context in Minas Gerais (MG). These geoecosystems' estimated original area in MG is 1.580 km², and they house 2.933 known vascular plant species (Carmo et al., 2018). Ferruginous rocky fields are found within AF official limits as high-altitude fields and vegetation refuges (Decree No. 6,660 of 2008) (Brasil 2008; Vasconcelos, 2014). They are mainly observed in MG Iron Quadrangle region, which is the largest mineral province in Brazil (Silveira et al., 2020). The AF law does not differentiate high-altitude fields and

often classifies them as native, non-forest plant formations located above the altitudinal limit of forest formations. They are also known for their own features and for being found on the biome's tops of mountain ranges, plateaus and '*chapadas*' (Article 3, item, IV, law 11.428/2006).

These areas' ecological vulnerability is worsened by their disjunct distribution in island ecosystems within an originally forest matrix, which has also been intensely degraded and suppressed, mainly because they cover one of the soils richest in iron ore on the planet (Jacobi et al., 2007; 2011). Preventing '*cangas*' and their ecosystem services' loss and degradation, as well as their suppression for mining, are the main strategies to conserve them (Neugarten et al., 2018; Fernandes et al. 2020; Kamino et al., 2020).

The Iron Fields in Minas Gerais' Iron Quadrangle have already irreversibly lost at least half of their original area (Salles et al., 2019). Fernandes et al. (2020) presented a priority actions plan that led to discussions set among scientists, industry representatives, environmental managers and other civil society members. However, it does not seem to have been reflected on State executive policies nor on the territory's reality. According to recent studies, iron rock fields offsetting in MG is inefficient, obsolete and figurative (Silveira et al., 2020; Alvarenga et al., 2022; Carmo & Kamino, 2023).

In addition to preventing biodiversity and its ecosystem services' loss, it is clear that net biodiversity gains are a trend towards both offsetting environmental impacts and fulfilling global multilateral agendas (Simpson et al., 2021; Maron et al., 2025),

such as the 2030 UN Agenda, its Sustainable Development Goals (SDGs) and Decade on Ecosystem Restoration. It also complies with ESG strategies and approaches (good environmental, social and governance practices in institutions).

MG is a AF deforestation champion; furthermore, it only launched one State Conservation Unit (UC) between 2020 and 2023. Therefore, it calls into question the environmental offsetting (EO) practiced in MG and highlights that ecological offsetting and forest restoration, or the creation of new protected areas, have not been effectively happening in the state. The aim of the present was to better understanding this scenario by analyzing how AF EO has been taking place in MG and why this instrument has not had impact on this biome offsetting and restoration. Based on the collected data and on the presented results, the goal was to reason on the ecological restoration and EO paradigm based on net biodiversity gain. Some recommendations to improve this environmental policy instrument was also presented, mainly for the AF EO context in Minas Gerais.

2. Methodology

All license suits processed between January 2020 and December 2023 by the Chamber for the Protection of Biodiversity and Protected Areas of the State Council for Environmental Policy (CPB-COPAM) of Minas Gerais State (MG) were screened to access AF EO data available on the electronic portal of the State Secretariat for the Environment and Sustainable Development (Minas Gerais, 2025). The

adopted time frame encompassed the time the first author worked as Civil Society and State University of Minas Gerais (UEMG) Representative counselor at CPB-COPAM.

The following information was extracted from each AF EO suit processed by CPB-COPAM over the assessed period, namely: license claim ID, Company, Undertaking type, Environmental Licensing Class, Meeting number and date, Suppression municipality, Suppressed phytophysionomies, Area suppressed by phytophysionomies, Total suppressed area, Compensated area, Offsetting municipality, EO forms (Land tenure regulation - TR - in Conservation Units – CU, Restoration, Environmental Servitude), Number of EO forms, Balance between suppression and compensation basins. Environmental offsetting (EO) aimed at land tenure regularization (TR) in a Conservation Unit (CU) was recorded as federal (ICMBio), state (IEF-MG) or municipal area. Requests by counselors to view the process and its returns, whenever issued, were taken into consideration and analyzed. The gathered data were organized, processed in Excel spreadsheets and analyzed through descriptive statistics.

The methodological approach also involved assessing and analyzing laws and regulations relevant to AF EO, as well as reviewing the scientific literature and data made available by institutions focused on both AF conservation and on its phytophysionomies.

TABLE 1 – Atlantic Forest biome phytophysiognomies and the number of suppressions authorized by the Minas Gerais environmental agency due to environmental offsetting in compliance with articles 17 and 32 of Federal law 11.428/2016, and with articles 48 and 49 of State Decree 47,749/2019.

Suppressed Phytosiognomies	Area (ha)	%
Semideciduous Seasonal Forest (SDSF)	1,620.80	56.3%
Deciduous Forest (DF)	596.83	20.8%
Cerrado (CE)	367.33	12.8%
Ferruginous Rocky Field (FRF)	164.76	5.8%
Quartzitic Rock Field (QRF)	37.16	1.3%
Rocky Field (RF)	37.04	1.3%
Candeal (Cand)	43.85	1.5%
Gallery Forest (GF)	4.95	0.2%
Total	2,864.73	100%

Source: Elaborated by the authors.

3. Results and discussion

3.1. Atlantic Forest law (AF) Environmental Offsetting (EO) in Minas Gerais State (MG)

In total, 128 AF EO suits were processed over 51 CPB-COPAM (Biodiversity Protection and Protected Areas Chamber of the State Council for Environmental Policy of Minas Gerais) meetings between January 2020 and December 2023. It means 32 suits per year and 2.5 suits per meeting, on average. Only 8 of these 51 meetings did not process AF EO suits. None of these 128 suits for suppressing native vegetation in the AF biome were refused by CPB-COPAM. Requests for review by advisory entities were recorded in 9% (12) of these suits, and they often came from both scholars and the production sector. Most of these review-request cases regarded suppressing ferruginous rocky fields or significant semideciduous seasonal forest areas.

The state environmental agency allowed removing 2,864.73 hectares (ha) of native vegetation within the AF biome limits over the four analyzed years. The semideciduous seasonal forest (SDSF), or inland Atlantic forest, was the most often removed phytophysiognomy and it represented 56% of the total area. The deciduous seasonal forest (DSF), or dry forest, was the second mostly removed phytophysiognomy (21%). Rocky field subcategories, namely: endemic, threatened and providers of essential ecosystem services regulation and water recharge accounted for 8% of removed area (Table 1).

Phytophysiognomy suppression request ranged from 0.04 to 358.08 ha - 15.32 ha, on average and standard deviation equals 36.80 ha. Semideciduous Seasonal Forest (SDSF) suppression ranged from 0.04 to 299.90 ha, Deciduous Seasonal Forest (DSF) ranged from

0.46 to 358.08 ha and Rupestrian Fields ranged from 0.07 to 36.86 ha. It is noteworthy that 358.08 ha and 299.90 ha areas are the two largest suppressed sights by an energy and mining enterprise, and they were followed by areas smaller than 100 ha. Mean suppressed areas dropped to 11.93 ha and standard deviation decreased to 16.70 ha when these two outliers were disregarded. These data point out significant losses, even when one deals with legal deforestation authorized by the environmental agency.

Amaral et al. (2025) highlighted the loss of more than 180 thousand hectares of mature AF remnants between 2010 and 2020, and approximately 95% of it resulted from illegal deforestation. Although these areas are legally protected and, despite their biodiversity, biomass production and ecosystem services provision relevance, they continue to be lost. The aforementioned authors emphasize the urgency of developing more effective measures to stop deforestation in this biome, to keep its biodiversity and to take advantage of its forests' multiple benefits, including their ability to mitigate, and to be resilient against the several impacts of climate extremes (Amaral *et al.*, 2025).

The offsetting area reached 5.836 ha and this number is in compliance with article 48 of State Decree 47.749/2019, according to which, the offsetting must be twice as big as the suppressed area within AF limits in Minas Gerais State. Offsetting was at least 1 hectare bigger than twice the size of the suppressed area in 16% (21) of the 128 analyzed suits, and it corresponds to the total of 107 ha of compensa-

ted area above the limit provided for in Minas Gerais legislation.

The suppression municipality was the same municipality where environmental offsetting took place in only 16% (21) of the 128 analyzed suits. All suits ended up in compensating the same macro-watershed where suppression took place. Offsetting and suppression took place in the same micro-watershed in 38% (49) of the analyzed suits.

In total, 56% (3.296.97 ha) of the whole offsetting area (5.836.47 ha) took place through land tenure regularization (TR) in a fully protected conservation unit (UC). In other words, on protected lands, according to the National System of Conservation Units (SNUC), Brazilian federal law n. 9.985, from 2000. Only 19% of the total offsetting area, or 1.086.29 ha, were restored and it can effectively represent some native vegetation coverage gain in the territory (Table 2).

Offsetting was exclusively calculated by TR in fully protected CUs in 70% (89) of the 128 analyzed suits. The total of 20 CUs benefited from TR in 3.296.97 hectares within their borders. Fourteen (14) of this total were state-owned areas managed by MG State Forestry Institute (IEF), 5 of them were federal areas managed by ICMBio, and 1 was a municipal area. According to data provided by SISEMA MG Conservation Units Indicators Panel (SISEMA, 2025) and by Conservation Units in Brazil portal of the Socioenvironmental Institute (ISA, 2025). Minas Gerais holds 86 fully protected CUs; 76 of them are state-owned and 10 are federal areas. Therefore, it can be inferred that 23% of these CUs accounted for

TABLE 2 – Environmental Offsetting (EO) types based on the Atlantic Forest law (AF), number of suits and on offsetting area, according to the analysis applied to the 128 suits processed by CPB-COPAM (Biodiversity Protection and Protected Areas Chamber of the State Council for Environmental Policy) between January 2020 and December 2023.

Offsetting Type	Process		Area in	
	#*	%**	Hectars	%
Land tenure regularization (LR) in a fully protected Conservation Unit (CU)	110	86%	3,296.97	56%
Area designated for perpetual environmental easement	14	11%	1,308.59	22%
	34	27%	1,086.29	19%
PNHR Creation (Private Natural Heritage Reserve)	2	2%	144.62	2%
	160	125%	5,836.47	100%

LEGEND: * Sum of the number of suits in the second column of the table (160) highlights that 25% of the total number of analyzed suits (128) adopted more than one offsetting type. ** The total of 128 suits was taken into consideration to calculate the percentage of suits, and this is the number of suits processed by Minas Gerais environmental agency over the assessed period - from 2020 to 2023.

Source: Elaborated by the authors.

some TR effort within their limits based on AF EO between 2020 and 2023. Furthermore, 50% and 18% of the Federal and State fully protected CUs in MG were granted with the licensing, respectively.

The mining sector accounted for almost 63% (1.800.20 ha) of the total suppressed area (2,864.73 ha) and for 38% (49) of the 128 AF EO suits processed by CPB COPAM over the 4 analyzed years (Table 3). Almost half (48% or n=61) of the screened suits came from the energy sector, and it regards 982 ha or 34% of the total suppressed area. Yet, it is clear that mining ventures require larger suppression areas than energy ventures. Altogether, the mining and energy sectors accounted for 86% of the suits and for 97% of the total area required for suppression. Infrastructure, sanitation, real estate and brewery sectors, altogether, accounted

for 14% of the analyzed suits and for 3% of the suppressed area (Table 3).

Most energy sector suits (89%) are only compensate by TR in CU. Almost half (n=24 or 49%) of the analyzed mining enterprise suits also made their AF EO exclusively by TR in CU. These data do not meet item II of article 32 of the AF law (Federal law n. 11.428), according to which,

the suppression of secondary vegetation at advanced and medium regeneration stage for mining activity purposes will only be allowed upon: [...] adoption of a compensatory measure including the recovery of an area equivalent to the undertaking area, with the same ecological features, in the same hydrographic basin and, whenever possible, in the same micro hydrographic basin, regardless of provisions in Art. 36 of law n. 9,985, from July 18th, 2000 [authors' emphasis]. (Brasil, 2006)

TABLE 3 – Number of suits and suppressed area based on venture types' (sector) requesting native vegetation suppression in Atlantic Forest domains in Minas Gerais State processed by the State environmental agency between January 2020 and December 2023.

Sector	Process #		Supressed area	
	N	%	Hectares	%
Mining	49	38%	1,800.20	62.84%
Energy	61	48%	982.15	34.28
Infraestructure	11	9%	58.75	2.05
Sanitation	3	2%	19.06	0.67
Real Estate	3	2%	3.33	0.12
Brewering	1	1%	1.24	0.04
Total	128	100%	2,864.73	100%

Source: Elaborated by the authors.

However, the same MG Decree (47.749/2019) determines AF offsetting to follow the 2:1 ratio (article 48) and allows it to exclusively happen through TR in CUs (article 49, item II).

According to the observed data, most of the legally suppressed AF areas in MG are compensate through tenure regularization (TR) in conservation units (CU), as shown in Table 2, and it helps better understanding why Minas Gerais is often among the states known for deforesting the Atlantic Forest the most (data from INPE & SOS Mata Atlântica yearly reports). Thus, no matter if the offsetting is twice the size of the suppressed area if most of it is implemented through TR in already protected areas, which means that there will always be native vegetation cover loss in the state. The 2EO:1AF ratio observed in MG can be misleading, but it does not work for offsetting.

According to the analysis applied to AF EO suits processed by CPB-COPAM, TR possibility in CUs is mostly convenient for

mining companies that own the areas used for environmental offsetting and the CU land to be regularized. Furthermore, it points out the State's submission to the mining sector.

Unlike what prevails in Minas Gerais State (MG), according to the scientific literature, environmental offsetting (EO) often happens through ecological restoration, landscape management and through the establishment of new protected areas by private resources (Bidaud et al., 2018; Moilanen & Kotiahoc, 2018). Contemporary ecological crises reinforce the need for EO to be based on net biodiversity gain, which is far and different from losses observed in the Atlantic Forest (MA), in MG.

3.2. Particularities and warnings about 'Canga' areas or ferruginous rocky fields in Minas Gerais

Canga areas in ferruginous rocky fields are rare and threatened ecosystems that provide vital environmental services to society, given their large responsibility for recharging aquifers, which are very important for populations' water security in their surrounding areas, such as Belo Horizonte, its metropolitan region and other cities in Minas Gerais Iron Quadrangle (Carmo & Kamino, 2015). It is worth highlighting the relevance of these *canga* areas for soil carbon fixing in their hydromorphic saturation areas, which is significantly higher in these ecosystems than in forest and tree vegetation (Guedes & Schaffer, 2009; Carmo & Kamino, 2015).

Erosion and threats to ferruginous rocky fields are increasing. SOS Mata Atlântica & INPE point out the loss of 4.700 hectares (4.5% of the total area) in this region between 2014 and 2019. Camini (2021) detected a growing and intense *canga* fragmentation process in Serra do Gandarela region, despite CUs' presence. The researcher analyzed several landscape metrics in this region and detected 8% increase in the fragments, 7% reduction in the area of the largest landscape fragment, 16% reduction in the mean area of fragments, 6.9% increase in edge areas, 37.2% drop in the mean size of fragments' central areas and 9.1% increase in the number of disjunct areas in the landscape. Furthermore, new suppressions in *canga* remnants remains high, mainly outside fully

protected conservation area limits, given the spatial match between these areas and mining titles of significant economic potential (Jacobi *et al.*, 2011; Alvarenga *et al.*, 2022).

Data reported in the current study reinforce these ecosystems' loss (threatened, irreplaceable and non-compensable) to iron ore mining. Between January 2020 and December 2023, 15 suits were processed by CPB-COPAM and they requested the total suppression of 213.36 ha of rocky fields. These suppressions ranged from 0.07 to 36.86 ha: 11.85 ha, on average, and recorded standard deviation equals 13.65 ha. Several of these suits regarded review requests by State University of Minas Gerais based on technical reviews warnings to the already known EO ineffectiveness in iron fields suppression in Minas Gerais, which were often neglected by the State.

The study on AF EO suits in CPB-COPAM led to the perception that Iron Quadrangle remaining rocky fields, which should be called the Iron-Aquifer Quadrangle, have been suppressed by mini-mines implementation after fragmented environmental licensing is issued. This scenario masks and omits irrecoverable and non-mitigating ecosystem impacts; therefore, these fields are not subject to environmental offsetting, which has been happening in regions bordering Serra do Gandarela National Park (PARNA), in Belo Horizonte metropolitan region.

Integrated Environmental Assessment (IEA) or Cumulative Impact Assessment (CIA) (under the umbrella of Environmental Impact Assessment - EIA), which were launched in Brazil by the National Environmental Policy (law 6.938/1981) (Brazil, 1981), is an envi-

ronmental management and policy instrument aimed at identifying and assessing synergistic and cumulative effects resulting from environmental impacts caused by a whole set of projects in a given region. IEA was launched in MG by DN COPAM 175/2012, which was updated by DN COPAM 229/2018 and by a series of Joint Resolutions issued by agencies that make up the environmental system in the State; however, this instrument is only applied in MG to hydroelectric projects. AAI or AIC application in mining impact contexts, mainly in mini-mines, such as the case of Serra do Gandarela PARNA region, is essential for the conservation of Iron-Aquifer Quadrangle biodiversity and for the population's water security in their territories.

4. Recommendations

There is the urgent need for changing Minas Gerais' stance on offsetting and conservation policies set for that of the Amazon rainforest, mainly for ferruginous rocky fields. The environmental agency's approach jeopardizes water security and the quality of life of more than 5 million inhabitants in Belo Horizonte and in its metropolitan region, which is the third largest metropolitan area in Brazil. It explains why essential ecosystem services provided by rocky fields have been lost, a fact that compromises water recharge and balance through rainwater infiltration, as well as its storage in aquifers, water supply by water springs and water flow rate maintenance in watercourses.

Minas Gerais EO regulations in AF should be reviewed in order to reverse the ease process supporting this offsetting through land tenure regularization (TR) in full-protection conservation units (CU). This TR attribution in CUs should target the EO of the conservation units' national system (SNUC) (article 36 of federal law 9.985, from 2000) (Brazil, 2000), which aims at managing and implementing CUs. In environmental and biodiversity conservation terms, it would be much more interesting if the state encouraged entrepreneurs to invest in both ecological restoration and related research for AF EO, including the goal of making ferruginous rocky fields or *canga* areas' restoration and rehabilitation feasible.

Among recommendations proposed in the present study one finds having the State creating an Environmental Compensation Conservation Unit (CU) category to include EO designated, restored or recovered areas. When it comes to building more connected, healthy and sustainable landscapes, these EO CUs could strategically expand the coverage of native vegetation through ecological restoration to promote net biodiversity gains, to improve the population's health and quality of life, to drive a sustainable restorative economy in compliance with 21st century's paradigm shifts. This action would also help reversing Minas Gerais State's leniency image and subservience to mining companies. It is worth recalling that two of the largest mining crimes and environmental tragedies ever recorded in the world happened in MG, namely: Mariana (2015) and Brumadinho (2019).

Accordingly, it is also important remembering that extensive ecosystem restoration is

increasingly seen as fundamental for biodiversity conservation (IPBES, 2018) and for mitigating climate emergency (IPCC, 2019). The best scientific evidence has pointed Brazil and the Atlantic Forest biome as hotspots with the greatest potential for forest restoration worldwide (Brancalion et al. 2019). In addition, the United Nations declared the 2020/2030 decade as that for ecosystem restoration. Furthermore, restoration encourages the green economy, which complies with important global climate and biodiversity agreements, with the Brazilian law for native vegetation protection (Federal Law 12.651, from 2012) and with its environmental regularization mechanisms and environmental reserve quotas (Brazil, 2012). Yet, it is essential bearing in mind that, among other international agreements, Brazil joined the Bonn Challenge in 2016 and committed to restore 12 million hectares by 2030. Therefore, one witness facts and evidence, and questions and reflections emerge, namely: how does Minas Gerais State, one of the world's largest mineral reserves, want to be seen and recognized in the global geopolitical context of the Anthropocene?

The adoption of the Integrated Environmental Assessment (IEA) or the Cumulative Impact Assessment (CIA) for all types of projects, mainly mining projects, is among the most urgent change in order to avoid and curb careless fragmented environmental licensing about Landscape Ecology principles. Thus, it promotes the offsetting of both biodiversity and its ecosystem services.

Last but not least, is it essential recognizing irreplaceable and non-compensable ecosystems, which must be assumed and addressed by environmental and territorial policy and management

actions taken by the State through its competent bureaus.

5. Conclusions

According to the collected data, in legal, ecological and practical biodiversity conservation terms, there is a shift between environmental offsetting in Minas Gerais State, Southeastern Brazil. Therefore, the adopted AF EO, despite complying with legal assumptions, has proven ineffective and led to biodiversity loss, besides moving environmental management and policy away from what it should be aimed for, namely: net biodiversity gain or, at least, no loss at all.

The 2:1 ratio offsetting set for AF suppression in MG accounts for an incorrect positive impression that, in its turn, masks the fact that such offsetting is most often provided by land tenure regularization (TR) in conservation units (CUs). When it comes to environmental offsetting and net biodiversity gain, it does not matter if the offsetting is twice as big as the suppressed area, if most of it is provided by the regulation of already protected areas; actually, it will always be some native vegetation cover loss in the state.

The present study reinforces the understanding that Atlantic Forest environmental offsetting in Minas Gerais, mainly in ferruginous rocky fields, is legalistic and ineffective. It reinforces outdated regulations that, in their turn, are distant and disconnected from the best scientific practices available. Therefore, there is no effective ecological offsetting. The collected

data reinforced the understanding that Atlantic Forest offsetting in Minas Gerais is conceptually wrong (it does not include rocky fields), obsolete (it does not take into consideration well-known facts) and ineffective (it does not protect the biome).

In summary, the current study highlights the three most urgent points to update and improve AF EO policies and instruments in MG:

(i) Encouraging EO achieved through ecological restoration and through its prevention through TR in CUs, alone; encouraging net biodiversity gain, the creation of new protected areas and the promotion of more resilient and sustainable territories.

(ii) Integrated Environmental Assessment (IEA) or Cumulative Impact Assessment (CIA) should be widely adopted, mainly for mining ventures, in order to avoid and curb fragmented licensing that leads to mini-mines, and increases landscape fragmentation, biodiversity erosion and ecosystem services.

(iii) Environmental and territorial policy and management carried out by the State through its competent bodies must recognize irreplaceable and non-compensable ecosystems where it is impossible to achieve any gain or to stop biodiversity loss.

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