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PANTANAL SCIENCE

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THE GENTLE GIANTS FROM THE SERRA DA BODOQUENA

PIONEERING RESEARCH PROJECT ON GREEN ANACONDAS MAKES NEW DISCOVERIES AND HELPS DEMYSTIFY THE SPECIES

37

IN MEMORY OF LIANA JOHN

All those involved in the production and creation of Pantanal Science mourn the loss of Liana John, our executive editor. Liana, an author and journalist, and to us the sweetheart of environmental journalism, left us in July 2021 after a long fight with cancer. Her environmental journalism was recognized by numerous prestigious awards.

Liana John's first collaboration on Pantanal Science was when she used her editing skills to transform the scientific language of an article about giant armadillos by Arnaud Desbiez into prose that was much more accessible to the general public. We were all delighted with her language style and decided that the "Liana gift" would be key to helping scientists communicate with the public. The articles authored by scientists were informative and had great content, but didn't have that friendly, right-to-the point style that Liana created and used so effectively to reach our readers. We presented Liana with our Pantanal Science project after finalizing the first volume, basically asking for help so that the journal could evolve – a dream shared by researchers working in the Upper Paraguay Basin – to be able to have an audience-friendly journal accessible for the community and public. To our great fortune, Liana agreed to participate and helped turn our dream into reality – increasing the level of professionalism and greatly improving Pantanal Science.

She went far beyond just working on the texts. She helped with the visual content, looking for skilled graphic artists, and making the journal so attractive that it gained national attention. With Liana's magic, Pantanal Science was soon recognized globally and available in three languages. The magazine is available online, but a printed version is also produced, so that the articles reach remote communities in the Pantanal, rural schools, and those folks who still enjoy turning pages.

Liana was an incredible professional, but also a partner and friend. Liana, you will always be in our lives. Thank you for sharing seven wonderful and productive years with us. It was an honor to work with you and watch you do your magic. Without a doubt, we know you would want to see Pantanal Science continue to evolve. We miss you so much, but continue to be inspired by your strength and dedication. We continue with our dream, your dream, and we dedicate Volume 7 to you.

Alexine Keuroghlian
Founder and general coordinator for Pantanal Science

Donald P. Eaton
Co-founder and Science coordinator for Pantanal Science

LEARNING FROM THE CYCLES OF LIFE

A number of impactful incidents have occurred since the previous volume of Pantanal Science, published in April 2021. A significant portion of the articles in that edition were written while the Pantanal was recuperating from the flames that burned and devastated the region during the two previous years. The fires came and left, and in addition to leaving a trail of destruction, taught us fundamental lessons about how to look after the region and prepare ourselves so that similar disasters do not happen again. Although it was a harsh lesson, revisiting the effects of wildfires and their impacts generated new knowledge and research opportunities for scientists working in the Pantanal and its surroundings. In this atmosphere of learning more and exploring favorable prospects for the Pantanal, we started to plan the 7th edition, which is presented here.

However, when we had every reason to believe that the journal would be, as always, prepared in an ambiance of hope and tranquility, we suffered another blow. We received the sad news for all who appreciate good environmental journalism that our dear Liana John, Executive Editor of all previous editions of Pantanal Science, had parted. She was more than a highly skilled journalist; she was for our team, a great friend and inexhaustible defender of our natural heritage. We were in doubt about what to do in such a heartbreaking situation? Where would we draw the strength and skill to continue with our plans? The answer came from Liana's own legacy and enthusiasm. The best posthumous tribute we could give to Liana would be to carry on with the journal, and so we did.

In this issue of Pantanal Science, we talk about life in its most diverse forms. Articles cover creatures ranging from tiny wild mice that survive wildfires by sheltering in partially-flooded burrows in the soil to the gigantic and fascinating anacondas of Bonito, one of the longest and heaviest snakes in the world. Another tells the story of small honeybees that provide employment and earnings for beekeepers in the Cerrado and the giant armadillos that also want to take advantage of beehive treasures. We also raise important conservation issues, like the threats associated with habitat fragmentation that become clear when comparing the genetic structure of white-lipped peccary populations between the fragmented Cerrado and more pristine Pantanal. Besides animals, we also address human lives, focusing on the communities that inhabit the Pantanal and face the daily challenges of adapting to changes. We present projects that rely on citizen science, where the knowledge and support of local communities go hand in hand with scientific findings. We discuss innovative opportunities to generate income in the Pantanal, such as the carbon credit market. And once again, we bring you articles written by researchers from Paraguay and Bolivia, our sister countries that share the Pantanal with Brazil and form part of the communication network described in the Pantanal Observatory article.

Despite the adversities and fatalities, life in the Pantanal continues to transform, renovate, and find its own path. WWF-Brazil strives to accompany these processes by supporting local partners and initiatives, while respecting and celebrating Pantanal culture. Thus, we strengthen our commitment to conservation and socio-environmental justice in this and other Brazilian biomes, each with its own unique characteristics, needs and challenges.

Happy reading!

Mauricio Voivodic
Executive Director
WWF-Brazil

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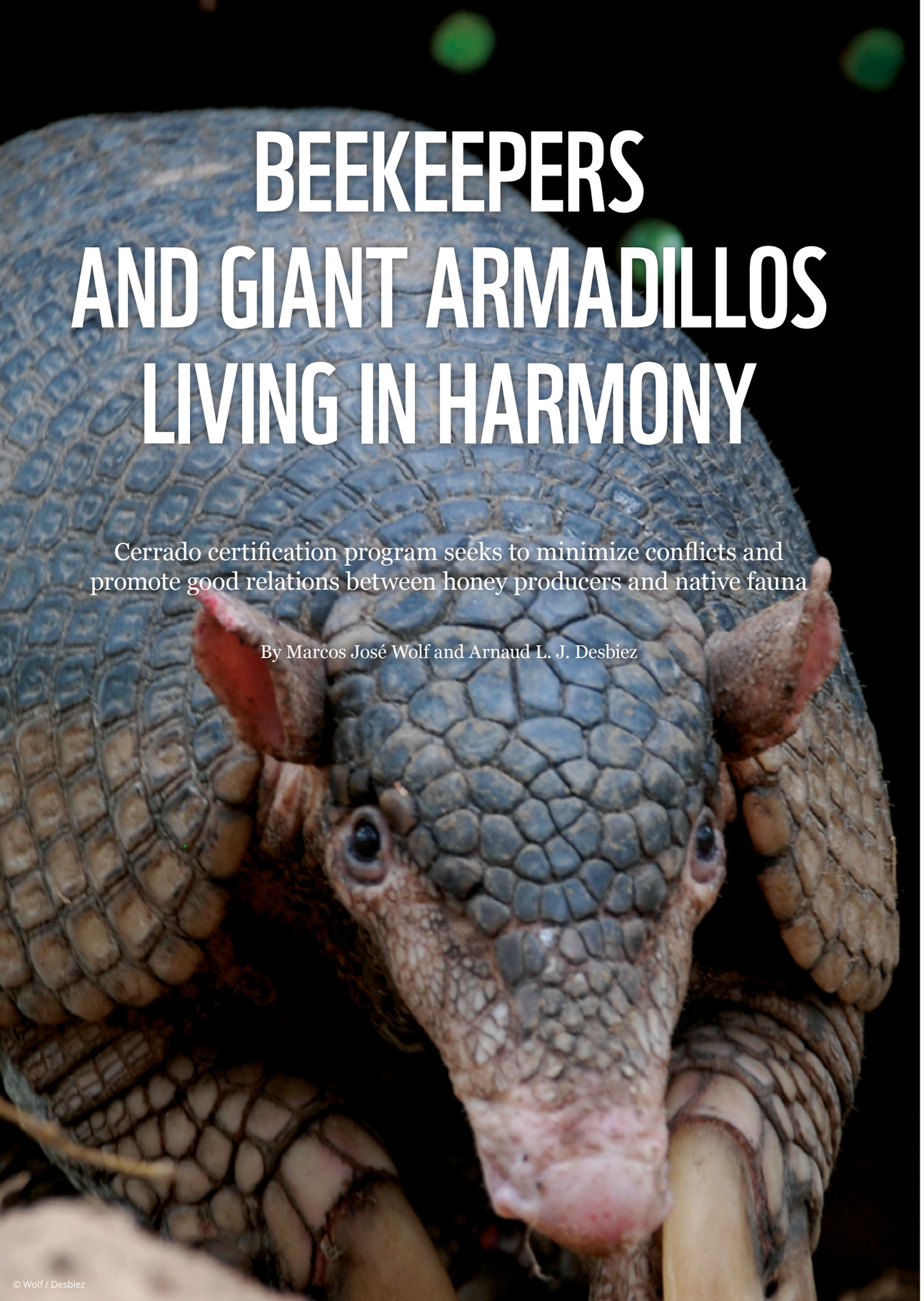
CONTENTS



BEEKEEPERS AND GIANT ARMADILLOS LIVING IN HARMONY

Cerrado certification program seeks to minimize conflicts and promote good relations between honey producers and native fauna

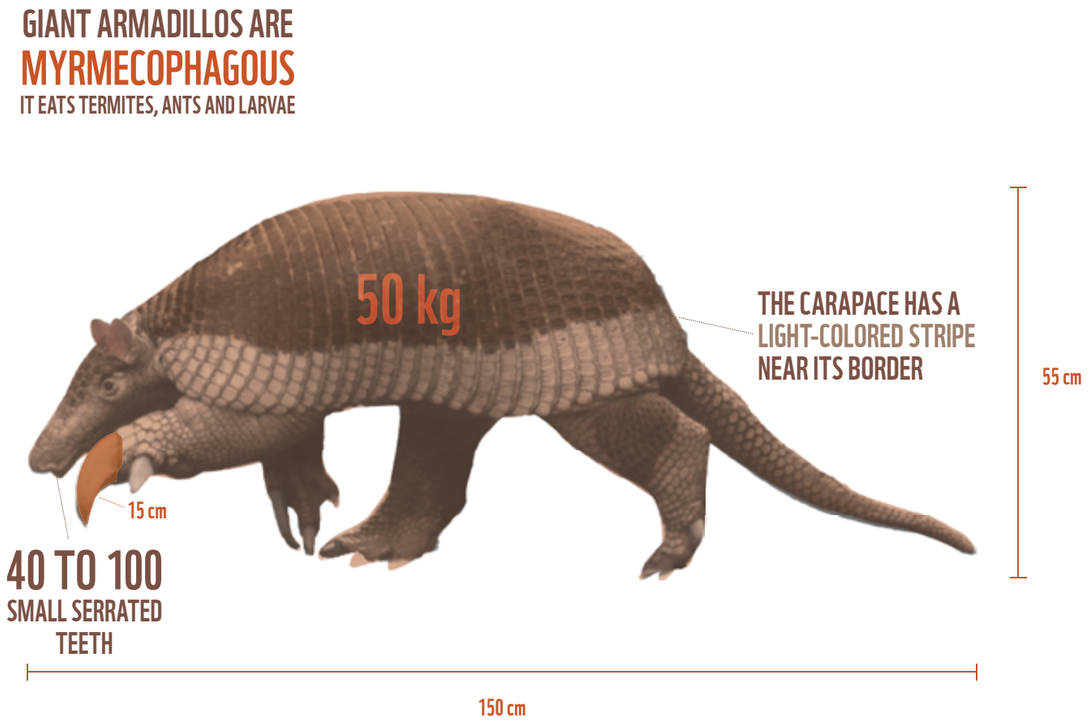
By Marcos José Wolf and Arnaud L. J. Desbiez

On the one hand, we have a large armadillo with huge claws looking for food, while on the other hand, we have beekeepers whose hives are damaged by the armadillo.

This situation can lead to potential conflicts with negative consequences for both the armadillos and beekeepers. These clashes led researchers to develop the "Giant armadillo-friendly honey" certification program, that promotes best-practices of honey production in areas where the giant armadillo occurs. This program encourages more environmentally sustainable honey production and adds value to the product.

The rare giant armadillo is the largest of 20 armadillo species, measuring up to 1.5 m in length and weighing up to 60 kg. Due to its solitary and nocturnal habits, and the fact that it spends a large amount of time in burrows, it can easily go unnoticed. Its low population growth rate makes it especially prone to extinction in degraded areas. This is one of the reasons that the giant armadillo is classified as "vulnerable" on the IUCN Red List of Threatened Species. The importance of the species goes beyond its mere presence in a region; because it constructs large burrows that provide refuge for over 70 other animal species, making the giant armadillo an important "ecosystem engineer".

Normally, in well preserved natural environments, the giant armadillos feed on termites and ants, playing an important role in controlling the populations of these insects. However, in areas where habitats are degraded by humans, the species may end up using other food sources. This is the case in most of the Cerrado of Mato Grosso do Sul, where natural habitat fragmentation has occurred due to roads and the expansion of agriculture and planted pastures. Unfortunately, these degraded areas also overlap with regional apiaries. Beekeepers often place their hives along the edges of the remaining Cerrado forest fragments, so that their bees can be near native wild flowers. In their searches for additional food sources, the giant armadillos in these regions soon become aware of the apiaries, destroying the honeycombs as they consume the easily accessible bee larvae.



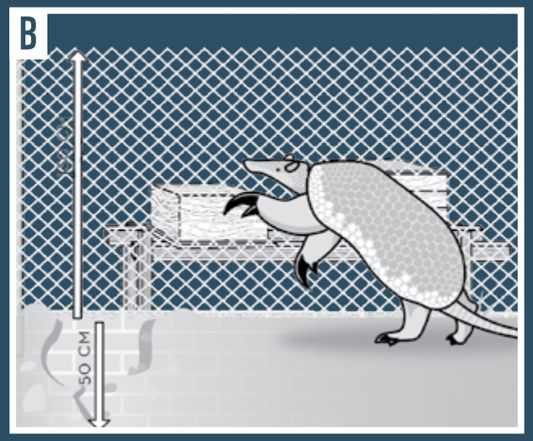
BEEHIVE PREDATION BY GIANT ARMADILLOS

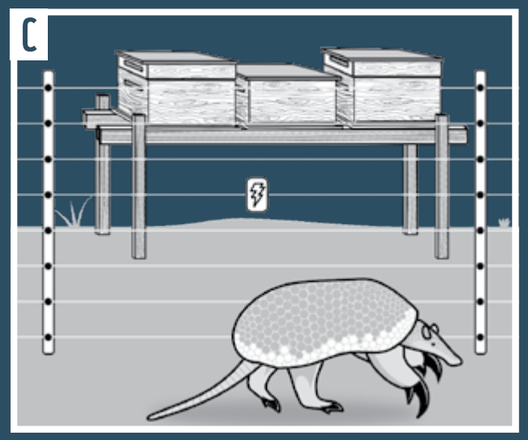
This predation can destroy beehives and affect beekeeper livelihoods, complicating the already difficult task of finding good hive locations with plants that attract honeybees. So, giant armadillos can add an additional unwanted challenge for the beekeepers. Beekeepers report that there is often little to salvage after a giant armadillo attack, and often end up discarding the beehive materials. This causes waste and creates a feeling of frustration. Because of giant armadillo predation on hives, some beekeepers will abandon certain areas, and others completely give up on producing honey.

A survey carried out between July 2017 and October 2019 showed that in the past five years, 73% of the beekeepers interviewed had suffered damage to their hives by giant armadillos, totaling approximately 6,265 destroyed hives. Considering that the cost of a destroyed beehive varied between about $100 and $150, the financial loss over five years was estimated to be greater than $626,500. In an attempt to minimize losses, some beekeepers have developed non-lethal methods of their own to prevent attacks. A total of 14 different techniques have been used by beekeepers to prevent beehive predation, despite the extra labor and financial costs.

HIGH EFFECTIVENESS

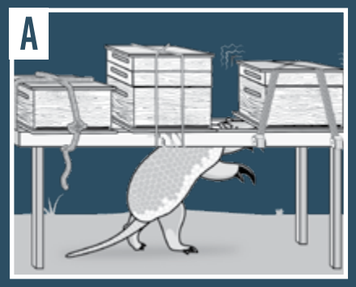
Highly effective methods for preventing predation by armadillos on beehives in the Cerrado of Mato Grosso do Sul, Brazil: (A) Elevated hives on stands 1.3 m above the ground; (B) Above-ground fencing with underground wall; (C) Electric fencing; (D) Beehives inside barrels.

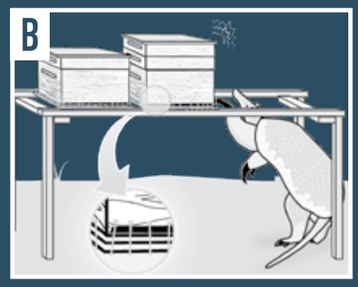




MODERATE EFFECTIVENESS

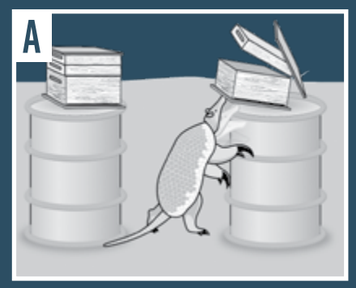
Moderately effective methods to prevent giant armadillo predation on beehives in the Cerrado of Mato Grosso do Sul, Brazil. (A) Hives secured with “X” knots; (B) Hives positioned on elevated stands with nails; (C) Stands with planks keeping the hives 20 cm away from the edges; (D) Four hives bolted to pallets on tires; (E) Fencing without underground wall; (F) Beehive on a pile of truck tires filled with sand.

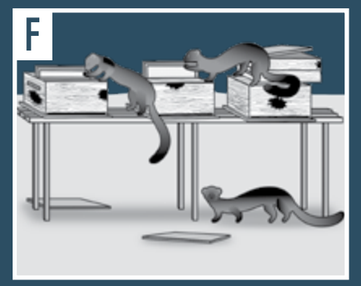




NOT EFFECTIVE

Methods that have not worked to prevent giant armadillo predation on hives in the Cerrado of Mato Grosso do Sul, Brazil. (A) Beehives on 200 L barrels; (B) Elevated stands less than 1.3 m above the ground; (C) Wooden pallets on tires; (D) Sensory methods; (E) Passing wildlife opportunists that are blamed for beehive predation carried out by giant armadillos and (F) Predation patterns by tayra (*Eira barbara*).





Inspired by these accomplishments, researchers from the Giant Armadillo Project evaluated the techniques and coordinated the development of a series of environmentally-sustainable best practices that promote coexistence between beekeepers and armadillos, promote protection of giant armadillos by beekeepers, and add value to the honey. Video recordings from camera traps showed that giant armadillos knock beehives to the ground while standing on their hind legs and using their tail for balance. At the same time, they use their long claws to hold onto structures and maintain balance. Despite the aggression of Africanized bees, giant armadillos were not easily discouraged by them thanks to their thick skin and protective armor.

Based on the information collected by the images and reports, the first step in developing best practices was the elaboration of a "Coexistence Guide" for beekeepers. This guide illustrates the 14 methods and the pros and cons of each. A series of illustrations that summarizes the information found in the Guide and additional information about the giant armadillo was developed using audience-friendly informative figures to facilitate social media dissemination among beekeepers. Simultaneously, a smartphone application is being tested that will allow producers to monitor the activity of giant armadillos at apiaries. This allows beekeepers to act as citizen scientists during their routine visits to the apiaries, recording observations of signs left by armadillos, such as tracks, burrows or possible hive predation. This application will also help maintain regular communication between beekeepers and researchers, as well as evaluate the effectiveness of the techniques applied and/or the need for improvements. Finally, the use of this application will help engage beekeepers in conservation efforts and increase their awareness about the importance of the giant armadillo.

As a way of turning conflicts into positive interactions between beekeepers and giant armadillos, the researchers also elaborated a certification program. Beekeepers that follow best practices to prevent armadillo attacks receive a certificate and a "Giant Armadillo-Friendly Honey" label to place on their products. At the other end of the supply chain, honey buyers support the initiative by selling a certified product that promotes giant armadillo conservation. An additional incentive and the next phase of the program, is to develop additional market opportunities through new partnerships and media dissemination that increase the visibility of armadillo-friendly honey.

Some beekeepers have already completed the certification process. Adriano Adames, for example, was one of the first to participate in the project, and is already marketing his products with the label. The researchers believe that well-informed and environmentally conscious consumers will be enthusiastic about buying armadillo-friendly honey. The researchers conclude: "Our hope is that, thanks to the certification, beekeepers and giant armadillos will have the opportunity to live in peace with each other, and the presence of these animals near the hives will become a benefit".

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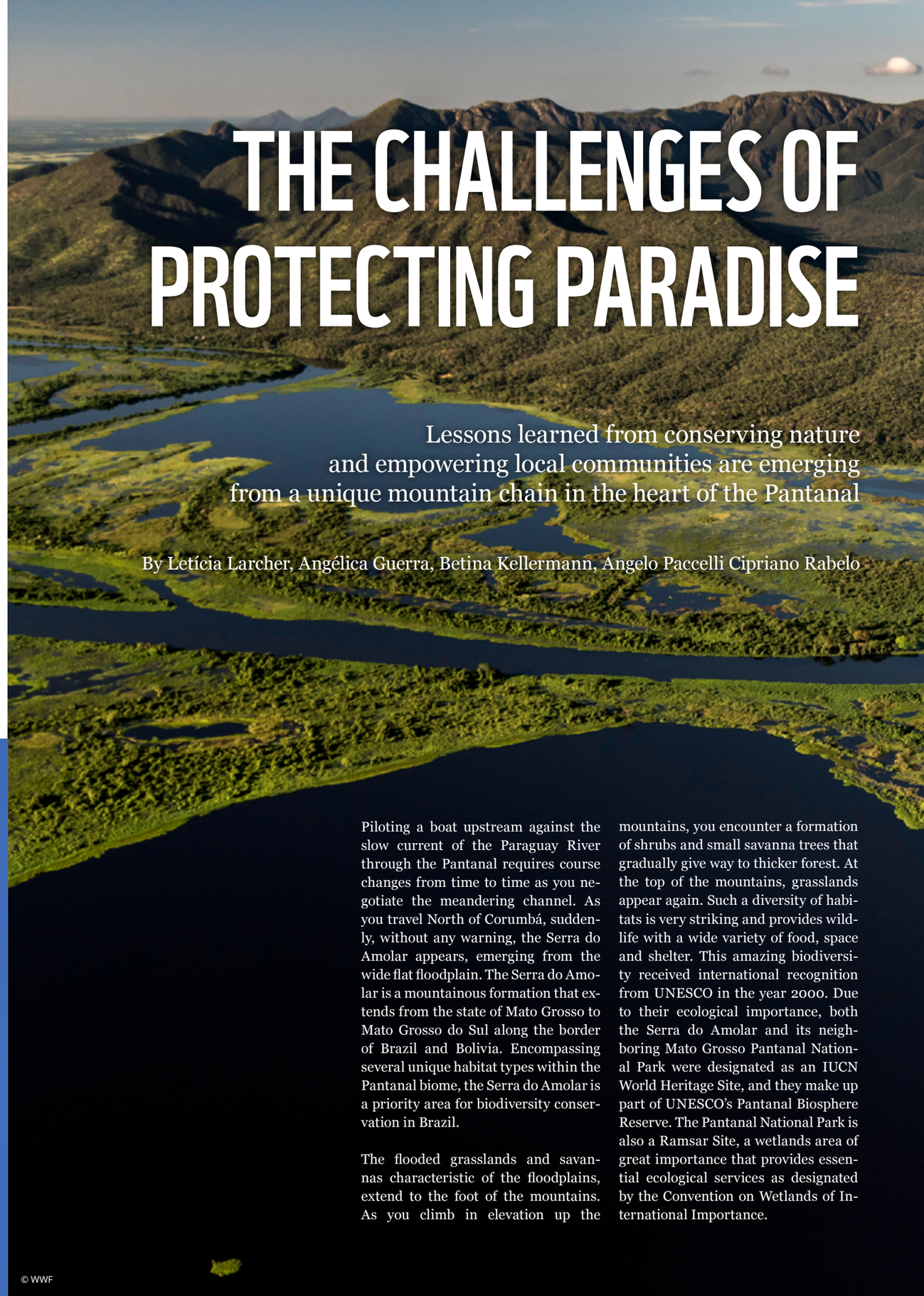

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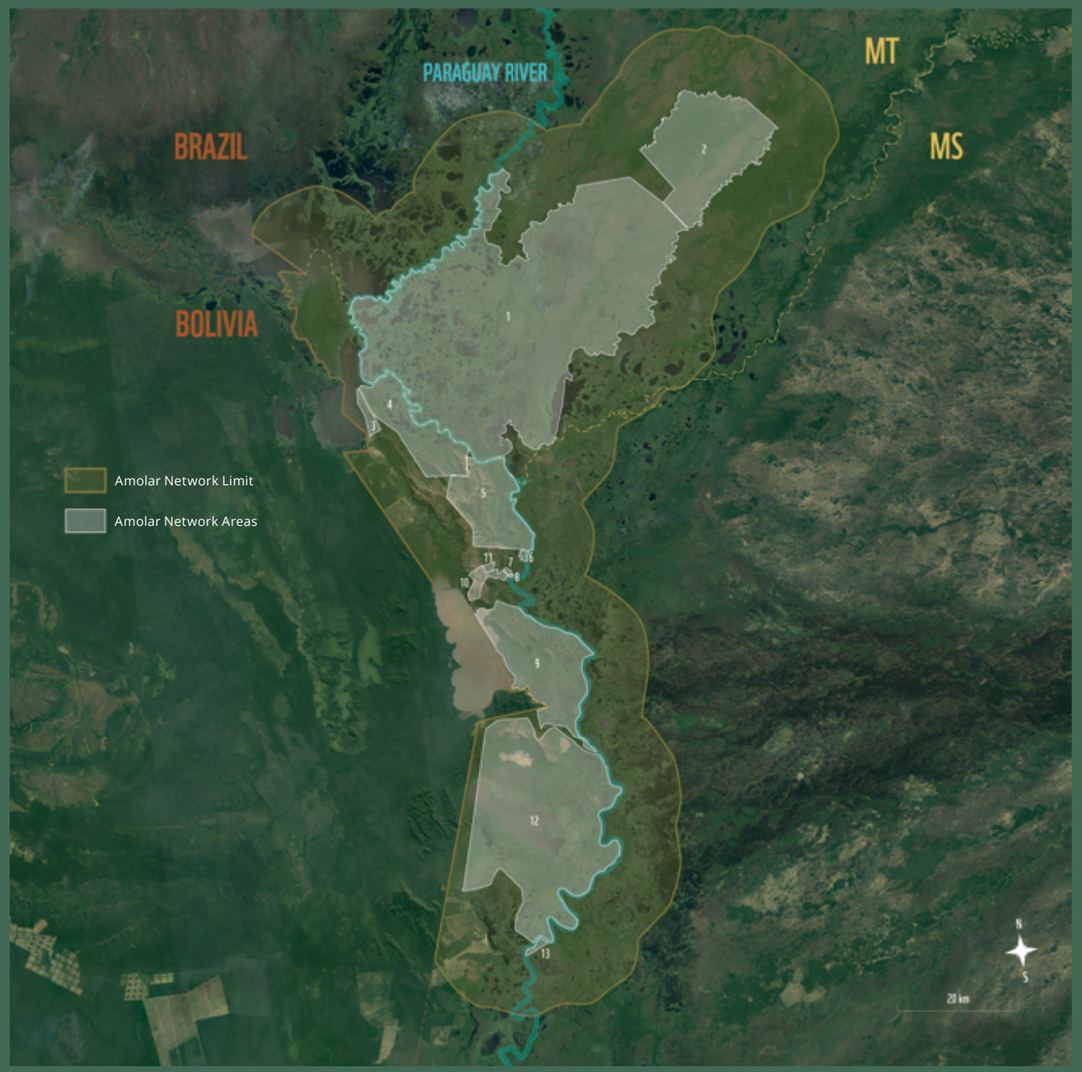
THE CHALLENGES OF PROTECTING PARADISE

Lessons learned from conserving nature and empowering local communities are emerging from a unique mountain chain in the heart of the Pantanal

By Letícia Larcher, Angélica Guerra, Betina Kellermann, Angelo Paccelli Cipriano Rabelo

Piloting a boat upstream against the slow current of the Paraguay River through the Pantanal requires course changes from time to time as you negotiate the meandering channel. As you travel North of Corumbá, suddenly, without any warning, the Serra do Amolar appears, emerging from the wide flat floodplain. The Serra do Amolar is a mountainous formation that extends from the state of Mato Grosso to Mato Grosso do Sul along the border of Brazil and Bolivia. Encompassing several unique habitat types within the Pantanal biome, the Serra do Amolar is a priority area for biodiversity conservation in Brazil.

The flooded grasslands and savannas characteristic of the floodplains, extend to the foot of the mountains. As you climb in elevation up the mountains, you encounter a formation of shrubs and small savanna trees that gradually give way to thicker forest. At the top of the mountains, grasslands appear again. Such a diversity of habitats is very striking and provides wildlife with a wide variety of food, space and shelter. This amazing biodiversity received international recognition from UNESCO in the year 2000. Due to their ecological importance, both the Serra do Amolar and its neighboring Mato Grosso Pantanal National Park were designated as an IUCN World Heritage Site, and they make up part of UNESCO's Pantanal Biosphere Reserve. The Pantanal National Park is also a Ramsar Site, a wetlands area of great importance that provides essential ecological services as designated by the Convention on Wetlands of International Importance.



SERRA DO AMOLAR PROTECTION AND CONSERVATION NETWORK

The continuous area created by the well-preserved ranches, RPPNs and the Pantanal National Park forms a natural unit in the Pantanal for integrating conservation strategies

1 Pantanal National Park
2 RPPN Dorochê
3 RPPN Rumo Ao Oeste
4 RPPN Acurizal
5 RPPN Penha
6 São Gonçalo Ranch
7 Santa Rosa Ranch
8 Serra Negra Ranch
9 RPPN Engenheiro Eliezer Batista
10 Vale Do Paraíso Ranch
11 Morro Alegre Ranch
12 Santa Tereza Ranch
13 Jatobazinho Ranch


© Nathália Segato

Given the importance of protecting the area, a Serra do Amolar Protection and Conservation Network was established in 2008. The Amolar Network is represented by private, governmental and non-profit institutions that manage different areas in the region. Instituto Homem Pantaneiro (IHP), a non-government organization, has overseen the Amolar Conservation Network since its inauguration. The aim of the Network is to develop management strategies for addressing conservation challenges in the region. The region, better known as the Amolar Network, is made up of five Private Natural Heritage Reserves (RPPNs) and seven ranches. Unlike the RPPNs, the ranches are not legal Conservation Units, but they share similar conservation aims and help form a mosaic of natural areas connected with the private reserves. The continuous area created by the well-preserved ranches, RPPNs and the Pantanal National Park with their rich biodiversity and variety of landscapes and ecosystems forms a natural unit in the Pantanal for integrating conservation strategies. Together with their partners, the Amolar Network is developing integrated management actions that support local livelihoods and optimize financial, technical and logistical resources.

Considering that only 5% of the Pantanal is legally protected in conservation units, the natural corridor created by the Serra do Amolar ranches and private reserves is of great conservation importance. Totaling almost 280 thousand hectares, it has incalculable value in terms of biodiversity, and an estimated monetary value of more than US$ 100 million – just considering the private reserves. According to the International Union for Conservation of Nature (IUCN), some species that are globally threatened with extinction are found in the region, such as the giant armadillo, giant anteater, giant otter and the Pantanal marsh deer. In addition, the region between Serra do Amolar and the Encontro das Águas State Park (in Mato Grosso) contains the greatest concentration of jaguars on earth.

In practical terms, the Amolar Network provides an opportunity for gaining understanding about regional needs and identifying potential collaborations between institutions. For example, a Technical Cooperation Agreement signed between the Instituto Homem Pantaneiro (IHP) and the Instituto Chico Mendes de Conservação da Biodiversidade (a federal conservation and biodiversity environmental agency - ICMBio) was established in 2021. This agreement includes cooperating with firefighting and prevention, environmental monitoring, and other actions that benefit the Pantanal National Park, the RPPNs and the neighboring ranches. Another accomplishment of the Amolar Network was the development of priority actions that pursue sustainable economic development. These are important for the riverside communities who potentially play important roles as conservation agents. In 2016, the Network developed a business plan to promote ecotourism activities in the region. This provides opportunities for local community members to generate income and receive other benefits from protecting natural areas around their communities, e.g., capacity building, food security, and a sense of belonging. As a result, communities gain a sense of pride for protecting their land and increasing awareness about their culture and history.


© Nathália Segato

LONG TERM STRATEGIES: THE REDD+ SERRA DO AMOLAR PROJECT

As a result of their actions, the Amolar Network became a pioneering model for a globally valued environmental service: the generation of carbon credits. The launch of the REDD+ Serra do Amolar project was an important milestone for regional climate action, being the first initiative in the Pantanal focused on mitigation of greenhouse gases. The project includes actions related to Agriculture, Forestry, and Other Land Use (AFOLU) sectors under the Reduced Emissions from Deforestation and Degradation (REDD) category.

Medium and long-term goals include reducing greenhouse gas emissions, preventing and fighting forest fires, protecting key species, valuing nature-based solutions, creating jobs and empowering local communities to act as conservation agents. To achieve these goals, four strategic activities were selected: ecotourism, research, fire prevention and governance/administration.

NEXT STEPS

The next steps for the Amolar Network include overcoming challenges faced by many conservation organizations. Some of these include finding innovative sustainability strategies and gaining a better understanding of regional environmental threats. For example, in 2020, the wildfires in the Pantanal destroyed almost 90% of the Amolar Network area. Because of this and the Network's commitment to mitigating climate change, protecting biodiversity and supporting local communities, short and medium-term projects were established that have already produced results.

Also during 2020, the Alto Pantanal fire brigade was created, employing six firefighters to promote fire prevention management practices. Partnerships were established to restore areas and habitats affected by wildfires, and different vegetation types with a range of ecological roles were planted to help reestablish wildlife populations. A wildlife rescue team was also mobilized to assist animals injured by fire, and a temporary emergency veterinarian rescue center was constructed in the Amolar region.

Regarding the history of sustainable human development and nature preservation in the Pantanal, the region serves as a model. Lessons learned from this history of coexistence will help protect the future of the biome. Novel practices and policies should build on this history. Although there are many challenges, it will be essential for all regional stakeholders to join forces to ensure the conservation of this unique portion of the biome and continue protecting natural habitats. This is the mission of the Amolar Network.

A MILLION SHADES OF GRAY

Studies indicate that in 2020 more than 17 million native vertebrates were killed outright by the catastrophic wildfires in the Pantanal

By Walfrido Moraes Tomas, Christian Niel Berlinck, Gabriel Paganini Faggioni, Christine Strussmann, Thiago Semedo, Alexandre de Matos Martins Pereira, Rafael Morais Chiaravalloti, André Restel Camilo, Gabriel Oliveira Freitas, Ronaldo Morato

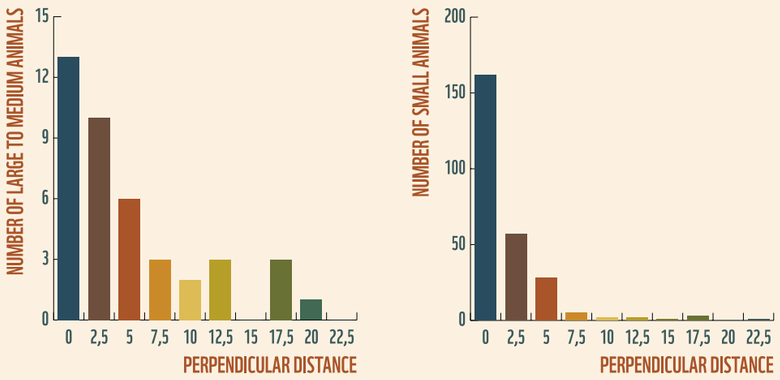
The 2020 Pantanal wildfires will remain marked in history for years to come. The fires that raged across 30% of the biome caused huge losses for rural communities, the regional economy, natural environments and the Pantanal's rich fauna. Shocking scenes of animals killed in the fires or badly burned made the news and social media, causing exceptional public uproar.

Collecting data in the aftermath of the fires was emotionally and logistically challenging, but obtaining quantitative measurements of the devastation was necessary in order to better understand the effects of fire on the ecosystem. During the peak of fires between August and November 2020, a team of researchers named "MOGU MATÁ" that was coordinated by Embrapa Pantanal and ICMBio/CENAP (federal agencies focused on conservation and biodiversity) was formed to estimate the number of vertebrate animals killed by the fires. Unfortunately, instead of carrying out their usual surveys of live animals, the researchers were looking for carcasses that normally only attract the interest of vultures – hence the origin of the name chosen for the research team, *mogu mata*, meaning yellow-headed vulture in the language of the Guato people, indigenous canoeists of the Pantanal. The team was composed of 30 researchers representing 21 institutions. Their work included sampling in locations that were hard to reach during extremely hot weather, hiking long distances and sometimes walking on tracts that were still burning.

Illustration © Patricia Sardá

THE MOGU MATÁ METHOD

To estimate the number of animals killed by fires in the different areas studied, a procedure was established using "distance sampling", a scientific method that estimates the density of fauna.



Number of vertebrate carcasses detected at different distances from the census trails in areas affected by the 2020 Pantanal fires. On the right, large to medium size vertebrates (greater than 2 kg), and on the left, small vertebrates (less than 2 kg)

With this method, animals (in this case, carcasses) are counted along established trails in fire impacted areas during periods up to 48 hours post-fire. The researcher records the perpendicular distance from the trail to the observed dead animal. This method is based on the logic that the further away the animal is, the more difficult it is to observe. In other words, a reliable detection distance is determined between the researcher and the specimen. The perpendicular distance, observed carcasses, total distance surveyed, and other mathematical calculations are used to generate accurate estimates of the number of dead animals per square kilometer at field sites.

Burned toucan (Ramphastos toco)

© Mogu Matá

The research team walked 126 line transects covering a total of 134 km through fire impacted areas in both the northern and southern Pantanal. The team counted 302 vertebrate carcasses, including amphibians, reptiles, birds and mammals. Based on extrapolations from these data, the team estimated that nearly 17 million animals belonging to 55 species were killed outright in the fire impacted areas. Sixteen million were small vertebrates (weighing less than 2 kg) and about 944 thousand were medium to large size vertebrates (over 2 kg). The 54 identified species included: 5 amphibians, 17 reptiles (lizards, caiman, anaconda and other snakes), 18 birds (ranging from small to large species) and 14 mammals (primates, anteaters, deer, armadillos, peccaries and rodents). Of the total number of dead animals, about 65% were snakes, especially aquatic ones (such as the water snake and anaconda).

These results undoubtedly underestimated the actual death toll, because they were based on animals that died immediately or within 48 hours of the fully-developed fires. Many additional animals potentially died during the weeks after the survey period from post-fire effects (smoke, injuries, etc.), and bats and countless invertebrates were not included in the surveys. In addition to demonstrating the magnitude of vertebrate animal losses, the survey results provided insights that go beyond the emotional impacts caused by the shocking images published in the media. The immense numbers will help raise awareness among public officials, rural landowners and other groups in the Pantanal about the necessity of adopting actions that will prevent similar environmental disasters in the future. Among the ideas discussed are: implementation of public policies and community outreach programs that promote more effective fire management practices, and the development of a fire risk alert system that reaches Pantanal communities more rapidly.

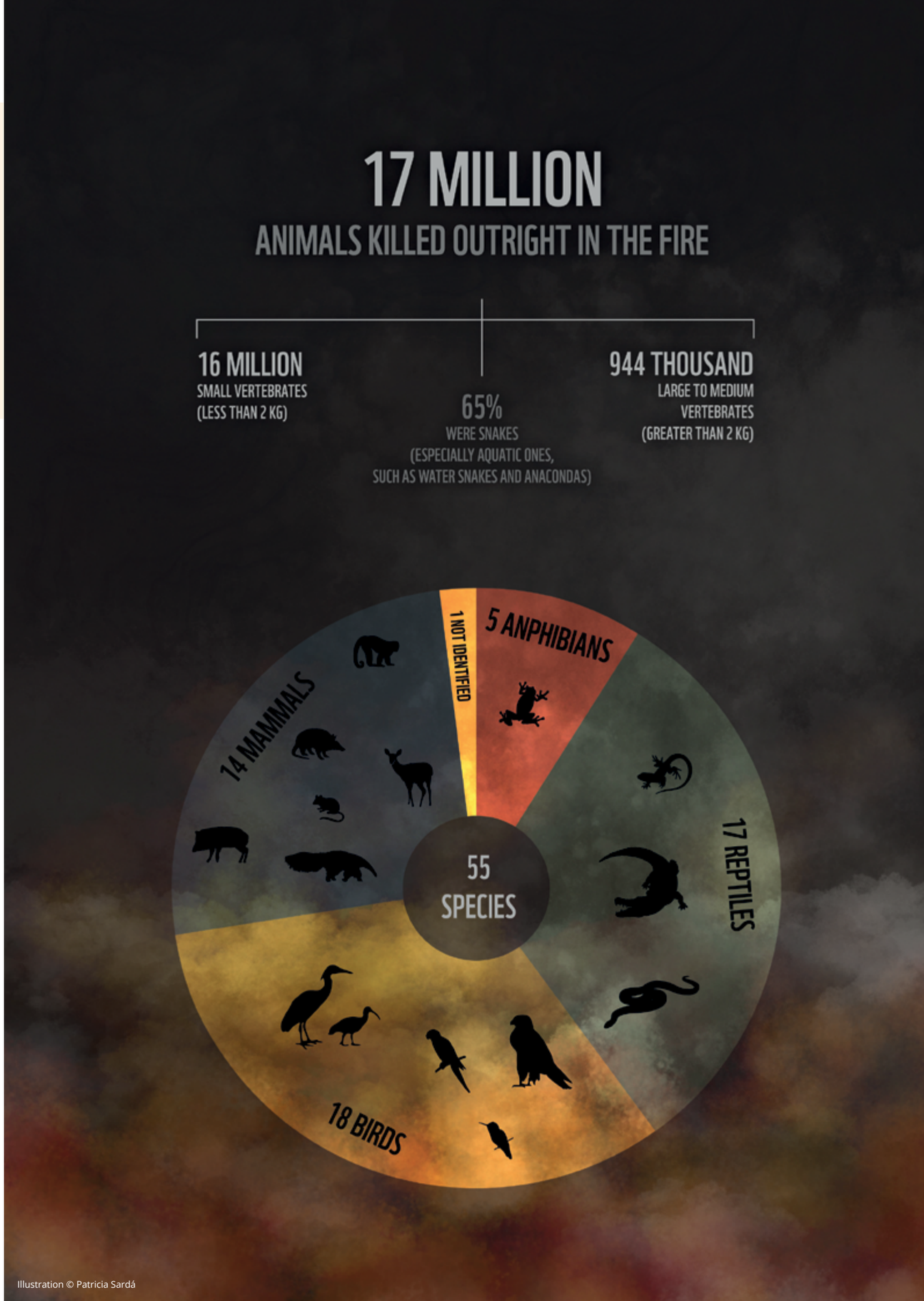


Illustration © Patricia Sardá

Out-of-control forest fires have increased in nearly every region of the planet. In Brazil, large-scale fires also occurred in the Amazon region in 2020. Numerous factors are associated with the occurrence of Amazon wildfires, but the main causes are human-induced, including global climate change and encroachment of human activity in natural areas. The situation is similar in the Pantanal – fires resulting from various factors interacting at different scales. For example, global climate change and tropical Atlantic Ocean temperatures affect the circulation of winds and the formation of rain over South America.

On a continental scale, decreased rainfall, caused in part by Amazon deforestation, influences the climate of central South America, reducing the precipitation that replenishes the river basin encompassing the Pantanal. Water from the Amazon reaches the Pantanal through so-called "flying rivers", huge atmospheric air masses saturated with water vapor that migrate thousands of kilometers and release rains over central, southeastern and southern Brazil. Increased Amazon deforestation that weakens the "flying rivers" and reduces rainfall in the Pantanal has led to prolonged and intense droughts, drying out the natural vegetation and increasing fuel biomass.

Illustration © Patricia Sardá

WHAT ARE FLYING RIVERS?

Flying rivers are huge atmospheric air masses saturated with water vapor that migrate thousands of kilometers and release rains over central, southeastern and southern Brazil.

On a local scale, fires are often a result of human activities, especially during the driest months between June and October. Due to the extreme heat and strong winds typical of this dry period, even small fires can spread rapidly and burn out of control. If this occurs during a period of extreme weather, disaster is almost guaranteed. Traditional practices used to reduce fire risk, such as relying only on cattle to reduce the biomass of dry vegetation fuel – a concept known as "firefighting cows" – are not sufficient.

Similar to other savannahs, naturally occurring fire in the Pantanal plays an important role in shaping the landscape and maintaining biodiversity. Therefore, a no-fire policy in is not an ideal path, but data show that irresponsible use of fire is also very damaging to the ecosystem. In view of dire climate change predictions and its impacts, the proposed way forward is to use prescribed burns that manage plant biomass in a controlled and planned manner. Well-managed prescribed burns must carefully consider factors such as fire frequency, the area burned, season, weather, and the type of vegetation. These are necessary steps to prevent similar catastrophic wildfires in the future.

Understanding the negative impacts of forest fires is necessary to strengthen incentives and arguments in favor of protecting nature and the most vulnerable human populations. However, it is important to note that estimating fire impacts in an absolute way is practically impossible. Beyond the shocking images of forests being ravaged by flames and dead and injured animals, our understanding of the impacts of these fires is incomplete and often based on limited data. For example, inadequate pre-fire data on Pantanal biodiversity made it challenging to access post-fire losses and shed light on how long it will take for the ecosystem to recover. Finally, in addition to promoting biodiversity conservation based on long-term studies, gaining a greater understanding about wildfires will help prevent future catastrophes for the Pantanal, its communities and rural landowners.

BONITO TODAY AND FOREVER

Integrated management actions aim to ensure the quality of crystalline waters that attract tourists to the Bonito region

By Rafael Morais Chiaravalloti and Juliane Ferreira Salvadori

Recanto Ecológico Rio da Prata - Jardim (MS) © Flávio André

The Bonito region is situated in the southwestern part of Mato Grosso do Sul state and is currently considered one of the most important ecotourism destinations in Brazil. Every year, around 200,000 people visit the region to experience the natural wonder of its crystal-clear rivers. The transparent waters, diverse aquatic wildlife and internationally recognized accommodations and tourism services provide visitors with an amazing experience.

The tourism program in Bonito that is based on nature conservation has received dozens of awards in recent years. In 2013, it received the title of “Best Destination for Responsible Tourism” by the World Travel Market, and the following year it was a finalist for the “Tourism for Tomorrow Awards” promoted by the World Travel and Tourism Council. It has been nominated 16 times by Viagem e Turismo magazine as the best ecotourism destination in Brazil.

On the one hand, the natural wonders of Bonito have enchanted visitors and attracted media attention from around the world. However, on the other hand, scenes showing the region’s famous clear waters turning muddy after heavy rains have caused public outrage and attracted negative media coverage. In 2019, for example, the murky waters were highlighted during national and international news reports.

During a two-year period, a team of researchers investigated how water transparency has changed over the last 10 years, the reasons for increased turbidity, and how to prevent the reoccurrence of similar events. The studies took place in the Rio da Prata Ecological Reserve - RPER (Recanto Ecológico Rio da Prata), a tourist destination along the Prata River that was negatively impacted by the appearance of murky waters after hard rainfall events. Snorkeling using diving masks and neoprene wetsuits is the main tourism activity at RPER and takes place in two stages beginning near and floating downstream from the springs of the Olho d’Água River until its channel meets the Prata River, and then continuing down the Prata river channel until the end of the tour.

Every day before opening for visitation, a team from the tourist establishment that manages the attraction evaluated the water quality in both rivers, and when necessary, used specific criteria to adjust tourism activities. When the team detected that snorkeling visibility was less than five meters, that section of the tour was closed for visitation. This systematic monitoring generated a very useful database for analyzing long-term visibility conditions in the rivers. These data were used by the team of researchers to analyze changes in water turbidity between January 2010 and December 2020.

Results showed that episodes when the visibility was less than 5 meters in the Olho d’Água River were very rare, and that over the ten year evaluation period, it was closed only a few times. This is probably because the 1.5 km long snorkeling route passes through an area that is strictly protected. In contrast, water transparency varied significantly along the Prata river stretch that extends beyond the property limits of the establishment organizing the snorkeling activity. On average, from 2010 to 2013, the operation closed part of the snorkeling tour for eight days a month. Snorkeling tour cancellations along the Prata River became even more frequent during the following three years, averaging 14 days per month between 2014 and 2016. In 2017 there was an improvement with the tour closing an average of 9 days per month.

Researchers developed four hypotheses to explain the water transparency variation. The first was that rainfall intensity alone was responsible for the changes in the number of days that the Prata River had visibilities of less than five-meters. The second hypothesis was that increases in the area of cultivated soybeans in the Prata River basin were causing changes in water transparency. The third hypothesis was that the interaction of the two factors, rainfall intensity and soybean cultivation, was responsible for water visibility changes. A fourth “null” hypothesis tested whether water transparency changes were caused by parameters not evaluated by the team, such as the number of tourists on an excursion, dike constructions, and other factors. The purpose of the null hypothesis was to evaluate if these other factors were more important than rainfall intensity and soybean cultivation. Rainfall data were obtained from the tourism establishment, and information about soybean cultivation was compiled from the MapBiomas database that showed changes in land cover from 2010 to 2020. Data analyses showed that the interaction of soybean cultivation and rainfall intensity was the main cause for the murky waters of the Prata river. But what does this mean in practice?

In the case of the Prata River basin, the study showed that rapid expansion of soybean cultivation has increased the impacts of rainfall on soil processes – such as erosion – that carry sediments in runoff to stream and river channels. For example, during a month with 300 millimeters of precipitation in the early 2000s, when there was very little soybean cultivation in the basin, there were on average about 16 days of murky waters. However, during a month with a similar amount of rainfall after rapid expansion of soybean cultivation between 2014 and 2016, the Prata River had 26 days of very turbid waters.

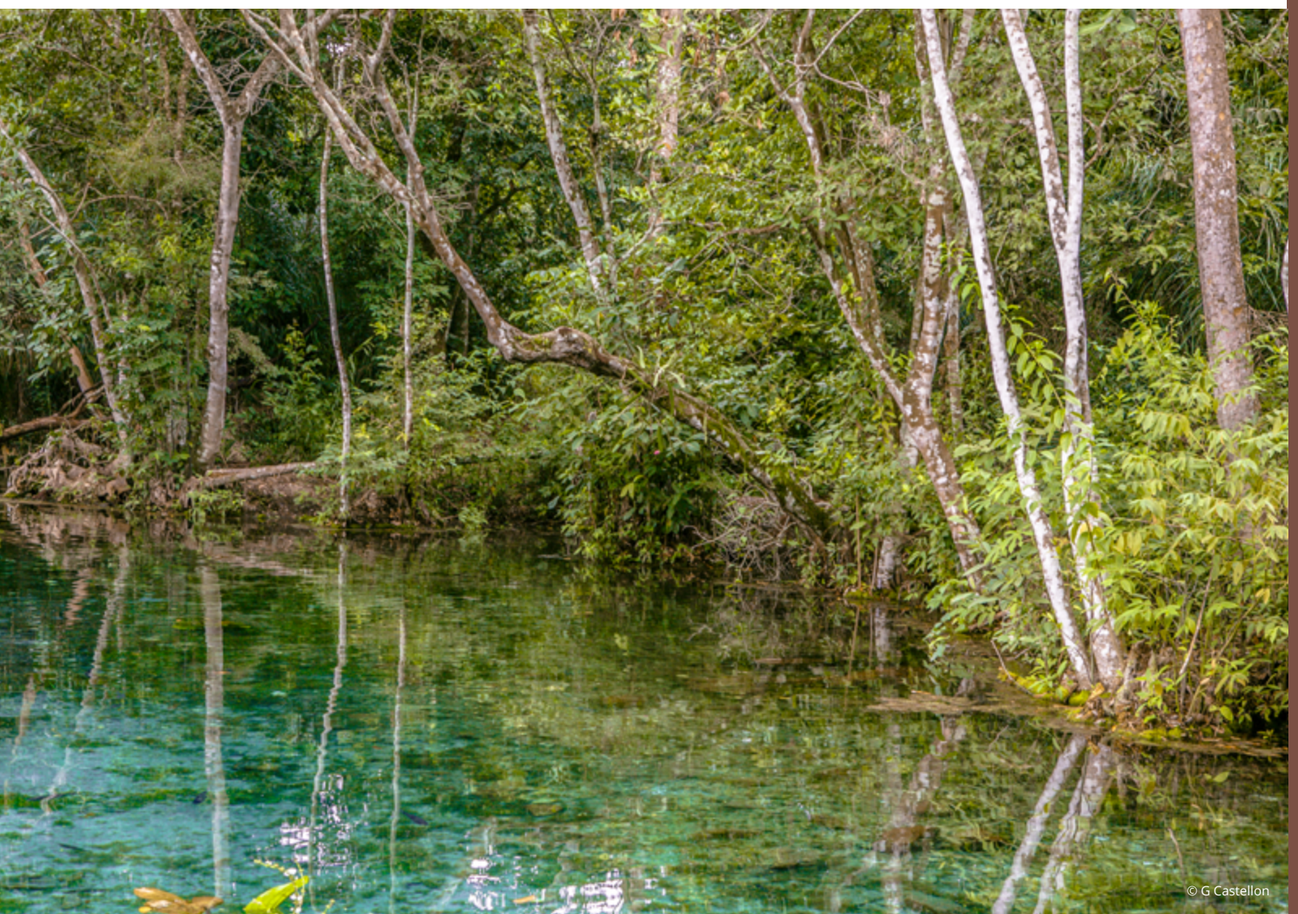
Dourado fish (*Salminus brasiliensis*)

Based on data from the study, mathematical models were developed by the researchers to simulate future scenarios of water transparency. The models showed that if soybean cultivation in the basin continues to increase, major impacts during heavy rainfall events will not only hurt the Prata River operation, but will also impact other tourist establishments that depend on crystal-clear river waters. Fortunately, this environmental tragedy has become an important part of a campaign to conserve the region's rivers.

In 2020, with the aim of ensuring that water transparency is maintained in the Bonito region – where tourism is directly or indirectly a significant portion of the community's livelihood – the Public Prosecutor's Office of Bonito, Instituto das Águas da Serra da Bodoquena – a local NGO – and the Instituto de Meio Ambiente de Mato Grosso do Sul –, a state environmental agency – created the "Águas de Bonito" project. This pioneering initiative has become a model for other conservation efforts in the country. The intent is to work in partnership with rural producers and implement environmentally sustainable practices, such as contour farming to reduce rainfall impacts on soil processes, fencing springs to prevent cattle access, and planting seedlings for reforestation purposes.

Concurrently, in December 2021, the governor of the State of Mato Grosso do Sul launched a program providing almost R$ 1 million to promote payments for environmental services. The program provides competitive funding for projects on private lands that conserve and restore forests and other types of natural vegetation. In addition, projects with initiatives that convert pastures and degraded lands into alternative land-uses that increase carbon storage can benefit from the funding. During this same time period, State Law nº 5,782 was enacted in the municipality of Bonito, establishing a "Watershed Priority Area" (*Área Prioritária Banhados*) to protect the Prata and Formoso River headwaters. The headwater region is classified as a conservation unit to guarantee environmental quality and regulate land-use practices across 14 thousand hectares – an area approximately the size of the city of Campo Grande.

These initiatives provide hope that the natural wonders of the Bonito region will be protected and remain globally-recognized tourist attractions. Participative land-use planning and sustainable use of natural resources, along with close monitoring of practices that cause environmental degradation, will be essential to conserve Bonito's crystal-clear waters.



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ESCAPING THE FLAMES

Study reveals that small animals in the Pantanal can use underground shelters to survive fires

By Thiago Borges Fernandes Semedo, Gustavo Simões Libardi, Christine Strüssmann, Gabriela do Valle Alvarenga, Christian Niel Berlinck, Walfrido Moraes Tomas, Guilherme Siniciato Terra Garbino

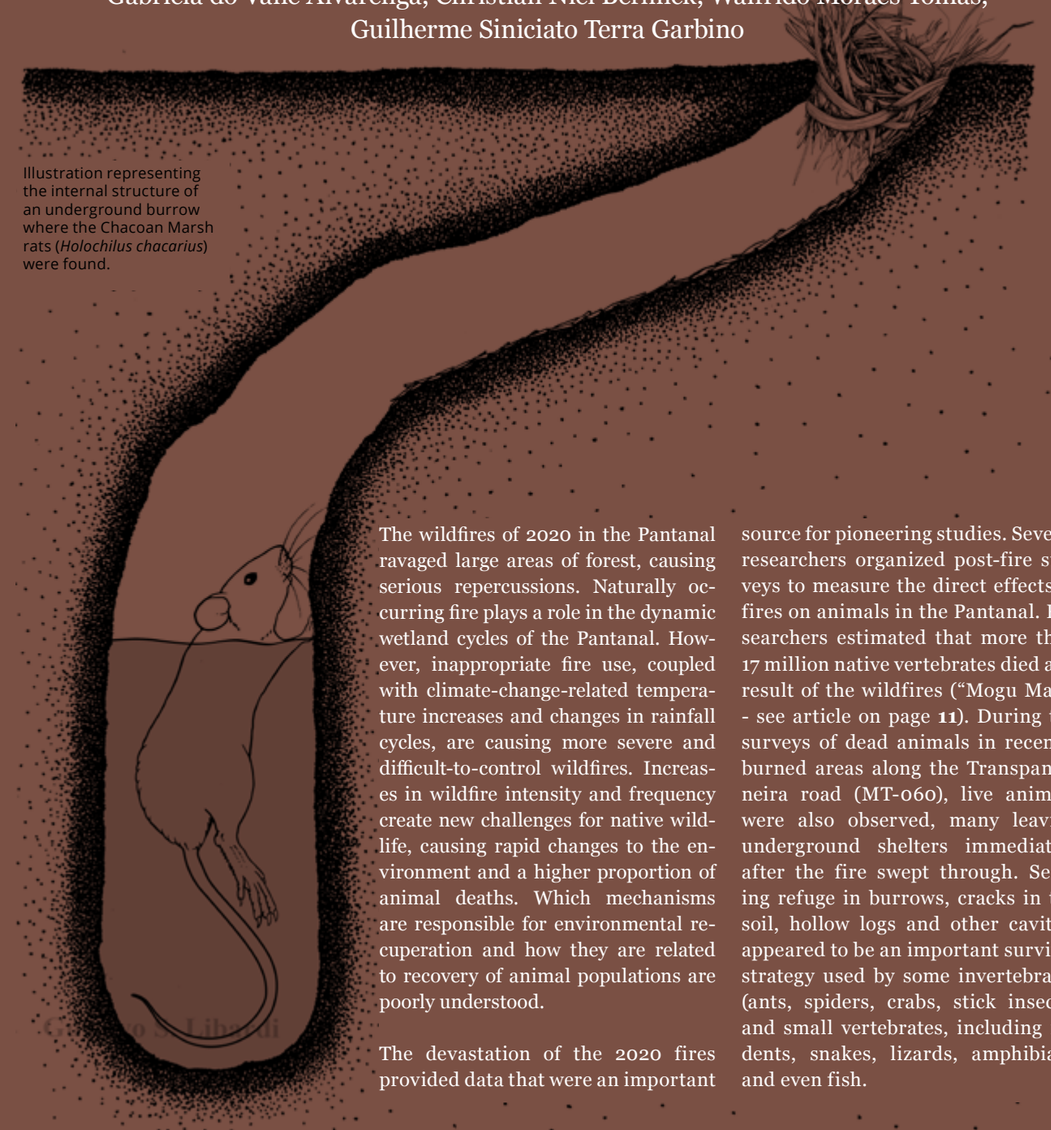


Illustration representing the internal structure of an underground burrow where the Chacoan Marsh rats (*Holochilus chacarius*) were found.

Illustration © Gustavo S. Libardi

The wildfires of 2020 in the Pantanal ravaged large areas of forest, causing serious repercussions. Naturally occurring fire plays a role in the dynamic wetland cycles of the Pantanal. However, inappropriate fire use, coupled with climate-change-related temperature increases and changes in rainfall cycles, are causing more severe and difficult-to-control wildfires. Increases in wildfire intensity and frequency create new challenges for native wildlife, causing rapid changes to the environment and a higher proportion of animal deaths. Which mechanisms are responsible for environmental recuperation and how they are related to recovery of animal populations are poorly understood.

The devastation of the 2020 fires provided data that were an important source for pioneering studies. Several researchers organized post-fire surveys to measure the direct effects of fires on animals in the Pantanal. Researchers estimated that more than 17 million native vertebrates died as a result of the wildfires ("Mogu Matá" - see article on page **11**). During the surveys of dead animals in recently burned areas along the Transpantaneira road (MT-060), live animals were also observed, many leaving underground shelters immediately after the fire swept through. Seeking refuge in burrows, cracks in the soil, hollow logs and other cavities appeared to be an important survival strategy used by some invertebrates (ants, spiders, crabs, stick insects) and small vertebrates, including rodents, snakes, lizards, amphibians and even fish.

On the left, animals found charred to death during the 2020 catastrophic fires in the Pantanal. On the right, landscape of study-site with some areas still burning just after teams arrived to carry out the surveys.

Agouti (*Dasyprocta azarae*)

Chacoan marsh rat
(*Holochilus chacarius*)

A recent study published by researchers from the Mogu Matá Project network (evaluating post-fire devastation) describes the use of underground burrows by the Chacoan marsh rat, a semiaquatic species native to the Pantanal. Some of the occupied burrows were partially flooded, demonstrating a little known behavior of the species and documenting an observation that was unprecedented for Brazil. The researchers also recorded a live catfish and crab sharing one of the flooded burrows with the Chacoan marsh rats. Other studies carried out in the Pantanal showed that cavities built by crabs can be shared with amphibians, suggesting the possibility that the burrows were initially dug by crabs and later modified by rodents to facilitate their survival.

Observations from studies like this one show how some environmental traits associated with a species' ecology can be fundamental to a species' survival. During periods with harsh environmental conditions, burrows with subterranean galleries or wider underground chambers can provide a refuge for numerous small mammals and other species until environmental conditions improve. These underground cavities can keep small animals insulated from the heat of a fire or provide water or moisture — resources especially rare during severe droughts. Small animals are more at risk during wildfires, because they are less able to flee. Instead of running, they normally find an underground burrow to escape. In environments historically exposed to fire, burrows may be important in preventing local extinctions and promoting reestablishment of surviving small mammal populations. This is especially important in the Pantanal, where above-ground rocky outcrops that could act as habitat refuges do not exist on the floodplain. Understanding the structure of underground cavities in the Pantanal and the animals responsible for their construction are fundamental in efforts to prevent the loss of these refuges and their role in alleviating the impacts of large fires.

The discovery of this behavior showing the use and sharing of partially flooded burrows by Chacoan marsh rats during fires raised other important questions for future research. What specific factors allowed the rodents to survive during the fire? Can the burrows also be used for breeding and nesting? Is the behavior an evolutionary adaptation for surviving fires and drought? Can rats, crabs, and/or other species be considered small-scale ecosystem engineers, like larger animals that transform the environment? Do survivors make a significant contribution to reestablishing fire-depleted populations? How important are these shelters in the recovery of Chacoan marsh rats and other species after severe fires in the Pantanal? Answering these questions will be important in order to understand the relationships between environmental factors, species, wildfire impacts and ecosystem recovery. Faunal survival during wildfires will depend on the intensity, duration, and frequency of the events, how the environment is impacted, the availability and quality of refuges and the unique traits of the species that use the burrows for refuge.

Finally, it will be important to understand how climate change is related to extreme events, such as the recent severe fires in the Pantanal. At the same time, educating the public about curious aspects of the region's natural history will stimulate more interest in discovering this unique and biodiverse place, e.g., through sustainable tourism that provides employment, alternative incomes and important incentives for conservation of the Pantanal.

Live animals found in underground cavities post-fire.

Yellow anaconda *(Eunectes notaeus)*

False water cobra *(Hydrodynastes gigas)*

Orange-legged monkey tree frog *(Pithecopus azureus)*

Anole lizard *(Anolis meridionalis)*

Cururu toad *(Rhinella diptycha)*

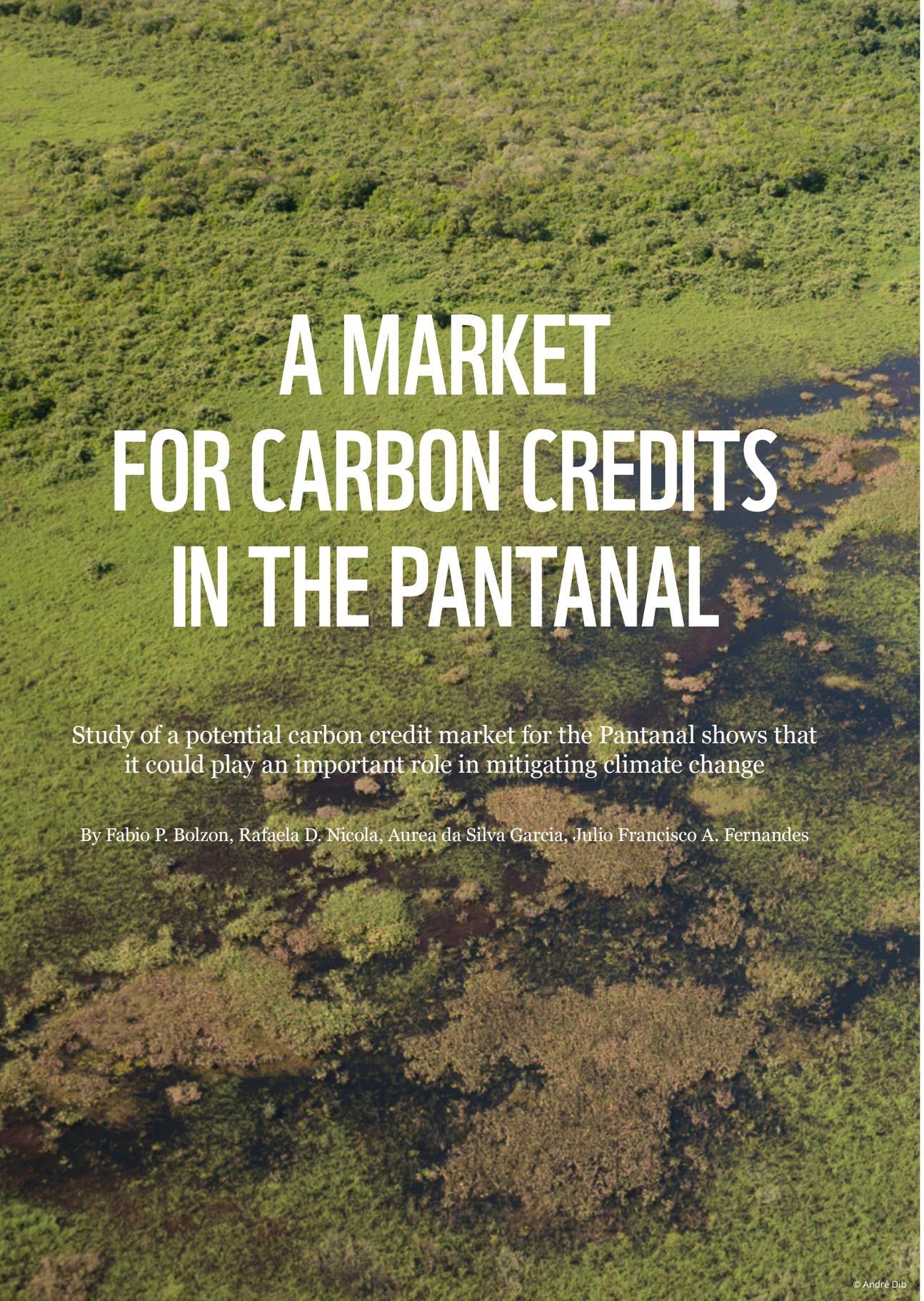
Brazilian guinea pig *(Cavia aperea)*

South American Small-handed Skink *(Manciola guaporicola)*

South American Small-handed Skink (Manciola guaporicola) found alive post-fire in an underground burrow during transect surveys in the Pantanal.

Rato-da-cana *(Holochilus chacarius)*

Chacoan Marsh rat (Holochilus chacarius) found inside a partially flooded burrow.



A MARKET FOR CARBON CREDITS IN THE PANTANAL

Study of a potential carbon credit market for the Pantanal shows that it could play an important role in mitigating climate change

By Fabio P. Bolzon, Rafaela D. Nicola, Aurea da Silva Garcia, Julio Francisco A. Fernandes

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Carbon is a chemical element of great importance in nature, a key ingredient seen in all forms of life. However, combined with oxygen, it forms the gas, carbon dioxide (CO_2), identified as one of the main greenhouse gas "villains" contributing to the "greenhouse effect" that causes global warming.

The current excess of CO_2 gas in the atmosphere as a result of emissions from human fossil fuel burning and land use change is one of the greatest causes of concern for scientists studying existing and future impacts of global warming on our planet. Finding possible solutions to reduce CO_2 and other greenhouse gas emissions (called climate change mitigation) will be essential. The use of carbon credit markets is one possible solution that can play an important role. Simply put, a market for carbon credits sets an overall limit for CO_2 emissions and allows flexibility in the global distribution of emissions. Countries that fail to meet their targets for reducing CO_2 emissions are allowed to purchase carbon credits from other countries that have met their targets and have accumulated excess carbon credits – a process called carbon offsetting.

The first large-scale debates on climate change and global warming took place during the 1992 United Nations Framework Convention (Eco92 or Rio92). On that occasion, governments of several countries, international institutions, and a significant portion of organized civil societies called for urgent actions to initiate a global agenda combating the effects of climate change on our planet – mainly through measures that will reduce greenhouse gas emissions. Subsequent events, such as the Kyoto Protocol treaty in 1997 and the Paris Agreement in 2015, reinforced, updated and detailed the binding emission reduction targets. Due to the complexity of carbon credit marketing, questions have been raised about its effectiveness as a tool for reducing emissions. Although a consensus about its effectiveness still does not exist, the trading of carbon credits has opened up new opportunities for environmental businesses – and the Pantanal can be part of the process.

Carbon credits can be generated in different ways: using renewable energy sources, improving the energy efficiency of projects, adopting sustainable land-use practices, reforesting areas and using carbon capture and storage (measures that remove CO_2 from

Dense tropical forest

© Richard Carey

Peat bogs

© Sean Board

the air and later store it in locations or chemical forms that do not return it to the atmosphere). In terms of generating carbon credits, Brazil is ideal for projects that involve stocking or sequestering carbon in forest vegetation when you consider the huge extent of the country's tropical forests. Generating electricity from renewable sources also has great potential. As the most biodiverse country in the world, projects promoting natural habitat conservation can help minimize climate change impacts and maintain essential ecosystem functions, such as water quality regulation and pollination. Considering that about 80% of the Brazilian Pantanal is fairly well-preserved, and that it is one of the most biodiverse biomes, it has great potential for implementing successful projects that generate carbon credits.

The Pantanal is a highly productive dynamic floodplain that supports an extraordinary level of biodiversity. The floodplain provides global-scale ecosystem services, and can be an important carbon sink. However, it does not store the same amount of carbon in its vegetation or soil as dense tropical forests, or even peat bog wetlands. At the same time, the seasonal flood pulse of the Pantanal that is responsible for the region's environmental heterogeneity and the diverse mosaic of grasses, savannas and forests allows a relatively harmonious coexistence between the conservation of natural areas and extensive livestock grazing – the main economic activity in the region. As the effects of climate change intensify – causing more extreme droughts, shortened rainy seasons, higher temperatures and others impacts that make cattle ranching less viable – businesses linked to carbon credits and nature conservation can provide a pathway to economic diversification. These types of businesses can potentially reduce pressures on natural resources, and at the same time, provide environmental and financial benefits.

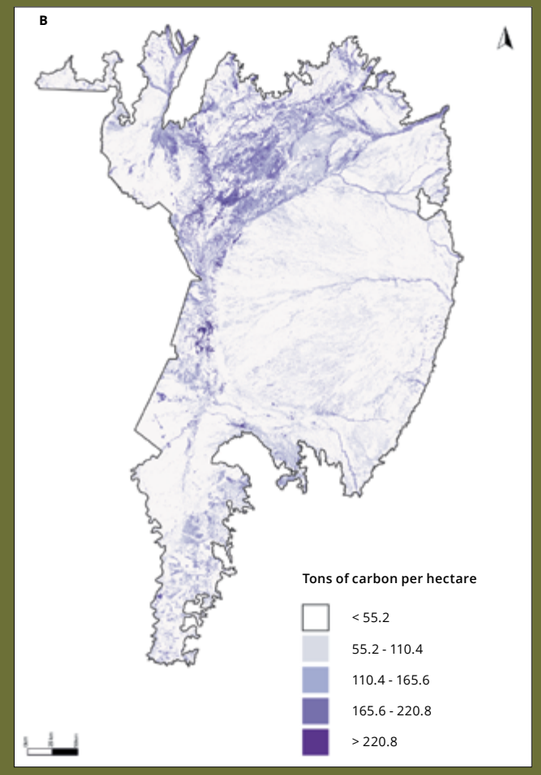
In this regard, a team of researchers recently published a study exploring the potential of a carbon credit market for rural properties in the Pantanal, using the REDD (Reducing Emissions from Deforestation and Forest Degradation) climate change mitigation mechanism. REDD projects can emphasize both the capturing of carbon from the atmosphere through reforestation and restoration, as well as preventing carbon losses from deforestation and poor land-use practices. The concept of REDD associated with sustainable land-use practices and increasing forest carbon stocks is known as REDD+. The researchers analyzed carbon credit market possibilities in quantitative and qualitative terms and also from the point of view of environmental legislation in the states of Mato Grosso and Mato Grosso do Sul, where the Pantanal biome is located. The analysis focused on forest formations, rather than areas with more open vegetation that is seasonally or permanently flooded. This decision was based on the fact that, in general, forest vegetation is more stable long-term, an important factor when working with REDD mechanisms.

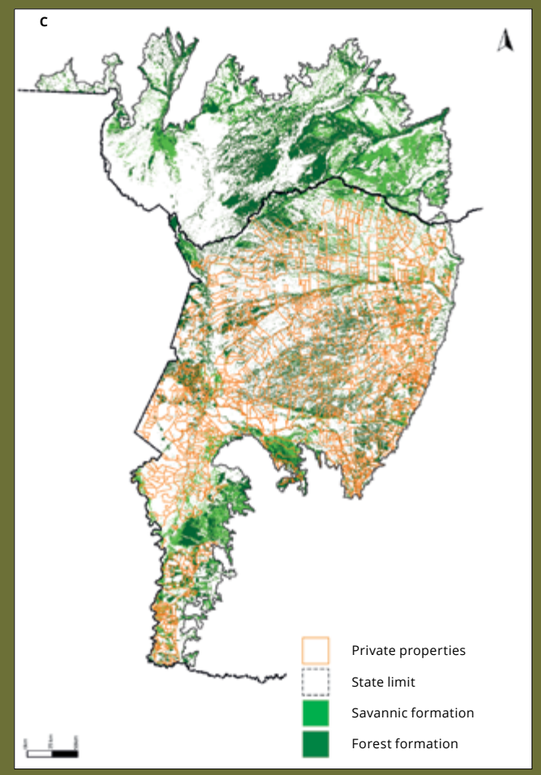
Due to the peculiarities of state legislation, only Mato Grosso do Sul (MS) presented opportunities for the development of REDD+ projects. The researchers found that, of the 1,771 rural properties analyzed in the southern Pantanal (MS), 283 properties (16% of the total) had native forest vegetation remnants (RVNF) that could legally be removed. This forest surplus (from a legal perspective) of approximately 100 thousand hectares contains more than 7.5 million tons of carbon, which represents over US$115 million in forest assets. Although this 100 thousand hectares corresponds to less than 1% of the total area of the Brazilian Pantanal, its conservation value is enormous in terms of its role in maintaining biodiversity, ecological functions and ecosystem services – essential benefits that humans obtain from nature.

In addition to containing the largest concentration of carbon per unit area within the biome, forested areas in the Pantanal function as essential ecological corridors and provide resources for many key species.

In addition to the environmental and economic benefits, well-designed REDD+ projects can and should promote nature conservation, creating benefits for local populations. These initiatives can serve as tools for community mobilization and social awareness, resulting in actions that include, for example, more effective firefighting and fire prevention strategies, such as the fire management project, "Operational Plans for Fire Prevention and Fighting and the Integrated Management of Fire". After all, no one in their right mind would want to see more than 100 million dollars burning right in front of them.

Although researchers identified surpluses among forest remnants (RVNF) that could be used for REDD+ projects, such initiatives would require the mobilization of a variety of decision makers and institutions, including national and international parties with limited knowledge about the dynamics of the Pantanal. For this reason, a specialized multidisciplinary organization will be needed to develop proposals and increase the chances of successfully implementing such projects. Finally, we know that a carbon credit market, alone, is not a magical solution for all of the Pantanal's environmental and social problems. However, in combination with other existing tools – payments for environmental services (PES), the ecological ICMS (mechanism for distributing tax revenue to municipalities with protected areas) and environmental compensation – it can provide the seeds for future CO_2 emissions reductions, guaranteeing the survival of the biome and all those that live in and depend on the Pantanal.





A Forest formations in the Pantanal Biome

B Above-ground carbon stock concentrations represented as tons of carbon per hectare

C Private properties in Mato Grosso do Sul that were selected to calculate surpluses of native forest vegetation remnants (RVNF)

FOREST FRAGMENTATION THREATENS WILDLIFE BIODIVERSITY

A white-lipped peccary study shows how the decrease and fragmentation of natural areas threatens their future and that of other species in the Cerrado highlands bordering the Pantanal

By Mozart Sávio Pires Baptista, Alexine Keuroghlian, Cibele Biondo

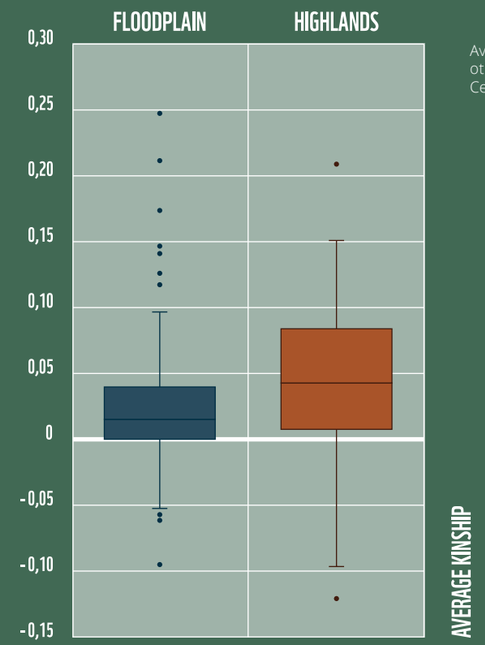
In our day-to-day life, we are used to using routes that take us from our home to where we want to go for a variety of reasons – whether it's for studying, going to work, shopping, visiting friends, or going out for a walk with the family. Depending on the location of our residence, we generally look for the easiest, fastest and safest routes.

Now imagine if, suddenly, between our home and the places we need to visit, a crater opens up that is very difficult to cross – or a big freeway is constructed with numerous lanes and intense traffic. Our commuting route will need to be changed, and maybe we'll have to avoid visiting certain places we used to go. What's happened is that our "habitat" has become fragmented.

This is basically what happens in nature when humans modify the environments and niches occupied by wildlife. As an example, we can use the case of white-lipped peccaries (WLPs), a threatened Brazilian ungulate (hoofed mammal). A study comparing populations of WLPs between the Pantanal basin and the surrounding highlands demonstrated how these herd-forming forest-dependent animals are impacted by habitat fragmentation.

The free movement of wildlife through their natural habitat allows for interactions with other individuals of the same species nearby, promoting the exchange of genetic material between different populations – a process known as gene flow. This process maintains genetic variation in a population that is essential for the long-term health and persistence of the species. Genetic variation helps populations of a species adapt to changing environmental conditions, improving a species' chances for long-term survival. For a healthy exchange of genes, it is essential that forest fragments (patches of forest remaining after deforestation of a continuous forested area) are well connected – in other words, are linked by natural vegetation corridors that connect wildlife populations from different fragments. In this manner, different groups of animals within a region have safe travel routes, can interact with each other and continue reproducing.

However, human encroachment into forested areas has caused habitat fragmentation, creating barriers between the remaining forest fragments. Returning to our initial example, it would be as if a crater opened up and formed a cleared area causing parts of the population to become isolated in separate fragments. Before the crater, the populations were meeting, interacting and reproducing without obstacles inhibiting their movements. The isolation process causes a loss of population genetic variability, because gene flow between different groups is interrupted by physical or ecological barriers. Consequently, these barriers reduce the ability for the isolated populations to survive in the changing forest fragment environments, increasing the risk of extinction.



Average white-lipped peccary kinship between each individual compared with other individuals of the same herd in the Pantanal floodplain and surrounding Cerrado highlands.

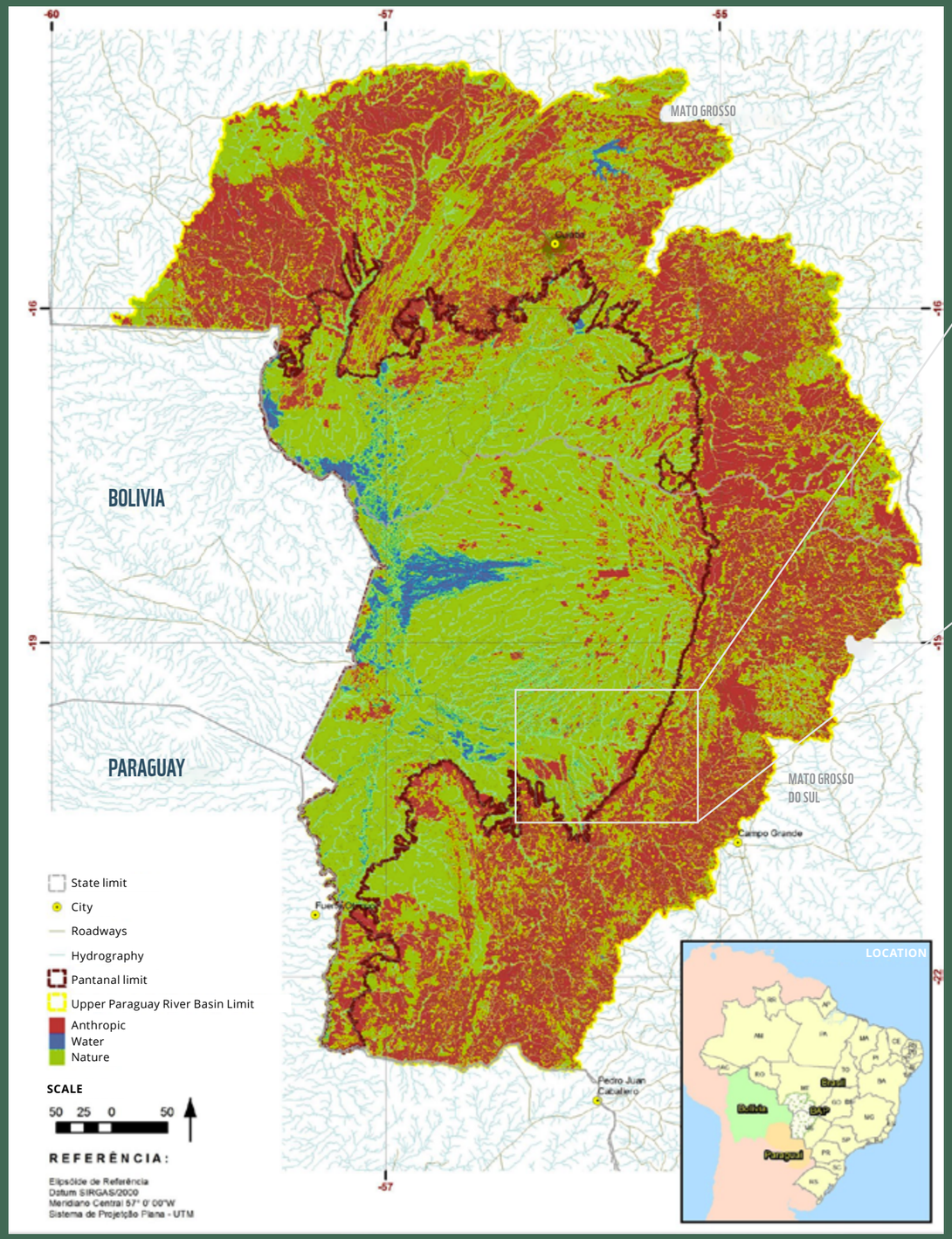
Our studies showed that, in general, WLPs from both environments – floodplain and highlands/plateau – show high levels of gene flow. However, when comparing WLP herds from each environment, individual peccaries within herds were less related to each other in the Pantanal compared to individuals within herds on the Cerrado plateau – indicating that movements of animals between herds and genetic variability within herds are greater on the less fragmented Pantanal floodplain. These results show that WLP movements are more restricted on the more fragmented Cerrado plateau, where the number of individuals able to migrate between herds is smaller. With forest fragmentation, the chances of encounters between different herds are reduced, decreasing the ability to exchange genetic material and consequently causing a disruption in gene flow.

Human occupation of the Upper Paraguay Basin (UPB) occurred differently for the Pantanal floodplain compared to the surrounding Cerrado highlands. The history of land-use over the last three decades was more intense in the highlands compared to the floodplain, where native areas remain relatively intact. The main reason the Pantanal floodplain is more intact is the historical/cultural use of native pastures and sustainable management practices that accompany the annual flood pulse. According to SOS Pantanal Institute, 2016 estimates showed that over 60% of the Cerrado highlands had been converted, while in the floodplain, it was about 13%. As a result, forests in the Pantanal basin are more connected and less fragmented, and therefore, gene flow is expected to be higher for populations of forest-dependent wildlife on the floodplain.

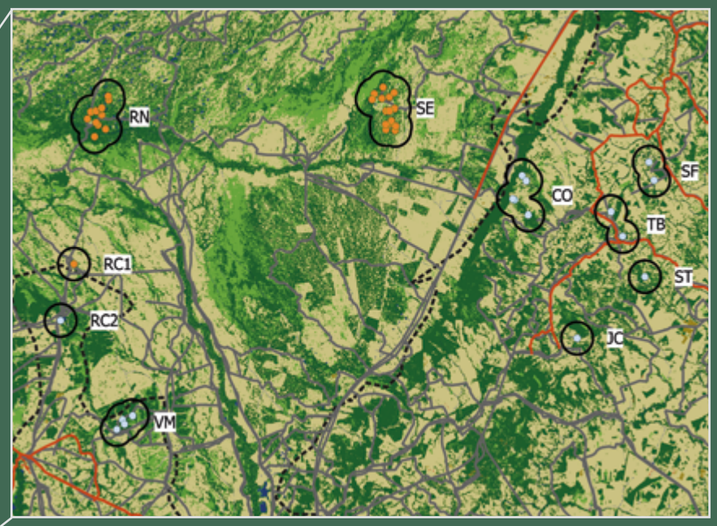
To test this hypothesis, researchers from the Peccary Project have been carrying out long-term genetic studies of WLP populations in both the Pantanal basin and the bordering Cerrado highlands for the last two decades. WLPs have ideal behavioral traits for this type of study, because they: (1) are forest dependent frugivores (fruit-eating), (2) are a wide-ranging species that uses a diversity of native habitats, (3) form large gregarious social herds, and (4) have multiple ecological roles. By overlaying genetic data with vegetation cover and land-use maps, (MapBiomas historical series), it was possible to develop isolation models that explain how landscape changes have impacted gene flow between WLP herds.

The researchers used three conceptual models to explain how the environmental differences between the floodplain and the surrounding Cerrado highlands reflect changes in the levels of WLP gene flow in both regions. In the isolation-by-distance model, rates of gene flow are proportional to the geographic distance over which the populations occur. In other words, genetic similarity between populations will decline as geographical distances increase. In the resistance-distance model, gene flow varies under different scenarios of landscape vegetation cover. Some types of vegetation cover, e.g., crops or planted pasture, are less permeable to wildlife movements than others, e.g., native forests. Finally, the isolation-by-barrier (IBB) model investigates gene flow in a landscape with impermeable features, e.g., roads and fences, which restrict gene flow between wildlife populations. In cases where habitat fragmentation has occurred, wildlife movements may be restricted by all three factors, i.e., distance between fragments (isolation-by-distance model), changes in vegetation cover (resistance-distance model) and the development of roads or other potential obstacles (IBB model).

Landscape modifications affect gene flow among white-lipped peccaries.



Map of the Upper Paraguay Basin showing vegetation and anthropic land coverage on the Pantanal floodplain and Cerrado plateau.
Source: WWF, 2016



Map of the study area showing the locations (10) where 51 sites were sampled in the Pantanal and adjacent Cerrado plateau, in Mato Grosso do Sul, Brazil. The "grassland" class includes native and exotic grasslands and wetlands. The "unvegetated" class includes mining areas, roads and human infrastructure.

Source: MapBiomas 4.0 land cover map, administrative boundaries 2016; IBGE (2015).

Agriculture and paved roads in the Cerrado highlands limit gene flow, increasing the vulnerability of WLP populations to losses of genetic variability and local extinctions. In general, Cerrado landscapes dominated by crops and planted pasture are more fragmented and impacted by human encroachment than native grassland areas in the Pantanal. The conversion of native habitat to agricultural and planted pastures is also associated with increased barriers due to fencing and new roads. The historical predominance of extensive native pastures in the Pantanal basin may have contributed to the conservation of gene flow levels when compared to the plateau. However, in recent decades, traditional practices in the Pantanal have been progressively replaced by the use of planted pasture an even agriculture on the floodplains. The negative effects of these rapid conversions without appropriate conservation planning will greatly impact wildlife conservation.

It was clear from our studies that WLPs avoided paved roads and large open areas – behaviors that are common for many native mammal species. If a species like the WLP, which is capable of long distance dispersal, is showing signs of genetic isolation due to impacts of habitat fragmentation, then species with smaller ranges and less ability to disperse long distances will certainly be impacted by habitat fragmentation and isolation. For this reason, ensuring connectivity (e.g., though the creation of natural vegetation corridors) between habitat fragments separated by roads and agricultural fields will be critical for maintaining wildlife movements.

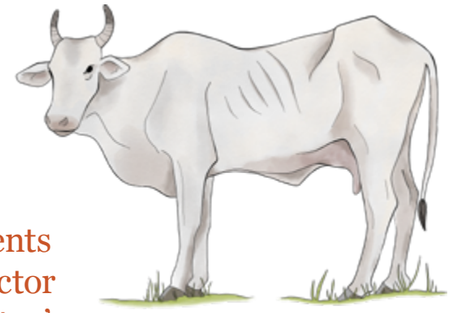
Our studies indicate that the main threats to WLP gene flow are largely restricted to the Cerrado plateau, where the negative effects of genetic isolation are already beginning to be detected. Conservation strategies such as reducing habitat conversion and preserving and recovering ecological corridors between fragments should be priorities for recuperating and maintaining wildlife gene flow. In the Pantanal floodplain, current levels of gene flow should be maintained and additional habitat conversion prevented.

Long-term conservation of wildlife populations will require viable landscapes that maintain the natural processes and reproductive cycles of the species in the UPB. Ecological corridors should be a priority to preserve connectivity between populations in fragmented habitats, especially between the larger forest fragments. For example, in the case of highways, safe and efficient wildlife crossings should be implemented. These structures can be green bridges, overpasses, tunnels, viaducts and culverts – all options to ensure a safe corridor passage. Wildlife crossing structures maintain animal movements and continued interaction between different populations. It would be as if, on that highway that separated us from the places and people we enjoyed visiting, an overpass or viaduct was built to facilitate access to these areas. We would be grateful and so would the white-lipped peccaries and other wildlife.

SUSTAINABLE CATTLE RANCHING IN THE PARAGUAYAN CHACO AND PANTANAL

Seeking to achieve a balance between economic development and environmental conservation, Paraguayan researchers are developing studies in cattle ranching areas

By Andrea Weiler, Alberto Esquivel, Sofía Albertini, Marco Heredia, Karim Musálem



In Paraguay, agricultural activity represents a growing and increasingly important sector of the economy. In fact, most of the country's economic growth depends on cattle ranching.

Despite the county's relatively small size – equal to less than half the area of the Brazilian state of Mato Grosso –, in recent years, Paraguay has become the world's fourth largest exporter of soybeans and the ninth largest exporter of beef. This recent agricultural development and improvements in production have been responsible for extensive conversions of natural environments to crops and planted pastures. In the Paraguayan Pantanal, where a diversity of natural environments still exists – ranging from grasslands and forests to wetlands and lakes –, there is potential for developing a more sustainable type of cattle ranching in which livestock coexist harmoniously with native wildlife species and their habitats.

Compared to other nations, Paraguay has had some of the highest rates of deforestation for several decades: between 1980 and 1990, deforestation rates in the eastern region – most notably, the Paraguayan Atlantic Forest – averaged approximately 445,000 hectares per year. In the western region, or Paraguayan Chaco – where the Pantanal is located – 9.5 million hectares (more than 20%) of its forested area was lost between 2000 and 2019. This unsustainable development driven by human population growth and increasing natural resource demands is occurring globally, and is not restricted to a single country. It is therefore crucial to develop processes and systems that promote sustainable food production.

This effort is in alignment with the United Nation's Sustainable Development Goals (SDGs) designed as part of their Agenda 2030. In the same context, the Food and Agriculture Organization of the United Nations (FAO) developed guidelines called the "Sustainability Assessment of Agricultural and Food systems" (SAFA), a tool that provides hierarchical qualitative metrics (indicators) of progress toward sustainability – or, sustainability performance – of production systems.

A recent study supported by the World Wildlife Fund through WWF-Paraguay, and conducted by a team of researchers from the College of Exact Sciences at the National University of Asunción, investigated the opportunities and challenges for cattle ranching production systems, and their potential for maintaining biodiversity. Using the SAFA methodology, the researchers evaluated sustainability performance on four cattle ranches covering a total area of 79,000 hectares in the Paraguayan Pantanal and Chaco. The 4 ranches were located in different ecological regions, each comprised of a particular set of natural vegetation formations, including dry forest, savanna, grasslands with shrubs, Cerrado and wetlands.

2030 AGENDA SUSTAINABLE DEVELOPMENT GOALS

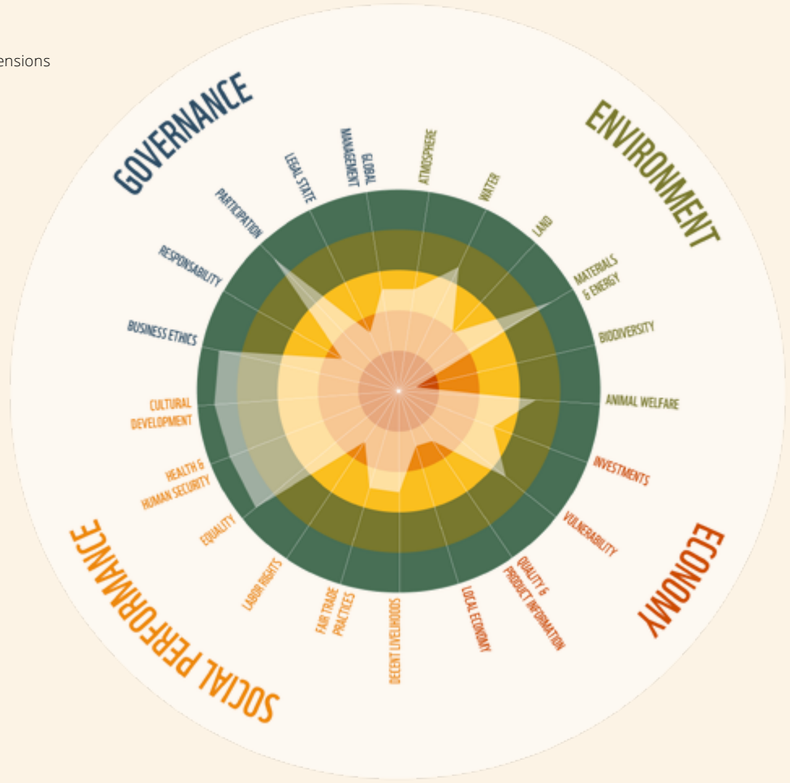
1. *No Poverty*
2. *Zero Hunger*
3. *Good Health And Well-Being*
4. *Quality Education*
5. *Gender Equality*
6. *Clean Water and Sanitation*
7. *Affordable and Clean Energy*
8. *Decent Work and Economic Growth*
9. *Industry, Innovation and Infrastructure*
10. *Reduced Inequalities*
11. *Sustainable Cities and Communities*
12. *Responsible Consuption and Production*
13. *Climate Action*
14. *Life Below Water*
15. *Life on Land*
16. *Peace, Justice and Strong Institutions*
17. *Partnerships for the Goals*

SAFA METHODOLOGY

Example of graphic representation and scoring of the dimensions and questions that are evaluated in the SAFA methodology.

PERFORMANCE	PERCENTAGE SCORES
Great	80 - 100%
Good	60 - 80%
Moderate	40 - 60%
Limited	20 - 40%
Unacceptable	0 - 20%

Figure 1:
The four SAFA dimensions of sustainability

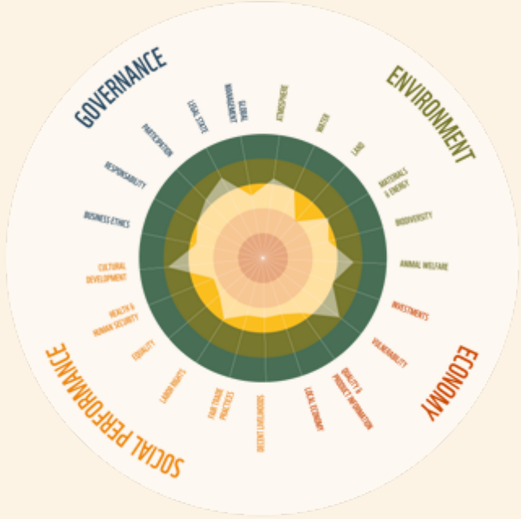


The four dimensions of sustainability that encompass SAFA metrics were considered during the study: environmental integrity, social well-being, good governance (set of actions that assist in decision-making processes), and economic resilience (capacity of the economy to recover from unforeseen events). The 4 dimensions were evaluated on three hierarchical levels: themes, subthemes, and indicators. Each theme was scored on a scale ranging from 1 to 5 (Figure 1) and represented by a radar chart, where: 1 (red) meant that the theme was rated as “unacceptable”; 2 (orange) as “limited”; 3 (yellow) as “moderate”; 4 as “good” (light green), and 5 as “best” (dark green).

The sustainability performance of the 4 cattle ranching production systems is shown in Figure 2, based on SAFA methodology and questions evaluated for each of the four dimensions of sustainability.

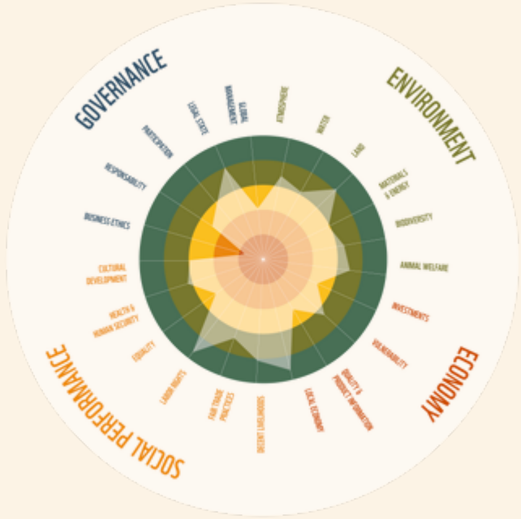
The indicator scores obtained for the four cattle ranching production systems ranged from “limited” to “high”. In terms of changes that are needed, the evaluation showed that the most important necessity for the ranch in the Dry Chaco region is improved water management. For the 2 ranches in the Dry Chaco - Cerrado transitional zone, issues concerning equal gender opportunities, labor rights, and cultural diversity need to be addressed. For the ranch in the Humid Chaco - Pantanal transitional zone, improving the relationship between the ranch and the local community, especially regarding complaints and legislative problems, were identified as important issues to be addressed.

DRY CHACO PANTANAL



DRY CHACO CERRADO

HUMID CHACO PANTANAL



HUMID CHACO CERRADO

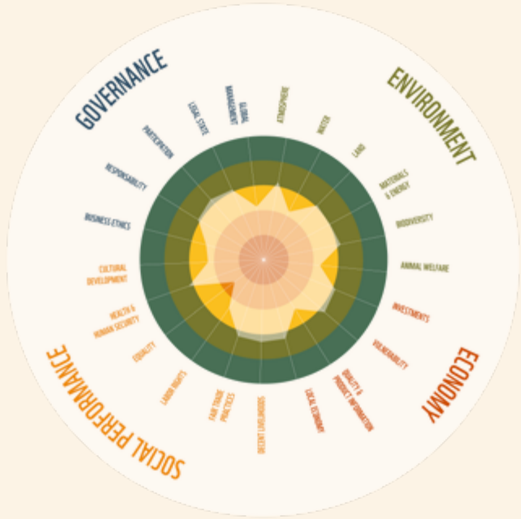


Figure 2:
The sustainability performance of the 4 cattle ranching production systems


© Andrey Gudkov

Jaguar (*Panthera onca*)

In addition to the SAFA evaluation, a ranch biodiversity assessment was conducted using camera trap surveys of medium- to large-sized mammals*. At the 4 ranches, from 16 to 25 mammal species were documented, including near-threatened and threatened species such as the jaguar, chacoan peccary (a relative of white-lipped and collared peccaries), giant armadillo, and maned wolf. The presence of these species indicates that mammal diversity is still relatively intact, and it stresses the importance of conserving native vegetation cover in these regions.

Generally, decisions about management of production systems are based on profitability, and are often focused exclusively on this parameter without considering other factors needed for a full assessment, such as the indicators evaluated by SAFA. In another study that focused on production system profitability, WWF together with the global, non-profit network, Agri benchmark, generated data that complemented the sustainability analysis. The study was based on interviews and workshops conducted in 2016 with landowners willing to provide data about their operations. The results showed that profitability varied dramatically among different types of cattle ranching production systems, ranging from $12.0 to $54.2 per hectare annually.

Extensive cattle ranching, typical of the Pantanal and lowland areas of the Humid Chaco, is considered less profitable, because the operations depend more on natural grasslands rather than planted pasture for grazing cattle. As a result, some landowners will switch to more intensive cattle operations, causing losses of biodiversity and natural ecosystems. In order to minimize these losses on ranches in the Pantanal and Chaco, sustainable land-use practices coupled with incentives – such as payments for ecosystem services – and other complementary activities need to be implemented to maintain both ranch profitability and environmental sustainability.

The challenge of successfully implementing sustainable cattle ranching production systems is making advances for all 4 pillars: social well-being, economy, environment, and governance. The analyses presented by this WWF-Paraguay supported project will serve as a basis for the development of strategies that improve sustainable cattle ranching in the region, contributing to Sustainable Development Goals that are so important for the future of the Pantanal and the planet as a whole.


© Daniel De Granville

Maned wolf (*Chrysocyon brachyurus*)


© Nicks Adventures Travel Company

Chacoan peccary (*Parachoerus wagneri*)

* Learn more from: "Mammals in Fire-Affected Areas Of The Bolivian Pantanal", page 47.


© André Labetaa

THE GENTLE GIANTS FROM THE SERRA DA BODOQUENA

Pioneering research project on green anacondas makes new discoveries and helps demystify the species

By Juliana de Souza Terra

© Daniel De Granville

Green anaconda (*Eunectes murinus*)

© Colette

Yellow anaconda (*Eunectes notaeus*)

Sucuri, giant anaconda, sucuriju, sucurujuba, boiaçu. These are just some of the common names given to this enormous reptile. The names vary depending on the region, but the public's fascination and fear of anacondas seems universal.

Since biblical times, snakes have intrigued humans and played a role in the popular imaginations of people worldwide. In recent decades, this fascination has intensified through movie productions with high doses of sensationalism. There are countless legends and myths involving anacondas that depict them as monsters – in spite of these stories, what is the real truth about these giant snakes?

Eunectes is a genus of boas, derived from the Greek word that means "good swimmer", in reference to their semiaquatic habits. Four species are currently recognized and found in South America: the green anaconda (*Eunectes murinus*), the yellow anaconda (*E. notaeus*), the spotted anaconda (*E. deschauenseei*) and the Beni anaconda (*E. beniensis*). The first three are found in Brazil, and in this article, we will focus on the green anaconda. Compared to the other species, the green anaconda has the widest geographic distribution, occurring in numerous South American countries. The green anaconda is the largest of the anacondas and the heaviest snake in the world. It is also the second longest snake, coming in close behind the Asian reticulated python.

Green anaconda (*Eunectes murinus*)

© Vladimir Wrangel

Green anaconda (*Eunectes murinus*)

© Vilmar

Until recently, observations of anacondas basking in the sun on tree branches were quite rare.

For a long time, due to a variety of reasons, little was known about wild anacondas. Only short reports of occasional observations were available. Basic information about the biology of the species obtained through rigorous scientific data collection was nearly non-existent. However, with a lot of effort, researchers are beginning to improve our understanding of the species.

Despite their size and magnificence, anacondas are vulnerable to human-mediated environmental impacts. This is cause for concern since they occur in developing countries with fewer resources for conservation efforts. Major threats include: human-caused habitat destruction, losses of natural prey populations, pollution, human-wildlife conflicts and poaching driven by fear and ignorant ideas about the species. The anaconda is a top predator in the food chain and depends on pristine healthy environments with an abundant and diverse prey base, so they can hunt and feed. A reduction in the availability of suitable habitat due to climate change impacts is another alarming threat to anaconda survival. Faced with such a scenario, it is essential to acquire science-based information about the green anaconda in order to identify and prevent negative impacts, and develop management and conservation strategies for their long-term survival.

In 2016, the "Sucuri Project" began a study of green anacondas in the Bodoquena mountain range (state of Mato Grosso do Sul, Brazil) located along the southern border of the Pantanal in the municipality of Bonito. The goal of the project was to gain an understanding about the species' natural history, including anaconda reproduction, food resources, environmental requirements and daily and year-round activity patterns. In addition to direct field observations and measurements by the research team, photographic records contributed by local residents also generated important additional information.

One of the biggest challenges of studying anacondas is finding them in the wild. Even though their large size would suggest that they are easy to observe, they are expert at hiding and blending into their environment. On top of their hiding skills, they leave few indirect signs of their presence, such as tracks, sounds or smells. For these reasons, selecting Bonito as a study site was ideal, because it offered a unique setting to study free-living anacondas. Bonito has a healthy representative population of green anacondas and

Green anaconda breeding ball

These observations confirm that anacondas are active during the day in the dry season, and are not restricted to nocturnal habits as was previously thought.

It is also during the dry season – usually between June and October –that anacondas enter their reproductive period. During this period, reproductive females release a chemical substance – a pheromone – into the air that is detected by male anacondas in the region. This draws in multiple males that gather around the female, forming a breeding ball – several males coiled around a female struggling for a chance to mate. A breeding ball can last for weeks and is usually observed along river banks among the vegetation close to the water. They also occur on the banks of shallow waterbodies. Females do not reproduce annually and can go up to three years without mating.

Among vertebrates, green anacondas show one of the greatest size differences between females and males, i.e., sexual dimorphism. The females can reach up to six meters in length, while males normally do not exceed 3.5 meters. The largest individual recorded by researchers was an adult female 5.13 meters long. Eyeballing anaconda size is strongly discouraged as a valid size estimate, because most people have the tendency to exaggerate when it comes to these impressive snakes. For this reason, reliable size or weight data should come from researchers following appropriate procedures to obtain accurate measurements.

The anaconda's diet consists of a wide variety of prey, primarily waterfowl, but also small and medium sized mammals, such as pacas, capybaras, capuchin monkeys, and peccaries, as well as caimans and occasional fish. They are usually ambush hunters, waiting at the edge of a water body for prey to approach. After feeding, they can spend months digesting, so they hunt only a few times a year.

Despite advances in scientific knowledge about the anacondas, more monitoring and research are urgently needed. The next steps for the "Sucuri Project" are to more thoroughly investigate their underwater behavior and activities and carry out long-term monitoring on their movements and use of habitats using radio-transmitters that allow tracking of individuals. By conducting scientific investigations and engaging local communities through dissemination of project results and promoting responsible wildfire viewing, the "Sucuri Project" is contributing to the demystification and conservation of anacondas, as well as the protection of their natural environments.

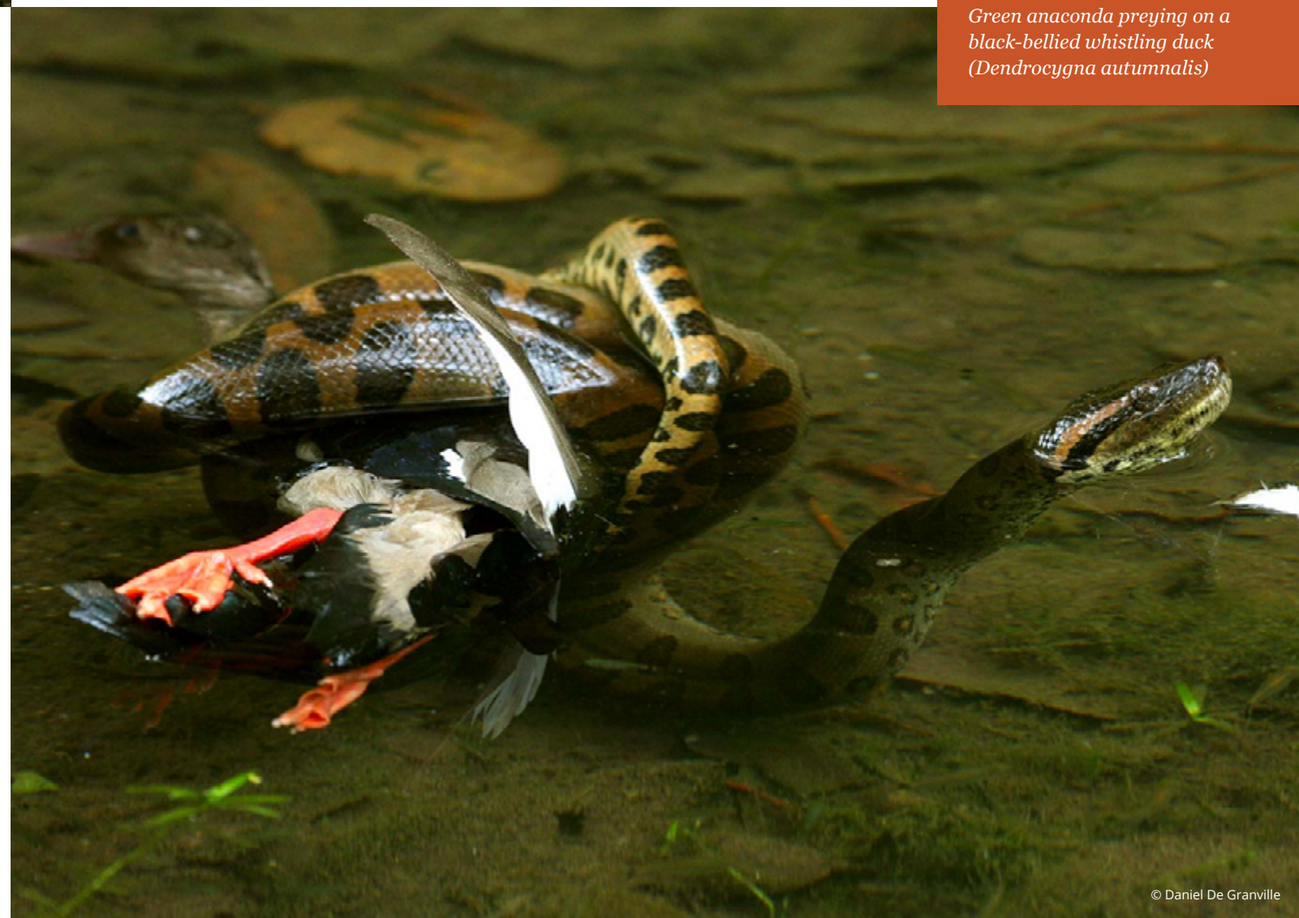
abundant aquatic environments with relatively easy access due to the tourism infrastructure in the municipality. Another major bonus is the characteristic crystal-clear waters of Bonito's rivers that allow researchers to make behavioral observations in the water, as well as on the land.

"Sucuri Project" activities included surveying rivers, streams and other aquatic habitats in the Bonito region. Whenever an anaconda was sited, researchers recorded its specific type of activity and other relevant information like date, time, location and details about the habitat used. When possible, the anacondas were captured, measured and marked to allow identification of the individual if it was recaptured. The animals also had their sex identified by observing pelvic spurs – modified scales, similar to small claws, located next to the cloaca. These spurs are large and visible in males, but not in females, a trait that enables sex identification.

Anaconda monitoring by the Project is ongoing and has provided interesting data over the years. During the rainy season, the period with the highest temperatures, they spend most of their time in water, on river or stream banks or in underwater burrows. They often use the river channels to move around during the rainy season. Winter is usually dry and cool, and during these months, the behavior of the anacondas is reversed. They spend most of the day out of the water, sunning on river banks or on the branches of riparian forest trees. Like all reptiles, anacondas do not produce their own heat, and therefore depend on the heat of the sun to speed up their metabolism and provide energy to carry out their activities. Such organisms are ectothermic, and the mechanism, by which ectotherms maintain their body temperature either by exposing themselves to sun or shade, is known as thermoregulation.

Until recently, observations of anacondas basking in the sun on tree branches were quite rare, with only three cases documented in the Ecuadorian Amazon in 1993. The dense riparian zone vegetation does not allow a lot of sun to reach the forest floor, so anacondas climb the trees to reach sunnier spots and stay warm. Our observations have shown that it is not unusual to find individuals on branches more than 3 meters off the ground. Only the larger females cannot climb trees and remain on the river banks. During the cool dry season, the anacondas usually leave the water around 10 am and show peak activity in the middle of the afternoon, between 1 and 3 pm. Around 4 pm, they begin to return to the water or to their burrows, where they probably spend the night.

Green anaconda preying on a black-bellied whistling duck (Dendrocygna autumnalis)



THE IMPORTANCE OF LONG-TERM RESEARCH IN THE PANTANAL

Long-term scientific studies, such as those carried out at the Taiamã Ecological Station, are of great importance in understanding the dynamics of the Pantanal

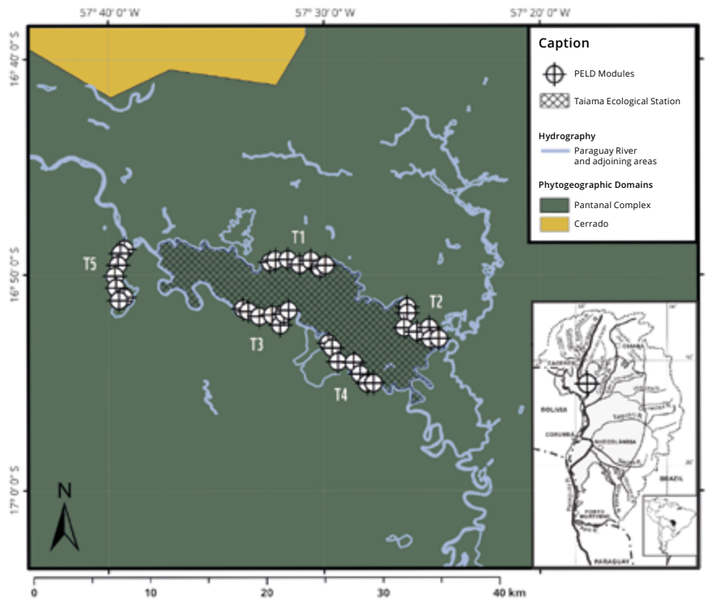
By Carolina Joana da Silva, Wilkinson Lopes Lazaro, Angélica Vilas Boas da Frota, Nilo Leal Sander, Solange Kimie Ikeda-Castrillon, Joari Costa Arruda, Josué Ribeiro da Silva Nunes

Aquatic macrophyte banks (*Eichhornia azurea* and associates) on the Paraguay River margins

The 2020 fires that raged across large areas of the Pantanal brought destruction and death. This catastrophe also shed light on an important realization: that the impacts from wildfires could have been less severe if there had been preventive fire management planning and ongoing scientific studies throughout the region.

In this regard, the work being carried out researchers at the Taiama Ecological Station – a conservation unit located in the region of Cáceres (MT) – can serve as a model for other research programs in the Pantanal and provide important information that will help prepare the region for similar events in the future.

Since 2017, the Taiama Ecological Station – or simply TES – has been designated as a reference site for scientific research within the federal government program known as the Long-Term Ecological Research Program (PELD). PELD, which was initiated in 1999 through funding from the National Council for Scientific and Technological Development (CNPq), is comprised of a network of 34 reference sites distributed throughout the Brazilian territory. At TES, the research is developed under the Project: "Ecological Dynamics in the Upper Paraguay River Floodplain" (PELD/DARP Pantanal), coordinated by UNEMAT (Mato Grosso State University) with the support of ICMBio (Chico Mendes Institute for Biodiversity Conservation).



Location of the Taiama Ecological Station in the Pantanal.
T - Transects, sampling sites for water quality, aquatic macrophytes, bird watching point and reference of tree vegetation modules

© Daniel Meunier

Water lily (*Victoria amazonica*) on the Paraguay River margins

TES is comprised of an 11,555 hectare island bordered by the Paraguay and Bracinho rivers. Five main macro-habitats have been identified, of which a type of wetlands, called batumes, make up about half of the island. Batumes are dominated by an array of aquatic plant species, ranging from the smallest flowering plant (*Wolffia brasiliensis*), measuring only 0.4 centimeters, to the enormous water lily (*Victoria regia*) with its 2.5-meter-wide floating leaves. Other macro-habitats include flooded grasslands, forests, and lakes. The water hyacinth (an aquatic plant species) dominates the landscape, especially along the river banks (Figure 2) and provides important habitat for other aquatic plants, invertebrates, birds, and fish.

Results of the first phase of the PELD project confirmed the rich biodiversity of the region, much of which occurs within TES. To date, 54 species of aquatic macrophytes (aquatic plants visible to the naked eye) and 451 species of microscopic algae have been catalogued. This richness of algae species is a result of large nutrient inputs that reach the Pantanal during annual floods. In terms of terrestrial plants, 42 species have been recorded in the forested areas, with abobreiro and guanandi trees predominating.

The bird list documented by PELD/DARP researchers has reached 278 species, including two that are classified as "Threatened" according to IUCN criteria: the chestnut-bellied guan and the bare-faced curassow. Another occurrence that deserves special attention is the first registration of the black tern in Central Brazil. This area is also an important wintering and breeding site for migratory birds. At TES, 49 migratory bird species have been documented, including Wilson's phalarope (a visitor from the Northern Hemisphere), the black skimmer (in Portuguese – *Taiamã*, the name given to the research station), swallows and birds of prey, such as the osprey. Project results from the first phase of the research have increased our understanding of the occurrence and distribution of birds on the floodplain, and how these patterns are related to ecological processes in the Pantanal.

Black tern (*Chlidonias niger*)

© AGAMI Agency

The Taiama Ecological Station protects a rich diversity of fauna and flora, but the area surrounding the station is also of great importance, especially for the livelihoods of local fishermen. The fishermen have extensive knowledge of at least 37 local fish species, including their dietary, commercial and medicinal uses, as well as the importance and uses of some species as bait fish. The fishermen set up seasonal campsites at varying distances from TES, depending on water level fluctuations. In February, during the flood season, they set up camp at higher elevations in an area known as Morrinho, about 40 km upstream from TES. As the water levels drop during the dry season between July and September, the camps are moved to a closer location downstream from TES. This seasonal variation in the use of areas surrounding TES emphasizes the importance of the Conservation Unit to maintain fisheries that support the livelihoods of local fishermen.

More than 30% of the area was burned during the 2020 fires, causing high mortality of numerous species, especially the abobreiro (purple coral tree), whose population was reduced by more than 40%. This tree provides important resources for many species of wildlife, including

Wilson's phalarope (*Phalaropus tricolor*)

© Vitorino B.

Black skimmer (*Rynchops niger*)

© Vitorino B.

Jabiru (*Jabiru mycteria*)

Illustration © Irene Sardá

birds – the losses potentially causing significant consequences for the diversity of TES in the future. Water quality also deteriorated during and after fires. Oxygen levels decreased and pH levels increased, altering the natural physiochemical properties of the water. In addition, the smoke and ash particles that settled in the water are potential sources of pollutants and harmful toxins that harm aquatic life and human populations.

The Paraguay River is currently threatened by policies and private initiatives that are driving harmful land-use practices, hydroelectric energy production and large-scale navigation. The direct threats come from deforestation, changes in flow patterns caused by construction of large and small hydroelectric power plants and alterations of the main river related to environmental licenses permitting construction of 4 river ports for the transport of grains produced in the highlands. Navigation of large barges in the meandering shallow channel of the Paraguay River will require channel alterations that affect natural flooding patterns in the heart of the Pantanal. Using scientific results and local knowledge, society can respond to these threats to help guarantee the sustainability of the region. The 2020 catastrophic fires may act as important warning highlighting the importance of long-term studies like PELD. Results from PELD will allow us to assess the long-term impacts of ongoing threats and catastrophic events on the structure, dynamics and recovery of the Pantanal.

Osprey (*Pandion haliaetus*)

© Harry Collins

SURVEYING MAMMALS IN THE FIRE-AFFECTED AREAS OF THE BOLIVIAN PANTANAL

© Leonardo

A camera trap study documents mammals frequenting protected areas with recurrent wildfires in the Bolivian Pantanal

Por Rafael Antelo, Lila Sainz e Victor Hugo Magallanes

Ocelot (*Leopardus pardalis*)

Although most of the Pantanal – about 60% – is in Brazilian territory, 22% of the area extends into Bolivia and 18% into Paraguay. Similar to what has been happening in the Brazilian Pantanal in recent years; the Bolivian floodplain has also suffered from large human-caused wildfires, even in supposedly protected areas. According to data from *Fundación Amigos de la Naturaleza*, in 2021 almost 700,000 hectares of the *Área Natural de Manejo Integrado* (ANMI) San Matías, and 136,000 hectares of the Otuquis National Park were burned, representing 24% and 13.5% of the protected areas, respectively. The smoke and ashes from these fires was accompanied by significant losses of Pantanal biodiversity, which is comprised in part of 1,800 plant species and more than 1,000 species of vertebrate animals, including fish, amphibians, reptiles, birds and mammals.

Among the vertebrates, the jaguar was selected as a key species to assess and strengthen the ecological connectivity between distinct natural areas. Such connectivity, essential for the maintenance of biodiversity, is threatened by agriculture, cattle ranching and roads that fragment the landscape.*

With support from the World Wildlife Fund (WWF), and at the request of the directors from AMNI San Matías and Otuquis National Park, the WWF-Bolivia team set up 35 camera traps to monitor the presence of jaguars and other mammals in the protected areas between September and October 2021. Camera traps consist of a digital camera connected to an infrared sensor that takes a photo, or records a video, when movement is detected in front of the camera. The camera traps register wildlife that would normally be difficult to observe, because they can be set up in numerous locations and are able to record images 24 hours/day.

In order to evaluate the occurrence of mammals in these protected areas with records of recurrent fires over the last 20 years, researchers deployed 20 camera traps in AMNI San Matías and 15 in the Otuquis National Park. The cameras were active for 90 days in the Otuquis National Park and for 42 days in ANMI San Matías, coinciding with a period that extended from the end of intense fires in September until the onset of the rainy season in October. Out of 2,053 records of mammals, 26 species were identified (Table 1), including small rodent species from the Muridae family. The crab eating fox was the most registered species, followed by the marsh deer and the agouti. At the other extreme, there were 5 species that were recorded only once. The jaguar came in 10th place with a total of 34 records obtained. It is important to note that both jaguar adults and young were recorded in both protected areas, indicating that they were reproducing. The challenge now is to maintain and/or improve the ecological connectivity between AMNI San Matías and Otuquis National Park in order to ensure gene flow between the populations in both areas.

* Learn more from “The Threats of Forest Fragmentation on Biodiversity”, page **26**.

Crab-eating fox (*Cerdocyon thous*)

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Table 1 - Total number of records for each species identified during camera trap surveys at the AMNI San Matías and Otuquis National Park. Unidentified species are indicated by: “sp.” (one species) or “spp.” (more than one species).

#	Scientific name	Common name	No. of records	IUCN Status	LRVB Status	PN ANMI Otuquis	ANMI San Matías
1	*Cerdocyon thous*	Crab-eating fox	641			X	X
2	*Blastocerus dichotomus*	Marsh deer	375		VU	X	X
3	*Dasyprocta variegata*	Agouti	122			X	X
4	*Myrmecophaga tridactyla*	Giant anteater	94	NT	NT	X	X
5	*Hydrochoerus hydrochaeris*	Capybara	90			X	X
6	*Leopardus pardalis*	Ocelot	65			X	X
7	*Tapirus terrestris*	Tapir	62	DD	VU	X	X
8	*Dicotyles tajacu*	Collared peccary	58	LC	NT	X	X
9	*Procyon cancrivorus*	Crab-eating racoon	36			X	X
10	*Panthera onca*	Jaguar	34	NT	VU	X	X
11	*Sylvilagus brasiliensis*	Brazilian rabbit	31			X	X
12	*Nasua nasua*	Coati	21				X
13	*Puma concolor*	Mountain lion	8			X	
14	*Tayassu pecari*	White-lipped peccary	8	NT	NT	X	X
15	*Dasypus novemcinctus*	Nine-banded armadillo	7			X	X
16	*Euphractus sexcinctus*	Six-banded armadillo	5			X	X
17	*Lycalopex gymnocercus*	Pampas fox	5			X	
18	*Eira barbara*	Tayra	3			X	
19	*Mazama americana*	Red-brocket deer	3			X	X
20	*Chrysocyon brachyurus*	Maned wolf	2	NT	NT	X	
21	*Mazama gouazoubira*	Grey-brocket deer	2			X	X
22	*Alouatta caraya*	Howler monkey	1	LC			X
23	*Herpailurus yagouaroundi*	Jaguarundi	1			X	
24	*Leopardus tigrinus*	Oncilla	1			X	
25	*Lontra longicaudis*	River otter	1	DD	NT		X
26	*Tamandua tetradactyla*	Collared anteater	1			X	
		TOTAL	**1677**				
	Mazama spp	Deer	110			X	
	Muridae	Rodent	54			X	X
	Felidae	Feline	1			X	
	Cavia spp	Guinea pig	1				X

IUCN: The International Union for Conservation of Nature
Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD)
LRVB: Red Book of Bolivian Vertebrates

© Johannes Jensås

Marsh deer (*Blastocerus dichotomus*)

These are the first results obtained from a camera-trap mammal survey in the protected areas of the Bolivian Pantanal, establishing a baseline that can help monitor the impacts of future fires in the region. The quantity and diversity of mammals observed in this fire-associated ecosystem suggested that, despite recurrent and intense human-caused fires, many mammal species have been able to persist. However, if the frequency of wildfires is not reduced, the ability of some mammals to adjust to post-fire conditions may be exceeded. To address this, WWF-Bolivia is developing strategies to reduce wildfires in this emblematic region.

© Daniel De Granville

Camera-trap

Agouti (*Dasyprocta variegata*)

© Adobe Stock

ECOLOGICAL RESTORATION WITH A TRADITIONAL COMMUNITY

In the Baía Negra Environmental Protection Area, scientists empower the local population to help recuperate degraded areas

By Felipe Luis Gomes Borges, Thiago Miguel Oliveira Saiefert, Gabriel Pesqueira da Luz, Carolina Ferreira Pauliquevis, André Luiz Siqueira, Letícia Couto Garcia

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For the last three years, the Pantanal's devastating fires that impacted large areas of the region caught global and national media attention because of the immense environmental damages and losses.

However, other relevant and less publicized impacts threaten this biome and demand attention. A relevant example comes from the Baía Negra Environmental Protection Area, located in the municipality of Ladário (MS), where the Project "Strategic and Participatory Restoration in the Pantanal: Baía Negra Environmental Protection Area (APA)" promotes actions to combat environmental degradation on several fronts. By integrating traditional communities in the actions, researchers are promoting novel tactics for these challenges.

The purpose of the Project is to restore 51 hectares over 24 months in the APA where environmental degradation is occurring for numerous reasons. A highly invasive and exotic tree, *leucaena* or lead tree (*Leucaena leucocephala*), occupies 47 hectares and prevents ecological succession and natural cycles of native plant species. This invasive plant is fast growing, has high seed production and is resilient to drought. Consequently, *leucaena* has the potential to readily invade native environments and is one of the first species to colonize areas disturbed by human activity. The remaining 4 hectares were degraded by mining activities and contaminated with significant accumulations of garbage.

The Baía Negra APA was created in 2010, with an area of approximately 6000 hectares, and classified as a sustainable development conservation area. According to the National System of Conservation Units (SNUC), a sustainable development conservation area permits the presence of human populations and the rational exploitation of natural resources. This is different from other categories that are more restrictive, such as National Parks or Biological Reserves. Due to a variety of ecosystem types within the conservation unit, the Baía Negra APA has a high diversity of widely- distributed fauna and flora. Ecosystems range from humid areas and large lakes (such as *Negra* and *Arrozal* lakes) to permanently dry areas in seasonal forest fragments. The APA also encompasses one of the only protected remnants of the so-called Chiquitano dry forest, a forest formation characteristic of east-central Bolivia. Traditional knowledge of local residents allows them to survive on fishing, sustainable plant extraction, tourism and subsistence farming. For this reason, their involvement in the APA Restoration Project has been essential for achieving desired results.

In the 4 hectares degraded by mining and garbage, restoration activities included garbage removal, soil mixing, fertilizing, and planting of native seedlings. The aim was to create favorable conditions for the recolonization of flora and fauna. In the 51 hectare region dominated by *leucaena*, manual management without the use of herbicides was required to slow the advance of the exotic tree. Monthly pruning is carried out, followed by sowing *guandu* beans (green fertilizer) in combination with planting of native seedlings. These steps create unfavorable habitat conditions for weeds, and also protect two existing local springs. At the same time, establishment of agroforestry systems adjusted to the needs of the local community and native biodiversity is also encouraged.

In addition, researchers are investigating whether the advancement of leucaena in the Pantanal is connected with the reduced floods and catastrophic wildfires that have impacted so much of the biome. To answer this and other questions, researchers are aligning their activities with targeted strategies for future control and prevention of droughts and fires developed by the Pantanal Fire Long-Term Ecological Research Team (PELD) and the Intervention Ecology Laboratory of the Federal University of Mato Grosso do Sul (LEI – UFMS).

All of the restoration activities rely on community participation, combining local traditional knowledge and scientific methods, while addressing the environmental, social and economic aspects of sustainability. By providing environmental benefits and scientific knowledge through research, and improving the quality of life by generating a form of income and exchanging information, the Project is addressing challenges that threaten the Pantanal in an integrated manner. Monitoring activities are facilitated by citizen scientists. The free and open-access citizen science software, *Sapelli*, is useful for territorial planning and conflict resolution, documenting resource use and occupation, and monitoring ecological restoration. The project installed *Sapelli* on the cell phones of community supervisors to map and characterize environmental features such as the presence of exotic species, ecological succession and fire.

Project initiatives align with Aichi Biodiversity Targets established by the Convention of Biological Diversity for the 2011 to 2020 period during the COP-10 conference in Japan. It is also in alignment with recommendations from the Ramsar convention and the MAB program (man and the biosphere program) of Biosphere Reserves. The Project is coordinated by ECOA – Ecology and Action in partnership with LEI – UFMS, under the technical coordination of the Ministry of the Environment (MMA) and has funding from the Global Environmental Facility (GEF), whose implementing agency is the Inter-American Development Bank (IDB) with the Brazilian Biodiversity Fund (FUNBIO) as the financial executor.

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The project combines traditional and scientific knowledge through the use of Sapelli Citizen Science software and participatory monitoring.

PANTANAL OBSERVATORY: INFORMING AND ENCOURAGING CIVIL SOCIETY IN THE UPPER PARAGUAY RIVER BASIN

Multidisciplinary network of institutions is a reference for tackling socio-environmental challenges in the Pantanal

By Cyntia Cavalcante Santos, Flávia Araújo, Áurea Garcia, Rafaela Nicola, Pedro Cristofori

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Occupying an area of about 180,000 km² in the Upper Paraguay Basin (UPB), the Pantanal is located in the Brazilian states of Mato Grosso and Mato Grosso do Sul, and portions of Bolivia and Paraguay.

The size of this biome is equivalent to the state of Oklahoma, USA. Civil society organizations are working together in the region as part of an initiative called the "Pantanal Observatory". The goal is to create a space to disseminate information (traditional and scientific) that contributes to decision-making, and ultimately promotes conservation of the region and its traditional cultures. Building on a series of actions during 2014, the Pantanal Observatory was officially inaugurated in 2015.

In 2014, the Ecosystem Alliance Program – an alliance of Wetlands International, Both ENDS, and IUCN NL – fostered a series of dialogues between five local non-governmental organizations that identified a need for a permanent platform to exchange and boost sustainability and conservation initiatives in the Pantanal. The initial ideas for the platform emerged during the CoP 12 Ramsar Conference in Punta del Leste (Uruguay), followed by contributions from discussions with organizations in Mato Grosso do Sul, Mato Grosso, Bolivia and Paraguay. The following year, mobilization grew and the initiative took shape when other organizations within regional communication channels joined, leading to the creation of the Pantanal Observatory (PO). IUCN Brazil was elected as the anchor institution, and WWF-Brazil, ICV (The Life Center Institute) and Mupan (Women in Action in the Pantanal) as the executive secretariat.

The Ecosystem Alliance Program in 2017 was continued through support to the PO via WWF-Brazil, from the "Sustainable Landscapes for the Pantanal" (PaSos) project. The meetings, capacity building and the development of strategic planning were serious commitments contributed by the civil society organizations. With the addition of new members such as SOS Pantanal, WWF-Bolivia,

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WWF-Paraguay, Sociedad Boliviana de Derecho Ambiental (SBDA) and Guyra Paraguay, the Pantanal Observatory reached 35 members. In 2019, the PO revised the strategic planning and defined its mission: *"to create a space to generate, disseminate and apply traditional knowledge and scientific information to the people in the region and the international community; to promote and catalyze effective and efficient practices of sustainable development and political influence in and for the Pantanal biome"*.

2020 brought worldwide challenges with the spread of the Covid-19 pandemic. Specifically for the Pantanal, the harsh reality was tough: devastating forest fires and water scarcity forced communities, institutions and governments to redefine their actions and adapt in the midst of the threats. The PO was forced to review its tactics and adapt to remote working conditions. The scenario was different for Bolivia, Paraguay and Brazil. The institutions had financial and technical resources to carry out numerous local actions within the limits set by pandemic conditions and ongoing environmental devastation. The PO remained active and its members provided necessary support, when possible, to communities in different parts of the region by strengthening and organizing fire-fighting brigades, or by defending water sources and common community spaces, and in general, making themselves available for essential activities.

In mid-2021, a joint effort promoted collaborations between institutions that strengthened the PO governance. The institutions connected once again and planned priority actions based on the new scenarios. After three online workshops and many contributions, it became clear that the collaborative actions and networking of the PO stood out as a regional reference for dealing with the current realities.

Currently, the PO works with a trinational network made up of 43 institutions. It has recently strengthened its governance process, reorganizing institutions into work centers, in which anchor organizations volunteer to lead the centers for a defined period in an organized and focused manner and in the interest of the group. These institutions work on various socio-environmental issues within the Upper Paraguay River Basin in Brazil, Bolivia and Paraguay. One of the most relevant actions in this collaborative effort is the analysis and production of technical reports on issues that threaten the Pantanal. By promoting the so-called political occurrence – a set of actions aimed at influencing an effective public policy, social standpoints or political developments directed at decision-makers – important issues relevant at the regional and international level have been discussed in a coordinated manner.

Since nature is not aware of borders or boundaries, some issues that occur in Brazil directly affect Bolivia and Paraguay. For example, we can refer to the "Project Law Statute of the Pantanal", a proposal that has been submitted to the Brazilian legislature and awaits new definitions. Another relevant topic is the installation of infrastructure projects in the Upper Paraguay Basin that threatens regional health. These include the construction of ports, the Paraguay-Paraná Waterway, Small Hydroelectric Centers and other hydroelectric projects. Confronted with such an array of threats, the PO has increasingly demonstrated its effectiveness as a fundamental tool in handling the continuous challenges and new threats that turn up in the region, endangering one of the world's largest wetlands.

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