

## Policy Forums

# Green versus green? Adverting potential conflicts between wind power generation and biodiversity conservation in Brazil



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## ABSTRACT

Here we advert for the degree of overlap between the expansion plans of the wind-energy sector and the conservation goals in the Brazilian Caatinga, the largest and most diverse dry forest of the Americas. This ecosystem harbors more than 70% of both installed capacity and planned expansion of wind-powered energy in Brazil. However, a great proportion of wind farms are both currently operating or planned to be installed in areas already mapped and selected as of very high and extremely high priority for biodiversity conservation. Infrastructure expansion must therefore be accompanied with increase protection to biodiversity and poverty amelioration to attain sustainable development goals. We claim that wind-energy companies to publicize their plans of expansion and assuming public commitments to safeguard the natural ecosystems, thus avoiding an undesirable conflict of interest.

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## Introduction

Brazil is the 8th largest wind energy producer worldwide generating 13.3 GW of this renewable energy (Associação Brasileira de Energia Eólica, 2017). One of the main regions of interest for wind-farms expansion is the Northeastern region of Brazil, dominated by the Caatinga ecosystem, a highly diverse seasonal tropical dry forest. Official estimates points that up to 75 GW of wind powered energy can be generated in the Caatinga, supplying more than half of the wind power capacity estimated for Brazil as a whole (Agência Nacional de Energia Elétrica, 2008) despite this ecoregion accounts for only 11% of the Brazilian territory. Wind farms are proliferating fast and being celebrated worldwide (Global Wind Energy Council, 2018), delivering relatively cheap and clean energy, but their impacts on natural ecosystems are yet to be quantified and deserves attention (Dai et al., 2015; Jones et al., 2015).

To date, wind farms cause direct and indirect environmental impacts such as suppression of vegetation, soil exposure (increasing susceptibility to erosion) and opening of new roads and clear-cuts for transmission lines (Dai et al., 2015). Also, serious concerns exist on the impacts of wind farms on volant vertebrate fauna (Thaxter et al., 2017). Other impacts are more political such as land

use restrictions (Dai et al., 2015; Gove et al., 2016) and a vague and relaxed approach by federal and state legislation regarding the possible impacts of wind farms (Valença and Bernard, 2015). For example, Pernambuco state (>80% of its territory within Caatinga domains) recently removed precautionary environment protection to explicitly facilitate the establishment of wind farms in its territory (Assembleia Legislativa de Pernambuco, 2018).

Wind energy tend to be stimulated by governments intending to generate jobs, diversify energetic supply sources and reduce greenhouse gases (GHG) emissions. In Brazil, wind energy avoided the emission of 17.8 Mi of tons of carbon in the year 2017, equivalent to the emission of 12 million cars (Associação Brasileira de Energia Eólica, 2017). This sector, thus, can help countries to accomplish with voluntary goals of reduction of GHG emission in the next years. Worldwide, if national economies intend to seriously move towards a low-carbon economy, then wind energy should play a very important role (Gasparatos et al., 2017). At the same time, uneven conservation efforts to meet target 11 of the Convention of Biological Diversity (protect 17% of terrestrial ecosystems) demands the creation of new protected areas in all Brazilian biomes but the Amazon (Pacheco et al., 2018). Protecting new areas constitute a political challenge for any society due to the trade off between benefits of protecting natural capital and create land restrictions on areas dedicated to conservation.

When interests of persons or organizations cannot be accomplished without deleterious effects on each others rights and

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interests, then we have a conflict of interest (COI). In conservation arena, COI can be very deleterious for both environmental enforcement and development purposes (Katrina, 2002; Liu et al., 2017). This is the case of recent COI between the energetic and conservation sectors around the constructions of hydropower dams in Brazilian Amazon, resulting in high financial costs of dams and little yet questionable compensations to socioecological systems impacted (Fearnside, 2006; Finer and Jenkins, 2012). In the case of wind energy, 70% of the priority areas for wind energy generation in Brazil are located in the Caatinga biome, that lacks the most elementary information on its conservation challenges and opportunities (Bernard et al., 2014). Quantifying and geographically locating the regions of potential COI between conservationists and energy companies is possible in the case of the Brazilian Caatinga because both sectors made their areas of interest publicly available (Associação Brasileira de Energia Eólica, 2017; Ministério do Meio Ambiente, 2016).

Here we present a spatially explicit analysis on the amount of Caatinga territory under potential COI between environment and wind-power sectors. Specifically, we show how both established and planned wind-farms overlap with priority areas for biodiversity conservation (or Conservation Priority Areas, hereafter CPA) in the Brazilian Caatinga creating potential COI between two stakeholders of the sustainable development. We argue that there is a plenty of opportunities for better planning the expansion of wind-farms across the Caatinga, helping Brazil to achieve sustainable development goals (United Nations, 2015) both in terms of expanding presence of renewable energy sources and safeguarding biodiversity and ecosystem services in protected areas. We claim that the lack of dialogue between conservationists and wind-power companies can both increase opportunity costs for wind-farms and reduce opportunities for a needed expansion of protected area system for the Brazilian Caatinga.

## Material and methods

### *Defining and mapping conflicts of interest (COI)*

Here we define conflict of interest between environment and energy sectors as the spatial overlap of interests for both the creation of new protected areas and the establishment of wind farms. We then considered as overlap, the spatial coincidence of either operating or planned wind turbine (or aerogenerator) within any of the 282 areas officially mapped by the Brazilian Ministry of Environment as of interest for biodiversity conservation of the Caatinga ecosystem (Ministério do Meio Ambiente, 2016). When wind farms coincide in space with legally protected areas there should be conflicts of interest due to at least one of the following reasons: (1) Establishment of wind farms within or nearby protected areas demands more expensive studies of environmental impact assessment by wind-energy companies; (2) Depending on the degree of protection, wind farms may not be allowed within or nearby protected areas. On the other hand, the Caatinga is one of the less protected ecoregions of Brazil totaling less than 10% of legally protected areas from which less than 2% is strictly protected (Melo, 2017). Thus, there is a deficit of biodiversity protection for this region in the form of declared protected areas that must be overcome in the future through the creation of new protected areas. Therefore, it is reasonable to expect that wind-energy companies may operate politically against land protection in areas of interest because it would increase their cost of establishment or even hamper its expansion.

We focused our analyses on the Northeastern region where the Caatinga ecosystem dominates (more than 80%). This is the only ecosystem exclusive of Brazil and the region concentrates most

of the wind-power generation in Brazil. The Caatinga covers 11% of the Brazilian territory and is the largest tropical dry forest of the Americas (Silva et al., 2017). The wind-energy is responsible for around a 7.5% share of the total Brazilian electricity consumption but reaches 60% in the Northeastern region where the Caatinga ecosystem domains. Geographic location and quantity of aerogenerators both in operation and projected for the future are available from the Geographic Information System for the Electric Sector – SIGEL (Agência Nacional de Energia Elétrica, 2018). We then, used these data updated to January 2019 and classified each aerogenerator as ‘operating’ or ‘planned’ and retrieved its geographic location.

### *Data analyses*

We first constructed maps using the above mentioned publicly available data from Brazilian government: (1) Priority Areas for Biodiversity Conservation of the Caatinga; and (2) Geographic Information System of the Electric Sector (SIGEL). From the first database we gathered all areas selected by the Brazilian Ministry of Environment-MMA for biodiversity conservation of the Caatinga. From the second database, we could extract the exact geographical location (latitude and longitude) of all wind turbines including those already operating and those planned to be installed in the future. We then used geographic information system (GIS) procedures to cut and unite layers combining both the positive and negative congruencies between CPA's and both operating and projected aerogenerators. Such an overlap resulted in a map of the areas where both biodiversity conservation and wind energy sector interests overlap. We define three categories of conflict: (a) existing conflict – when a given CPA have at least one aerogenerator operating within its limits with no explicit plans of expansion; (b) growing conflict – when both operating and projected aerogenerators coincide with a CPA; and (c) potential conflict – for those CPA that current do not have any operating aerogenerator but there are plans for the installation of wind farms (according to SIGEL database). It is important to note that the SIGEL database does not provide any perspective of when the planned aerogenerators will be installed and at which pace because it depends on many bureaucratic steps such as environmental licenses and many other legal requirements. However, to be listed in the SIGEL database means that there is an ongoing process of establishment. We then calculated the number of aerogenerators (both operating and planned) and the area under conflict grouped by category of priority for conservation. For calculation of the area under conflict, we considered the whole area of each CPAs because each of them is intended to be treated as a political unit of conservation planning and management. We also calculated the overlap between existing protected areas (i.e. those areas already declared as legally protected by either federal or state governments) and both operating and planned wind turbines to understand what categories of PA are more likely to harbor wind farms. All GIS analyses were made using QGIS 2.18 and descriptive statistics were conducted using R language (R Development Core Team, 2016).

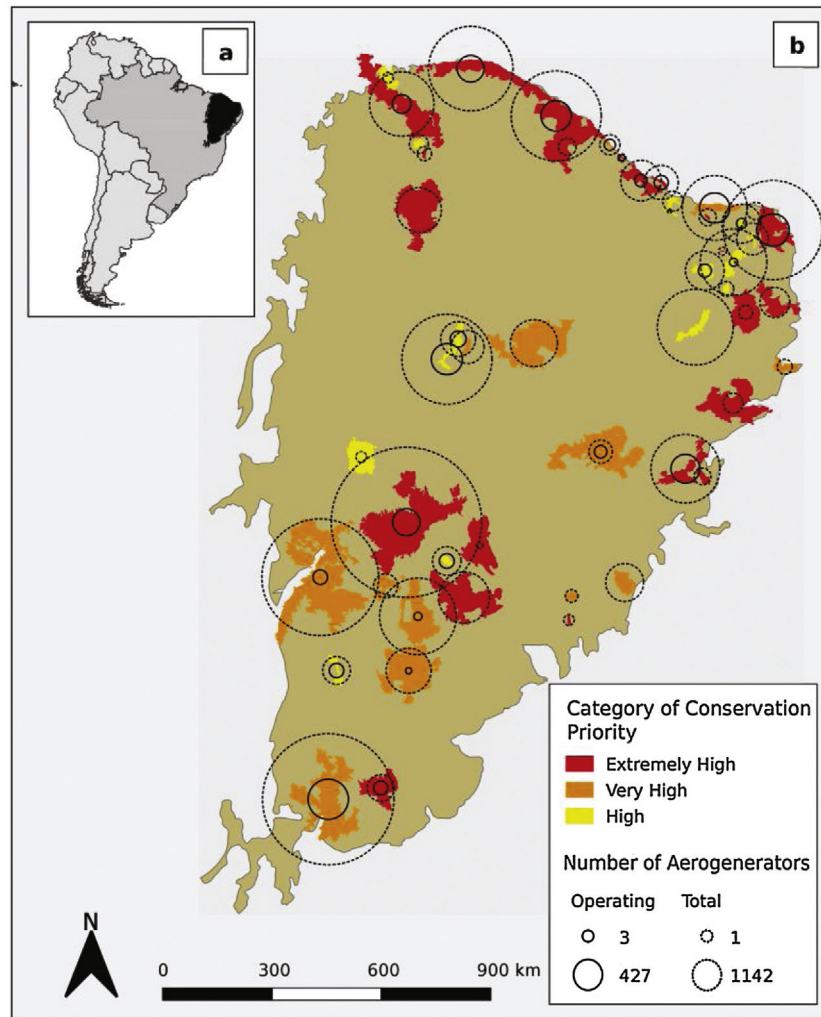
## Results

Until early 2018, there were 6313 wind turbines operating in Brazilian territory from which 4925 (78%) are within the Caatinga domains (Table 1). The expansion plans of the wind-power sector preview the establishment of 14,696 new aerogenerators, from which 84.6% are to be installed in the Caatinga (Table 1). Forty-seven percent (N=2616) of the already installed turbines lies within 18 out of the 282 CPAs in Caatinga (Fig. 1A) representing more than five million hectares of areas mapped for conservation with operating aerogenerators (Fig. 2A). The potential sources of

**Table 1**

Summary of the representation of each main terrestrial ecosystem in Brazil and the number of both operating and planned aerogenerators (as of early 2018) and the projected increase according to Brazilian official estimations. Note the concentration of wind-energy generation within the Caatinga domains.

Brazilian terrestrial ecosystems	Coverage of Brazilian territory (%)	Operating aerogenerators	Planned aerogenerators	Increase (%)
Amazonia	49.3	0	0	0
Caatinga	9.9	4925	12,444	253
Cerrado	23.9	185	609	329
Pampa	2.1	829	1208	146
Pantanal	1.8	0	0	0
Atlantic Forest	13	372	435	117

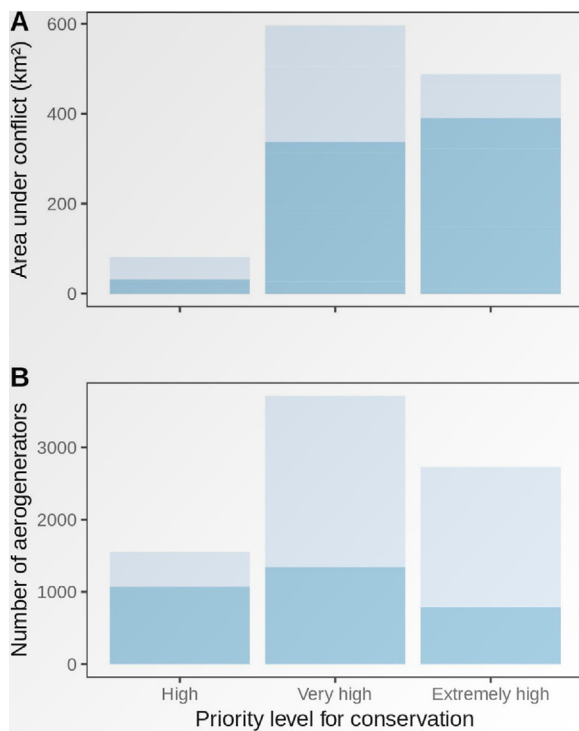


**Fig. 1.** Map South America (a) highlighting the Caatinga ecosystem (b) showing the conservation priority areas (CPA) with no legal protection grouped by the prioritization rank (yellow, orange and red colored areas). Size of continuous circles represent the amount of operating aerogenerators while dashed circles sums projected aerogenerators.

**Table 2**

List of legally protected areas with both operating an planned aerogenerators and the percentage of increase. All protected areas are of sustainable use category and seven of them belong to the less protective category – APA (Area of Environmental Protection) – according to the Brazilian legislation. RDS (Sustainable Development Reserve) is dedicated to the management of natural resources by traditional populations.

Protected Area	Area (ha)	Operating aerogenerators	Planned aerogenerators	Increase (%)
APA Boqueirão da Onça	505,694	87	736	846
APA Chapada do Araripe	972,605	585	532	91
APA das Onças	36,000	0	7	700
APA Lago de Sobradinho	1,018,000	42	250	595
APA Lagoa de Itaparica	78,450	44	85	193
APA Rio Pacoti	2914	11	0	0
APA Serra da Ibiapaba	1,628,450	68	42	62
RDS Ponta do Tubarão	12,960	62	0	0



**Fig. 2.** Total area (A) and number of aerogenerators (B) currently operating in early 2019 (dark blue) and the planned expansion (soft blue) grouped by conservation priority status (high, very high and extremely high) of the areas in the Brazilian Caatinga.

conflict will increase with time as another 5570 aerogenerators (48% of the expansion planned) are expected to be operating within CPAs of the Caatinga in the near future (Fig. 1B). Such an expansion will both add pressure to already impacted CPAs and create new pressure over many others summing up to 11.6 million hectares of Caatinga (13% of the Caatinga territory) where interests of both biodiversity conservation and wind energy generation might coexist in space and time (Fig. 2A). Briefly, the number of aerogenerators now operating in 13 CPAs (5.5 million ha) is expected to grow by 157% in the future. Moreover, 29 CPAs (4.6 million ha) that currently do not have any operating wind farms are expected to receive some 2136 new aerogenerators. Very high and extremely high priority areas for biodiversity conservation must receive 4678 new aerogenerators – i.e. 84% of the expansion will occur over CPAs as a whole (Fig. 2B). Also, there are 899 aerogenerators operating within eight legally protected areas (PA) of sustainable use but this number is expected to more than double in the future (Table 2). All these PA overlap with at least one of the conservation priority areas (CPA) and seven of them belong to the less protective category of the Brazilian legislation, APA (Area of Environmental Protection).

## Discussion

The current and projected distribution of wind farms overlap with millions of hectares of Caatinga that were officially mapped as targets for biodiversity conservation but are not yet officially protected. Also, wind farms are already installed in less protective categories of protected areas and expanding. The expansion of the wind energy sector is expected to more than double the amount of areas of potential conflict within the Caatinga domains. Yet, most of this expansion will occur over very high and extremely high priority areas for conservation, demanding urgent and proactive actions to prevent undesired environmental damage or conflicts of interest that may result in opportunity loss for biodiversity conservation.

The legal protection of these CPAs are crucial to safeguard the integrity of the ecological infrastructure of the Caatinga and should, ideally, coexist with the development infrastructure of wind farms that must serve to provide sustainable energy without hampering the legal protection of the natural capital of this region.

While environmental laws tend to impose additional requirements, commitments and compensation to safeguard ecosystems, wind energy lobby is expected to move against environmental law enforcement to make the establishment of wind farms cheaper (Valença and Bernard, 2015). It is reasonable to expect, therefore, that wind farm companies tend to block or make it difficult the creation of any officially protected area (PA) within the areas selected for biodiversity conservation, specially categories more restrictive to human use but more effective for biodiversity conservation. The establishment of wind farms are current allowed only in less protective categories such as those of sustainable use, especially APA, as we could register (Table 2). Once created, PA's of restrictive use can make more expensive or even impede the establishment of wind farms within their areas or in the surroundings according to Brazilian environmental laws (Valença and Bernard, 2015). Wind-farms are, by law, considered of low impact and therefore only simplified impact assessments (RAS in the Portuguese abbreviation) are legally requested for the establishment of wind farms. These cheaper studies become more complex and expensive when wind farms plan to operate in the surroundings of protected areas of restrict use (Brasil, 2014).

The expansion of wind farms over protected areas tend to generate more conflicts of interest with traditional populations such as the case of RDS Ponta do Tubarão where fishermen and tourism operators have complained about the establishment of wind farms in the sensible ecosystem of coastal dunes (Pontes, 2017). Another emblematic case, well documented in the Brazilian media, is the mosaic of protected areas in the region called “Boqueirão da Onça”. After more than a decade of negotiations, two contiguous protected areas were created in 2018, the National Park Boqueirão da Onça (ca. 346,000 ha) and the APA Boqueirão da Onça (ca. 505,000 ha). Instead of creating a great PA to safeguard one of the last jaguar populations of the Caatinga, split the area into two, one of restricted use (National Park) and other of sustainable uses (APA) was mainly due to political pressure of wind-energy sector already established in the APA region (Calheiros, 2011).

The prospects for the renewable energy in Brazil (wind-powered included) point to a future participation of more than 50% of this sector in the Brazilian energy matrix by 2026 (Ministério de Minas e Energia, 2016). For the geopolitical perspective, Brazil must promote and facilitate wind energy as it helps the country to accomplish with the decrease of GHG emissions at the same time it guarantees power supply for a growing economy. However, such an increment in power generation represents a large infrastructure improvement with the construction of new roads and transmission lines for the energy generated within the least protected terrestrial ecosystem in Brazil and one of the most impacted by climate change, the Caatinga (de Oliveira et al., 2012; Silva et al., 2017). At the same time, conservation efforts have moved forward to protect the Caatinga, mapping the priority zones for biodiversity conservation (Ministério do Meio Ambiente, 2016), estimating ecosystem services delivery (Manhães et al., 2016) and creating new federal and state protected areas in the past few years. Therefore, such expansion of wind-energy infrastructure must not compete with the creation of new protected areas for biodiversity in the Caatinga but, otherwise, run in parallel with no prejudice to environmental legislation.

We finally advocate for the urgent need to avoid an undesirable COI between two sectors that should be part of the same broad strategy for achieving the goals of sustainable development (United Nations, 2015). Clean and cheap sources of energy such as wind



powered must be part of the same broad strategy as protecting biodiversity through creation of protected areas that sum up the minimum required of 17% of each terrestrial ecosystem (United Nations, 2015). Wind-farm companies could be turned into a key player in promoting the protection of the Caatinga, supporting the creation of new protected areas and helping governments to implement and manage the existing ones. Wind energy sector must not take for granted that their operation is “green” and should move towards more proactive environmental programs to safeguard the Caatinga, the very ecosystem from where most of their good and profitable winds blows.

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