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comment

The highly threatened and little known Amazonian savannahs

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The biodiversity of the Amazonian savannahs may be lost before it is known, unless scientists, conservationists and policymakers come together quickly to protect it.

The conservation value of the world's tropical savannahs has been increasingly recognized, owing to their rich and abundant flora and fauna, and high levels of species endemism[1,2]. These dynamic systems of grassland and open woodland cover 15 million to 24.6 million km^2 of South America, Africa and Asia[2]. In South America, the largest savannah complexes are the Cerrado in Brazil, Bolivia and Paraguay, and the Llanos in Venezuela and Colombia (Fig. 1). However, further islands of savannah of varying size occur within the Amazon biome, known as Amazonian savannahs, which are severely threatened. We estimate that the Amazonian savannahs constitute a total area of approximately 267,164 km^2 (Fig. 1, Table 1). Almost 90% of the total area occurs in Bolivia and Brazil, with smaller areas in Venezuela, Guyana and Suriname (Fig. 1, Table 1). The largest complexes are the Beni savannahs in Bolivia (~127,096 km^2); the Guyanan savannahs in Brazil, Venezuela and Guyana (~82,382 km^2); the Sipaliwini–Parú savannah in Brazil and Suriname (~15,453 km^2); and the Cerrado of Amapá in Brazil (~13,027 km^2; Fig. 1).

Research gaps

The Amazonian savannahs are of particular importance for conservation, being home to unique flora and fauna, with communities composed of savannah and forest species, including numerous endemics[3,4]. However, the Amazonian savannahs have been little studied in relation to the Cerrado and Llanos, from which they have long been isolated by the Amazon Rainforest[2]. We found just 136 studies of the Amazonian savannahs, carried out over 80 years, covering nine of the main taxonomic groups (Fig. 2, Supplementary Table 1). Of these studies, almost a third focus on plants, with far fewer studies of reptiles, birds, mammals and invertebrates, and hardly any of amphibians and fish (Fig. 2). The vast majority of these studies were conducted wholly or partly in Brazil (111), concentrated largely in the Brazilian part of the Guyanan savannahs (31) and the relatively small area of savannah near the village of Alter do Chão, in the central Amazon (39).

Research focus in these areas likely reflects their proximity to important research centres in Manaus, Santarem and Boa Vista. Although restricted in number and geographic coverage, these studies clearly show that heterogeneity exists in the composition of floral and faunal communities between different Amazonian savannahs (for a review, see refs [3,4]). However, more studies are urgently required to better characterize the biodiversity of these areas as the lack of information on the occurrence and abundance of different species in these habitats hinders conservation efforts. For example, a comprehensive international plan to prioritize conservation areas for the jaguar (*Panthera onca*) in all habitats within its range did not include areas within Amazonian savannahs due to a lack of information on jaguar status[5].

Conservation gaps

Here, we estimate that ~13.4% of Amazonian savannahs are currently within

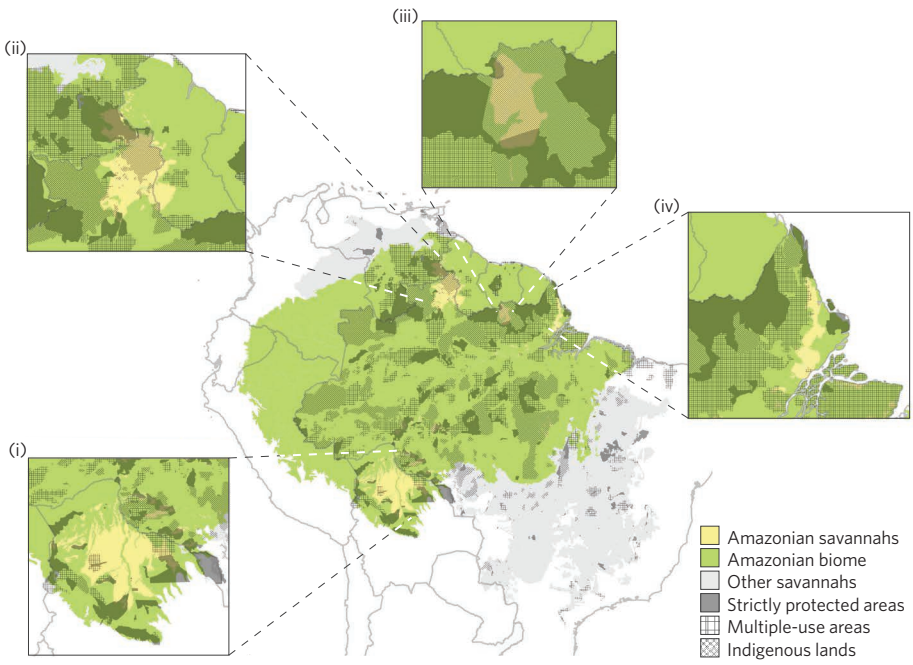

Figure 1 | The distribution of Amazonian savannahs and the three types of protected area throughout the Amazon biome. 'Other savannahs' are the Cerrado in Brazil, Bolivia and Paraguay, and the Llanos in Venezuela and Colombia. The inset panels show the four largest complexes of Amazonian savannahs: (i) the Beni savannahs in Bolivia; (ii) the Guyanan savannahs in Brazil, Venezuela and Guyana; (iii) the Sipaliwini–Parú savannahs in Brazil and Suriname; and (iv) the Cerrado of Amapá in Brazil.

Table 1 | Total area of Amazonian savannahs, and the extent of coverage by protected areas.

Location	Area, km² (% of total area)	Protected area, km² (% of total area)		
		Strict protection	Multiple use	Indigenous lands
Bolivia	127,096 (47.6)	9,629 (7.6)	10,365 (8.2)	0
Brazil	112,961 (42.3)	13,916 (12.3)	5,788 (5.1)	45,540 (40.3)
Guyana	13,447 (5.0)	0	77 (0.6)	0
Venezuela	13,085 (4.9)	11,639 (88.9)	760 (5.8)	0
Suriname	575 (0.2)	575 (100)	0	0
Total	**267,164**	**35,759 (13.4)**	**16,990 (6.4)**	**45,540 (17)**

'strictly protected' (SP) areas (equivalent to IUCN categories I–IV); ~6.4% are within areas of 'multiple use' (MU; equivalent to IUCN categories V and VI); and ~17% are within 'indigenous lands' (IL), with coverage varying nationally (Table 1). In 2004, the major Amazonian savannah complexes in Brazil were recognized as conservation priorities for the country by the Ministry for the Environment[6]. Since then, 27 new IL, 19 new MU and 7 new SP areas have been designated that, at least in part, cover areas of Amazonian savannah in Brazil, representing increases of 73, 79 and 37%, respectively, to the number of protected areas. Among these is Campos Amazônicos National Park in the states of Amazonas, Rondônia and Mato Grosso established specifically to protect important areas of Amazonian savannahs from advancing degradation in the region. During this same period, no new protected areas were designated in areas of Amazonian savannah in Venezuela and Suriname, however Bolivia and Guyana have each established one new MU area covering Amazonian savannahs.

The Cerrado of Amapá, despite being recognized as a Very High conservation priority for Brazil, is the least protected of the major complexes of Amazonian savannah. Furthermore, it is mostly protected by MU areas where various activities are permitted, including, for example, small-scale livestock production and agricultural activities. In contrast, the Sipaliwini–Parú savannah and the Guyanan savannahs are protected largely by IL and SP areas, though a significant part of the Brazilian side of the Guyanan savannahs remains unprotected. Throughout the Brazilian Amazon, IL cover an area five times greater than do SP, and have often prevented deforestation completely despite high rates of deforestation around their edges[7]. However, existing and potential future protection for the Amazonian savannahs is threatened by legislation awaiting approval by the Brazilian National Congress that seeks to open up IL to mining and to restrict the creation of new, and expansion of existing protected areas of all types[8].

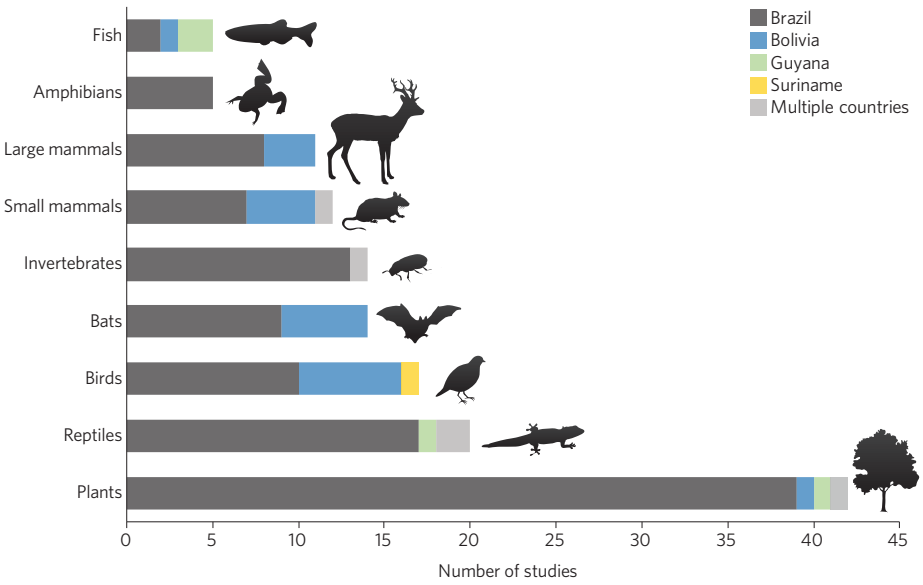

Figure 2 | The number of studies conducted in the Amazonian savannahs, broken down by country and taxonomic group.

Anthropogenic threats

Human intervention in the Amazonian savannahs has long played a role in shaping the environment, and current key threats include conversion of land for large-scale agriculture and plantations, increases in infrastructure, and uncontrolled fires, all of which are interlinked. For example, in the late 1990s and early 2000s, the Brazilian part of the Guyanan savannahs were considered to be the country's new "agricultural frontier"[9], and between 2004 and 2015 the area in Roraima devoted to soybean plantation almost doubled from 120 to 238 km² (ref. [10]). This increase was in part driven by a large influx of soybean farmers from southern Brazil[11] stimulated by the establishment of new settlements and the paving of two major highways, which allowed for the export of products to major urban centres in Manaus and Boa Vista[9]. It is also important to note that this increase occurred after the Brazilian Guyanan savannahs were recognized as an Extremely High conservation priority[6]. Like Roraima before it, Amapá was recently named Brazil's "final frontier" of soybean production[12], again despite the recognition of the Cerrado of Amapá, since 2004, as a Very High conservation priority for Brazil[6]. In 2013, 45.5 km² had been planted with soybeans, an area which more than doubled to 113.7 km² by 2015[10], and which by 2026 may cover 4,000 km² of the Cerrado of Amapá[12]. While a moratorium exists restricting commercial soybean agriculture in areas of the Amazon biome deforested after 2006, this protection does not extend to the Amazonian savannahs[1].

Across the Amazonian savannahs, there is increasing pressure from soybean, rice and other grain production[3,12,13]. Planting of eucalypt and pine monocultures in savannah areas is also on the rise in many countries, particularly Brazil and Colombia[14], and this is a growing threat across the Amazonian savannahs. The Beni savannahs have a long history of human intervention, altering the very nature of the habitat and making them unique among the Amazonian savannahs[4]. However, extensive

cattle ranching and a high frequency of burning have increasingly threatened these savannahs, while rice farming is a growing threat[13]. In Roraima, redirection of public policies has supported large development projects, including commercial tree plantations and irrigated rice[3]. Commercial plantations of eucalypts and soybeans have also been established within the Cerrado of Amapá. These pressures can be expected to increase with improvement and construction of new and existing highways in the region. Indeed, with the exception of the Guyanan savannahs, the road networks around the major Amazonian savannahs remain poorly developed, and arguably a lack of good infrastructure has, until now, acted to protect them from development.

The ongoing investigation by the Brazilian government regarding the completion of highway BR-210 is particularly concerning for the conservation of the Amazonian savannahs. If completed, the BR-210 would link Boa Vista in Roraima with Macapá in the state of Amapá, passing through the state of Pará[15], close to the third largest Amazonian savannah complex, the Sipaliwini–Parú savannah, where threats are currently limited to small-scale hunting and uncontrolled burning[16]. The stretch of the BR-210 that has already been completed within the state of Roraima has already led to the loss of large areas of forest along the highway[17], and this habitat loss would almost certainly extend to forests and Amazonian savannahs along the proposed extent of the rest of the highway. Furthermore, while both infrequent natural fires, and more-frequent use of fire by indigenous peoples, have formed part of the history of the Amazonian savannahs since pre-Columbian times[18], the presence of roads and, as a result, ignition sources dramatically increases the frequency of fires in these habitats[19].

What the Amazonian savannahs need

Here we show that the Amazonian savannahs are little known, highly threatened and under-protected. Legal frameworks, policy instruments and multi-stakeholder agreements are now urgently required to: (1) recognize the Amazonian savannahs as distinct and unique habitats and commit each country to protecting them; (2) invest resources to study the social and environmental importance of these areas, to allow for (2a) participatory zoning to identify key areas for protection and for development of sustainable uses, taking into account the potential environmental and social impacts of development and of protection for conservation; (3) support the implementation of further public and private protected areas in the Amazonian savannahs, taking in to account 2a and ensuring that equitable decisions are made; (4) introduce or adapt legislation to ensure that wood and grains produced in areas of Amazonian savannah are not from newly cleared areas, for instance Brazil's Soy Moratorium should now be expanded to incorporate the Amazonian savannahs; and (5) implement appropriate monitoring and enforcement within and outside of protected areas to prevent biodiversity loss in these unique and imperilled habitats. Following these steps will contribute to a better understanding of the Amazonian savannahs, and guarantee their protection. This in turn will aid in our understanding of the various ecosystems that make up the Amazon, and as such contribute to efforts to protect the future of all the biodiversity of this vast tropical biome. ❐

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Author contributions

W.D.C. conducted the literature search to quantify the number of studies carried out in the Amazonian savannahs. K.M. conducted the GIS analyses to calculate total areas, and areas protected. Both authors contributed equally to the ideas and writing of the manuscript.

Additional information

Supplementary information is available for this paper.

Competing interests

The authors declare no competing financial interests.