

Supplementary Material – Additional Information

Brazilian protected areas and current mining legislation

Brazilian protected areas include conservation units and indigenous lands. There are two types of conservation units: ‘strictly protected areas’ and ‘sustainable use protected areas’. ‘Strictly protected areas’ hold the maximum protective level and mining activities are explicitly forbidden within them (Law 9985/2000). ‘Sustainable use protected areas’ hold less restrictive conditions, and include seven different subtypes of protection figures: ‘environment protection areas’ (APA from their initials in Portuguese), ‘areas of relevant ecological interest’ (ARIE), ‘national/state forests’ (FLONA/FLOTA), ‘extractive reserves’ (RESEX), ‘wildlife reserves’ (REFAU), ‘sustainable development reserves’ (RDS) and ‘private reserves of natural heritage’ (RPPN). Mining activities are only allowed in ‘environment protection areas’ and ‘areas of relevant ecological interest’ (APA and ARIE). Finally, ‘indigenous lands’ are areas where the native populations hold all exploitation rights of the land they have traditionally occupied. The Brazilian Constitution of 1988 considers the possibility for the Parliament to regulate mining activities in indigenous lands, although laws of this nature have not been approved yet. Since the Constitution drafting process, the mining lobby has been trying to concretize this right arguing on the relevance of the mineral heritage of Brazil for the economic development of the country. Defenders of indigenous rights are opposed to mining in indigenous lands due to the high socioenvironmental costs of the activity. The first legislative initiative rose in 1989; while the bill PL1996/96 was created in 1996 and discussed on the parliament since then (<http://www.camara.gov.br/>). Thus, despite long-standing discussions confronting mining and conservationist interests since 1988, there is still no specific legislation to regulate mining in Indigenous lands.

Materials and Methods

Study area

The study area is the whole country of Brazil, focusing on regions where mining enterprises are established or plan to establish in the near future within protected areas (including conservation units and indigenous lands). We considered protected areas defined at federal, state and municipal spheres, and corrected for superposition among them giving priority by protection level.

Data origin and preparation

Geospatial mining data corresponding to the polygonal boundaries of mining projects registered until June 2015 was obtained from the National Mineral Production Department (DNPM) site (<http://sigmine.dnpm.gov.br/webmap/>). These polygons only represent the area in which the mining project is or is intended to be established. Thus, secondary adjacent impacts of mining activities are not considered here and we define 'impact' as the spatial extent of mining projects. Existing mining projects have an average extension of 354.5 ha; while planned projects (see below) have an average extension of 783.5 ha.

DNPM site also provided information on the licensing phase of each mining project. This information was interpreted according to the 'Miner's Guide' publication available at the DNPM website (<http://www.dnpm-pe.gov.br/Legisla/Guia/index.php>), which provides information on legal arrangements for exploitation of mineral resources, as well as on the necessary licensing procedures for each type of mining exploitation.

There are four different systems of licensing depending on type of mining exploitation: (1) Permission and Concession System. This system is used for all minerals except those protected by monopoly (oil, natural gas and radioactive minerals), and applies to areas between 50 and 2000 hectares depending on the explored material. Contrary to other systems, it is needed a previous permission authorizing the applicant to search for a certain mineral substance (research requirement phase). Once conceded, the research occurs during the research permission phase. If the company is indeed interested after this search, it may ask for exploration permission (mining requirement phase). Projects in the

phase of research requirement are considered here as potential, meaning that they have lower possibilities to be accomplished than planned projects, and are therefore not included in the analysis. (2) Licensing System. This system is used for immediate use of substances in construction, such as red clay and limestone for soils correction (Brazilian Law 6567/78) and applies to small areas (maximum of 50 hectares). This is a much faster process compared to the ‘permission and concession system’, since it does not require a previous research. (3) Extraction System. This system is restricted to immediate use of substances in public constructions carried out directly by the government bodies of the Union, States, Federal District and Municipalities (Brazilian Decree 3358/2000), and applies to very small areas, with no more than 5 hectares. (4) ASM Permission System. This system applies to artisanal and small scale mining (ASM, Brazilian Decree 98.812/90), developed in areas up to 50 hectares. Each licensing system has a procedure with different nomenclature for licensing phases (Table S1). Considering the meaning of licensing phases at each licensing system, mining projects were reclassified as: ‘potential projects’ for projects that are in a phase of research requirement, ‘planned projects’ for projects that are in a phase of license requirement, and ‘existing projects’ for projects that are already conceded. By definition, potential projects have lower probabilities to be developed than planned projects. For simplicity, and in order to get more robust and conservative results, we decided not to include potential projects in our analysis. Thus, in this work we focus only in planned and existing projects. As a reference, we identified 1787 potential projects (vs. 1851 planned projects) in strictly PAs, 3315 (vs. 11240) in APAs and ARIEs, 1689 (vs. 46) in other sustainable use PAs, and 3809 (vs. 541) in indigenous lands.

Geospatial data on Federal conservation units and indigenous lands were obtained from *Instituto Chico Mendes de Conservação da Biodiversidade* (ICMBio), while polygons on state and municipal conservation units were obtained from the Brazilian Ministry of the Environment (MMA).

Data analyses

The basic information for our analysis is the proportional and absolute overlap of the polygons of ‘existing’ and ‘planned’ mining projects with protected areas. The

proportional and absolute overlaps are presented in Figure 1 and Figure 2, respectively. We defined four potential legal scenarios for the near future (see table 1 in main text), and calculated the area occupied by projects classified as ‘planned’ in the near future considering these four scenarios and the type of protected area the project was overlapping with. We also calculated the area occupied by projects classified as ‘existing’ within each protected area. In order to avoid overestimation of mining impacts, before all calculations we revised spatial superposition among PAs. In the case of superposition among conservation units, we eliminated superposed areas of those with the lower protective level. In case of superposition between conservation units and indigenous lands, we did not eliminate any area as there is not a clear hierarchy among them and we consider them to be affected by different bills and to have different conservation objectives. All numbers referring to number of projects or area of impact in the text are explicitly calculated for this work.

Estimation of time for a project to become accepted

In order to estimate the average time that a planned project would need to be conceded and thus become of class existing, we analyzed how long did this process take with other processes in the past based on DNPM process register. We selected the 10 more-recent existing mining projects occurring at each type of PA considered in the study (i.e., APA & ARIE PAs, other sustainable use PAs, strictly PAs and indigenous lands), summing up a total of 40 projects. We searched each of these projects at the DNPM official site (<https://sistemas.dnmp.gov.br/PortalMPF/Site/ConsultarProcesso.aspx>) using the process protocol number, and annotated the year that the process reached a planned phase and the year that it reached an existing phase for the first time (see Table S1).

The average time that a planned project needs to be conceded was estimated as the average of the difference between these two years, and resulted in 0.5 years for APA & ARIE PAs (range 0 - 2 years), 2.8 years for other sustainable use PAs (range 0 - 8 years), 3.4 years for strictly PAs (range 0 - 8 years), and 5.3 years for indigenous lands (range 0 - 12 years). The average estimate was 2.86 years. 95% of sampled PAs were accepted within eight years, while only two projects (5% of samples), that were settled in indigenous lands, needed 12 years to obtain permission. Considering that mining projects

in indigenous lands only represent the 3.6% of the total, it may be safe to assume that most planned mining projects may be conceded in a time-frame of eight years. It should be noted that this time estimation is based on past processes. Time of concession could be reduced in the future with the approval of other complementary bills that would facilitate and accelerate the licensing process (e.g., PLS654/2015, PEC65/2012).

Table S1. Licensing procedure systems in Brazil associated to different types of mining exploitation. Licensing phases for each system are shown with all possible nomenclatures considered at DNPM database. These phases define mining projects as ‘potential’, ‘planned’ or ‘existing’ (of which only the last two are considered in this study).

Licensing procedure system	Type of Mining Exploitation	Licensing phases of Potential Projects (not included in the analysis)	Licensing phases of Planned Projects	Licensing phases of Existing Projects
Lic.1 - Permission and concession system	all minerals except those protected by monopoly	Research requirement	Research permission; Mining requirement;	Mining concession;
Lic. 2 - Licensing system	substances in construction		Licensing registration requirement; Licensing requirement; Licensing;	License registration
Lic. 3 - Extraction system	substances in public constructions		Extraction registration requirement	Registration statement; Extraction registration
Lic. 4 - ASM permission system	artisanal and small scale mining (ASM)		ASM permission requirement; ASM requirement; ASM	ASM permission

Figure S1. Spatial distribution of protected areas and mining in Brazil. Existing (a) and both existing and planned mining projects (b) are shown in black; while each type of protected area is shown in a different color.

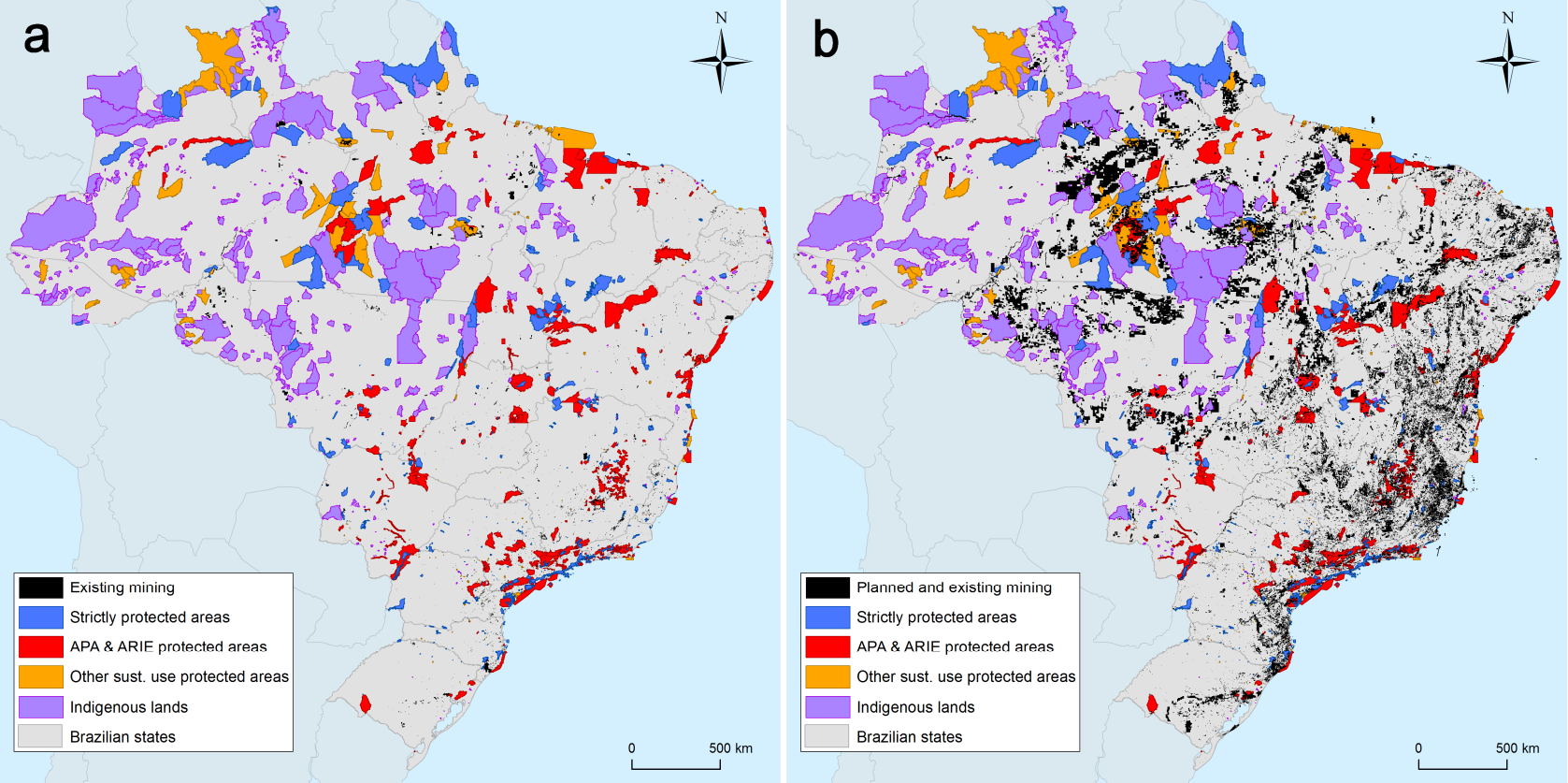


Figure S2. Detail of Figure 2 (corresponding to the grey rectangle in that figure) for APA & ARIE protected areas (a), other sustainable protected areas (b), strictly protected areas (c) and indigenous lands (d). See Figure 2 legend for further information.

