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Mangrove near the Praia do Estaleiro São Paulo, Brazil
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Cerrado, Caatinga, Gran Chaco and Mata Atlântica: South American flagships of biodiversity

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Once you visit the extraordinary and unique ecosystems of Latin America, you would like to learn more about them. We learned a lot from our guides and lecturers during the IAVS excursions and plenary presentations and we are very grateful for this shared knowledge and experience. For many of us, these recent trips were the first time we visited these types of ecosystems. They were so breath-taking that some of us fell in love with them immediately, while others did after only a few days of absorbing their complexity and uniqueness. However, we also learned that these ecosystems will not necessarily persist into the future and that some systems are becoming degraded, whereas others may be completely destroyed.

The **Cerrado, Caatinga, Gran Chaco, Mata Atlântica** are just some of the unique ecosystems of Latin America. How could we, as scientists, help to prevent further destruction of these valuable habitats? Scientists are usually not very powerful, but if we will talk about the incredible values of these natural ecosystems and about the imminent threats, we can perhaps at least make other people aware of them. This was the primary motivation that leads us to publish this synthesis with the intent of introducing these threatened ecosystems more broadly to the scientific community. To provide a firm foundation we invited several colleagues from Latin America to contribute their opinions on the conservation status of these systems. Along with this information, we introduce briefly each of the ecosystems and describe our impressions and experience from visiting these ecosystems during the IAVS excursions.

Cerrado

The 'Cerrado' is the most extensive savanna region in Latin America, extending across the plateaus of east-central Brazil and spanning altitudes of 300–1000 m above sea level (Fig. 1). The region itself is composed of a mosaic of habitats that have been classified in various ways. For convenience, in our article we follow the classification by Ribeiro & Walter (2008). The Cerrado region is home to the most species-rich of all tropical savanna grasslands and woodlands, which became known generally as 'cerrado'. This region also has a high level of endemism and has been recognised as one of the global biodiversity hot spots (Mittermeier *et al*. 2011). Mendonça *et al.* (2008) listed 12,356 vascular species as occurring in Cerrado.

Fig. 1. The location of the cerrado biome in South America. Source: https://en.wikipedia.org/wiki/Cerrado

"*Cerrado*" means (in Portuguese) 'closed' or 'semi-closed' – a place where horseback riding is difficult. The name Cerrado is used in several ways: Firstly, it is the region supporting extensive Brazilian savanna formations, with other vegetation types embedded; secondly, it is being applied for a biome characterised by grasslands dominated by C4 grasses, with scattered trees and shrubs. Originally this biome occupied nearly 23% of the territory of Brazil. This concept includes a range of vegetation formations from open grasslands to closed woodlands. Within these, pockets of dry, wet and riparian (gallery) forests and non-wooded wetlands (veredas) are found, and although these are vital elements of the cerrado landscapes, in biome schemes they represent either azonal vegetation (riparian forests and woodlands, veredas) or extrazonal occurrence of vegetation typical of neighbouring biomes such as Amazonian rainforest, Mata Atlântica and Seasonal Dry Tropical forests. Campos rupestres ('rocky fields'), also found in some part of the cerrado region, are yet another special vegetation type associated with cerrado.

The core cerrado is grassland, with shrubs and trees covering 5%–70%. This woody cover basically reflects, under mesic nutritional conditions, water availability (or amount of precipitation), with high cover being characteristic of high-precipitation regions.

Faces of the cerrado savanna

As with many savanna systems on other continents, the South American cerrado has many physiognomic faces, ranging from grassland appearance to semi-closed forests.

Brazilian botanists and ecologists recognise *campos limpos* (grasslands), *campos sujos* (shrubby grasslands), *campos cerrado* (semi-closed woodlands) and *cerradão* (closed-canopy, dense savanna woodlands, sometimes called also 'forests'). Across several campos categories, so called *campos com murundus* (mounds) are recognised. *Campos rupestres* are part of the Cerrado region, though they deviate ecologically and floristically from the core cerrado savannas. Their biogeographic position has been intensively studied but remains controversial.

Campo cerrado (Figs. 2c and 2d, next page) represents the core physiognomic face of the cerrado biome; it is savanna woodland where tree cover varies from 5% to 70%. Characteristically no closed (interlocking) canopy is formed. Trees are small and tortuous, often with thick and corky bark, and leathery and hairy leaves. In this vegetation type, sunlight reaches the soil surface, supporting a dense herbaceous (and in places also shrubby) understorey.

Campos com murundus (mounds) is considered a peculiar face of either campo sujo or campo limpo and is characterised by regularly spaced mounds. The mounds promote soil aeriation and increase water infiltration and as such favour colonization of typical cerrado woody elements shrubs and small trees. This type of campo has tree cover of 50%–70% and occurs on drier, more aerated soils with regularly spaced mounds. Trees are virtually absent in nearby depressions. The origin of the hummocks used to be controversial and was often ascribed to activity of termites, however a recent study by Silva *et al*. (2015) revealed that their origin, at least those studied by the authors, is a consequence of topographic erosion.

Campos limpos (singl. *campo limpo* and freely translated as 'clean field'; Fig. 2a, next page) is herb-dominated vegetation, characterised by mixture of grasses, sedges, herbs with no trees or shrubs. They are commonly found on hill slopes, plateau bases and neighbouring water springs.

Campos sujos (also known as 'dirty fields'; Fig. 2b, next page) represents a grassland with very sparse cover of scattered shrubs and small trees. In general, it colonises shallow soils. It also includes dry, wet and hummock communities.

Cerradão (cerrado forest; Fig. 2g, next page), when compared to cerrado s.str. (=campo cerrado), contains trees that are taller (up to 12–15 m) and denser (up to 90% cover). Most importantly, unlike the extrazonal forest types found in the Cerrado region, cerradão is floristically composed of typical cerrado woody elements. Few shrubs, herbs and grasses are found in the understory as a result of the reduced incidence of sunlight at the soil surface. Soil fertility defines the dystrophic and mesotrophic subtypes.

Campos rupestres ('rocky fields') constitute a complex vegetation system, in places having variously grassland or shrubland appearance. Common to both facies is the shallow, nutrient-poor sandy soil and abundant rocky outcrops. In places, campos rupestres can be temporarily water-rich, especially during rainy season. Often they are exposed to winds and wide variation in daily temperatures. These habitats, supporting very species-rich vegetation, are usually limited to higher elevations where sandstone geology dominates the ancient landscapes of the Brazilian shield.

Cerrado wetlands

Veredas are small-sized marshes (Fig. 2e, next page) occurring in depressions collecting fine-size soil material (loam and clay) and producing water-saturated habitats, which continue to appear green (hence the name 'vereda') during the dry season. In places, these depressions support ***Palmeirals*** (palm-dominated groves) with buriti palm (*Mauritia flexuosa*)(Buritizal) on poorly-drained soils and

Fig. 2 The diversity of vegetation physiognomies of the Cerrado region: a) Campo limpo; b) Campo sujo (campo rupestre); c) sparse and d) typical Campo cerrado; e) Vereda; f) Palmeiral; g) Cerradão and h) Mata seca. Photos: Manoel Cláudio Da Silva Júnior

Attalea speciosa (Babaçual), *Syagrus oleracea* (Guerobal) and *Acrocomia aculeata* (Macaubal) occur on well-drained soils.

Forests of the Cerrado Region

Besides the cerradão, there are other forest formations embedded within the Cerrado region. These are either azonal (riparian and gallery forests) or extrazonal (tropical wet forests and seasonal tropical dry forests).

The azonal alluvial forests fall within two categories (not always recognised as separate classification entities) – gallery and riparian forests.

Gallery forest (Mata de galeria) is an evergreen riparian forest associated with smaller watercourses. The high tree density results in 70% to 95% cover. Waterlogged and drier subtypes, depending on length of influence of the groundwater, are recognised. Its highly variable floristic composition accounts for more than 30% of the vascular flora in the cerrado region, despite occupying only 5% of its extent.

Riparian forest (Mata ciliar) is deciduous or semi-deciduous riparian vegetation with 50% (dry season) to 90% (rainy season) cover. The floristic composition differs from that of gallery forests and its width is often greater than 100 m.

Dry forest (Mata seca; Fig. 2h previous page) is a deciduous, semi-deciduous or evergreen forest located away from watercourses on the most fertile soils with or without limestone outcrops. The canopy, up to 15–25 m tall, has seasonally variable tree cover of 0% (dry season) to 95% (rainy season). These forests are part of the global SDTF (Seasonal Tropical Dry Forest) biome, with its flagship – caatinga – bordering the cerrado savannas to the East.

What local specialists said about Cerrado

Giselda Durigan
São Paulo, Brazil

Every time I take a botanist or ecologist from other country to visit the Cerrado, the first impression is "what a huge biodiversity!!!"

What do you consider the main threat to the Cerrado?
The rapid and overwhelming land conversion for agriculture, forestry and pastures. At present, only about half the original area of the biome still has native vegetation, and the remnants are often threatened by biological invasions and fire suppression.

Could you estimate how many species of plants live in the Cerrado, and how many of these species do not live anywhere else?
More than 12,000 plant species are already recorded in the cerrado biome, of which about half are endemic.

Is it more difficult to persuade people to conserve non-forest ecosystems than forested ones?
Yes. I cannot clearly understand why, but the bigger the organism, the higher its value under human's perspective. Therefore, a typical human's reaction is much stronger when a tree is eliminated, compared to the destruction of grasses or forbs. People, in general, do not see the value of non-forest ecosystems.

We are scientists focussing on vegetation from all around the word. We understand the importance of maintaining all ecosystems, their component biodiversity and the ecosystem services they provide. Which arguments do you think should be used to persuade the governments and the public to protect these ecosystems?
I do believe the protection of the headwaters of most large rivers in Brazil is an incontestable argument to persuade governments and society as a whole that replacing native cerrado vegetation by other land uses can severely threaten people's health and the economic stability of Brazil. Land-use planning should prioritize this ecosystem service, in addition to hotspots of biodiversity within the cerrado biome.

What kind of publicity could help to preserve the cerrado? How can the scientific community, including the IAVS for example, contribute to this aim?
Giving publicity to the huge importance of cerrado vegetation for water protection and production is crucial. The huge biodiversity of small plants is also a surprise for people in general, and even for scientists. In 1 m^2 we can find up to 40 plant species. In 1,000 m^2 we can find more than 200 species. It is much higher than the diversity of African or Australian savannas, and even higher than that of many tropical forests.

In addition, cerrado has astonishing landscapes, charismatic animals, wonderful flowers and delicious fruits. We have to give these elements broad visibility. We have to disseminate the concept of "old-growth grasslands", to demonstrate that small plants can be long-lived, fragile, and very difficult to cultivate. That means once lost, recovering them will be almost impossible.

Human beings are more eager to love and protect what they are more familiar with. What interesting fact about the cerrado would you teach people who are not scientists? What plant or animal representing the cerrado would you introduce to them?

I would like to show people a short movie with scenes from the cerrado before fire, during fire and two months after fire, when it turns into a huge garden of rare and peculiar plants vigorously sprouting and blooming. Even for botanists, it is unforgettable. For me, the blue flowers of the dwarf shrub *Jacaranda decurrens*, the perfectly symmetric pink-flowers of *Gomphrena macrocephala* or the different species of *Eriocaulaceae* are good examples among hundreds of attractive plants in the cerrado that can get people's attention.

What botanists said about their visit of the Cerrado

Robert Peet (United States):

This is an amazingly diverse and unique set of ecosystems. I kept trying to place them in the context of other ancient grassland ecosystems seen on IAVS excursions: southwestern Australia, South Africa, southeastern US. The woody diversity at the genus and family level seemed the greatest I had seen in savanna-like vegetation. The floristic connections with the southeastern US were striking, yet the shift in diversity from almost exclusively the herb-layer in the southeastern US to include the woody layer in the cerrado was equally striking and unexpected.

Riccardo Guarino (Italy):

I think that the first threat is urban sprawl. We should not forget that Brasilia was built right in the middle of the cerrado. When I landed, I took a nice tour of the architectural creations of Oscar Niemeyer, the gardens of Roberto Burle Marx, and the Marianne Peretti art works. Everything inspired in me rhetoric and desolation. The EUR, in Rome, seems much, much better (...need I say more?). Spaces are so large that the buildings, while large, seem small and disproportionate. The theatre seems abandoned, as well as the garden surrounding it. The Museu Nacional is pretty empty (with the exception of rather insignificant temporary exhibitions). The frame of

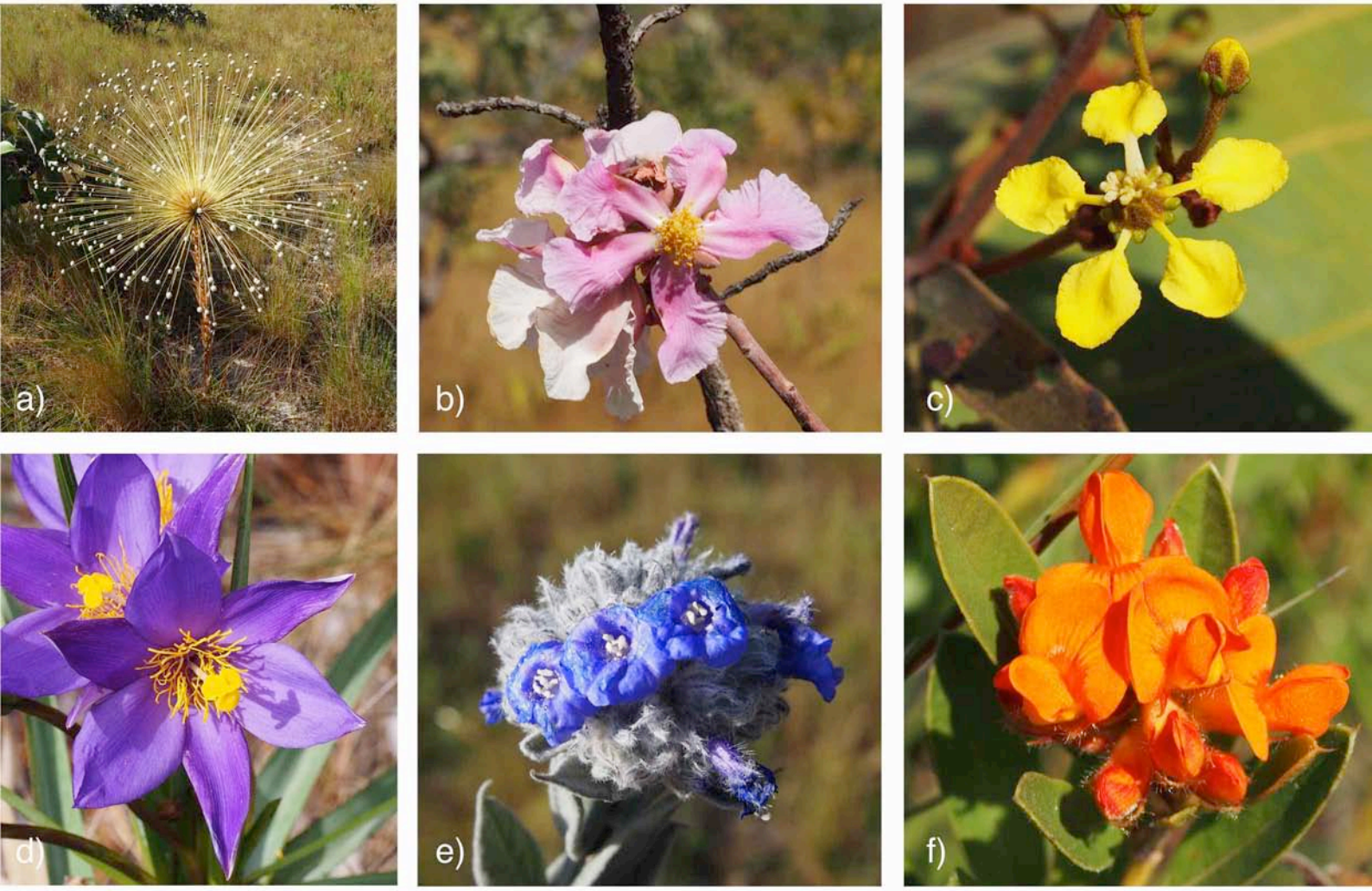

Fig. 3 Flowers of the Cerrado: a) *Paepalanthus* sp. (*Eriocaulaceae*); b) *Kielmeyera rosea* (*Calophyllaceae*); c) *Heteropterys byrsonimifolia* (*Malphigiaceae*); d) *Vellozia* sp. (*Velloziaceae*); e) *Evolvulus* (*Convolvulaceae*); f) *Eriosema glaziovii* (*Fabaceae*). Photos: Monika Janišová (a) and Radim Hédl (b–f)

cars whizzing (on six lane roads) contributes to making these places hostile and unsuitable for man: void zones, fear scapes. My final impression of the monumental axis of Brasilia is that it is a huge waste of space. Rhetoric of a power that celebrates itself constructing buildings, of which it does not grasp the meaning.

Monika Janišová (Slovakia):
The diversity of patterns, shapes, and strategies in the Cerrado is incredible. One can feel the creativity and phantasy of living systems in these primeval ecosystems, which have developed for many millions of years. One also can guess how difficult it is to survive here, in such harsh conditions. The tortuous trunks and traces of fire act as witnesses of this struggle. I was astonished and I could not stop taking more and more photographs.

The cerrado is not only beautiful, but it fulfils also important life-supporting functions on our planet. This is a pragmatic argument to protect it. Another, less pragmatic argument is that the Cerrado is an endless source of inspiration and surprise. There is nothing to get bored about here.

Laco Mucina (Australia):
Seeing, experiencing, smelling, enjoying cerrado has always been my dream. It was one of the last large pieces of savanna I had not seen – and now I have! What a feast!! In some places I felt I was somewhere in the Central Bushveld of South Africa, the country of my heart, yet that unexpected species diversity in cerrado made me eat humble pie. And, of course, it really does "work" like any other proper savanna: C4 grasses dominate, form biomass to be burned and carry regenerating fire, trees and shrubs adding a bit more structure and colour, offering food and shelter for many animals. What I miss are those herds of antelopes that the African savanna would support, but you cannot have it all and there is probably a good reason why the large herbivores are not so abundant. Yet, I was most in awe when I set my foot into a campo rupestre. Poor soils support the highest diversity... is it not strange? Not to somebody who has studied South African fynbos or Australian kwongan or maybe just a humble garrigue on siliceous substrates in the Mediterranean. Campos rupestres are the real biodiversity gems!

Caatinga

Caatinga is a dryland biome endemic to the north-eastern corner of South America (Fig. 5). It can be broadly characterized as ranging from shrubland to relatively open woodland with many thorny species. The more-or-less scattered trees usually do not exceed 15 m of height. The name "caatinga" is derived from the local Tupi language, where caa means forest and *tinga* means white, probably referring to whitish appearance of trunks of some woody species. The vegetation of the caatinga is relatively variable and hosts thousands of species endemic to this biome. Taxonomically and ecologically, the three most significant plant families are *Fabaceae*, *Cactaceae* and *Euphorbiaceae*. Interestingly, caatinga is one of the world's three biodiversity centres for cacti. *Bromeliaceae*, *Acanthaceae* and *Bignoniaceae* are other examples of fairly common and diverse groups. Caatinga experiences strongly seasonal climate. For most of the year (about six to nine months) the region is rainless, which causes woody plants to lose their leaves and most of the ground vegetation to retreat into a dormant stage. With the onset of the rainy season, vegetation changes abruptly. Human populations have for thousands of years inhabited the Caatinga region. It contains numerous important archaeological sites with characteristic outdoor rock paintings. The region was also among the first settled by the first Europeans arriving in the early 1500s. The current human pressure, including deforestation and overgrazing by sheep and cattle, poses serious threats to persistence of the extant caatinga ecosystems.

What botanists said about their first visit of the Caatinga

Radim Hédl (the Czech Republic):
What is your impression from the Caatinga?
The caatinga, at least what we could see in a three-day visit to the Catimbau National Park (near Buique, Pernambuco State), is a truly fascinating dry tropical ecosystem. Soils are extremely poor, sandy, shallow, and still they support considerable biomass of plants, and are able to feed the local human population and

Fig. 5 Position of the caatinga biome in north-eastern Brazil. Source: https://en.wikipedia.org/wiki/Caatinga

Fig. 4 The huge biodiversity of the Cerrado region is reflected also in the diversity of tree barks, as seen during just a short walk in the Chapada dos Veadeiros near Alto Paraiso de Goias. Photos: Monika Janišová.

livestock. Perhaps the most stunning recognition for me was that it has been like this for quite a long time. We visited rock paintings over three thousand years old, and the region is famous for such prehistoric sites. Historically, the caatinga biome has been closely linked to the human presence, which did not start with the arrival of white settlers but which has much deeper roots. We still need to understand it properly to fully appreciate this unique biome.

Why is the Caatinga important for ordinary people and why should it be protected?

Who are ordinary people? I am an ordinary person, so I can answer this question in an ordinary way: if the caatinga thickets would vanish, it would be sad news. The existence of any ecosystem has a value that can be hardly evaluated in terms of "services". Why it should be protected? Because many people depend on it, grew up and live their lives in the Caatinga region. It is a general reason for protecting any part of functioning environment.

For me, it was particularly interesting to compare the caatinga with the cerrado, which we visited during the post-conference excursion. Both are seasonal tropical biomes, and at the first glance the difference seems to be only a matter of subjective judgement. Neither climate nor soils would clearly differentiate the caatinga from the cerrado. It is mostly vegetation and its composition, which is highly specific, but there is such a great variability in ecosystem types within each of these biomes that it is difficult for me to tell, for example, how similarly looking ecosystems in tropical Asia differ from them (apart from species composition). It motivates me to read more and try to understand them better.

Fig. 6 Multiple views at the Caatinga. Photos Radim Hédl

Fig. 7 Beautiful flowers of the Caatinga: a) *Jatropha mutabilis*; b) *Clusia nemorosa*; c) *Commelina* sp.; d) *Justicia aequilabris*. Photos: Radim Hédl

Mata Atlântica

Historically speaking, Brazil started its development in the Mata Atlântica. The fleet of the Portuguese navigator Pedro Álvares Cabral anchored in the region where the present-day State of Bahia is located. The Atlantic Forest is also the domain of Brazilwood, whose name was given to the country (*Paubrasilia echinata* (Lam.) E. Gagnon, H.C. Lima & G. P. Lewis, *Fabaceae*).

The Mata Atlântica covers a large extent of the Brazilian coastline along the Serra do Mar hillsides. Its original area of 1,200,000 km² of large-sized forest has been deforested and only 11%–16% exists currently (Ribeiro *et al.* 2009). The original distribution spanned a continuous band from Rio Grande do Norte and Ceará (northeastern Brazil) to Rio Grande do Sul (southern Brazil).

Due to the fact that it spans a broad range of altitudes and latitudes (Fig. 8), the Mata Atlântica exhibits diverse vegetation physiognomies and landscapes. The most remarkable of them is the Dense

Fig. 8 Position of the Mata Atlântica ecoregion in south-eastern Brazil Source: https://en.wikipedia.org/wiki/Atlantic_Forest

"There I saw, for the first time, a tropical forest in all its sublime grandeur – nothing but the reality can give an idea of how wonderful and magnificent this landscape is."

Charles Darwin

Ombrophilous Forest (we consider this physiognomy as the *sensu stricto* Atlantic Rainforest; Fig. 9a), a lush and biodiverse floristic formation located close to the ocean. Further inland, the forest exhibits formations where the plants lose partially their leaves and the vegetation can be described as Seasonal Semideciduous Forest (Fig. 9b). Furthermore, in the southern Brazilian States of Paraná, Santa Catarina and Rio Grande do Sul, a portion of the Atlantic Forest is dominated by Araucária (*Araucaria angustifolia* Bertol. Kuntze, *Araucariaceae*) in Moist Forest and or Mixed Ombrophilous Forest (Fig. 9c).

It plays a key role in the stabilization of the steep and complex coastal terrain and preventing landslides. It has rugged topography where shallow soil and rocky outcrops are often visible. Such an exuberant forest is supported by high humidity levels, which come from the ocean and stay at the Serra do Mar owing to the high mountains immediately to the west.

About 70% of the Brazilian population lives in cities at a maximum distance of 200 km from the coastline and shares space with this biome, and whose historical occupation led to an intense loss of the Mata Atlântica forests.

What local specialists said about the Mata Atlântica

Gabriel Pavan Sabino
Rio Claro, Brazil

What do you consider the main threat to the Mata Atlântica?

The destruction of the Brazilian Mata Atlântica has been ongoing since European colonization in the 1500s, beginning with the exploration of Brazilwood (*Paubrasilia echinata*). We can also mention the economic cycles, such as gold mining and cultivation of sugarcane and coffee, which resulted in a lot of forest loss. Currently, the main cause of destruction of the Mata Atlântica is the disordered human occupation. Forests are being converted into large areas of livestock, sugarcane, eucalyptus and pine

Fig. 9 Various physiognomies of the Brazilian Mata Atlântica: a) Dense Ombrophilous Forest, Stadual Park os Serra do Mar, Cunha, São Paolo; b) Seasonal Semideciduous Forests, Bonito, Mato Grosso do Sul State; c) Mixed Ombrophilous Forest, São José dos Pinhais-PR. Photos: Gabriel Pavan Sabino and José Sabino

plantation. The spreading of invasive plants is also a huge problem in the conservation of forest remnants.

Could you estimate how many species of plants live in the Mata Atlântica? How many of these species do not live anywhere else?
In a recent paper, the Brazil Flora Group (2015) updated the inventory of the Brazilian seed plants. For the Mata Atlântica, they found 15,001 species of angiosperm, 7,432 of which are endemic (49.5%).

Consulting the flora, I've just checked the numbers: Angiosperms (15,504 species), Bryophytes (1,335 species), Gymnosperms (10 species), Ferns and Lycophytes (898 species) and Fungi *sensu lato* (3,012). Total: 20,759 species of plant and fungi known from the Brazilian Mata Atlântica. (Available at: http://floradobrasil.jbrj.gov.br/reflora/listaBrasil/ConsultaPublicaUC/ConsultaPublicaUC.do, accessed on: X/2016).

Is it more difficult to persuade people to conserve non-forest ecosystems than forested ones?
This is a good question. Definitely non-forested ecosystems are more targeted (and even more expansive), commercially-speaking, than the forested ones. I think that there are another two good reasons that make humans save more non-forested formations:

i) Economic use of forests: in the case of Brazil, Mata Atlântica, the use in different historical stages from Brazilwood to sugarcane to coffee and, more recently, the expansion of cities along the Brazilian coast. ii) It seems to me that - as we are primates that evolved in savannahs (open formations) – we have an evolutionary tendency to avoid closed formations such as forests.

Which arguments should be used to persuade the governments and the public to protect the Mata Atlântica?
The ecosystem services seem to be the most current approach to convince politicians and decision makers, as they address the most utilitarian view of nature, so much so that the UN set up recently (2012) the IPBES (www.ipbes.net) that takes this approach. It is more obvious to us experts as we more widely understand the importance of their roles and functions in the natural world.

What kind of publicity could help to preserve the Mata Atlântica? How can the scientific community, including the IAVS for example, contribute to this aim?
Public comprehension of science has been a challenge in Brazil. On one side, the dissemination channels have improved in recent years, while on the other hand the anthropogenic pressures have also increased and the remaining few pieces are increasingly restricted to fragmented areas.

Thus, it is increasingly necessary to produce and disseminate authoritative content on this topic. Fortunately, it has advanced here. There are NGOs, such as SOS Mata Atlântica, with 30 years of

Fig. 10 *Brachycephalus* sp., Cunha, São Paulo, Brazil

Fig. 11 A big and old Jequitibá-Rosa *Cariniana legalis* (*Lecythidaceae*), Santa Rita do Passa Quatro, São Paolo, Brazil

Fig. 12 Multiple views at Mata Atlântica in the Serra do Mar State Park near Cunha, São Paolo, Brazil. Photos: Monika Janišová

participation in numerous conservation actions, as well as specific projects with flagship species, like the Golden Lion Tamarin (*Leontopithecus rosalia*). Strengthening these actions and defending them in many different venues (internet, cable TV, channels that broadcast nature such as Nat Geo, Animal Planet, Discovery, BBC etc.) seem to me a solid way to reach a large public audience. Increasing, the production of media in videos and scientific blogs is bringing people closer to the riches of the Mata Atlântica.

Human beings are more eager to love and protect what they are more familiar with. What interesting fact about the Mata Atlântica would you teach people who are not scientists? What plant or animal representing the Mata Atlântica would you introduce to them?

There is a fabulous richness in the Mata Atlântica. When Darwin visited it in 1832 he marvelled with first contact at the vastness of species of tropical environments. This is well reported in several of his travelogues. Using these examples, both the vegetation that amazed him, as well as many other groups such as the insects, can be a way to help connect people. The Mata Atlântica is, at the same time, so close to the great urban centres of Brazil (São Paulo, Rio de Janeiro, Salvador, Curitiba, among other cities) and so distant because most Brazilians have no idea of the richness of this heritage. Another approach could be with endemic groups as frogs of the *Brachycephalidae* family where the whole family is endemic to this biome (Fig. 10, page 18).

A plant that could very well represent the Mata Atlântica (at least the physiognomy of Seasonal Semideciduous Forests) is the *Cariniana legalis* (*Lecythidaceae* family), known as “Jequitibá-rosa” (Fig. 11, previous page). The Jequitibá-rosa is a beautiful tree, reaching 50 meters in height and many centuries in age.

What botanists said about their first visit of the Mata Atlântica

Robert Peet (United States):
I was aware that there was great human pressure on these systems, but both the extent and the long-history greatly exceeded my expectations.

Monika Janišová (Slovakia):
The way in which space is occupied by plants in Mata Atlântica is amazing. The various mixtures of trees, palms, woody ferns, lianas and bromelias are so decorative that I was feeling like I was in the best gallery of the world. I was also impressed by the extent and quality of the research. It is so difficult to approach the plots, to collect the material, to grasp all the biodiversity, to avoid everything dangerous, ... I think all scientists working in the rainforests are heroes.

Gran Chaco

The Gran Chaco is a hot dry plain in interior south-central Latin America (Fig. 13). The name is of Quechua origin, meaning "Hunting Land". The climate varies from tropical in the north to warm-temperate in the south, but in most of the region it is subtropical with average temperatures between 19°C and 29°C and total annual precipitation between 450 and 1200 mm. Chaco soils range from sandy to heavy clay and are determined mainly by the drainage. The vegetation is associated with the soil patterns, reflecting also the east-west division. To the east, it is a parklike landscape of clustered trees and shrubs interspersed with tall, herbaceous savannas. Thorn shrubs, low trees and cacti are characteristic of the western Chaco. The area is only sparsely populated. In recent years, cattle ranching and soy cultivation have lead to significant deforestation and increased threat for the Chaco extraordinary biodiversity.

Fig. 13 The location and borders of the Gran Chaco region. The natural border to the west is the Andes and, to the east, the Paraguay River; its northern and southern borders are less well-defined.
Source: https://en.wikipedia.org/wiki/Gran_Chaco

What local specialists said about the Gran Chaco

Jose Paruelo
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What do you consider the main threat to the Gran Chaco?
We can affirm that deforestation is the main threat to the chaco ecosystems, which are seriously exposed to agricultural clearing and timber extraction, both authorized and illegal. The deforestation rate in this biome is the highest in the world, even higher than for tropical forests (Hansen *et al*. 2013, Vallejos *et al*. 2014). Land cover transformation is driven by agribusiness and associated with the land grabbing phenomena (Rulli *et al*. 2013).

Could you estimate how many species of plants live in the Gran Chaco? How many of these species do not live anywhere else?
The Gran Chaco, which is among the largest regions of seasonally dry subtropical forests in the world, (ca. 1,200,000 km^2), occurs in Argentina, Paraguay, Bolivia and Brazil (Cabido *et al*. 2008). It comprises one of the few areas worldwide where the transition between the tropics and the temperate belt does not occur in the form of a desert, but rather as semi-arid forests and woodlands (Morello & Adamoli 1974). Although most authors agree that these subtropical, seasonally-dry forests are characterized by a specific vegetation composition and unique flora, there are still no comprehensive floras, checklists or vegetation databases that allow us to answer to this question.

Which arguments should be used to persuade the governments and the public to protect the chaco?
In Argentina the law aimed to preserve native ecosystems focuses only on forest; there is no regulation on the transformation of grasslands, shrublands, wetlands and savannas of the Chaco region. In Paraguay the situation is even worst in terms of level of protection. So, we think that to preserve visible, non-forested ecosystems is an urgent need.

Land transformation is generating benefits that have (mainly) private appropriation (particularly

agricultural commodities). The scientific community should warn the government and the public as to the type and magnitude of public services provided by the chaco ecosystems that are being lost due to land cover transformation. Such services include biotic, cultural and ethnic biodiversity. Some emblematic cases include animal (e.g. the yaguareté, *Panthera onca*, a major feline), and plant species (e.g. different species of the genus *Schinopsis* such as *S. lorentzii* and *S. balansae*, Anacardiaceae), both are listed as threatened by the IUCN. Additionally, the xerophytic forests are critical to regulated water fluxes and groundwater recharge. The rise to groundwater level due to deforestation is a major concern in the area due to the risk of soil salinization.

What kind of publicity could help to preserve the chaco? How can the scientific community, including IAVS for example, contribute to this aim?

The scientific community must place stress on the known and documented consequences of land-cover transformation in the Chaco from habitat losses to the reduction in ecosystem services. Moreover, as vegetation scientists we must also point out the unknowns (e.g. the lack of a comprehensive vegetation inventory, or an updated list of endemic and endangered species).

Human beings are more eager to love and protect what they are more familiar with. What interesting fact about the chaco would you teach people who are not scientists? What plant or animal representing the chaco would you introduce to them?

What has happened with the quebrachos (*Schinopsis balansae* and *S. lorentzii*), the "history of the quebrachos", tells us also the history of the colonization and degradation of the chaco. The hard wood of the quebrachos made them a very valuable resource in railroad construction and its high content of tannins turned this species into a key resource in leather tanning. Foreign companies exploited both the quebrachos and local workers to send overseas

Fig. 14. Multiple views at the chaco ecosystem. Photos: José Paruelo and Melisa Giorgis

the material for tanneries and built railroads to ship agricultural commodities to Europe. Both the forests and the local aboriginal communities paid a high price in terms of ecological and social degradation after the industrial exploitation collapsed. A movie from the 1970´s captures the essence of the process; its name is precisely "Quebracho" (https://www.youtube.com/watch?v=CNje5ieYdKU).

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