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Biodiversity, threats and conservation challenges in the Cerrado of Amapá, an Amazonian savanna

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Abstract

An Amazonian savanna in northern Brazil known as the Cerrado of Amapá is under imminent threat from poor land-use planning, the expansion of large-scale agriculture and other anthropogenic pressures. These savannas house a rich and unique flora and fauna, including endemic plants and animals. However, the area remains under-sampled for most taxa, and better sampling may uncover new species. We estimate that only ~9.16% of these habitats have any kind of protection, and legislative changes threaten to further weaken or remove this protection. Here we present the status of knowledge concerning the biodiversity of the Cerrado of Amapá, its conservation status, and the main threats to the conservation of this Amazonian savanna. To secure the future of these unique and imperilled habitats, we suggest urgent expansion of protected areas, as well as measures that would promote less-damaging land uses to support the local population.

Keywords
Brazil, Protected areas, Development policy, Land clearing

Introduction

Tropical savannas are dynamic systems of grassland and open woodland that cover 15 to 24.6 million km^2 of South America, Africa and Asia (Silva and Bates 2002), occupying one-fifth of the Earth's surface (Scholes and Archer 1997). A large part of the human population lives and works within these ecosystems, which house more pastoral land and wild herbivores than any other in the world, and which have a significant impact on the global economy (Sankaran et al. 2005; Scholes and Archer 1997). Tropical savannas are also recognised globally for their rich and unique biodiversity, and this, together with high levels of anthropogenic disturbance, has led to increasing conservation concern (e.g. Klink and Machado 2005). In South America, the largest savanna complexes are the Cerrado in Brazil, Bolivia and Paraguay, and the Llanos in Venezuela and Colombia (Silva and Bates 2002). However, further islands of savanna of varying size occur throughout the Amazon biome, known as Amazonian savannas (Carvalho and Mustin 2017; Prance 1996). The Amazonian savannas represent a distinct ecosystem within the large Amazonian region (see Prance 1996), different also from the white-sand ecosystems that further pepper the Amazon biome (see Adeney et al. 2016). These Amazonian savannas have generally been under-studied (see Carvalho and Mustin 2017) and are highly threatened, principally as a result of land-grabbing and the advance of cultivation of *grãos* (grains and pulses, mainly soybeans and maize), plantations of exotic woody species (eucalyptus and acacia), and un-controlled fires (Barbosa et al. 2007; Carvalho and Mustin 2017; Aguiar et al. 2014).

It has been estimated that, in Brazil, 12.3% of Amazonian savannas are within Strictly Protected areas (IUCN categories I-IV), 5.1% in Multiple Use areas (IUCN categories V-VI) and 40.3% in Indigenous Lands (Carvalho and Mustin 2017). Indigenous Lands have been shown to be effective in preventing deforestation (Nepstad et al. 2006), however, the effectiveness of protected areas in preventing degradation depends not only on protection type but also on the level of anthropogenic pressure to which the areas are exposed, and the intensity of enforcement among other factors (Nolte et al. 2013; Pfaff et al. 2014). Furthermore, some types of multiple use areas can offer protection of both biodiversity and local communities in the face of large-scale development, but it should not be assumed that local needs, expectations and attitudes toward conservation are easily compatible with conservation goals (Kohler and Brondizio 2017).

In recent years, a lack of protection of less isolated areas of Amazonian savannas (Cerrado of Amapá, Lavrados of Roraima and smaller fragments including those at Humaitá, Santarém and Monte Alegre), has facilitated the opening up of new areas to plantations of *grãos* and associated degradation of savanna areas (Barbosa 2013;

Barbosa and Campos 2011; Carvalho and Mustin 2017; Vidal 2017). Since 2006, deforestation of Amazonian forests to make way for soybean plantations has declined considerably, thanks largely to the implementation of a moratorium on soya (Gibbs et al. 2015). However, the expansion of soybean cultivation in Brazil has shifted the agricultural frontier to other areas such as the region between the states of Maranhão, Piauí, Tocantins, and Bahia, known as MAPITOBA, and has maintained its expansion across the Cerrado (Gibbs et al. 2015). The moratorium on soya is not applicable in the Cerrado biome, and is also seemingly not being applied to savanna habitats within the Amazon, opening up these areas to large-scale production of *grãos*. This can lead to deforestation and degradation, conservation conflicts and conflicts over land, increased burning, and displacement of traditional populations (Barbosa 2013; Barbosa et al. 2007; Domingues and Bermann 2012; Fearnside 2006; Gibbs et al. 2015; Vidal 2017).

The Cerrado of Amapá

The Cerrado of Amapá is one of the largest, least protected and arguably the most threatened complexes of Amazonian savanna in Brazil at present (see Carvalho and Mustin 2017). It covers approximately ~7.2% of the total area (~140,012 km^2) of the state of Amapá, in the far north of Brazil. Amapá has no road connections to the rest of the country and has very limited connections with neighbouring French Guiana. These facts have doubtless contributed to protecting the Cerrado of Amapá from large-scale agricultural activities until now. However, the state does have a port at the mouth of the Amazon River that allows for export of *grãos*, wood and minerals to China (via the Panama Canal) and Europe (Monteiro 2015).

The Cerrado of Amapá is characterised by a mosaic of areas with open woody vegetation, areas with a denser woody shrub layer, and open grassy areas with sparser shrubs and trees, and by seasonally flooded areas in the transition zone with floodplains (Castro 2009; Mochiutti and Meirelles 1994; Oliveira 2009). This ecosystem is also intersected by gallery forests (Castro 2009; Mochiutti and Meirelles 1994). The Cerrado of Amapá can be subdivided in to areas dominated by one of four main vegetation types: shrub savanna (*savana arborizada*), woodland savanna (*savana florestada*), grass savanna (*savana gramíneo-lenhosa*) and park savanna (*savana parque*) (Figures 1 and 2). There is clear variation in the composition and number of species that can be encountered in different locations in the Cerrado of Amapá. For example, the woody species *Salvertia convallariodora* is not found in the savanna areas to the north of the Araguari River, despite being one of the most abundant species in the savannas to the south of this same river (GEA et al. 2016).

The Cerrado of Amapá is among the most threatened ecosystems in the state (IBGE 2004b) and is subject to high human pressure containing both the largest urban centres and the majority of the network of highways of the state (see Figure 3). Since 2004 it has been recognised as a "very high" conservation priority for Brazil (Brazil 2004). Despite this recognition, and despite representing ~7% of the area of the state,

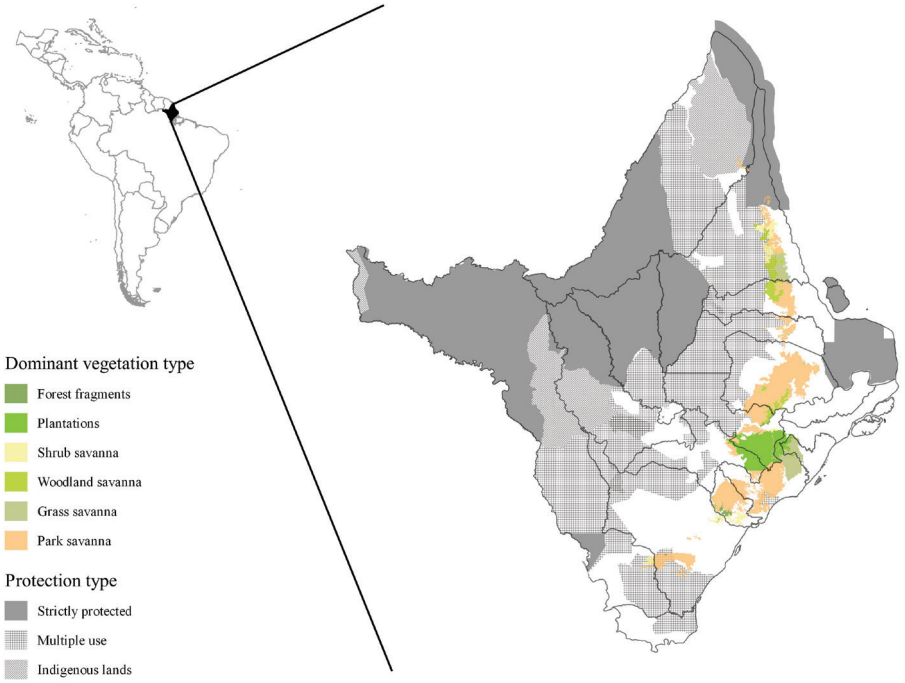

Figure 1. Spatial distribution of dominant savanna types and protected areas in the state of Amapá. Distribution of the four dominant savanna vegetation types (based on the Brazilian Institute of Geography and Statistics (IBGE) vegetation cover map for the Amazon (IBGE 2004a), and the three categories of protected areas (based on the shapefiles of Conservation Units and Indigenous Lands available from the Amapá State Environmental Secretariat (SEMA-AP 2016) and the World Database on Protected Areas (IUCN and UNEP-WCMC 2016) in the state of Amapá. Solid grey lines show the limits of the sixteen municipalities that make up the state. The shapefile of boundaries of the municipalities was also obtained from the Amapá State Environmental Secretariat.

as well as a significant percentage of its economically productive area, the Cerrado of Amapá has not received the attention that we argue it deserves. Here we present the status of knowledge concerning the biodiversity of the Cerrado of Amapá, its conservation status, and the main threats to the conservation of this Amazonian savanna. We further suggest pathways necessary to conserve this unique ecosystem and to secure its future in the face of mounting anthropogenic threats.

Biodiversity

To date, at least 378 plant species, 350 species of invertebrates, 200 bird species, 108 mammals (including 38 bat species), 26 species of fish, 41 amphibian species and 26 reptile species have been reported in the Cerrado of Amapá (Aguiar and Naiff 2010; Avila-Pires 1995; Azevedo 1967; Barbosa and Souto 2011; Boss 2009; Boss and Silva

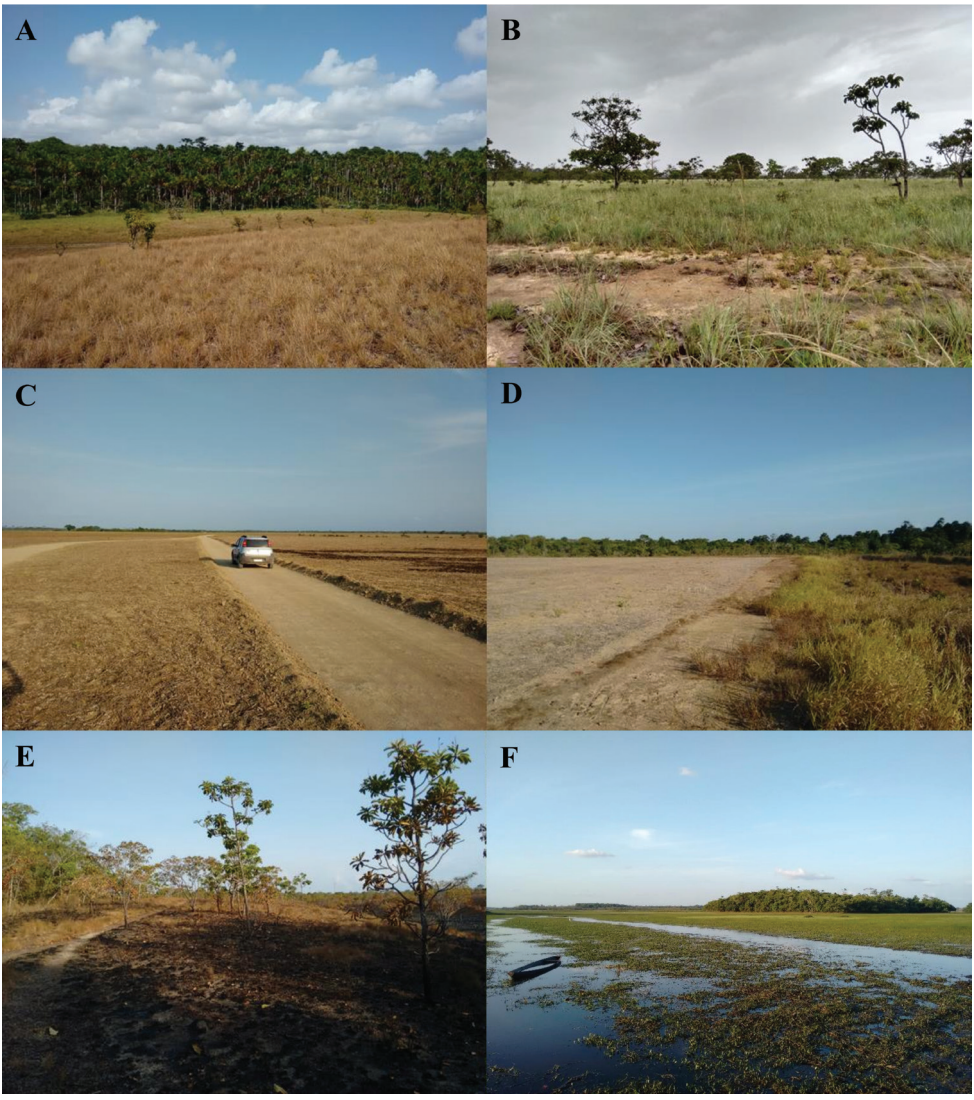

Figure 2. Images of habitat types and soybean plantations in the Cerrado of Amapá. **A** Grass savanna with gallery forests in the background, showing characteristic presence of palms **B** Area of park savanna **C** Area of park savanna converted to plantations of soybeans and maize **D** The right-hand side of the image shows what is left of an area of park savanna, the left-hand side shows an area prepared for planting with soybeans and maize, and in the background are natural forest fragments that occur within the Cerrado of Amapá **E** An area of park savanna after being burned; and **F** flooded savanna with grass savannas and a natural forest fragment behind.

2015; Cantuáriua 2012; Carvalho et al. 2009; Castro 2009; Costa-Campos 2015; Costa-Neto 2014; Costa-Neto et al. 2017; Deus et al. 2013; França et al. 2006; Galardo et al. 2013; Hamada et al. 2003; Jardim Botânico do Rio de Janeiro 2016; Jesus-Barros et al. 2012; Lima et al. 2017; Melo 2006; Mendes-Júnior 2013; Mesquita 2005; Mes-

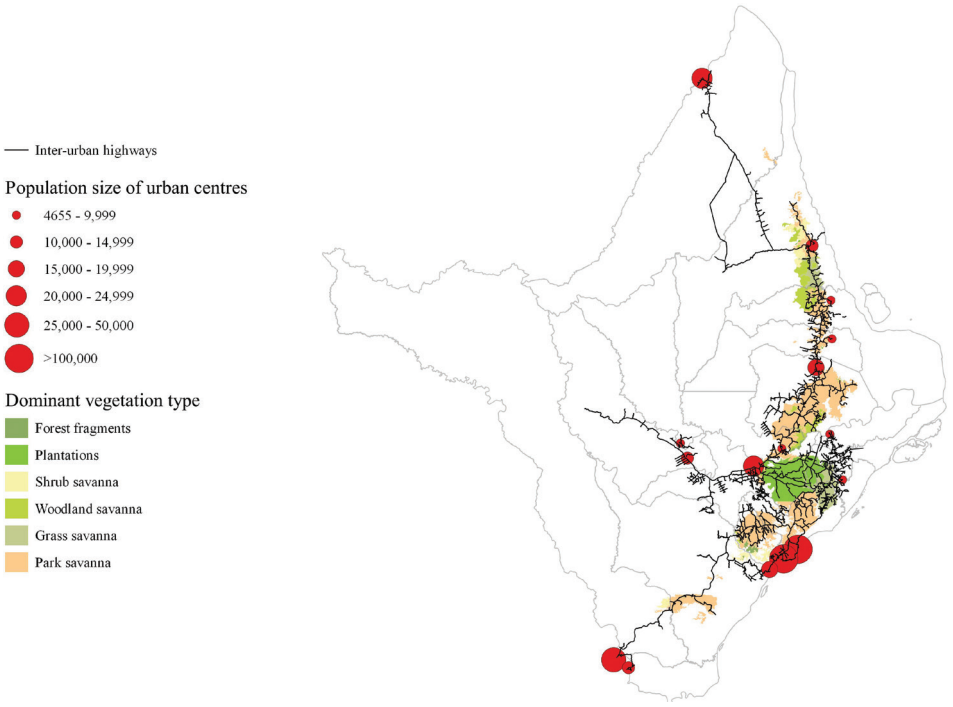

Figure 3. Highways and conurbations in the Cerrado of Amapá. The network of main highways (black lines), and municipal limits (grey lines) in the state of Amapá obtained from the Amapá State Environmental Secretariat (SEMA-AP 2016). The total length of highways in the state is 3,578.5 km, of which 1,999.9 km (55.9%) is within the Cerrado of Amapá. Of the 16 urban centres, 11 are within 10 km of the Cerrado of Amapá (points, with the size of the point proportional to the population – information obtained from IBGE (2016)).

quita et al. 2007; Nunes 2001; Pereira-Junior et al. 2013; Rocha et al. 2014; Saraiva et al. 2011; Schunck et al. 2011; Silva et al. 2013; Silva et al. 1997; Silva et al. 2006; Silveira 2003; 2006). Of the plant species reported, two are endemic to the state of Amapá – the carpet grass *Axonopus amapaensis* G. A. Black and the herb *Borreria amapaensis* E. L. Cabral & Bacigalupo (Jardim Botânico do Rio de Janeiro 2016; Rocha et al. 2014). Furthermore, the species' *Appendicularia thymifolia* (Bompl.) DC and *Chamaecrista desvauxii* var. *saxatilis* (Amshoff) H.S.Irwin & Barneby (Collad.) Killip occur only in the Guianan shield (Jardim Botânico do Rio de Janeiro 2016; Silva et al. 2015). The species *Philodendron carinatum* E.G.Gonç., also found in the Cerrado of Amapá, is considered rare in Brazil (Temponi et al. 2009). Amphibian species richness is high relative to other Amazonian savannas, likely maintained by the complex mosaic of savanna, forest patches, swamps and temporary ponds (Lima et al. 2017). Two fish species have also been described from the Cerrado of Amapá – the Amapá tetra *Hyphessobrycon amapaensis* (Zarske and Géry 1998), and *Melanorivulus schuncki* (Costa and De Luca 2010). The Amapá tetra has a very restricted distribution, and as such maintaining the integrity of the streams in which it is found is extremely important for

the conservation of this species (Nogueira et al. 2010). At least two of the mammals that have been recorded are endemic to the Amazonian savannas – Alston's cotton rat *Sigmodon alstoni* and a recently discovered species of opossum *Cryptonanus* sp. (Silva et al. 2013; Voss 2015). However, the area remains under-sampled for most taxa, and new state records of species of amphibians, birds and mammals have been made in the Cerrado of Amapá (Costa-Campos and Freire 2015; Schunck et al. 2011; Silva et al. 2013; Silva et al. 1997), highlighting the possibility of encountering new species and/or extending the ranges of existing species with better sampling of the region.

Owing to its geographic isolation and therefore relatively well-preserved state, Amapá is particularly important for the conservation of some species. For example, the only known populations of red-handed howler monkey (*Alouatta belzebul*) to the north of the Amazon River are found in the state of Amapá, where preliminary surveys show that occurrence of this species is predominantly limited to riparian forest within the Cerrado of Amapá (R. Hilário, unpublished data). To the south of the Amazon River, most populations of this species are highly threatened by the arc of deforestation, with just 10 small populations of this species remaining outside of the main area of deforestation pressure, in the Northeast Region of Brazil (Veiga et al. 2008). The species is listed as vulnerable by the IUCN (IUCN 2016). The Cerrado of Amapá is also recognised as an Important Bird Area (IBA) by Bird Life International, owing largely to the presence of large numbers of two declining bird species – the shrike-like tanager *Neothraupis fasciata* and the rufous-sided pygmy tyrant *Euscarthmus rufomarginatus* (De Luca et al. 2009). Both species are listed as near threatened in the IUCN Red List, with the principal threat being destruction and degradation of their Cerrado habitats (IUCN 2016). Importantly, *E. rufomarginatus* was previously listed as vulnerable, and was down-graded specifically due to its presence outside the highly threatened Cerrado biome, in the Amazonian savannas (IUCN 2016). As such, the massive conversion of the Cerrado of Amapá for agricultural production would represent a substantial loss of important habitat for *E. rufomarginatus*, and the species would almost certainly be up-graded once more in the IUCN Red List.

Conservation status

While the state of Amapá has ~72% of its territory covered by protected areas (Dias et al. 2016), these areas are almost entirely made up of *terra firme* (lowland tropical forest) and *várzea* (floodplain) forests, and flooded areas, and just 917.69 km^2 (~9.16%) of the Cerrado of Amapá has protection in strictly protected areas, multiple use areas and Indigenous Lands (Table 1). At least an additional 68.9 – 274.9 km^2 of savanna habitats fall within quilombos, traditional lands of the descendants of escaped African slaves, which are recognised under Brazilian Federal law as protected areas (Brazil 2006). However, biodiversity conservation is not usually a primary objective of these areas and their effectiveness in protecting against degradation has not been well documented. The vast majority of protected savanna habitats in Amapá are within multiple

Table 1. Total area and area protected of the four savanna types, and area of exotic plantations. Total area and area protected in each of three protection categories, of each of the four main vegetation types in the Cerrado of Amapá, and the total recorded area of plantations of exotic woody species. All values were calculated in ArcGIS v10.4.1 (ESRI 2011) using the Brazilian Institute of Geography and Statistics' vegetation cover map for the Amazon (IBGE 2004a), and the shapefiles of Conservation Units and Indigenous Lands available from the Amapá State Environmental Secretariat (SEMA-AP 2016) and the World Database on Protected Areas (IUCN and UNEP-WCMC 2016).

Vegetation type	Total area (km^2)	Strictly Protected (IUCN I-IV) (km^2)	Indigenous Lands (km^2)	Multiple Use (IUCN V-VI) (km^2)	Total area protected (km^2)
Park Savanna	6048.76	40.24[1,2]	27.03[3]	414.5[4,5,6]	481.77 (8%)
Grass Savanna	930.22			11.09[5]	11.09 (1.19%)
Woodland Savanna	835.36			247.19[5]	247.19 (29.6%)
Shrub Savanna	549.6			177.64[5,6]	177.64 (32.32%)
Plantations	1657.46				NA
TOTAL	10,021.4	40.24 (0.4%)	27.03 (0.27%)	850.42 (8.49%)	917.69 (9.16%)

Numbers indicate the following protected areas: [1]Cabo Orange National Park; [2]Seringal Triunfo Private Reserve; [3]Uaça Indigenous Lands; [4]Curiaú Environmental Protection Area; [5]Amapá State Forest; [6]Rio do Cajari Extractive Reserve.

use or sustainable use areas (IUCN category V-VI; 850.42 km^2, 8.49% of the total area) (Table 1).

Protection also varies across the four dominant vegetation types. For example, the grass savannas, the second most common savanna type in the Cerrado of Amapá, are the least protected, with just 1.19% of their 930.22 km^2 falling within the Amapá State Forest, a multiple use area (Table 1). This PA covers a total of ~403 km^2 of the Cerrado of Amapá, including areas of each of the four dominant savanna vegetation types. However, there have been proposals to revoke the act of creation of the Amapá State Forest (Euler 2016), originally established to consolidate the Biodiversity Corridor of Amapá (GEA 2010). This PA contains significant stretches of savanna-forest transition zones, and is incorporated in the mosaic of protected areas of the state (see Dias et al. 2016), in recognition of its importance for biodiversity conservation (Euler 2016). The Amapá State Forest also protects the only stretches of woodland savanna found within PAs, and about two-thirds of the shrub savannas that have protection (Table 1). As such, were it to be down-sized or degazetted, the grass savannas and woodland savannas of the Cerrado of Amapá could lose all protection, and shrub savannas could have their protection substantially reduced.

Park savannas represent ~60% of the total area of the Cerrado of Amapá, and are the only dominant vegetation type to be protected outside of multiple use areas (Table 1). However, most of their protection is still offered by multiple use areas including the Amapá state forest, the Rio do Cajari Extractive Reserve, and the Curiaú Environmental Protection Area (Table 1). Environmental Protection Areas (APAs), such as Curiaú, are not, however, subject to the same environmental licensing requirements for activities that have the potential to be polluting or to cause environmental degradation that govern other conservation units in Brazil (Brazil 2011). Instead, the large-scale

planting of crops is controlled by the same legislation (Resolution CONAMA 237/97) that governs environmental licensing of crop plantations and other activities in any part of the country (CONAMA 1997). Furthermore, Curiaú does not currently have a management plan, meaning that specifics of what is or is not permitted within the PA limits have not been made official.

Approximately 40 km^2 of park savanna is also protected by strictly protected areas – the Cabo Orange National Park and the Seringal Triunfo Private Reserve (Table 1), and a further ~27 km^2 fall within the Uaça Indigenous Land (Table 1). There is an overlap between Cabo Orange National Park and the Cunani Quilombo and owing to conflicting legislation, negotiations are on-going regarding the limits of the two protected areas which could eventually lead to a reduction in the amount of savanna habitat under strict protection. In Brazil, Indigenous Lands offer very effective protection (Nepstad et al. 2006), but the Brazilian federal government is currently considering modifications to legislation that would allow for exploitation of natural resources within Indigenous Lands (Fearnside 2016). As such, should the legislation be approved, Indigenous Lands could be opened up to mining and large-scale planting of crops (Fearnside 2016). Taking all of this into consideration, we conclude that the Cer rado of Amapá does not currently have effective long-term protection.

Major threats: present and future

While there is no good estimate available of the total area of the Cerrado of Amapá that has been cleared and/or degraded, estimates suggest that at least 450 km^2 have been cleared (Sano et al. 2017), and one estimate does suggest that up to ~1,949 km^2 (~19.5% of the total area) have been altered for use in silviculture, mechanized agriculture, livestock production and exploration of mineral resources (GEA et al. 2016). This includes at least 148.6 km^2 planted with soybeans in 2016 (an increase of almost 70% from 2013) (see Figure 2 C, D; IBGE 2017), with an expected increase to ~4,000 km^2 planted with soybeans by 2026 (almost 40% of the total area of the Cerrado of Amapá) (Silva 2016), with export facilitated by improvements to the Port of Santana (Monteiro 2015). Approximately 1,657.5 km^2 of the Cerrado of Amapá is also already planted with plantations of eucalyptus (Table 1). Massive silvicultural plantations in the Cerrado of Amapá were planned in the 1990s as a contribution to migrating global carbon emissions (Ab'Sáber et al. 1990; Fearnside 1998), but have not been planted as planned. However, such plans could be revived as Brazil's Intended Nationally Determined Contribution (iNDC), announced at the 2015 Paris Conference of the Parties under the climate convention, calls for "restoring and reforesting 12 million hectares of forests by 2030, for multiple purposes" (Brazil 2015).

Increases in infrastructure, including the construction of a new port, are acting to increase interest in use of the Cerrado of Amapá for plantations of crops and woody species, and the area has been recently referred to as Brazil's "final frontier" of soybean production (Silva 2016). *Grilagem* (land grabbing, or the illegal appropriation

of public land) with subsequent 'legalisation' of land-ownership rights is a further key contributing factor to the increase in area planted with eucalyptus and soybeans in the Cerrado of Amapá (CPT 2015; Silva 2014). With deeds of ownership in hand, future owners will be able to sell their lands or to acquire financing for investments in equipment and infrastructure for planting soybeans and eucalyptus (Gallazzi 2016; Silva 2016). Despite legislative tools to control deforestation (e.g. permanent preservation areas, legal reserves, and the Rural Environmental Register or CAR – *Cadastro Ambiental Rural* in Portuguese), and promotion of zero deforestation, land-grabbing continues in Amapá and other parts of the Amazon, contributing to on-going deforestation and conflicts (Benatti et al. 2006; Hill 2016; Oliveira 2013; Silva 2014; Tinoco and Sá 2016). This situation may be aggravated by the passing of Federal Lands to the state of Amapá, which occurred on 15th April 2016 (see decree in Brazil 2016), though land grabbing, land conflicts and the expulsion of local farmers have been on-going in the state since 2002 (Silva 2014).

The Cerrado of Amapá and other Amazonian savannas are further threatened by un-controlled burning over large areas that occurs as a result of poor fire management practices in areas where fire is used to clear areas for plantation and for livestock production (see Figure 2 E; Barbosa et al. 2007). Indeed, thousands of fire outbreaks have devastated the Cerrado of Amapá each year (Figure 4), mainly in the dry season (Figure 5). The number of "hot pixels", or 1-km^2 areas on a MODIS satellite image that contain one or more fires, has been on the increase since 2007 with dramatic increases in more recent years, with the number more than doubling between 2014 and 2015, and remaining very high in 2016 (Figure 4). In general, the number of fire outbreaks is higher in municipalities with a greater area of savanna habitats, including Tartarugalzinho and Macapá, where the highest numbers of fires occur and which are also the two municipalities with the largest areas of savanna habitats (Figure 4). Obvious exceptions to this pattern are Ferreira Gomes and Porto Grande, which is probably a reflection of the replacement of much of the savanna habitats in these municipalities with plantations of eucalyptus and acacia (see Figures 1 and 4), where fires are controlled by the companies that administer these plantations. While fire in Amazonian savannas has been present since pre-Columbian times, as indicated by charcoal in the soil (e.g. Turcios et al. 2016), these clear increases in recent years could be driven by climatic influences or by the expansion of commercial agriculture in some municipalities. Indeed, expansion of agriculture and livestock production across the state is likely to aggravate this threat, and in turn lead to a loss of biodiversity from the Cerrado of Amapá. The presence of roads, and consequent ignition sources, dramatically increases the frequency of fires in Amazonian savannas (Barbosa and Fearnside 2005b) and the Cerrado of Amapá contains more than half of the inter-city highways in the state (Figure 3).

The Cerrado of Amapá, other Amazonian savannas and forest areas that are still well-preserved in the states of Amapá and Roraima, and to the north of the Amazon River in the state of Pará, also face increased threats from the potential completion of the BR-210 Highway. The BR-210, if completed, would link Boa Vista in the state of Roraima with Macapá in the state of Amapá, crossing the state of Pará (G1 - GLOBO 2016). The stretch of the BR-210 that has already been constructed in Roraima has led

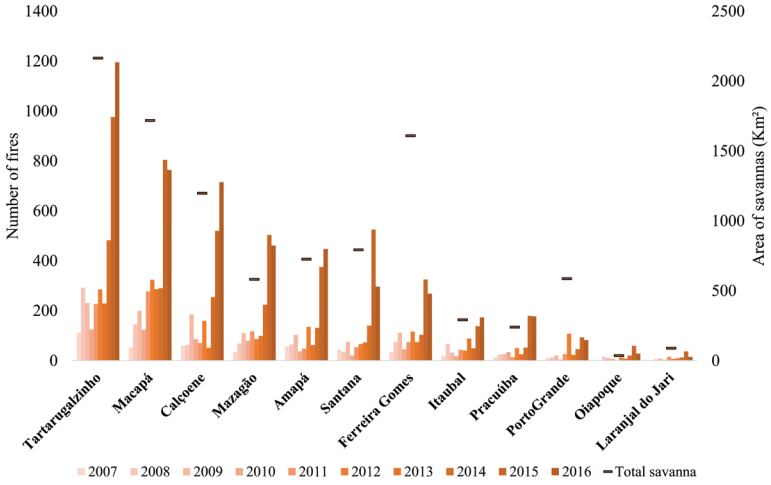

Figure 4. Fire in the Cerrado of Amapá, 2007 – 2016. Total number of hot pixels between 2007 and 2016, and total area of savanna habitats per municipality, in order of total number of outbreaks between 2007 and 2016. The hot pixels were quantified from shapefiles of the occurrence of burns obtained from the databases of the *Instituto Nacional de Pesquisas Espaciais* (INPE) (https://prodwww-queimadas.dgi.inpe.br/bdqueimadas/). Based on these shapefiles, and using ArcGIS v10.4.1 (ESRI 2011) the total number of hot pixels per year and per month within the Cerrado of Amapá were quantified in accordance with the Brazilian Institute of Geography and Statistics vegetation cover map for the Amazon (IBGE 2004a) and overlaid with the municipality boundaries available from the Amapá State Environmental Secretariat (SEMA-AP 2016). The area of savanna habitats was quantified as described in the legend of Figure 1.

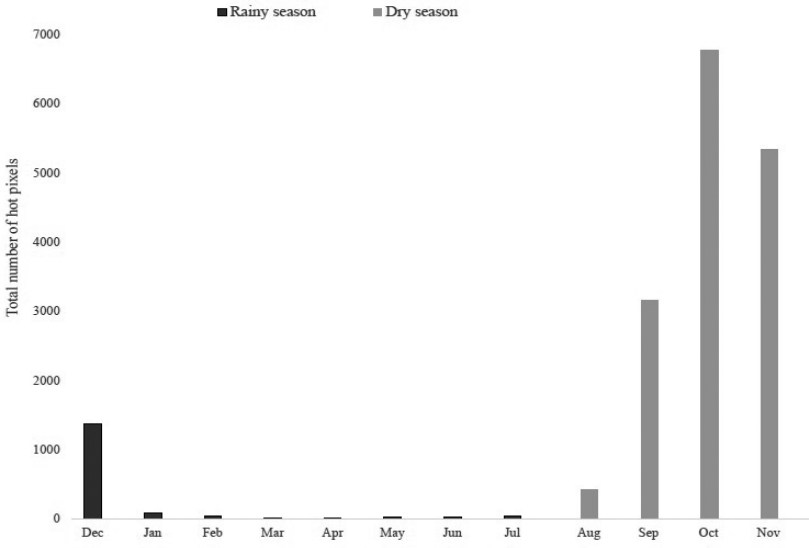

Figure 5. Total fires per month in the Cerrado of Amapá, 2007 – 2016. Total number of hot pixels in the Cerrado of Amapá between 2007 and 2016 in the rainy and dry seasons (summed across all municipalities and all years). The hot pixels were quantified as described in the legend of Figure 4. The classification of months in to the rainy and dry seasons followed Tavares (2014).

to the loss of large areas of forest along the highway (Barni et al. 2015), and in Amapá, practically all the deforestation that has occurred in recent years has occurred immediately adjacent to highways (SEMA-AP 2014). This construction, and the subsequent advance of illegal mining, land occupation and conflicts led to the organisation and ultimate recognition of the land rights of the Waiãpi indigenous people in 1996 (Gallois 1998). However, if completed, the planned highway would cross well-preserved areas and pass through Indigenous Lands, including those of the Waiãpi, and other protected areas. The threat to these areas would increase even further should legislation currently awaiting approval in the Brazilian National Congress be passed, thereby authorising mining within Indigenous Lands, and transferring the power to create new protected areas and Indigenous Lands to the legislative branch, where representatives of large landholders are a dominant influence (see Fearnside 2016).

The way forward

The current network of protected areas is insufficient to ensure the protection of the Cerrado of Amapá in the face of looming threats from large-scale planting of soybeans, plantation trees and other crops. Plans are already underway for zoning of the area for these economic activities (GEA et al. 2016), and we assert that this process must be open, equitable and participatory, involving local researchers, conservationists and crucially the rural, traditional and indigenous populations living in and around the Cerrado of Amapá, following the rules established in Brazilian Federal law concerning Ecological-Economic Zoning (Brazil 2002). To allow for the identification of representative areas for the protection of the region's biodiversity, investment of resources in research is now urgently required. Indeed, while many parts of the Cerrado of Amapá remain under-sampled, it is already clear that much heterogeneity exists in the flora and fauna of these savannas. As such, implementation of new protected areas within the Cerrado of Amapá must now be guaranteed, and these PAs must be positioned to be representative of the savanna ecosystem, taking in to account this heterogeneity and the social value of the different areas (Fearnside 2015; Fearnside and Ferraz 1995). Without such a process, there is a risk of losing a unique and important biodiversity before it has been properly documented.

Other priorities for sustainable development of the Cerrado of Amapá should include implementation of sustainable management practices, including appropriate management of the fire regime (Borges et al. 2016), soil conservation measures (Hudson 1995) and reduced pesticide and herbicide usage (Grovermann et al. 2017). Mechanisms should also be put in place to protect the many freshwater springs that originate in, or feed into, the Cerrado of Amapá. Crucially, proper monitoring will be required to evaluate the impacts of all activities in these unique savanna habitats, and particularly to ensure that negative biodiversity and social impacts of large-scale intensive agriculture and plantations are minimised. Indeed, sustainable development in the region will be impossible without a planning approach that generates income to

sustain local rural populations (Dias et al. 2016). Mechanisms that support and favour the continued development of markets and incentives for small-scale producers will be crucial for the sustainable development of the state of Amapá. At a broader scale, we further highlight the need to recognise the Amazonian savannas as a distinct and important habitat type, different from others large areas of savannas (i.e. Brazilian Cerrado), which would allow specific conservation initiatives to be implemented as part of a broader conservation policy. For example, Brazil's soya moratorium, which requires that soybeans not be produced in Amazonian forest areas deforested after July 2006 (Gibbs et al. 2015), could and should now be extended to require the same of soybeans produced in areas of Amazonian savanna (see Carvalho and Mustin 2017).

Productivity could be increased through integrated crop-livestock-forest systems (ICLFS) in areas already planted with eucalyptus. ICLFS contribute to soil conservation, using the soil more intensively but in concert with ecological management tools such as direct planting (Moraes et al. 2014). This type of approach to increase productivity has been promoted as a form land sparing to prevent the loss of stored carbon under the assumption that new areas will not be opened for agriculture (Pacheco et al. 2013). Brazil's voluntary pledges at the 2005 15th Conference of the Parties of the climate convention (COP-15) include the use of technologies such as ICLFS to help cut carbon emissions (Kichel et al. 2014). Brazil's Low-Carbon Agriculture (ABC) programme was launched in 2010 (Brazil 2010), and this programme further incentivizes implementation of ICLFS through provision of low-interest loans, although uptake has been slow (Angelo 2012; Strassburg et al. 2014). However, land sparing is a difficult conservation strategy because financial success of more productive commercial agriculture leads to more, rather than less, clearing for agricultural expansion (e.g. Fearnside 1987; 2002; Kaimowitz and Angelsen 2008).

Avoiding the conversion of Amazonian savannas to agriculture would contribute to maintaining climatic stability at local and regional scales (Butt et al. 2011) and benefit biodiversity conservation. The roots of savanna vegetation store a significant quantity of below-ground carbon (Barbosa et al. 2012). Without an effective programme to avoid savanna conversion, the quantity of carbon released by the savannas of Amapá could reach 8.15 t ha^{-1} [estimate based on data from arboreal vegetation near Macapá collated by JJT and estimates available for Roraima according to Barbosa and Fearnside (2005a) and Barbosa et al. (2012)]. This release would represent a loss of US$ 27 ha^{-1}, since each ton of carbon could be sold for US$ 3.30 in the Voluntary Carbon Market (Hamrick and Goldstein 2016).

Here we draw attention to the Cerrado of Amapá, a biodiverse and highly threatened ecosystem that has to date received very little attention and almost no protection, compared with forested parts of the state. We have shown that there is an urgent need to implement protected areas, with local communities, scientists, conservationists and policy-makers working together to construct a sustainable and equitable plan for their management. By doing so, we can ensure the sustainable development of this isolated state in the far north of Brazil, providing solutions that result in positive social, economic and biodiversity outcomes– the so-called 'triple bottom line' for conservation.

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